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Science, Innovation and Electronic Information Division

Starting the new century: technological change in the Canadian private sector, 2000-2002

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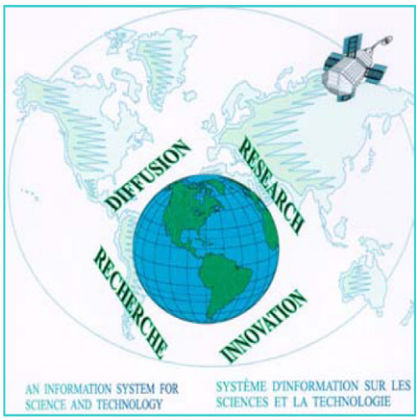

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Starting the new century: technological change in the Canadian private sector, 2000-2002

Survey of Electronic Commerce and Technology, 2002

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The Science and Innovation Information Program

The purpose of this program is to develop **useful indicators of science and technology activity** in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed in five key entities:

- **Actors**: are persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.
- **Activities**: include the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.
- **Linkages**: are the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, the source of ideas for innovation in industry.
- **Outcomes**: are the medium-term consequences of activities. An outcome of an innovation in a firm may be more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.
- **Impacts**: are the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and we are continuing with our efforts to understand the characteristics of innovative and non-innovative firms, especially in the service sector that dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology in which it invests over five billion dollars each year. In the past, it has been possible to say only *how much* the federal government spends and *where* it spends it. Our report **Federal Scientific Activities, 1998 (Cat. No. 88-204)** first published socio-economic objectives indicators to show *what* the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, all of this information has been used to provide a context for performance reports of individual departments and agencies.

As of April 1999, the Program has been established as a part of Statistics Canada's Science, Innovation and Electronic Information Division.

The final version of the framework that guides the future elaboration of indicators was published in December, 1998 (**Science and Technology Activities and Impacts: A Framework for a Statistical Information System,** Cat. No. 88-522). The framework has given rise to **A Five-Year Strategic Plan for the Development of an Information System for Science and Technology** (Cat. No. 88-523).

It is now possible to report on the Canadian system on science and technology and show the role of the federal government in that system.

Our working papers and research papers are available at no cost on the Statistics Canada Internet site at http://www.statcan.ca/cgi-bin/downpub/research.cgi?subject=193.

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Preface

Innovation and the adoption and dissemination of technologies and practices are vital to economic growth and development. It is through innovation that new products are introduced to the market, new production processes are developed and introduced, and organisational changes are made. Through the adoption of newer, more advanced, technologies and practices, industries can increase their production capabilities, improve their productivity, and expand their lines of new products and services.

In 1993, the first survey of innovation and the adoption of advanced technologies in the Canadian manufacturing sector was carried out. It was followed in 1996 by a survey of innovation in the communications, financial services and technical business services industries. The Survey of Innovation, 1999 surveyed manufacturing and was the first innovation survey of selected natural resource industries.

Biotechnology surveys carried out in 1996, 1997 and 1999 have examined both the development of new biotechnology products and processes and the use and planned use of biotechnologies. The 1999 Survey of Innovation, Advanced Technologies and Practices in the Construction and Related Industries is the first survey of the innovation and advanced technologies and practices in the construction sector. A number of surveys have focused on the use and planned use of advanced technologies and practices: surveys of advanced manufacturing technologies were carried out in 1987, 1989, 1993 and 1998; and surveys of the use and planned use of information and communication technologies were carried out in 1999, 2000 and 2001.

In 2001, SIEID piloted the Knowledge Management Practices Survey that gathered information on the use and planned use of a series of business management practices as well as the reasons for implementing these practices and their perceived results. Interest in business practices continued with the addition of a question on how private sector enterprises and public sector organisations use electronic networks to share business information within their organisations and with other organisations to the 2001 Survey of Electronic Commerce and Technology.

This study is one in a series of studies that the Science, Innovation and Electronic Information Division (SIEID) has undertaken that have examined technological and organisational change in the Canadian economy. The Survey of Electronic Commerce and Technology, 2000 contained two questions on organisational and technological improvements. These two questions provided the first cross-economy data on this issue, covering both firms in the private sector and organisations in the public sector. In 2002, the Survey of Electronic Commerce and Technology asked a question on technological acquisition the results of which are explored in this working paper.

Acknowledgements

This report provides new Statistics Canada estimates of technological change in the Canadian private sector. The results are based on information from the Survey of Electronic Commerce and Technology, 2002. Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

The publication of this report was made possible by the contribution of many people including Bryan van Tol, Marie-Claude Duval and Guy Sabourin as well as Claire Racine-Lebel, Lucienne Sabourin, Adele St. Pierre, Craig Kuntz and Fred Gault.

Introduction

According to an article in the *Globe and Mail* by Jim Carroll "Resistance is futile" (Carroll 2003: B1) when we think of change. Technological changes are occurring at home, work and play. In the workplaces, change occurs in how business is conducted, its production processes and office procedures and much of this change is related to introducing new or significantly improved technologies. Technological change in the workplace includes the seemingly simple purchases of off-the-shelf technologies such as accounting software; colour printers with double-sided printing and facsimile capabilities; and sophisticated medical diagnostic machines and equipment. Acquisition of new or significantly improved technologies is not limited to purchases, but also includes leasing and licensing as well as customising and developing technologies. Another technology acquisition method, which could incorporate all of the other technology acquisition methods, is "putting into place an improved production facility" by for example retro-fitting pulp and paper mills. At the turn of the new century, the Canadian private sector is not resisting the lure of change — four out of ten private sector firms introduced technological change between 2000 and 2002.

This paper is based on information from the 2002 Survey of Electronic Commerce and Technology (SECT) (see Appendix: for Methodology) and concentrates on the acquisition of significantly improved technologies in the private sector. The private sector and its two major sub-sectors, the goods producing and services producing sectors, are presented by employment size groups. The technological change rates by major sector are also provided.

Definition of Technological Change

The following two questions determined if firms were involved in technological change, and, if so how they were involved:

"During the last three years, 2000 to 2002, did your organisation acquire significantly improved technologies?"

"If yes, how did you acquire significantly improved technologies?

- By purchasing off-the-shelf technologies?
- By licensing new technologies?
- By customising or significantly modifying existing technologies?
- By leasing new technologies?
- By developing new technologies (either alone or with others)?
- By putting in place an improved production facility?

Two of the questions "by leasing new technologies" and "by putting in place an improved production facility" were asked for the first time in 2002.

An additional question on training due to technological change overall was asked. (The question did not refer specifically to the method used to acquire the significantly improved technology.)

"Did any of these improvements require training?"

Impact of size on technological change

Without a doubt large firms were more likely to have introduced technological change between 2000 and 2002 across all of the sub-sectors (see Table 1). This finding is not new, large firms traditionally have had higher rates for technological change (Earl 2002a and 2002b). Of interest, is the evenness of introduction of technological change between the sub-sectors within each employment size group. This result suggests that introduction of technological change is more associated with firm size than with industrial sector. Perhaps the costs associated with the introduction of technological change which can include the acquisition costs, work interruption for installation, training, potential short-term loss of production are more easily borne by larger firms. The overall rate of technological change is only slightly increased by the removal of firms with no full-time employees across the sectors (see Tables 1 & 2). Throughout the paper, the private sector overall will be analysed, however, the tables show both the total private sector and the private sector with one or more full-time employees.

Sector influence on technological change

Within the goods producing sector, construction and forestry, fishing and hunting showed the lowest inclination towards acquiring significantly improved technologies between 2000 and 2002 — just three out of ten firms undertook technological change. Utility firms, on the other hand, led the goods producing sector with seven out of ten firms undergoing technological change. The low technological change rate posted by construction reduced the overall rate for the goods producing sector, as construction accounted for 40% of firms in this sub-sector. Manufacturing firms, half of which introduced technological change, comprised 45% of the goods producing sector and 56% of this sector's firms that acquired new technologies between 2000 and 2002 (see Table 3).

Overall, the services producing sector's inclination towards technological change mirrored that of the goods producing sector. The two major sub-groupings diverged for large enterprises of 500 or more employees with services producing sector enterprises leading at nine out of ten firms acquiring new technologies as compared to eight out of ten for their goods producing counterparts. Within the services producing sector, the technological change rates for the goods related services and intangible services were similar across the employment size groups. The goods related services withstood the lower technological change rate posted by transportation and warehousing as this industry comprised just less than one quarter of the sub-sector. Wholesale and retail trade led the goods related services with just under one half of firms in these industries introducing technological change between 2000 and 2002.

Table 1: Technological change rates for private sector enterprises by employment size groups, 2000-2002

	Technological Change Rate (%)
Total Private Sector	41.8 A[1]
Total Goods Producing Sector	40.5 A
Total Services Producing	42.0 A
Goods Related Services	40.1 A
Intangible Services	42.8 A
0 Full-time Employees[2]	
Private Sector	16.5 A
Goods Producing Sector	15.1 B
Services Producing Sector	16.6 A
Goods Related Services	8.7 B
Intangible Services	18.4 A
1+ Full-time Employees	
Private Sector	45.5 A
Goods Producing Sector	43.7 A
Services Producing Sector	45.9 A
Goods Related Services	42.9 A
Intangible Services	47.1 A
1-99 Full-time Employees	
Private Sector	44.7 A
Goods Producing Sector	41.8 A
Services Producing Sector	45.2 A
Goods Related Services	42.2 A
Intangible Services	46.5 A
100-499 Full-time Employees	
Private Sector	75.5 A
Goods Producing Sector	73.2 B
Services Producing Sector	76.7 B
Goods Related Services	68.2 C
Intangible Services	81.0 B
500 + Full-time Employees	
Private Sector	89.2 A
Goods Producing Sector	81.7 A
Services Producing Sector	91.4 A
GoodsRelated Services	90.8B
Intangible Services	91.8 A

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

Note: Estimates for goods producing and services producing sectors were developed by aggregating NAICS classes as outlined below. Goods producing includes NAICS groups: 11 (excluding 111-2,114, 1151 and1152), 21-23 (excluding 238), and 31-33. Services producing sector includes NAICS groups: 41, 44-45, 48-49, 51-56 (excluding 551114), 61-62 (excluding public sector enterprises), 71-72, and 81. Goods related services includes NAICS groups: 41, 44-45, and 48-49. Intangible services includes NAICS groups: 51-56, 61-62 (excluding public sector enterprises) 71-72 and 81 (excluding 814). Taken together goods related services and intangible services aggregate to the services producing sector.

[1] See Table 6 in the Appendix for interpretation of the quality indicator.

[2] The category 0 full-time employees includes firms that only hire part-time workers; firms that contract hiring of employees to another firm which in turn pays the employees; firms in joint ventures whose partner(s) hire employees and some self-employed individuals.

Three industries in intangible services posted higher than average technological change rates for 2002: information and cultural industries; educational services and professional, scientific and technical services. The top two of these three industries, however, are the smallest components of intangible services and taken together they represent less than 4% of firms in intangible services. On the other hand, firms in professional, scientific and technical services comprised 27% of intangible services. Therefore, the technological change rates for the sub-sectors also depend in part upon their industrial composition as well as upon the size of the firm.

Table 2: Technological change by sector, 2000-2002

	Technological Change	**Technological Change**
	Total %	1+ **Full-time Employees** %
Private sector	**41.8A**	**45.5A**
Goods producing sector	***40.5A***	***43.7A***
Forestry, Fishing and Hunting	29.0C	34.2C
Mining and Oil and Gas Extraction	46.0C	49.6C
Utilities	72.6C	79.2B
Construction	30.7B	33.7B
Manufacturing	50.8A	51.6A
Services producing sector	***42.0A***	***45.9A***
Goods related services	*40.1A*	*42.9A*
Wholesale Trade	47.2A	48.3A
Retail Trade	42.3A	44.8A
Transportation and Warehousing	27.3A	31.2B
Intangible Services	*42.8A*	*47.1A*
Information and Cultural Industries	66.2B	69.6B
Finance and Insurance	49.7B	55.9B
Real Estate and Rental and Leasing	32.6B	42.2B
Professional, Scientific and Technical Services	56.3A	61.3A
Management of Companies and Enterprises	29.2B	42.8C
Administrative and Support, Waste Management and Remediation Services	36.5B	44.0B
Educational Services (excluding public administration)	65.1C	64.3C
Health Care and Social Assistance (excluding public administration)	45.2B	45.8B
Arts, Entertainment and Recreation	43.2C	46.9C
Accommodation and Food Services	26.9B	28.0B
Other Services (excluding public administration)	36.4A	38.4A

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

Table 3: Distribution of firms by sector, 2002

	Proportion of firms	Proportion of firms undergoing technological change
	%	%
Total private sector	**100.0**	**100.0**
Goods producing sector	***13.9***	***13.5***
	100.0	*100.0*
Forestry, Fishing and Hunting	10.2	7.3
Mining and Oil and Gas Extraction	4.1	4.7
Utilities	0.8	1.4
Construction	40.0	30.3
Manufacturing	44.9	56.3
Services producing sector	***86.1***	***86.5***
	100.0	*100.0*
Goods related services	*28.7*	*27.4*
	100.0	*100.0*
Wholesale Trade	27.0	31.8
Retail Trade	49.3	52.1
Transportation and Warehousing	23.7	16.1
Intangible Services	*71.3*	*72.6*
	100.0	*100.0*
Finance and Insurance	4.2	4.9
Real Estate and Rental and Leasing	11.7	8.9
Professional, Scientific and Technical Services	26.9	35.4
Administrative and Support, Waste Management and Remediation Services	8.7	7.4
Health Care and Social Assistance (excluding public administration)	11.5	12.1
Accommodation and Food Services	10.7	6.7
Other Services (excluding public administration)	17.2	14.6
All Other Services*	9.1	10.1

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

* All Other Services groups Information and Cultural Industries; Management of Companies and Enterprises; Educational Services (excluding public administration); and Arts, Entertainment and Recreation.

Training in support of technological change

Large firms across the private sector continued to show higher inclinations towards supporting technological change with training — nine out of ten provided training (see Table 4) (Turcotte, Léonard and Montmarquette 2003: 18-9; Betcherman, Leckie and McMullen 2000; Leckie, Léonard, Turcotte and Wallace 2001; and Statistics Canada 2001). Again the costs associated with training such as time loss and administrative fees, may have deterred smaller firms from providing training (Sussman 2002: 9; Turcotte *et al*: 11). Alternatively, the small firms may already have had the required skills to use the newly acquired technologies or may use an employment strategy of hiring workers with the needed skills coincident with the technological adoption (Leckie *et al* 2001). The newly acquired technologies may

also have been of the type that required less formal training to put into application such as more sophisticated new office machinery and telecommunications devices.[1]

Table 4: Training rates due to technological change, 2000-2002

	Training due to Technological Change
Total Private Sector	**55.7B**
Total Goods Producing Sector	59.6B
Total Services Producing	55.1B
Goods Related Services	59.2B
Intangible Services	53.5A
0 Full-time Employees	
Private Sector	25.6C
Goods Producing Sector	13.7E
Services Producing Sector	27.1C
Goods Related Services	9.2D
Intangible Services	29.0C
1+ Full-time Employees	
Private Sector	57.3B
Goods Producing Sector	61.6C
Services Producing Sector	56.6B
Goods Related Services	60.1B
Intangible Services	55.2A
1-99 Full-time Employees	
Private Sector	56.1B
Goods Producing Sector	59.5C
Services Producing Sector	55.6B
Goods Related Services	59.0B
Intangible Services	54.3A
100-499 Full-time Employees	
Private Sector	83.0C
Goods Producing Sector	79.1D
Services Producing Sector	85.0C
Goods Related Services	89.8C
Intangible Services	83.0C
500 + Full-time Employees	
Private Sector	87.9D
Goods Producing Sector	93.8B
Services Producing Sector	86.3E
Goods Related Services	94.0B
Intangible Services	82.6D

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

[1] Turcotte *et al* (2003: 21) found that "innovation and the introduction of a technology does not seem to greatly influence the proportion of employees trained in locations offering training." However, they also found that the probability of training increases when a firm introduces an innovation or a new technology (39) which is supported by much of the literature on technological change and training.

By industrial sector, there are few significant differences in the training rates in support of technological change. The low rate for forestry, fishing and hunting differs from the high rate for information and cultural industries and each is different to the average for the private sector. However, due to the data quality just three of the other industries posted rates that can be said to be significantly different from the private sector's average and then just slightly — professional, scientific and technical services with a marginally lower training rate with retail trade's and manufacturing higher. Of interest, 96% of retail trade's firms fell in the 1-99 employees category, and 64.8% C of these firms trained in support of technological change. On the other hand, 91% of firms in professional, scientific and technical services engaged in undertaking technological change had 1-99 employees, but these firms offered training due to technological change at a much lower rate, 48.7B, although not lower than the average for intangible services. While the majority of firms in manufacturing had between 1-99 employees, at 86% of all manufacturing firms acquiring new technologies, this group was proportionally smaller than its counterpart groups in the other two industries. Two thirds of manufacturers of this size offered training in support of technological change.

Table 5: Training due to technological change by sector, 2002

	Training due to Technological Change	**Training due to Technological Change**
	Total %	1+ Full-time Employees %
Total private sector	**55.7B**	**57.3B**
Goods producing sector	***59.6B***	***61.6C***
Forestry, Fishing and Hunting	30.7D	32.1D
Mining and Oil and Gas Extraction	58.7E	58.2E
Utilities	60.7E	60.7E
Construction	48.8D	53.5D
Manufacturing	69.3C	69.3C
Services producing sector	***55.1B***	***56.6B***
Goods related services	*59.2B*	*60.1B*
Wholesale Trade	56.4C	56.8C
Retail Trade	64.6C	65.3C
Transportation and Warehousing	47.2D	49.3D
Intangible Services	*53.5A*	*55.2A*
Information and Cultural Industries	71.6D	73.3D
Finance and Insurance	60.7C	62.5C
Real Estate and Rental and Leasing	49.7B	51.5C
Professional, Scientific and Technical Services	47.4B	49.2B
Management of Companies and Enterprises	58.1D	61.5D
Administrative and Support, Waste Management and Remediation Services	53.4C	54.3C
Educational Services (excluding public administration)	55.6D	62.1D
Health Care and Social Assistance (excluding public administration)	62.5B	61.9B
Arts, Entertainment and Recreation	47.5E	55.4E
Accommodation and Food Services	63.3D	63.3D
Other Services (excluding public administration)	53.2B	54.3B

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

While firm size and industrial sector probably play important roles in the differences in rates of training in support of technological change, other factors most likely encourage or inhibit training[2]. The costs in relation to perceived benefits of training are important, especially to smaller firms in need of maintaining positive cash flows. The types of new technologies acquired may also contribute to the need or its lack of training. For instance, some new office machinery which may greatly reduce costs or improve worker efficiency might not require extensive training. An example would be a new photocopying unit that incorporated many new features not available on earlier model machines but whose operations are similar. Firms in professional, scientific and technical services might have acquired new on-line services or significantly upgraded software or, scientific diagnostic assays which greatly assist them in their work, but that did not require formal training to operate. On the other hand, new sales systems, customer relationship management systems and anti-theft security systems that are being deployed in retail trade may require formal training in order for the front-line staff to utilise the new technologies correctly and fully. Also, some methods of acquiring new technologies such as licensing and leasing, neither of which were popular with small firms, may increase the need for training.

Methods used to acquire new technologies

How firms acquire new technologies ranges from the simple quick purchase of readily available off-the-shelf technologies to sophisticated and time intensive customisation of existing technologies, the development of new technologies or putting in place improved production facilities. Other methods include leasing and licensing new technologies. Purchasing off-the-shelf technologies was the most popular way to acquire new technologies with four out of five firms that introduced new technologies using this acquisition method. Customisation or significantly modifying existing technologies ranked second with just over one-third of firms that undertook technological change using this technique. Modification of technologies by firms to improve output is an activity of long-standing especially in the manufacturing sector (Statistics Canada 1991 p. 73). Licensing (18.3A), developing (15.9A), leasing new technologies (15.6A) and putting in place improved production facilities (13.5A) followed.

Larger firms showed a greater inclination towards the more sophisticated methods of acquiring new technologies such as developing or licensing new technologies than the smaller firms. Firms with 500 or more full-time employees were more likely than firms with 1-99 full-time employees to lease new technologies but equally as likely to put into place an improved production facility. Data quality makes it difficult to determine if any of the industries have greater inclinations towards employing some of the more sophisticated technology acquisitions methods.

The pattern seen for the private sector overall is mirrored by the two major sub-sectors, goods producing and services producing sectors. It should be noted that goods related services are slightly less inclined towards licensing new technologies while more likely to customise existing technologies than are intangibles services.

[2] Other factors not discussed here include unionisation, gender, age, occupation, employment status, job tenure and educational attainment of the employees see Gilbert 2003; Sussman 2002; Leckie *et al* 2001; Betcherman *et al* 2000; and Turcotte *et al* 2003.

Table 6: Adoption rates by method used to acquire technology – enterprises that acquired new technologies, 2000-2002

	Purchasing Off-the-Shelf Technologies		Licensing New Technologies		Customising or Significantly Modifying Existing Technologies		Leasing New Technologies		Developing New Technologies		Putting in Place an Improved Production Facility	
	Total	1+Full-time emps*	Total	1+Full-time emps.	Total	1+Full-time emps.	Total	1+Full-time emps.	Total	1+Full-time emps.	Total	1+Full-time emps.
Total private sector	**80.7A**	**80.2A**	**18.3A**	**18.7A**	**35.9A**	**36.7A**	**15.6A**	**16.0A**	**15.9A**	**16.3A**	**13.5A**	**14.0A**
Goods producing sector	***79.2A***	***78.8A***	***15.4A***	***15.6A***	***36.7A***	***36.8A***	***15.8A***	***16.0A***	***20.2A***	***20.6A***	***21.9A***	***22.9A***
Forestry, Fishing and Hunting	88.6C	87.8C	6.5C	6.9C	21.5D	23.0D	F	F	16.4D	17.6D	8.3C	8.9C
Mining and Oil and Gas Extraction	87.3C	87.2C	19.4C	19.6C	35.0D	34.4D	19.7D	19.9D	13.6C	13.7C	18.0D	18.3D
Utilities	83.2D	83.2D	19.2B	19.2B	52.1D	52.1D	16.3B	16.3B	32.0D	32.0D	20.3D	20.3D
Construction	77.7B	76.4B	10.3B	10.0B	30.1C	29.1C	16.8B	17.3B	9.2B	8.8B	6.1A	6.9B
Manufacturing	78.1A	78.1A	18.9A	18.9A	41.9B	41.9B	16.3A	16.3A	26.9A	26.9A	32.6B	32.6B
Services producing sector	***80.9A***	***80.4A***	***18.8A***	***19.2A***	***35.8A***	***36.7A***	***15.5A***	***15.9A***	***15.2A***	***15.6A***	***12.1A***	***12.6A***
Goods related services	*76.9A*	*76.8A*	*15.2A*	*15.4A*	*40.9A*	*41.3A*	*16.2*	*16.4A*	*17.3A*	*17.2A*	*11.8A*	*11.8A*
Wholesale Trade	81.1B	81.0B	15.9A	16.1A	44.7B	45.0B	15.0A	15.1B	18.4B	18.5B	10.1A	10.1A
Retail Trade	75.1A	74.9A	16.2A	16.4A	37.9B	38.2B	19.0A	19.2A	16.1A	16.2A	13.3A	13.2A
Transportation and Warehousing	74.4B	74.7B	10.3A	10.9B	43.3C	43.7C	9.5B	10.1B	19.1B	17.8B	10.5B	10.5B
Intangible Services	*82.4A*	*81.8A*	*20.2A*	*20.7A*	*33.8A*	*34.9A*	*15.3A*	*15.8A*	*14.4A*	*15.0A*	*12.2A*	*12.9A*
Information and Cultural Industries	83.1B	82.7B	32.8B	33.6B	48.2C	49.4C	26.1C	26.7C	30.3B	31.0B	24.5B	22.7B
Finance and Insurance	69.7C	69.8C	26.5B	26.0B	56.3C	57.8C	26.7C	26.3C	22.0B	23.5B	25.9C	25.4C
Real Estate and Rental and Leasing	78.3B	76.8B	20.6B	24.4B	28.1B	27.1B	21.6B	20.7B	11.7B	10.2B	12.9B	15.3B
Professional, Scientific and Technical Services	85.9A	85.3A	23.7A	23.7A	30.2A	31.5A	14.5A	15.4A	17.4A	18.6A	10.8A	11.7A
Management of Companies and Enterprises	71.2D	66.6D	21.7D	25.1D	33.5D	38.9D	8.7B	10.1C	9.6B	11.1C	11.4C	13.3C
Administrative and Support, Waste Management and Remediation Services	88.1B	87.3B	19.0B	20.2B	40.2B	41.8B	15.5B	16.5B	22.5B	24.0B	13.3B	14.0B
Educational Services (excluding public administration)	84.7C	83.0C	26.7C	29.9D	32.3D	32.1D	9.5B	10.6C	15.3C	17.1C	10.4B	11.6C
Health Care and Social Assistance (excluding public administration)	79.6B	80.1B	12.7B	12.8B	32.5B	32.2B	14.5B	14.7B	5.0A	5.1A	10.9A	11.0A
Arts, Entertainment and Recreation	85.6C	83.3C	18.5C	21.6C	29.7C	34.6D	6.4B	7.4B	6.1B	7.1B	3.8A	4.4A
Accommodation and Food Services	79.3B	79.3B	13.9B	13.9B	44.3C	44.3C	9.7B	9.7B	9.6B	9.6B	11.2B	11.2B
Other Services (excluding public administration)	82.1B	81.6B	15.5A	15.5A	30.2B	31.1B	14.4A	14.8A	11.3A	11.6A	11.6A	11.9A

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

Table 7: Rates for methods used to acquire new technologies by private sector enterprises by employment size – enterprises that acquired new technologies, 2000-2002

	0 Full-time Employees	1 or more Full-time Employees	1-99 Full-time Employees	100-499 Full-time Employees	500+ Full-time Employees
	%	%	%	%	%
Purchasing Off-the-Shelf Technologies	89.9B	80.2A	80.1A	81.6B	84.2B
Licensing of New Technologies	11.6B	18.7A	17.6A	41.1B	51.0C
Customising or Significantly Modifying Existing Technologies	20.8B	36.7A	35.8A	56.3B	65.1C
Leasing New Technologies	8.5B	16.0A	15.6A	22.3B	29.8C
Developing New Technologies	7.8B	16.3A	15.4A	33.5B	53.7C
Putting in Place an Improved Production Facility	3.5A	14.0A	13.6A	24.4A	21.8B

Source: Survey of Electronic Commerce and Technology, 2002; Statistics Canada.

Canadian firms are engaged in technological change

Canadian firms are actively engaged in technological change with large firms leading the way. The industrial sector meanwhile seemed to have less of impact on the rate of technological change than firm size. This suggests that larger firms can more readily absorb the costs associated with technological change which include not only the initial lay-out for technological acquisition but also the often associated training, work interruption due to installation as well as potential short-term loss of productivity. While technological change is introduced fairly consistently across the major sub-sectors of the economy, some variation was seen in the rates for industrial classes. For instance, within the goods producing sector, construction and forestry, fishing and hunting showed the lowest inclination towards technological change. About half of manufacturing firms underwent technological change and utilities showed a marked inclination towards introducing technological change. Leaders in technological change in the services producing sectors included retail and wholesale trade, information and cultural industries, education services and professional, scientific and technical services.

Training in support of technological change occurred more frequently in large firms, again suggesting that costs associated with training such as time loss and administration might strongly inhibit small firms from offering training. It may also indicate that small firms select their technological changes to match the skills available in the firms; or that they make hiring decisions based upon technology acquisitions or that they acquire technologies that require less formal training. The most popular method to acquire new technologies was to purchase them off-the-shelf. This acquisition method was trailed by customisation of existing technologies. The most costly method of acquiring new technologies, putting in place improved production facilities was the least popular acquisition method.

Four out of ten Canadian firms underwent technological change between 2000 and 2002 suggesting that the lure of change is strong and not dependent upon externalities such as preparation for the Year 2000. The new century and new millennium have begun and Canada's private sector continues to be actively engaged in technological change.

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Appendix

Methodology of the Survey of Electronic Commerce and Technology 2002 (SECT)

1. Introduction

The Survey of Electronic Commerce and Technology 2002 (SECT) is an annual survey in its fourth year. It collects information on communication and technology such as the use of computers, Internet and web sites, as well as the use of Internet to do electronic commerce from a sample of Canadian enterprises.

The collection began in November 2002 and data for the reference year 2002 was published in April 2003. The data are collected for the 12 month fiscal period for which the final day occurs on or between January 1, 2002, and December 31, 2002.

2. Coverage

The sample used for this survey covers most industrial sectors. These are described using the North American Industrial Classification System (NAICS). Some sectors are excluded such as:

Sector 11 Sub-sector 111, 112, 114, 1151 and 1152 (Crop and Animal Production Industries, Fishing, hunting and Trapping industries, Support Activities for Crop and Animal Production industries),
Sector 23 Sub-sector 238 (Construction –Specialist contractors),
Sector 91 Sub-sector 913 (Local Governments)
Sector 55 Sub-sector 551114 (Head office),
Sector 81 Sub-sector 814 (Private households).

3. Survey Frame and Target Universe

The frame consists primarily of the Business Register (**BR**) developed by Statistics Canada. The sampling unit is the enterprise. For more information on the Business Register and the sampling unit, refer to Cuthill (1998).

An administrative list is also used to cover the public sector. This list is provided and maintained for the needs of the survey by the Science, Innovation and Electronic Information Division (SIEID) at Statistics Canada. These units are sampled with certainty.

Because of the dynamic nature of businesses and/or units missed by the frame used, some units may be added once the sample has been selected to obtain a better coverage for the desired reference year. These units are sampled with certainty.

The initial sampling frame contains approximately 1,770,000 enterprises.

Exclusions

Once the new universe is constructed, all units with income less than a certain limit are eliminated from the frame. We consider these units to have a negligible impact on electronic commerce. The exclusion allows us to reduce the response burden of small units.

The limit that delineates the out-of-scope units is determined as a function of industrial sector (NAICS), following the industrial level for publication. The limit is calculated in such a way that a maximum of 5% of the total revenue in the industrial sector becomes out-of-scope with a maximum exclusion threshold of $250,000.

After exclusion, the sampling frame contains approximately 646,000 enterprises. This frame is our target population.

4. Sampling

The sampling consists of stratification, allocation and sample selection that are described in the following text.

Stratification and Allocation

First, some units for which we expect very large sales over the Internet were identified. These predetermined units were to be selected with certainty and thus were removed from the stratification and allocation process described below.

The remaining units on the frame were first stratified by NAICS at the level required for estimation. Then, within each industrial level, we built three strata by size: large units which are sampled with certainty, and medium and small units, in which the sampling is conducted using a probability of selection. The size variable is the Gross Business Income for the private enterprises and the Number of Employees for the public enterprises.

The method used is the Lavallée-Hidirouglou algorithm (1988) which does the stratification and the sample allocation to strata by minimizing the sampling size while attaining the target CV based on the size variable (see section 8 for more details on CVs).

A sample of around 21,000 enterprises allows us to obtain a target CV less than 4% in all industries except for the agriculture and construction sectors where a CV of 7% was targeted.

Once the stratification and the allocation were done, we increased the sample size in some strata when necessary in order to obtain a minimum sampling fraction of 1% and a minimum of five units by stratum when possible. The next step is to select the sample of enterprises.

Selection

All predetermined units and all units in the take-all strata were selected with certainty, while a random sample was selected in the take-some strata under the constraint of maximizing the overlap with the previous year's sample. The Kish and Scott method (1971) was used and a global overlap of 84% with the last sample was obtained.

5. Collection and Data Editing

A questionnaire was mailed to enterprises and respondents were encouraged to complete and return it.

At data collection, some edits were applied to each questionnaire such as rules of consistency. For more details on the edit rules, see VanTol (2002).

Units that had not responded or had answered incorrectly were subject to mail, telephone and fax follow-up to ensure the data was obtained or corrected if needed. Also, some follow-ups were done when there were contradictions between reported data and historical data.

Finally, we prioritized the follow-ups by taking into account the size of the enterprise, the importance of the missing variables, the kind of inconsistencies on the questionnaire and the coverage by industrial sector.

The definition of response rate varies depending on the needs. We will give here the response rate based on responding units among units where a questionnaire was sent.

Units sampled: 21,224 enterprises
Units sent out for data collection: 19, 428 enterprises
Responding units: 14,421 enterprises
Response rate: 74%

Some units selected are not sent for data collection. These are units where their status changed since the frame was created and/or are errors on the frame such as duplicates, out-of-business or out-of-scope. There is no interest to send these units for collection.

6. Outlier Detection

Outlier detection was done on the variable "Sales over Internet". The detection was made within two groups: public sector and private sector. A method using the distance between observations was used (Nobrega, 1998).

Close to 15 units were detected as outliers. These units were analyzed and corrected as necessary. About 10 units were corrected. The units that are outliers and correct were promoted to a take-all stratum in order to represent only themselves. We consider that these units are misclassified during the sampling and do not correctly represent other units in the stratum. The selection probability for residual units was then recomputed.

7. Edit and Imputation

Once the survey collection was closed, some records remained incomplete and/or inconsistent. The missing and/or inconsistent fields on these records were imputed. Globally, around 9% of the fields were imputed due to missing data while 0.1% of the fields were imputed due to inconsistencies. Only partial questionnaires were imputed. In the case of total non-response, no imputation was performed. We simply reweighted responding units at estimation (see section 8. Estimation).

Many imputation methods were used: deterministic imputation, imputation using administrative data, historical imputation and donor imputation.

Deterministic imputation was used when answers from questions related to the question needing imputation lead to only one possible answer. 2.5% of the fields were imputed in this matter.

Imputation using administrative data was used to impute the question referring to the number of employees by using the number of employees available on the BR. Only 0.1% of the fields referring to the number of employees were imputed.

Historical imputation was used to impute some stable questions over time when the enterprise positively responded the year before. Only 100 fields were imputed under this method.

Donor imputation was finally used in the remaining cases to replace missing or incoherent values with those of the nearest respondent according to characteristics such as size, industrial classification and key variables from the questionnaire. We also checked to be sure that the imputed values did not affect the questionnaire's consistency. Imputation was conducted within homogeneous groups, the initial imputation group corresponding to the stratum. If there were not at least 10 potential donors and 25% of donors in a group, or if imputation from all available donors would result in questionnaire inconsistencies, we moved to a more aggregated imputation group in the following order:

NAICS-3 level and size grouping;
NAICS-3 level;
NAICS-2 level and size grouping;
NAICS-2 level.
Private/Public Sector.

Note that outlier enterprises were excluded from the donor pool. When imputation was done, we adjusted the sales value over the Internet by the ratio of imputed and donor's revenue. 6.5% of the fields were imputed by donors.

When we could not find a donor for an enterprise, it was manually imputed. This situation did not happen this year. Finally, when imputation was completed, we reapplied the initial edit rules to assure the consistency of all the questionnaires going into the estimation process. Imputation flags were created to keep information about imputed fields. Also, outlier detection was performed again on sales over Internet in order to detect outliers that could have been created during the imputation.

8. Estimation

Statistics Canada's Generalized Estimation System (GES) was used (see 2001 GES). The estimation was done in two phases: the first phase sample was the initial sample and the second phase sample was the respondents. The same stratification was used at both the first and the second phases.

Three types of estimates were produced:

1) In the case of **percentage variables (*P*)**, a ratio was used to derive an estimate.

$$\hat{P}_d = \frac{\sum_s w_i z_i p_i(d)}{\sum_s w_i z_i} \text{ where } p_i(d) = \begin{cases} p_i \text{ if } i \varepsilon d \\ 0 \text{ otherwise} \end{cases}$$

2) In the case of **categorical variables (*C*)**, again a ratio was used.

$$\hat{C}_d = \frac{\sum_s w_i z_i c_i(d)}{\sum_s w_i z_i} \text{ where } c_i(d) = \begin{cases} 1 \text{ if } i \varepsilon d \text{ and the category was chosen} \\ 0 \text{ otherwise} \end{cases}$$

3) In the case of **numerical variables (Y)**, the usual estimator of the total was used.

$$\hat{Y}_d = \sum_s w_i y_i(d) \text{ where } y_i(d) = \begin{cases} y_i \; if \; i \varepsilon \, d \\ 0 \, otherwise \end{cases}$$

The variable w_i represents the final weights of the unit i after reweighting to take into account the non-response. The variable z_i is the auxiliary variable that may be revenue, the number of employees or others depending on the variable being estimated. This variable, if used, allows us to produce economically weighted estimates which give more weight to large units.

For formulas for variance estimation of a two-phase design for each type of variable (*P*, *C* and *Y*), please refer to Arcaro (1998).

Calculation of CV

The coefficient of variation (CV) is computed using the ratio:

$$CV(\hat{Y}(d)) = \frac{\sqrt{\hat{V}(\hat{Y}(d))}}{\hat{Y}(d)}$$

where the numerator represents the estimate's standard deviation. Variable Y may represent any of the types of variables already discussed. However, in cases of percentage or categorical variables, we modified the CV calculation by using Y(d)=0.5. This way, we avoid getting very small or very large CVs due to Y(d) being close to 1 or close to 0.

This coefficient tries to give a relative measure of the error made when using a sample instead of using a census to derive an estimate about the whole population.

9. Confidentiality

Some confidentiality rules were used to suppress any information that might lead to disclosure of the data supplied by a respondent. These rules ensure that there is no disclosure of information supplied by respondents. The rules themselves are confidential and are not available for consultation.

10. Sampling Error and Non-Sampling Error

The difference between an estimate based on sample data and the value obtained by surveying the entire population is called the sampling error. This difference varies with sample size, variability of the variable of interest, sampling design, and estimation method. In general, the larger a sample, the smaller its sampling error. If the population is very heterogeneous, a larger sample size is required to produce a reliable estimate.

The sampling error is measured by a quantity known as the standard deviation. The latter indicates the expected variability of the estimate that would be produced if we sampled repeatedly. The actual value of the standard deviation is unknown, but it can be estimated from the sample.

Another measure of precision is the coefficient of variation (CV). The CV is simply the standard deviation expressed as a percentage of the estimate. Hence it is a relative measure of precision and can be used for comparisons across industries or provinces. The smaller the CV, the more reliable the estimate.

As well as sampling error, there are non-sampling errors such as frame problems, response errors, data capture errors, etc. Although every effort is made to keep such errors to a minimum, they always exist. They are not taken into account in computing the CV. Measures such as response rate, coverage rate, imputation rate and non-response studies (Duval and Landry, 2000) can be used as indicators of the possible extent of non-sampling errors.

Here are some results of the response rate among the 21,224 enterprises sampled:

Questionnaires completed: 36%
Questionnaires partially completed: 28%
No response before deadline: 21%
Unable to locate: 11%
Out-of-scope or out-of-business: 4%
Refusal: 0%

When the estimates are published, a scale distinguishes between the various qualities of accuracy. It combines the effect of sampling (using the CV) and the imputation rate (each imputed value adds to the uncertainty of the results). The scale is presented in Table 6.

Table 6. Quality indicator interpretation

	Imputation rate			
CV	0.00 - 0.10	0.10 - 0.33	0.33 - 0.60	0.60 - +++
0.00 - 0.05	A	B	C	F
0.05 - 0.10	B	C	D	F
0.10 - 0.15	C	D	E	F
0.15 - 0.25	D	E	F	F
0.25 - 0.50	E	F	F	F
0.50 - +++	F	F	F	F

A: Excellent B: Very good C: Good
D: Acceptable E: Use with caution F: Unpublishable

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