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Technological change in the public sector, 2000-2002

By Louise Earl

Science, Innovation and Electronic Information Division (SIEID)
7-A, R.H. Coats Building, Ottawa, K1A 0T6

Telephone: 1 800 263-1136

This paper represents the views of the author and does not necessarily reflect the opinions of Statistics Canada.

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Louise Earl

Science, Innovation and Electronic Information Division
7-A, R.H. Coats Building
Statistics Canada
Ottawa, ON, K1A 0T6

How to obtain more information:
National inquiries line: 1 800 263-1136
E-Mail inquiries: infostats@statcan.ca

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Contacts for more information

Science, Innovation and Electronic Information Division

Director Dr. F.D. Gault (613-951-2198)

Assistant Director Craig Kuntz (613-951-7092)

The Science and Innovation Information Program

Special Advisor, Science and Technology
Dr. Frances Anderson (613-951-6307)

Chief, Knowledge Indicators
Michael Bordt (613-951-8585)

Chief, Innovation, Technology and Jobs
Daood Hamdani (613-951-3490)

Special Advisor, Life Sciences
Antoine Rose (613-951-9919)

Science and Innovation Surveys Section

Chief, Science and Technology Surveys
Antoine Rose (613-951-9919)

FAX: (613-951-9920)

E-Mail: Sieidinfo@statcan.ca

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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.

Table of Contents

Preface 7
Acknowledgements 8
Highlights 9
Introduction 11
Definition of Technological Change 11
Public Sector Technological Change 12
Methods of Acquiring Significantly Improved Technologies 14
Technology adoption within the public sector 15
The Public and Private Faces of Education and Health Care 18
Concluding Remarks 19
References 21
Appendix: Methodology of the Survey of Electronic Commerce and Technology, 2002 (SECT) 23
How to order catalogued publications 30


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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 technology acquisition. The results of this question for the public sector are explored in this paper.

Acknowledgements

This report provides new Statistics Canada estimates of the rate of technological adoption by public sector organisations. 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

Technology adoption is important to the public sector — overall the rate of technological adoption in the public sector (82%) stood at twice that of the private sector (42%). Quite obviously, not all turn of the century technological change within the public sector was directly linked to the Year 2000 phenomena.

When organisations of the same size are compared, however, there is little difference in the rates of technology adoption between the private and public sectors.

Public sector organisations appear to refresh their technologies on a continual basis. It also appears that the public sector organisations are highly committed to training in support of technological change, with almost every organisation that introduced new technologies also providing training. This rate was almost twice the rate of the private sector overall.

As expected, for organisations adopting new technologies, purchasing off-the-shelf technologies was the method most used within both the public (86%) and private (81%) sectors. Purchasing off-the-shelf technologies could be considered a low risk option as the organisation does not have to support any development costs and, if necessary, can acquire technical and training support from the vendor or a third-party supplier.

Developing new technologies has a much higher level of risk and coincident costs as the organisation must be willing to dedicate time and resources to the project while accepting the possibility of failure. This suggests that the organisations must face strong needs that offset the costs and potential risks. Public sector organisations appeared willing to accept these risks as just over half of public sector organisations customised or significantly modified existing technologies with four out of ten developing their own new technologies.

Education and health care are carried out by both the public and private sectors. Overall, the public sector educational and health care institutions are more likely to have adopted technologies than their private sector counterparts. Again, employment size played an important role in levelling the technological adoption rates of private and public sector educational and health care institutions — with little difference between the high rates seen for large institutions.

Overall the Canadian public sector is leading the private sector in technological change and in supporting new technology acquisition with training. Methods used to acquire new technology shows a strong mix of complex and simple suggesting that cost effectiveness is an important consideration in the public sector.


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Introduction

For 2002, the rate of technology adoption in the public sector stood at close to double that of the private sector: 82% versus 42%. Quite obviously, not all turn of the century technological change within the public sector was directly linked to the Year 2000 (Y2K) phenomena. Rather, public sector organisations appear to refresh their technologies on a continual basis. It also appears that the public sector remains committed to supporting the acquisition of significantly improved technologies through training (94% of public sector organisations that acquired significantly improved technologies provided training).[1]

This paper is based on information from the 2002 Survey of Electronic Commerce and Technology (SECT) (see the Appendix for more details on the survey) and concentrates on the acquisition of significantly improved technologies in the public sector. To provide context, comparisons are made to the private sector with special attention given to employment size groups. The paper outlines the methods employed to acquire new technologies. It also provides an overview of three sectors within the public sector: educational services; health care and social services; and public administration.

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.)

[1] For an historical overview of technological change 1998-2000 and 2000-2002, see Earl 2004b. Earl 2002a discusses technological and organisational change in the public and private sectors for 1998-2000. The *Oslo Manual* (OECD/Eurostat) was used as the basis for the questions on technological change.

"Did any of these improvements require training?"

Public Sector Technological Change

Introduction of change — technological or organisational — occurs more frequently in larger organisations (Earl 2002a:10; Earl 2002b: 12; Earl 2004b: 10; and Van Tol and Li 2003: 9-10), and this fact favours the public sector which is mainly comprised of organisations of at least 500 full-time employees (see Table 1).

Table 1: Distribution of public and private sector organisations, by employment size groups in the survey universe, 2002

	Public Sector		Private Sector*	
Employment Size Group	**Estimated Number of Organisations**	**% of Organisations**	**Estimated Number of Organisations**	**% of Organisations**
0 full-time employees**	Not applicable	Not applicable	78,524	12.8
1-9 full-time employees	9	1.1	381,942	62.1
10-19 full-time employees	15	1.9	73,769	12.0
20-49 full-time employees	39	4.8	49,557	8.1
50-99 full-time employees	61	7.5	17,708	2.9
100-299 full-time employees	135	16.7	8,830	1.4
300-499 full-time employees	105	13.0	1,687	0.3
500+ full-time employees	445	54.9	2,573	0.4
Total* **	810	99.9	614,590	100.0

* Please see Appendix for survey frame and target universe methodology. In order to reduce response burden on small units, all units with income less than a certain limit are eliminated from the frame. 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.
** 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.
*** May not add due to rounding of weighted data and percentages.
Source: Survey of Electronic Commerce and Technology 2002, Statistics Canada.

The private sector generally lagged the public sector in the acquisition of significantly improved technologies. However, this lower overall rate for technological change reflects the lower rates recorded by small firms. When organisations of the same size are compared, minimal variation occurs between the technology adoption rates recorded for organisations of at least 500 full-time employees between the private and public sectors.

Smaller private sector firms may find the costs associated with introducing technological change such as acquisition costs, potential work interruptions and time loss due to training that can reduce productivity too heavy a burden.

Table 2: Percentage of private and public sector organisations acquiring significantly improved technologies, by employment size group, 2000 - 2002

	Public Sector		Private Sector	
Employment Size Group	**Technology adoption rate**		**Technology adoption rate**	
	% of Organisations	**Reliability***	**% of Organisations**	**Reliability**
0 full-time employees	Not applicable	Not applicable	16	A
1-9 full-time employees	51	D	40	A
10-19 full-time employees	59	C	53	A
20-49 full-time employees	74	B	59	A
50-99 full-time employees	68	B	66	B
100-299 full-time employees	79	A	75	B
300-499 full-time employees	86	A	79	B
500+ full-time employees	87	A	89	A
Total	82	A	42	A

*For an explanation of the reliability codes, see Appendix.
Source: Survey of Electronic Commerce and Technology 2002, Statistics Canada.

Table 3: Percentage of organisations acquiring significantly improved technologies which undertook training to support their technological acquisitions in the private and public sectors, 2000 - 2002

	Training in support of technological acquisitions	
	%	**Reliability**
Public Sector - total	94	B
500 or more full-time employees	95	B
Private Sector - total	56	B
500 or more full-time employees	88	D

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

In the public sector, one-half of the smallest organisations acquired new technologies between 2000 and 2002 whereas, over the same period, nine out of ten of the largest organisations underwent some form of technological change. Almost every public sector organisation that acquired significantly improved technologies between 2000 and 2002 provided training to support their technological acquisitions. Overall, private sector firms were less willing to absorb the extra costs of training with just over half indicating that their technological acquisitions required training (see Table 3). However, again there was very little variation in the training rates in support of technological change for larger organisations in the private and public sectors which accords with a growing literature on firms' propensity to provide training (see Turcotte, Léonard and Montmarquette 2003; Gilbert 2003; Sussman 2002; Earl 2002a and 2002b; Earl 2004b; Leckie, Léonard, Turcotte and Wallace 2001; and Betcherman, Leckie and McMullen 2000).

Methods of Acquiring Significantly Improved Technologies

Six methods of acquiring significantly improved technologies are available from the Survey of Electronic Commerce and Technology 2002. These are purchasing off-the-shelf technologies; licensing new technologies; customising or significantly modifying existing technologies, leasing new technologies, developing new technologies (either alone or with others); and putting in place an improved production facility. How organisations acquire new technologies in part reflects the risks they are willing to take to introduce technological change. For instance, purchasing off-the-shelf technologies could be considered a low risk option as the organisation does not have to support any development costs and, if necessary, can acquire technical and training support from the vendor or a third-party supplier. On the other hand, developing new technologies has a much higher level of risk and coincident costs as the organisation must be willing to dedicate time and resources to the project while accepting the possibility of failure. This suggests that the organisations must face strong needs that offset the costs and potential risks. Therefore, technology adoption can vacillate between routine to radical depending upon the organisation's needs and some technological change can be considered adaptive or disruptive and in all cases requires change in management strategies (Freeman 1988; Burgelamn and Maidique 1988; West and Farr 1990; Twiss 1992; Utterback 1994; and Christenson 1997).

As expected, acquiring off-the-shelf technologies was the method most used for technology adoption within both the public and private sectors (see Table 4). In fact, 86% of public sector organisations that acquired significantly improved technologies purchased off-the-shelf technologies (81% for the private sector). Licensing new technologies was the second most popular method of acquiring technology at 63% for the public sector. The private sector overall, however, lagged far behind in using this method at just 18% suggesting again that costs associated with this form of acquiring technology may discourage private sector firms, especially smaller firms from using this method for technology adoption. Just over half of public sector organisations customised or significantly modified existing technologies as a method to introduce technological change with four out of ten developing their own new technologies. Leasing new technologies was almost twice as important to public sector organisations at 29% as it was to private sector firms at 16% as a method to acquire technology. For both the public and private

sectors, putting in place an improved production facility was the least important method employed to introduce technological change and this is not surprising given the scale and likely expense of this method.

Of interest, is how much more balanced the rates of using the more complex and expensive methods of acquiring significantly improved technologies become when the larger organisations in the public and private sector are compared. In fact large public and private sector organisations only differed, and then just slightly, in their usage of licensing new technologies. The public sector showed a slightly higher inclination towards this acquisition methodology. These findings are in keeping with the innovation literature that has for many years shown a relationship between organisational size and technological change (see for example King 1990 and Fagerberg 2002).

Table 4: Methods used to acquire significantly improved technology in the private and public sectors, all organisations and organisations with 500 or more full-time employees that acquired technology, 2000 - 2002

All Organisations				
Method	**Public Sector**		**Private Sector**	
	%	**Reliability**	**%**	**Reliability**
Purchasing Off-the-Shelf Technologies	86	A	81	A
Licensing New Technologies	63	A	18	A
Customising or Significantly Modifying Existing Technologies	54	A	36	A
Leasing New Technologies	29	A	16	A
Developing New Technologies	41	A	16	A
Putting in Place an Improved Production Facility	17	A	13	A
Organisations With 500 or More Full-Time Employees				
Method	**Public Sector**		**Private Sector**	
	%	**Reliability**	**%**	**Reliability**
Purchasing Off-the-Shelf Technologies	89	A	84	B
Licensing New Technologies	71	A	51	C
Customising or Significantly Modifying Existing Technologies	58	A	65	C
Leasing New Technologies	34	A	30	C
Developing New Technologies	45	A	54	C
Putting in Place an Improved Production Facility	21	A	22	B

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

Technology adoption within the public sector

The Survey of Electronic Commerce and Technology provides information on three sectors within the public sector: educational services; health care and social assistance; and public administrations. Organisations in health care and social assistance comprised 40% of the public sector (see Table 5). One quarter of the public sector's organisations was in public administration and the remaining organisations were in educational services.

Table 5: Distribution of public sector organisations, by sector, 2002

Sector	Number of Organisations	Distribution of Organisations
Educational Services	289	35.7%
Health Care and Social Assistance	320	39.5%
Public Administration*	202	24.9%
Federal Government Public Administration	*37*	*4.6%*
Provincial and Territorial Public Administration	*159*	*19.6%*
Total Public Sector	810	100%

*Public Administration is composed of four sub-sectors of which only two sub-sectors are shown, therefore, the counts and percentages do not add. See Appendix for exclusions.
Source: Survey of Electronic Commerce and Technology 2002, Statistics Canada.

Of interest in 2002, just three-quarters of organisations in public administration recorded technology adoption, trailing the other two major components of the public sector (see Table 6). This suggests that the flurry of activity leading up to the Year 2000 slowed slightly after the turn of the century. However, government on-line initiatives as well as new purchases, and enhancements to existing systems, may be factors in keeping the public administration's technological change rate fairly high.[2] Overall organisations in public health care and social assistance and educational services appeared to have entered a period of greater activity in renewing their technologies. However, there was no significant difference in the technological adoption rates for large organisations across the sectors (see Table 7). Training to support technological change was uniformly important across the sectors with almost every organisation that underwent technological change also training (see Table 8).

Table 6: Percentage of public sector organisations acquiring significantly improved technologies, by sector, 2000-2002

	Technology adoption	
Sector	**% of Organisations**	**Reliability**
Educational Services	86	A
Health Care and Social Assistance	83	A
Public Administration	76	B
Federal Government Public Administration	87	B
Provincial and Territorial Public Administration	72	B

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

[2] For more information on government on-line please see http://www.gol-ged.gc.ca/pathfinder-expl/pathfinder-expl_e.asp and Statistics Canada 2003.

Table 7: Percentage of public sector organisations with 500 or more full-time employees acquiring significantly improved technologies, by sector, 2000-2002

	Technology adoption	
Sector	**% of Organisations**	**Reliability**
Educational Services	88	A
Health Care and Social Assistance	88	A
Public Administration	82	B

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

Table 8: Percentage of public sector organisations acquiring significantly improved technologies which undertook training in support of their technological acquisitions, by sector, 2000-2002

Sector	**Training in support of technological acquisition**	
	%	**Reliability**
Public Sector: Total	94	B
Public Sector: 500+ full-time employees	95	B
Educational Services	93	A
Educational Services: 500+ full-time employees	93	A
Health Care and Social Assistance	94	A
Health Care and Social Assistance: 500+ full-time employees	96	A
Public Administration	97	B
Public Administration: 500+ full-time employees	98	B

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

The three sectors within the public sector showed some differences in their preference towards methods of acquiring new technologies (see Table 9). For instance, while all three sectors showed their marked preference towards purchasing off-the-shelf technologies, educational services overall led this category. However, when organisations of at least 500 employees are compared, health care and social assistance is just edged out by educational services. Licensing new technologies was the second most popular method employed to acquire new technologies across two of the three sectors. Customising or significantly modifying existing technologies was almost twice as popular with organisations in public administration, which rated this method on par with purchasing off-the-shelf technologies, than with the other two sectors. Health care and social assistance, overall, perhaps indicating the expenses of putting in place improved production facilities, rated this method much lower than the other two sectors. However, one-tenth of large health care organisations which includes hospitals put into place improved production facilities in 2002 perhaps resulting from changes in health care spending. It is of interest that four out of ten large organisations in public administration and in health care and social assistance leased new technologies. This suggests that these sectors are looking for alternate and perhaps more cost-effective means of acquiring technologies which may have longer shelf-lives, but that still require continual upgrading such as machines used for diagnostic tests.

Table 9: Methods used to acquire significantly improved technologies by sectors within the public sector, 2002

Methods	Educational Services		Health Care and Social Assistance		Public Administration	
	Total	500+ full-time employees	Total	500+ full-time employees	Total	500+ full-time employees
	%	%	%	%	%	%
Purchasing Off-the-Shelf Technologies	92 A	93 A	83 A	85 A	82 B	89 B
Licensing New Technologies	65 A	70 A	58 A	73 A	69 B	68 C
Customising or Significantly Modifying Existing Technologies	48 A	52 A	43 A	46 A	83 B	89 B
Leasing New Technologies	23 A	27 A	29 A	37 A	38 B	43 C
Developing New Technologies	43 A	47 A	24 A	29 A	66 B	71 C
Putting in Place an Improved Production Facility	22 A	28 A	7 A	11 A	24 B	27 C

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

The Public and Private Faces of Education and Health Care

Education and health care are carried out by both the public and private sectors. Overall, the public sector educational and health care institutions are more likely to have adopted technologies than their private sector counterparts. Again, however, employment size played an important role in levelling the adoption rates of private and public sector institutions. In fact, technological adoption rates for educational and health care institutions of at least 500 employees were similarly high (see Table 10).

Table 10: Percentage of organisations acquiring significantly improved technologies in Educational Services and Health Care in the private and public sectors, 2000-2002

	Public Sector		Private Sector	
Size of Organisation	**Technology adoption 2000-2002**		**Technology adoption 2000-2002**	
Educational Services	**%**	**Reliability**	**%**	**Reliability**
All enterprises	86	A	65	C
1-99 full-time employees	79	B	64	C
100-499 full-time employees	83	A	96	A
500+ full-time employees	88	A	100	A
Health Care and Social Assistance	**%**	**Reliability**	**%**	**Reliability**
All enterprises	83	A	45	B
1-99 full-time employees	69	B	45	B
100-499 full-time employees	83	A	83	D
500+ full-time employees	88	A	87	D

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

Concluding Remarks

Technology adoption is important to the public sector — overall the rate of technological adoption in the public sector stood at twice that of the private sector. However, when organisations of the same size are compared, there is little difference between the sectors. It appears that organisations had overcome the Y2K situation that may have forced many to undertake significant technological change in the years leading up to 2000. Perhaps in support of government-on-line initiatives, public sector organisations seemed inclined to continue their active acquisition of significantly improved technologies with almost all of them making off-the-shelf purchases. Customisation of technologies was a preferred method of technological change for larger public administrations which might indicate that post Y2K upgrades were made to some systems. Developing new technologies, another complex method of undertaking technological change was equally important as licensing technologies in the public administration perhaps indicating that simpler methods available for technological change are employed when possible. Public sector health care and social assistance and educational institutions led their private sector counterparts in technological change. In fact, these two sectors led the public sector with organisations in public administration trailing at just three-quarters adopting significantly improved technologies in 2002.

The public sector organisations are highly committed to training in support of technological change, with almost every organisation that introduced new technologies also providing training. This rate was almost twice the rate of the private sector overall. The private sector, however, is comprised mainly of small firms which have low rates for both technological change and for training. The seemingly lower inclination towards technological change in smaller organisations may be due in part to the costs associated

with change. Introducing new and sometimes much more complex technologies includes costs over and above the initial acquisition costs. Other costs include work interruption for installation and worker training when necessary. Lost time and initial worker productivity are costs that have to be explored prior the adoption of new technology. Smaller firms may find these costs outweigh the perceived benefits of the technological change. On the other, when large organisations across the private and public sectors are compared, a levelling of the technological change rates and training in support of change occurs. This suggests that larger organisations are better able to afford technological change.

Overall the Canadian public sector is leading the private sector in technological change and in supporting new technology acquisition with training. Methods used to acquire new technology shows a strong mix of complex and simple suggesting that cost effectiveness is an important consideration in the public sector.

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

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.

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-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 allow Statistics Canada to comply with its mandate of non-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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