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An historical comparison of technological change, 1998-2000 and 2000-2002, in the private and public sectors

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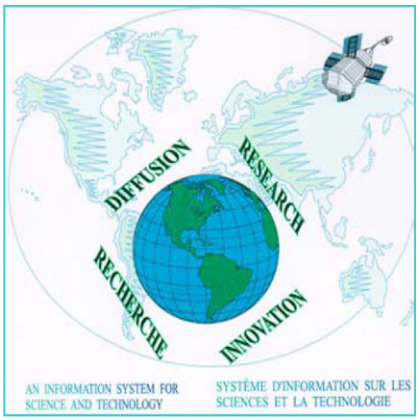

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The Science and Innovation Information Program

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 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. They can also innovate.

In 1993, the first Statistics Canada 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. The recently conducted Survey of Innovation 2003 surveyed selected services industries.

Biotechnology surveys carried out in 1996, 1997, 1999 and 2003 have examined both the development of new biotechnology products and processes and the use and planned use of biotechnologies. 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 have been conducted annually since 1999.

In 2001, Science, Innovation and Electronic Information Division (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 (SECT).

This study is one in a series of studies that SIEID has undertaken that have examined technological and organisational change in the Canadian economy. The SECT, 2000, contained two questions on organisational and technological improvements. These two questions provided the first cross-economy data on this issue, covering firms in the private sector and organisations in the public sector. In 2002, SECT asked a question on technological acquisition which is used to provide the comparable data for technological adoption which is explored in this historical comparison.

Acknowledgements

This report provides historically comparable rates of technological adoption from Statistics Canada for the private and public sectors. 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, Adele St. Pierre and Fred Gault.

Highlights

The historically comparable data used in this paper from the Surveys of Electronic Commerce and Technology 2000 and 2002 suggest some levelling off of the rate of technological change especially within public administration organisations.

In 2002, larger enterprises and organisations again showed higher tendencies towards technological change than their smaller counterparts. Nine out of ten private sector enterprises with 500 or more full-time employees adopted significantly improved technologies in both 2000 and 2002. On the other hand, the technology adoption rate for large public sector organisations declined from 97% in 2000 to 85% for 2002.

Small private sector firms with one to 99 full-time employees recorded a slight decline from about one-half of these firms adopting new technologies between 1998 and 2000 to just over four out of ten between 2000-2002. The rate of technology adoption for small public sector organisations remained fairly stable at about two-thirds for both time periods.

The consistency in the technological adoption rates for the periods 1998-2000 and 2000-2002 suggest that organisations actively acquire new technologies at a fairly consistent rate even when they are not faced with preventing business interruptions such as those anticipated for Year 2000.

Making off-the-shelf purchases continued to lead as the most popular method used to adopt new technologies for all organisations.


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Introduction

The acquisition rate of new technology, either products or processes, is one indicator of economic innovation (OECD/Eurostat 1997, Schumpeter 1942). According to results from the Survey of Electronic Commerce and Technology (SECT) 2002, four out of ten Canadian businesses acquired significantly improved technologies between 2000 and 2002. For the purposes of this paper, the acquisition (SECT 2002) or introduction (SECT 2000) of significantly improved technologies is also known as technological change. When comparable data for 1998-2000 and 2000-2002 (based on the definition and survey universe employed by SECT 2000) are used the propensity to adopt new technologies in the private sector has remained constant.

While the rate of technology adoption in the public sector remained at four out of five organisations introducing significantly improved technologies — a level about twice as high as that for the private sector — this rate also shows little change from 2000. The elevated 2000 technological change rate for the public sector, was driven by the major component of the public sector — public administration. In 2000, almost every organisation in public administration had undergone technological change, however, comparable results show that for 2002 just three-quarters of these organisations acquired significantly improved technologies.

Definition of technological change

The results for SECT 2000 technological change are based on the following questions:

"During the last three years, 1998 to 2000, did your organisation introduce significantly improved technologies?"

"If yes, how did you introduce significantly improved technologies? (Check all that apply)

- By purchasing off-the-shelf technologies?
- By licensing new technologies?
- By customising or significantly modifying existing technologies?
- By developing new technologies (either alone or in conjunction with others)?"

For purposes of historical comparison, the results of SECT 2002 have been modified so that they are based on similar questions and survey universe to those of SECT 2000. For this reason, respondents from the construction sector as well as respondents that indicated they only acquired significantly improved technologies "by leasing new technologies" and/or "by putting in place an improved production facility" (both indicated in italics and with asterisks below), have been excluded from the SECT 2002 results presented here.

The complete SECT 2002 question read as follows:

"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?**

Finally, it should be noted that the main question itself was changed subtly by replacing the verb "introduce" used in the 2000 with the verb "acquire." The technology adoption rates for 2002 based on the entire SECT 2002 question and universes were 42% (A) for the private sector and 82% (A) for the public sector[1]. These findings compared with the comparable figures of 40% (A) and 81% (A) show that the addition of two questions, a slight change in the wording and the increased industrial coverage made little difference to the rate of technology adoption.

Change in the number of organisations undertaking technology adoption

According to SECT 2000, there were an estimated 550,903 private sector enterprises and 819 public sector organisations included in the survey coverage (Earl 2002a: 10). Based on the historically comparable SECT 2002 there were an estimated 580,432 private sector enterprises and 811 public sector organisations. The private sector universe therefore increased by a compound annual growth rate of 2.6% while the public sector coverage saw a slight decline (-0.1%) over the two year period. However, both the private and public sectors registered modest declines in the number of enterprises acquiring new technologies — - 2.5% in the private sector and -5.2% in the public sector based on the historically comparable data.

Introduction of technological change

In 2002, larger enterprises and organisations again showed higher tendencies towards technological change than their smaller counterparts (See Tables 1 & 2). In fact the rates of technological adoption by employment size between the public and private sector in 2002 showed very little variation. Within the public sector, the larger organisations showed declines with the largest enterprises moving downwards from almost every organisation experiencing technological change between 1998 and 2000 to 85% (A) from 2000 to 2002. A much lower proportion of organisations in public administration acquired new technologies between 2000 and 2002 than had occurred previously.

[1]The letter A in parentheses is a quality indicator. These are explained in the Appendix.

Table 1: Technology adoption rates for the private sector, 1998-2000 and 2000-2002

	Technology adoption rate 1998-2000	Technology adoption rate 2000-2002
Total Private Sector	44% B	40% A
Total Goods Producing Sector	46% B	45% A
Total Services Producing Sector	43% B	40% A
Goods Related Services	39% B	38% A
Intangible Services	46% B	41% A
0 Full-time Employees[1]		
Private Sector	20% B	16% A
Goods Producing Sector	29% C	7% B
Services Producing Sector	19% B	16% A
Goods Related Services	18% C	9% B
Intangible Services	19% B	18% A
1+ Full-time Employees		
Private Sector	48% B	44% A
Goods Producing Sector	51% B	47% A
Services Producing Sector	48% B	43% A
Goods Related Services	42% B	40% A
Intangible Services	51% B	45% A
1-99 Full-time Employees		
Private Sector	47% B	43% A
Goods Producing Sector	48% B	44% A
Services Producing Sector	47% B	43% A
Goods Related Services	41% B	40% A
Intangible Services	50% B	44% A
100-499 Full-time Employees		
Private Sector	84% C	75% A
Goods Producing Sector	77% C	74% B
Services Producing Sector	87% C	76% B
Goods Related Services	96% B	68% C
Intangible Services	81% D	80% B
500+Full-time Employees		
Private Sector	92% C	89% A
Goods Producing Sector	89% B	81% A
Services Producing Sector	93% C	91% A
Goods Related Services	99% B	90% B
Intangible Services	88% E	92% A

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002; Statistics Canada.
Note: For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.
Estimates for goods producing and services producing sectors were developed by aggregating NAICS classes as outlined below. Goods producing sector includes NAICS classes: 11 (excluding agriculture), 21, 22, and 31-33. Services producing sector includes NAICS classes: 41, 44-45, 48-49, 51-56, 61-62 (excluding public sector enterprises), 71-72, and 81. Goods related services include NAICS classes: 41, 44-45, and 48-49. Intangible services include NAICS classes: 51-56, 61-62 (excluding public sector enterprises) 71-72 and 81. Taken together goods related services and intangible services aggregate to the services producing sector.
[1] 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.

The lower rate of new technology adoption for organisations in public administration may reflect the successful completion of Year 2000 (Y2K) preparations and a return to a less exaggerated rate of technological change over the first years of the new century.

Table 2: Technology adoption rates in the public sector by employment size groups, 1998-2000 and 2000-2002

PUBLIC SECTOR				
Employment Size Group	**Technology adoption 1998-2000**		**Technology adoption 2000-2002***	
	%	**Reliability**	**%**	**Reliability**
1-99	63	E	66	A
100-499	89	A	81	A
500+-	97	A	85	A
Total	85	D	81	A

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002, Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Technology adoption rates and industrial sectors

The technology adoption rates for 2000-2002 by industrial sector and by employment size group within the private sector showed very little variation from the rates recorded for 1998-2000 (see Table 1). Again the rates for the smaller enterprises stood at about half the rates recorded for the largest enterprises across all industrial sectors. For the public sector, we have already mentioned the significantly lower technological change rate in the public administration. This decline was echoed to a slightly lesser extent by educational services. Public and private sector organisations in health care and social assistance showed no variation in their rates of technological change although public sector health care and social assistance organisation continued to record higher technological change rates (see Tables 3 & 4).

Table 3: Percentage of public sector organisations adopting technology, by sector, 1998-2000 and 2000-2002

	Technology adoption 1998-2000		**Technology adoption 2000-2002***	
	%	**Reliability**	**%**	**Reliability**
Educational Services	93%	A	84%	A
Health Care and Social Assistance	80%	D	82%	A
Public Administration	96%	A	76%	B

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002, Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Table 4: Technology adoption rates in the private sector by sector, 1998-2000 and 2000-2002

	Technological Change 1998-2000	Technological Change 2000-2002
	%	%
Total private sector	**44 B**	**40 A**
Goods producing sector	***46 B***	***45 A***
Forestry, Fishing and Hunting	27 C	29 C
Mining and Oil and Gas Extraction	31 D	45 C
Utilities	64 D	72 C
Manufacturing	51 B	48 A
Services producing sector	***43 B***	***40 A***
Goods related services	*39 B*	*38 A*
Wholesale Trade	45 C	46 A
Retail Trade	38 B	39 A
Transportation and Warehousing	33 C	26 A
Intangible Services	*46 B*	*41 A*
Information and Cultural Industries	63 C	64 B
Finance and Insurance	60 C	45 B
Real Estate and Rental and Leasing	37 B	30 A
Professional, Scientific and Technical Services	59 B	55 A
Management of Companies and Enterprises	31 C	28 B
Administrative and Support, Waste Management and Remediation Services	53 C	35 B
Educational Services (excluding public administration)	54 D	65 C
Health Care and Social Assistance (excluding public administration)	50 C	44 B
Arts, Entertainment and Recreation	42 C	42 C
Accommodation and Food Services	29 C	24 B
Other Services (excluding public administration)	38 B	34 A

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002; Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Methods of introducing technological change

Organisations had the choice of four methods of introducing or acquiring significantly improved technologies. These are purchasing off-the-shelf technologies; licensing of new technologies; customising or significantly modifying existing technologies and developing new technologies (either alone or in conjunction with others).

Purchasing off-the-shelf technologies

Purchasing off-the-shelf technologies again ranked first with both private and public sector organisations as the foremost method of acquiring significantly improved technologies in 2002 (see Tables 5 & 6). This method could be considered the least risky and perhaps most cost-effective method of introducing new technologies. Developmental risks are greatly reduced by purchasing off-the-shelf technologies and successful introduction is almost always guaranteed. Both the goods producing and the services

producing sectors recorded increases in the rate of purchasing off-the shelf technologies. This suggests that enterprises which may have held off acquiring new software in the years leading up to Y2K may have decided to upgrade their information communication technologies. Post Y2K, upgrades to word processing, spreadsheet, and operating systems; amongst other popular software, have come onto the market.

Table 5: Adoption rates by method used to introduce technology – private sector enterprises that introduced new technologies, 1998-2000 and 2000-2002*

	Off-the-Shelf Purchases		Licensing New Technologies		Customising or Significantly Modifying Existing Technologies		Developing New Technologies	
	1998-2000	2000-2002	1998-2000	2000-2002	1998-2000	2000-2002	1998-2000	2000-2002
	%	%	%	%	%	%	%	%
Total private sector	**73B**	**85A**	**15B**	**20A**	**41B**	**38A**	**18B**	**17A**
Goods producing sector	***70B***	***84 A***	***16B***	***18 A***	***48 B***	***41 B***	***21B***	***26 A***
Forestry, Fishing and Hunting	F	89 C	F	66 C	F	21 D	6 D	16 D
Mining and Oil and Gas Extraction	58 E	88 C	15 C	20 C	49 E	35 D	32 E	14 C
Utilities	64 D	84 D	19 B	19 B	54 C	53 D	16 C	32 D
Manufacturing	71 B	83 A	15 B	20 A	51 B	44 B	23 B	28 A
Services producing sector	***73 B***	***85 A***	***15 B***	***20 A***	***40 B***	***38 A***	***18 B***	***16 A***
Goods related services	*68 B*	*82 A*	*14 B*	*16 A*	*46 B*	*44 A*	*18 B*	*18 A*
Wholesale Trade	69 C	84 B	15 C	16 A	47 C	46 B	19 C	19 B
Retail Trade	67 C	82 A	13 B	18 A	45 C	41 B	19 B	18 A
Transportation and Warehousing	69 D	79 B	11 C	11 B	45 D	46 C	12 C	20 B
Intangible Services	*75 B*	*87 A*	*15 B*	*21 A*	*38 B*	*36 A*	*18 B*	*15 A*
Information and Cultural Industries	73 D	86 B	14 C	34 B	52 D	50 C	29 D	31 B
Finance and Insurance	65 D	78 C	25 C	29 C	53 D	63 C	23 C	24 B
Real Estate and Rental and Leasing	71 C	85 B	10 C	22 B	33 C	30 B	15 C	13 B
Professional, Scientific and Technical Services	78 B	89 A	17 B	24 A	33 C	31 A	22 B	18 A
Management of Companies and Enterprises	88 D	74 D	14 D	23 D	21 E	35 D	14 D	10 B
Administrative and Support, Waste Management and Remediation Services	76 C	91 B	23 C	20 B	54 D	41 B	36 D	23 B
Educational Services (excluding public administration)	81 D	85 C	20 D	27 C	38 D	32 D	22 D	15 C
Health Care and Social Assistance (excluding public administration)	78 C	82 B	9 B	13 B	41 C	34 B	9 B	5 A
Arts, Entertainment and Recreation	72 D	88 C	10 C	19 C	46 D	31 D	13 C	6 B
Accommodation and Food Services	67 C	88 B	17 C	15 B	43 D	49 C	8 C	11 B
Other Services (excluding public administration)	76 C	88 A	11 B	17 B	30 C	32 B	12 B	12 A

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002; Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Table 6: Adoption rates by method used to introduce technology - public sector, total and organisations with 500 or more employees that introduced new technologies, 1998-2000 and 2000-2002

	TOTAL PUBLIC SECTOR			
Type of Technological Change	**1998-2000**		**2000-2002**	
	%	**Reliability**	**%**	**Reliability**
Purchase of Off-the-Shelf Technologies	85%	A	87%	A
Licensing New Technologies	43%	B	64%	A
Customising or Significantly Modifying Existing Technologies	52%	C	55%	A
Developing New Technologies	31%	B	41%	A
PUBLIC SECTOR ORGANISATIONS WITH 500 OR MORE EMPLOYEES				
	1998-2000		**2000-2002**	
	%	**Reliability**	**%**	**Reliability**
Purchase of Off-the-Shelf Technologies	88%	A	90%	A
Licensing New Technologies	58%	A	72%	A
Customising or Significantly Modifying Existing Technologies	65%	A	58%	A
Developing New Technologies	42%	A	46%	A

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002, Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Customising or significantly modifying existing technologies

Overall, customising or significantly modifying existing technologies once again was the second most popular method to acquire new technology within the private sector. For the public sector organisations, this method slipped into third place. Again this suggests that the public sector organisations had completed their systems work to conform to Y2K. Modifying existing technologies could be considered to have a lower risk of failure than developing new technologies since it is presumed that the original technology supported most of the users needs. However, customising existing technologies may have greater costs than purchasing off-the-shelf technologies as the modifications would necessarily require expenditures time and resources for development, implementation, testing, documenting and perhaps training.

Within the private sector, finance and insurance recorded the highest rate for customisation or significant modification of existing technologies. This high rate suggests that similar to the finding for 2000 for administrative and support, waste management and remediation services, that enterprises in finance and insurance "have unique technological needs that are not fulfilled by other suppliers" (Earl 2002b: 21). In the case of finance and insurance technological changes could include an increased presence of electronic banking services that require enhanced security while allowing easy access.

Licensing new technologies and developing new technologies

Equally popular with one-fifth of private sector enterprises were licensing new technologies and developing new technologies as methods of acquiring new technologies. These rates for 2002 were very similar to those recorded for 2000. The public sector, on the other hand continued to show a more marked preference towards licensing new technologies while still maintaining a higher rate of developing new technologies than the rate recorded by the total private sector. These two methods of introducing technological change can require the greatest investment of time and resources to implement thus increasing the risk to organisations using these methods for implementation of technological change. Once again it is important to note that employment size did impact the preference for method of introduction of new technologies in both the private and public sectors.

Employment size and methods of introducing technological change

The public sector with its larger organisations showed little variation between the rates of acquiring new technologies across the four methodologies overall and for organisations with 500 or more employees (see Table 6). The private sector, on the other hand, once again showed a more marked variation by employment size as well as by methodology used to acquire new technologies. The most popular methodology for introducing new technologies — purchasing off-the-shelf technologies — had an equally elevated high rate across all of the employment size groups (see Table 7).

Table 7: Rates for methods used to introduce new technologies by private sector enterprises by employment size – enterprises that introduced new technologies, 1998-2000 and 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
		%	%	%	%	%
Off-the-Shelf Purchases	1998-2000	73 C	73 B	73 B	67 C	87 C
	2000-2002	93 B	85 A	85 A	83 B	85 B
Licensing New Technologies	1998-2000	13 B	15 B	14 B	33 C	44 E
	2000-2002	12 B	20 A	19 A	41 B	51 C
Customising or Significantly Modifying Existing Technologies	1998-2000	38 C	42 B	40 B	67 C	70 D
	2000-2002	20 B	39 A	38 A	57 B	65 C
Developing New Technologies	1998-2000	13 B	19 B	18 B	37 D	47 E
	2000-2002	7 B	18 A	17 A	34 B	54 C

Source: Surveys of Electronic Commerce and Technology, 2000 and 2002; Statistics Canada.
*For purposes of historical comparability, the estimates for technological change adoption 2000-2002 reflect the following changes to the 2002 survey universe: removal of NAICS class 23 and removal of respondents that only responded to either "by leasing new technologies" or "by putting in place an improved production facility" or only both of these two questions.

Licensing new technologies in 2002 followed a very similar pattern across the employment size groups to that which had been recorded for 2000; moving from about one in ten of the smallest employment size group to one in two of the largest employers using this methodology. Similar patterns can be seen for the two reference years for customising or significantly modifying existing technologies and for developing new technologies.

Conclusion

The acquisition of new technologies continues to be important to both public and private sector organisations, especially larger organisations. The historically comparable data shown here from the Surveys of Electronic Commerce and Technology 2000 and 2002 suggest some levelling off of the technological change rates especially within public administration organisations. The consistency in the technological adoption rates for the periods 1998-2000 and 2000-2002 suggest that organisations actively acquire new technologies at a fairly consistent rate even when they are not faced with preventing business interruptions such as those anticipated for New Year's Day 2000.

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Appendix: Methodology of the Survey of Electronic Commerce and Technology 2002 (SECT)[2]

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.

[2] See also www.statcan.ca key words Survey of Electronic Commerce questionnaire and survey entry.

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-Hidiroglou 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 Van Tol (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.

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

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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