Catalogue no. 11-622-MIE — No. 015
ISSN: 1705-6896
ISBN: 978-0-662-47362-6

Research Paper

The Canadian Economy in Transition Series

New Economy: Using National Accounting Architecture to Estimate the Size of the High-technology Economy

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Statistics Canada
Micro-economic Analysis Division

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Published by authority of the Minister responsible for Statistics Canada

December 2007

Catalogue no. 11-622-MIE, no. 015
Frequency: Occasional

ISSN 1705-6896
ISBN 978-0-662-47362-6

Ottawa

Cette publication est aussi disponible en français (nº 11-622-MIF au catalogue, nº 015).

Authors' names are listed alphabetically.

Note of appreciation

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 cooperation and goodwill.

Acknowledgements

We are grateful to Karen Wilson, Kishori Lal, Yusuf Siddiqi, Roger Jullion and André Loranger of Statistics Canada for their many helpful comments and suggestions.

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Abstract

This paper illustrates how the statistical architecture of Canada's System of National Accounts can be utilized to study the size and composition of a specific economic sector. For illustrative purposes, the analysis focuses on the information and communications technology (ICT) sector, and hence, on the set of technology-producing industries and technology outputs most commonly associated with what is often termed the high-technology economy. Using supply and use tables from the input-output accounts, we develop integrated ICT industry and commodity classifications that link domestic technology producers to their principal commodity outputs. We then use these classifications to generate a series of descriptive statistics that examine the size of Canada's high-technology economy along with its underlying composition. In our view, these integrated ICT classifications can be used to develop a richer profile of the high-technology economy than one obtains from examining its industry or commodity dimensions in isolation.

Keywords: information and communications technology, high-technology industries, technology use, national accounting

Executive summary

This analysis uses the data from Canada's System of National Accounts to investigate the domestic production and domestic use of information and communications technologies (ICT). Using the input-output accounts, we develop an ICT classification system that links domestic technology producers to their principal commodity outputs. We then produce a series of descriptive statistics that focus on different aspects of technology production and technology use. Two estimates of the importance of technology production are reported—the contribution that ICT producers make to total gross domestic product (GDP) and their share of gross domestic output. We compare these to two basic estimates of technology use—the share of technology spending in final domestic demand and the share of technology spending in total domestic demand (which includes spending on final goods and services and production inputs). The paper also presents comprehensive estimates of ICT spending in different economic sectors.

Our tabulations inform a series of basic questions about the size and composition of Canada's ICT economy. We address several of these below.

What share of domestic economic activity is accounted for by technology producers? Are estimates of the importance of technology producers sensitive to measurement?

An industry's value-added is the unduplicated value of the goods and services that it produces, that is, its contribution to GDP. Statistics on value-added provide one means of assessing the relative importance of technology-based production. In 1997, the set of ICT-producing industries examined in this paper accounted for 3.8% of total GDP. This share increased to 4.6% in 2000, and declined to 4.2% in 2003. The high-tech boom and bust was limited to manufacturing, as ICT manufacturers made a smaller contribution to GDP in the goods sector in 2003 (2.1%) than in 1997 (3.1%). ICT service industries increased their share of service sector GDP from 4.2% in 1997 to 5.2% in 2003.

The relative size of ICT production is similar when it is evaluated against gross output. The share of gross output accounted for by the production of ICT goods and services is qualitatively similar to the GDP shares of technology producers. ICT goods and services accounted for 3.8% of gross output in 1997, 4.4% of gross output in 2000, and 3.6% of gross output in 2003. ICT products made up a much larger share of the gross output of goods in 2000 (4.7%) than in 1997 (3.5%). However, by 2003, the share of goods production accounted for by technology products had fallen well below its 1997 level. By contrast, the share of services output accounted for by ICT services increased from 2000 to 2003.

How much domestic spending is on ICT? Is final spending on technology-based goods and services much different than total spending?

Many studies of the new economy focus on how extensively ICT technologies are being used. This analysis presents two summary statistics that describe the overall size of technology expenditures in the domestic economy. The first is the share of final domestic demand accounted for by ICT goods and services. The second is the share of total domestic demand accounted for by these ICT goods and services. These statistics include expenditures on both domestically produced ICT commodities and foreign-produced ICT commodities.

Final domestic demand is the sum of all domestic spending on final goods and services—the combined total of personal expenditures by consumers, investment expenditures by businesses and current and investment spending by governments. Final purchases of ICT goods and services accounted for 4.2% of final domestic spending in 1997. This grew to 5.1% by 2000, and subsequently fell to 4.4% in 2003. In all years studied, final expenditures on ICT make up a much larger share of final goods spending than final services spending. In 2000, ICT goods amounted to 9.1 % of all final spending on goods. ICT services, by contrast, were only 1.4% of all final spending on services.

Statistics on final expenditures exclude business spending on intermediate inputs—goods and services that are consumed or transformed in the production process. We combine these intermediate expenditures with final expenditures to estimate the total domestic demand for ICT goods and services. This more comprehensive measure basically covers all ICT spending, final or otherwise, by consumers, businesses and governments in the domestic economy. With this measure, the relative importance of technology increases slightly. Spending on ICT goods and services accounted for 4.9% of total spending in 1997, 5.6% in 2000, and 4.7% in 2003. These shares mask large differences between goods and services. In 2000, spending on ICT goods accounted for about 8% of all spending on goods, while purchases of ICT services amounted to about 2% of total spending on services.

Who buys more ICT goods and services? Firms or households?

It depends largely on what types of expenditures are being measured—spending on final ICT goods and services, which includes personal expenditures and business investment, or all spending on ICT goods and services, final or otherwise, which brings business spending on intermediate technology inputs into mix.

Consumers and firms spend roughly equivalent amounts on final ICT goods and services. In 1997, personal expenditures by consumers and investment spending by businesses each accounted for roughly 45% of final technology purchases. Government purchases made up the remaining 10%. By 2003, consumers had increased their share slightly, to 48% of all final spending.

The relative size of business and household spending changes dramatically when business spending on technology inputs—inputs that are consumed or transformed in the production process—are included in the mix. Intermediate spending on ICT inputs accounts for about two-thirds of all technology spending by firms. Consequently, businesses spend about $3 on ICT commodities for every dollar spent by consumers.

How much consumer spending is devoted to ICT? How much business investment is?

Spending on ICT goods and services amounted to 3.3% of all consumer spending in 1997, and 3.6% of all consumer spending in 2003. Spending on ICT assets accounted for a much larger share of business investment (10.4% and 10.5% in 1997 and 2003 respectively).

Which economic sectors are the heaviest users of ICT capital?

Three sectors—manufacturing industries, information and cultural industries, and finance, insurance and real estate industries—together account for about 50% of total ICT spending. Manufacturing firms make the largest outlays on technology-based goods and services (with 29% of the total ICT purchases in 1997, and 20% in 2003).

A different picture emerges when examining the intensity of technology use across industries. In 2003, the information and cultural industries sector, which includes many ICT service industries, allocated the largest percentage of its total spending to ICT goods and services (33%), well ahead of professional, technical and management services, the next most ICT-intensive sector (19%). About 40% of these expenditures on technology in the information and cultural industries is investment spending on technology assets.

Manufacturing re-emerges when the focus shifts from investment to intermediate inputs. Over 80% of ICT purchases in manufacturing are on intermediate production inputs, not technology assets. Moreover, these expenditures on ICT inputs accounted for a sizable share of all intermediate spending on technology in the economy (39% of the economy total in 1997 and 25% in 2003). Despite the size of these intermediate expenditures, manufacturing industries are not the most intensive users of technology inputs, as measured in relation to their total spending on production inputs. ICT production inputs made up only about 5% of all intermediate spending in manufacturing in 1997, and only 3% in 2003. In information and cultural industries, the sector with the highest ratio of technology inputs to total inputs, the rate stood at about 24% in 2003.

Chapter 1. Introduction

This paper illustrates how the statistical architecture of Canada's System of National Accounts (SNA) can be used to study the size and composition of the Canadian high-technology sector. The analysis focuses on the domestic production and domestic use of information and communications technology (ICT) goods and services. Much of the earlier research on high technology has examined these industry and commodity dimensions in isolation—focusing either on the operating characteristics of technology producers or, alternatively, on the adoption of a exogenous set of technology-based products. All of these studies attempt to shed light on the importance of advanced technology. Those that focus on technology producers do so by examining the amount of economic resources, labour, and capital that are devoted to high-tech production.[1] Those that examine technology use focus on how the integration of ICT capital influences industrial or macroeconomic outcomes.[2] Seldom are these two dimensions, technology production and technology use, investigated using an integrated statistical framework that explicitly links ICT commodities to ICT industries. This paper describes how national accounting architecture can be used to develop such a framework.

Our starting premise is that the statistical integration of these two dimensions—technology production and technology use—is desirable in order to develop a richer portrait of an economy's high-tech demography. In what follows, we develop an integrated set of industry and commodity definitions to evaluate Canada's ICT sector, and present a range of descriptive statistics that can be used to study its size and composition. Our tabulations are designed to shed light on a range of topics that are not fully addressed in earlier studies of the ICT economy. A short list includes the following:

- What are the principal commodity outputs of domestic ICT producers?
- Does the relative importance of technology production depend on how production is measured? How does the contribution that ICT industries make to gross domestic product (GDP) differ from the share of gross output accounted for by ICT goods and services?
- How does the size of ICT production compare with the magnitude of domestic technology use? Do these two measures, production and use, yield significantly different estimates of the size of the high-tech economy?
- Who are the major users of technology-based goods and services? How does the amount of technology spending by businesses compare with ICT purchases by households and governments? How much consumer and business spending is accounted for by ICT?

- To what extent does capital spending on ICT goods and services underestimate total business spending on these commodities (the sum of technology investments and intermediate spending on technology inputs)?
- Which industries make the largest purchases of ICT goods and services? Which sectors use these goods and services most intensively, either as investment or production inputs?

The organization of the paper is as follows. Chapter 2 begins with a brief description of the SNA architecture on which our estimates of ICT production and use are based. We then outline the methods used to define a set of domestic ICT industries and an associated set of ICT commodities.

Chapters 3 and 4 use these industry and commodity definitions to generate descriptive statistics that can be used to evaluate the size and composition of the ICT economy. Chapter 3 focuses on two estimates of technology production: (i) the contribution that ICT industries make to total GDP and (ii) the share of gross output accounted for by the production of ICT goods and services.

Chapter 4 focuses on the use of technology-based goods and services. Using the commodity classification developed in Chapter 2, we examine the importance of technology spending to final domestic demand. We also examine how these final expenditures on technology are distributed between and within final demand sectors (as consumer spending, business investment, or government investment). Chapter 4 then develops a more comprehensive measure of technology use by incorporating intermediate spending on technology inputs into our expenditure estimates. This allows us to examine the total domestic demand for ICT goods and services.

Chapter 5 is a more detailed analysis of technology use in Canadian industry, focusing both on ICT capital investments and production inputs. We examine the distribution of technology spending across industries and the intensity of technology use within industries. Chapter 6 concludes.

In Appendix A, we discuss how the ICT commodity classification used in this study compares to the ICT commodity definition being developed by the Organisation for Economic Co-operation and Development.

In Appendix B, we further discuss the distinction between the commodity-based final expenditure ratios and the industry value-added ratios that capture the contribution of technology producers to total GDP.

Endnotes

1. Statistics Canada's research program is illustrative. The agency has responded to the growing demand for statistical information on the new economy by producing a set of analytical products that explore the structural characteristics of technology-producing industries. The agency's Science, Innovation and Electronic Information Division publishes an annual compendium on the information and communications technology (ICT) sector that includes data on output, employment, research and development (R&D), trade and revenue. Beckstead and Gellatly (2003) report on long-run production and performance trends in the technology sector, focusing *inter alia* on profit rates, labour skills, and productivity performance. Beckstead et al. (2003), Beckstead and Brown (2005), and Heisz et al. (2005) examine the geography of ICT employment growth. Labour market conditions in technology industries, including analyses of work arrangements and job quality, are documented in Drolet and Morissette (2002), and Vaillancourt (2003).
2. Studies that concentrate on technology use point to a strong relationship between the adoption of advanced technologies—notably information and communications technologies—and associated changes in labour productivity and market share (Baldwin, Sabourin and Smith, 2003; Baldwin and Sabourin, 2004). This microeconomic research has found that the performance-enhancing effects of ICT capital remain apparent after controlling for the array of idiosyncratic factors that influence productivity growth, such as R&D intensity, firm nationality, capital intensity and business location. In a complementary fashion, macroeconomic studies have established a clear link between aggregate investments in ICT capital and business sector output and productivity growth (Armstrong et al., 2002; Harchaoui and Tarkhani, 2004). Business investments in technology-based assets, such as computer software, hardware and telecommunications equipment, grew by 16% per annum during the 1980s and the 1990s. These investments factored significantly into Canada's improved productivity performance during the late 1990s.

Chapter 2. National accounting architecture and the ICT economy

2.1 An input-output analysis of ICT industries and commodities

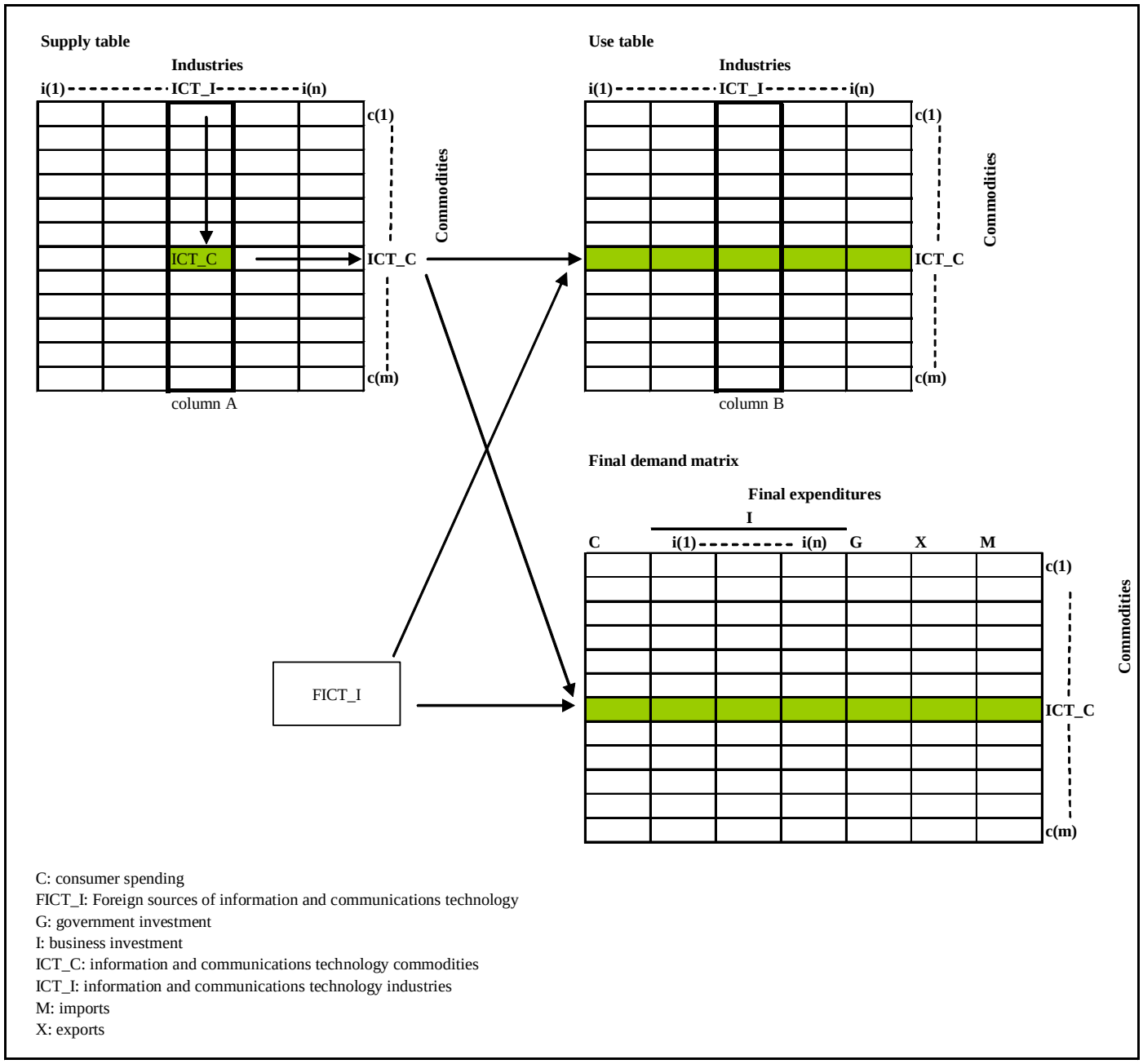
The System of National Accounts (SNA) is an integrated statistical architecture used in the production of official economic statistics. Generally portrayed as a sequence of accounts, the SNA provides for national estimates of "the whole economic process from production of income, through redistribution of income, consumption and saving, through to accumulation of fixed and financial assets, to the position of net worth" (Wilson, 2005: 7). The cornerstone of the SNA is the production of official estimates of gross domestic product (GDP).[3]

In this paper, we make extensive use of input-output tables. These tables depict an integrated set of industry and commodity relationships that are essential for producing the official industry and commodity accounts.[4] The industry accounts maintain information on the commodity composition of output for specific industries and the full costs of production for these industries (including the earnings of labour and capital). The commodity accounts deal with the supply and disposition of specific goods and services to different sectors of the economy.[5] In what follows, we illustrate how these industry-to-commodity linkages can be used, in conjunction with expenditures on final demand, to study the size and composition of the information and communications technology (ICT) sector.

Figure 1 is a stylized depiction of the supply and use tables that form the core of the input-output system. These tables together trace the flow of output (the set of goods and services produced by specific industries) to different uses. The production of this output is depicted in what is referred to as the supply table. Each domestic industry is assigned an individual column in this table; hence, column i(1) reports the gross output derived from the production activities of industry (1) (with each cell within this column corresponding to a specific commodity [good or service]). The detailed supply table reports gross output distributions for over 300 industries, encompassing approximately 700 distinct commodities.

For illustrative purposes, we denote one column in this supply table as ICT_I—to represent the collection of technology-producing industries that together comprise Canada's ICT sector. (ICT_I is actually an amalgam of 14 separate SNA industries, which we list in Section 2.2). Firms located in ICT_I generate technology-based output, denoted in Figure 1 as ICT_C. (This technology-based output is an amalgam of 21 specific goods and services, which we describe in Section 2.3.) The shaded area in the supply table thus depicts the value of the output associated with the production of technology-based goods and services (ICT_C) by domestic technology suppliers (ICT_I).[6] Our subsequent portrait of the technology economy is based on this integrated definitional framework which links technology producers to their major commodity outputs. We describe our operational definitions below.

Figure 1 A stylized representation of information and communications technology production and use based on national accounting architecture



C: consumer spending
FICT_I: Foreign sources of information and communications technology
G: government investment
I: business investment
ICT_C: information and communications technology commodities
ICT_I: information and communications technology industries
M: imports
X: exports

Source: Statistics Canada, authors' representation based upon the Canadian input-output accounts.

2.2 Defining ICT industries

ICT industry statistics benefit from the existence of a well-codified classification system that identifies a small set of industries as ICT-based. Developed by the Organisation for Economic Co-operation and Development (OECD), this classification system defines the ICT sector as "the combination of manufacturing and service industries, which electronically capture, transmit and display information" (Statistics Canada, 2001: 12). In manufacturing, these industries "[m]ust be intended to fulfil the function of information processing and communication including transmission and display" and "[m]ust use electronic processing to detect, measure and/or record physical phenomena or to control a physical process." (OECD, 2000: 7).

Similarly, ICT service industries offer products that "[m]ust be intended to enable the function of information processing and communications by electronic means." (OECD, 2000: 7)

Statistics Canada has adopted an official version of this ICT classification based on the North American Industry Classification System (NAICS). This Canadian variant designates eight five-digit NAICS industries as ICT manufacturing and fifteen as ICT services. Data on the ICT sector are routinely available from Statistics Canada's major production programs. The SNA has designated ICT industries as a special aggregate, and releases monthly GDP estimates for ICT service industries and ICT manufacturing industries (Messinger, 2002).

While the statistical information that Statistics Canada publishes on technology industries is consistent with the OECD ICT standard, one often encounters slight differences in coverage because of differences in the amount of industry detail that is available from various data sources.[7] These measurement and classification issues are germane to the current analysis, as the level of industrial detail available from the input-output accounts—the data source that is required to link ICT industries to specific ICT commodities—does not allow us to extract data on all NAICS-based ICT industries with complete precision. Many of these NAICS technology industries, particularly in manufacturing, are measured precisely. In other cases, the industry classification system used in the input-output accounts nests NAICS-based ICT industries within larger aggregates that contain a mixture of ICT and non-ICT components. This occurs for certain service industries.

Consequently, the set of technology-producing industries studied in this analysis, while generally consistent with the official ICT standard, differs slightly from this standard because of the measurement limitations described above. We have chosen to omit a residual group of SNA service industries from our ICT industry definition when (1) their corresponding SNA industries contain both ICT and non-ICT components, and (2) the contribution of the non-ICT component to industry output is qualitatively significant. In earlier studies of ICT industries (Beckstead and Gellatly, 2003; Becktead et al., 2003) we took a different approach by splitting out these nested ICT components (via external data sources) and apportioning these to our ICT industry estimates. We cannot pursue a similar strategy here because we are using our ICT industry definition to generate an associated set of ICT commodities, and the intuitive appeal of these split-and-allocate strategies is greatly diminished when developing an integrated industry-to-commodity framework.[8]

Table 1 Selected[1] System of National Accounts information and communications technology industries, ranked by value of gross output

SNA[2] ICT[3] industry	Goods or services sector	Relationship to statistical target: corresponding 1997 (NAICS[4]) ICT industry
1. Telecommunications	Services	SNA industry is equivalent to NAICS 5133
2. Computer systems design and related services	Services	SNA industry is equivalent to NAICS 54151
3. Telephone apparatus manufacturing	Goods	SNA industry is equivalent to NAICS 33421
4. Software publishers	Services	SNA industry is equivalent to NAICS 51121
5. Navigational, measuring, medical and control instruments manufacturing	Goods	SNA industry is equivalent to NAICS 33451
6. Pay TV, specialty TV and program distribution	Services	SNA industry contains both ICT (NAICS 51322) and non-ICT (NAICS 51321) components.
7. Semiconductor and other electronic component manufacturing	Goods	SNA industry is equivalent to NAICS 33441
8. Commercial and service industry machinery manufacturing	Goods	SNA industry is equivalent to NAICS 33331
9. Computer and peripheral equipment manufacturing	Goods	SNA industry is equivalent to NAICS 33411
10. Communication and energy wire and cable manufacturing	Goods	SNA industry is equivalent to NAICS 33592
11. Radio and television broadcasting and wireless communications equipment manufacturing	Goods	SNA industry is equivalent to NAICS 33422
12. Data processing services	Services	SNA industry is equivalent to NAICS 51421
13. Information services	Services	SNA industry contains both ICT (NAICS 51419) and non-ICT components (NAICS 51411, 51412).
14. Audio and video equipment manufacturing	Goods	SNA industry is equivalent to NAICS 33431

1. Five 1997 NAICS ICT service industries—NAICS 41732, 41791, 41731, 53242 and 81121—were excluded from the SNA ICT sector definition because of measurement limitations.
2. System of National Accounts.
3. Information and communications technology.
4. North American Industry Classification System.

Source: Statistics Canada, 1999 supply table, Canadian input-output accounts.

Our set of technology-producing industries, and its relation to the NAICS ICT standard, are presented in Table 1. Fourteen SNA industries make up our ICT industry definition (ICT_I).[9] In 1999, these accounted for about 73% of the gross output of the ICT sector.

2.3 Defining ICT commodities

Analyses of the commodity dimensions of the ICT economy often focus on a small set of pre-defined goods or services, or on sector-specific definitions of advanced technology that are designed to capture salient aspects of the production process.[10] This can give rise to situations where commodity- and industry-based definitions of the ICT economy may differ significantly from one another. In this section, we outline an integrated commodity definition of ICT

based on the major commodity outputs of the domestic technology industries described in Section 2.2.

To define our set of technology commodities (ICT_C), we use data from the supply table to generate the sales distribution of all commodities that are associated with our set of technology-producing industries (ICT_I). We then rank order this vector of commodity outputs based on their contribution to the total sales of these industries. Our selection criteria for identifying major technology outputs is based on two distributional factors: (a) the contribution of specific commodities to the total sales of *all* technology-producing industries, and (b) the contribution of specific commodities to the total sales of *individual* technology-producing industries. Our dominant criterion for selection is factor (a). All individual commodities that accounted more than 1 % of the total sales of the technology sector (ICT_I) were classified to the commodity set (ICT_C). Sixteen commodities were selected based on this rule.

One possible concern with factor (a) is that it may fail to identify commodities that account for a large percentage of sales in specific technology-based industries, in situations where the overall contribution of these industries to the total sales of ICT_I is relatively modest. To ensure that our selection method is not unduly biased against small technology-based industries, we supplemented our commodity list by introducing factor (b), applying a 10% selection rule to individual commodities. Five additional commodities were added to ICT_C based on this second criterion.

Our final list of major ICT goods and services is reported in Table 2. Of the 21 commodities, 14 are goods and 7 are services. (It is worth noting that of the 14 goods, 10 are classified as ICT-based by the OECD). Taken together, these goods and services account for about 90% of the total sales of domestic technology industries (ICT_I).

This integrated industry-to-commodity approach is appealing in several respects. First, it establishes a list of technology goods and services based on a measure of domestic market share, namely, the contribution that specific commodities make to the total sales of technology-producing industries. The resulting amalgam of technologies is thus endogenously determined, as opposed to being defined *ex ante*. Second, this commodity set is broad enough in scope—in terms of its sales coverage and underlying commodity composition—to generate robust comparisons of technology use in different sectors of the economy.[11]

It should be stressed that work is currently underway at the OECD on developing ICT commodity definitions—definitions that, in principle, represent important commodity outputs of technology-producing industries. A tentative definition of ICT goods is currently available, using a classification system that supports comparisons with the SNA commodities listed in Table 2 (see OECD, 2001). Work on a final list of ICT services is ongoing. We discuss how our ICT commodity list compares to the emerging OECD standard in Appendix A.

Table 2 Major information and communications technology commodities, ranked by contribution to the ICT[1] sector output

ICT commodity	Commodity type
1. Telephone and other telecommunications	Services
2. Computer systems design and related services	Services
3. Telephone and related equipment, including facsimile	Goods
4. Software products development	Services
5. Computers, video units, printers, etc.	Goods
6. Cable and other subscription programming	Services
7. Integrated circuits	Goods
8. Broadcasting and radio communications equipment	Goods
9. Printed circuits	Goods
10. Data processing services	Services
11. Lab and scientific instruments, and flight simulators	Goods
12. Wire and cable, insulated, excluding aluminum	Goods
13. Semi-conductors	Goods
14. Measuring and controlling instruments	Goods
15. On-line information services	Services
16. Radar and radio navigation equipment	Goods
17. Optical fibre cables	Goods
18. Service industry machinery	Goods
19. Other information services (including news syndication, microfilm, recording	Services
20. Photocopy and microfilm equipment	Goods
21. Radio, stereo, cassette and CD players, and accessories	Goods

1. Information and communications technology.
Source: Statistics Canada, 1999 supply table, Canadian input-output accounts.

In subsequent chapters, we use these industry and commodity definitions to examine the size and composition of Canada's ICT economy. Our descriptive tabulations focus, in turn, on different aspects of domestic technology production and domestic technology use.

Endnotes

3. A full description of the structure of the Canadian System of National Accounts (SNA) is well beyond our scope here; for an extensive overview, see Wilson (2005).
4. As Wilson (2005: 13) notes, supply and use tables "are the thread that ties the system together and have a big impact on the quality of the [national accounting] system both in terms of statistical integrity and analytic usefulness."
5. A more extensive discussion of the organization of the industry and commodity accounts is found in Baldwin and Harchaoui (2006).
6. This assumes that production is specialized—that technology industries (ICT_I) produce the full set of ICT goods and services (ICT_C). This is a reasonable simplification. Ninety-seven percent of the ICT commodity outputs reported in Table 2 are produced by the set of ICT industries listed in Table 1.
7. One highly visible example is the special tabulations on employment in computer and telecommunications industries that are published from the Labour Force Survey, the agency's flagship vehicle for its national employment estimates. Computer and telecommunications industries are a subset of the official ICT standard (see Bowlby and Langlois, 2002).
8. To see this, consider the case of ICT wholesaling, which we handled via a split-and-apportion strategy in Beckstead and Gellatly (2003). ICT wholesaling industries account for a reasonably small share of total wholesaling activity. In this earlier paper, we estimated this ICT component and then used it to adjust our ICT industry estimates. In the current analysis, this would involve using some portion of wholesaling industries (and other similarly measured industries) to generate a ranking of principal commodity outputs—one that could, in effect, include partial commodities (e.g., some wholesaling margins, but not others). In addition to being operationally cumbersome, this would greatly hamper the interpretability of the commodity list. As a consequence, we have opted for the more straightforward keep-and-drop approach described herein.
9. Twelve of these input-output industries have equivalent definitions from the North American Industry Classification System. In two cases, the decision to include the SNA industry was sensible based on the revenue coverage of its nested ICT component (data on these revenue ratios were obtained from Statistics Canada's Business Register).
10. Research on the relationship between ICT use and productivity growth is illustrative. Following conventions set out in the productivity literature, these studies focus on a narrow set of pre-defined information technologies—hardware, software and telecommunications equipment. See Armstrong et al. (2002), and Harchaoui and Tarkhani (2004).

11. A point worth noting—innovation and technology surveys have yielded substantial information on the differences in technology adoption rates across industries and business populations. These rates often depend on qualitative information on technology use provided by survey respondents (e.g., Did your firm use ICT technologies?). Using Statistics Canada's annual Survey of Electronic Commerce and Technology, Earl (2002) reports rates of technological change in the private sector based on the adoption of "significantly improved technologies." Uhrbach (2004) reports how rates of use for a basic set of ICTs (including e-mail, computers, websites, Internet, and on-line purchases) vary by firm size. Uhrbach and van Tol (2004) also examine how the use of ICTs by firms complements the utilization of other advanced technologies.

Chapter 3. The domestic production of ICT goods and services

We begin by examining two supply-based measures, each of which can be used to estimate the relative importance of information and communications technology (ICT) production. These are (1) the economic contribution that ICT producers make to total gross domestic product (GDP), and (2) the share of all goods and services produced that is accounted for by ICT commodities.

3.1 Contribution to GDP

The Canadian System of National Accounts (SNA) produces official estimates of total GDP from three distinct methods: the sum of value-added approach; the expenditure approach; and the distribution of income approach. In this section, we concentrate on the first of these methods to examine the output of technology industries—one means of estimating the size of the technology economy.

National accountants often speak in terms of an industry's *value-added* when describing its contribution to total GDP. An industry's value-added is the difference between its gross output and its expenditures on all intermediate inputs used in generating this output. Estimates of industry value-added are designed to provide "detailed description[s] of the supply side of domestic production." (Statistics Canada, 2002: 7). Value-added also represents the income that is earned by factors of production, such as labour and capital, within an industry.

Within the SNA, these intermediate expenditures are recorded in the use table, which we depict in the upper-right quadrant of Figure 1. When viewed from an industry perspective (each industry is a separate column), the use table records all intermediate spending on individual goods and services that are consumed or transformed within an industry's production process (each cell within the column corresponds to a separate commodity).[12] When viewed from a commodity perspective (each commodity is a separate row), this table records how the intermediate spending on a particular commodity is distributed across industries (each cell along the row being a separate industry). It should be stressed that these intermediate expenditures include ICT inputs purchased both from businesses located in Canada and from businesses located abroad.

The value added of domestic ICT producers can be obtained from the supply and use tables depicted in Figure 1. Here our focus is on the amalgam of domestic technology industries (which we denote as ICT_I) as opposed to the corresponding bundle of industry outputs (similarly depicted as ICT_C). The GDP contribution of domestic ICT industries is the

difference between its gross output (column A in the supply table) and the sum of its intermediate expenditures on all commodity inputs (column B in the use table). This difference (A minus B) is the value-added associated with ICT industries. Obtaining estimates of value-added for all industries in this fashion and then summing these yields an estimate of total GDP—a measure of "the unduplicated value of production" (Statistics Canada, 2002: 11).[13] We can obtain a measure of the relative importance of ICT production by dividing the value-added from ICT industries by the total value-added.

Table 3 reports the percentage of total GDP accounted for by ICT industries in three years, 1997, 2000 and 2003. We selected these years because the 1997-to-2000 period captures the acceleration of ICT spending that occurred at the end of the long-run expansionary phase of technology markets. Data for 2003 capture the impact of the downturn in technology markets in the post-2000 period.

Table 3 Contribution of information and communications technology industries to gross domestic product, 1997, 2000 and 2003

	1997	2000	2003
		percent	
Contribution of ICT[1] industries to value-added GDP[2]	3.8	4.6	4.2
Contribution of ICT manufacturing industries to GDP of goods sector	3.1	4.0	2.1
Contribution of ICT service industries to GDP of services sector	4.2	5.0	5.2

1. Information and communications technology.
2. Gross domestic product at basic price.
Source: Statistics Canada, supply and use tables, Canadian input-output accounts.

In 1997, the value-added contributions of technology producers represented 3.8% of total GDP; by 2000, this share had increased to 4.6%. By 2003, the contraction in technology markets saw the contribution of technology industries decline to 4.2% of GDP.

Two general observations regarding these GDP estimates warrant emphasis. First, ICT production in Canada centers on the provision of technology services, not the manufacture of technology products. Firms in ICT service industries accounted for 74.1% of ICT GDP in 1997 and 84% of ICT GDP in 2003.[14] The short-run contractions in ICT GDP occasioned by the technology downturn were localized to ICT manufacturing. By 2003, the nominal dollar contribution that ICT manufacturing industries made to total GDP was less than in 1997—with the downturn fully eliminating the strong growth in ICT manufacturing GDP that occurred during the late 1990s. (ICT manufactures contributed $7.7 billion to GDP in 2003, slightly less than the $8.2 billion in 1997; in 2000, their contribution stood as high as $13.7 billion).

GDP shares are extensively used in practice because they capture the unduplicated value of production associated with a particular aspect of the economic system—here the business activities associated with technology manufacturing and the provision of technology services. This is a straightforward means of measuring the importance of ICT production.

The contribution that ICT industries make to GDP depends, as noted earlier, both on the amount of gross output that these industries produce and on the amount of intermediate inputs used in the production of this output. Consequently, industries that embed large quantities of intermediate goods and services into the production of their final products will, all else equal, generate less value-added—that is, make lower contributions to GDP—than those whose production routines rely on fewer intermediate goods and services. Industries in the former camp can produce large amounts of gross output while, at the same time, making comparatively small contributions to total GDP. In light of this, it is useful to consider an alternative measure of the size of technology production—the share of output accounted for by ICT goods and services.

3.2 Share of gross output

In Table 4, we divide the gross output obtained from the production of the ICT commodities listed in Table 2 by the gross output obtained from all commodities. These figures can be obtained directly from the supply table depicted in Figure 1.

Table 4 Share of gross output accounted for by the production of information and communications technology goods and services, 1997, 2000 and 2003

1997	2000	2003
	percent	
Gross output of ICT[1] goods and services relative to gross output of all goods and services	3.8	4.4	3.6
Gross output of ICT manufactured goods relative to gross output of all goods	3.5	4.7	2.5
Gross output of ICT services relative to gross output of all services	4.1	4.2	4.4

1. Information and communications technology.
Source: Statistics Canada, supply and use tables, Canadian input-output accounts.

These gross output shares do not measure the contribution that ICT producers make to GDP. Gross output shares embed large amounts of duplication, as goods and services are gradually transformed from raw inputs into finished products as they move along their vertical supply chain.[15] However, these gross output ratios may still be of interest to many readers, because they provide a basic measure of the amount of technology produced, relative to the economy's total productive output.[16]

The gross output shares associated with ICT goods and services are qualitatively similar to the GDP shares reported in Table 3. In 1997, ICT goods and services accounted for 3.8% of all gross output. This increased to 4.4% in 2000, and declined to 3.6% in 2003.

The gross output share for ICT products mirrored changes in the GDP contribution of ICT manufacturing industries (Section 3.1). ICT products accounted for 3.5% of goods production in 1997. By 2000, this share had increased to 4.7%, only to decline to 2.5% in 2003. There was no comparable decline in the gross output share of ICT services. These technology services accounted for 4.2% of the gross output of services in 2000, and 4.4% in 2003.

The GDP and gross output ratios reported in Tables 3 and 4 are straightforward means of evaluating the importance of technology-based production. While conceptually different, these ratios provide similar estimates of the size of the domestic technology sector—approximately 4% of economic output. This was not obvious *a priori* because GDP shares—the contribution that different industries make to total GDP—depend both on the amount of gross output that an industry produces and on the amount of intermediate inputs used in the production of this output. In the next chapter, we turn to descriptive statistics that measure the demand side of the ICT economy—statistics that focus both on its size and composition.

Endnotes

12. This matrix has the same industry and commodity dimensions as the supply table—approximately 300 industries by 700 commodities. It is critical to note that not all of the intermediate expenditures on ICT that are recorded in the use table are purchased from domestic suppliers. Firms acquire these inputs from either domestic sources (ICT_I) or foreign sources (denoted as FICT_I in Figure 1).
13. This sum of value-added approach is generally referred to as "output-based GDP"; for additional discussion, see Statistics Canada (2002).
14. The ICT economy is not unique in this regard, as the same can be said of the Canadian economy generally. In 2003, service industries accounted for 67% of total GDP.
15. The GDP shares reported in Table 3 factor out this duplication by effectively isolating a particular stage of this vertical process.
16. While the technology goods and services under study are, by design, major outputs of domestic technology industries, the concept being evaluated in these ratios—the gross output associated with the production of technology-based goods and services—is not equivalent to the gross output of ICT industries, which includes in principle, both ICT and non-ICT products and services. The gross output ratios reported in Table 4 are based strictly on the ICT commodity definition (Table 2) which does not limit the production of these commodities to specific sectors.

Chapter 4. The domestic use of ICT goods and services

A growing number of empirical studies link expenditures on information and communications technology (ICT) capital to productivity or economic growth. Some of these studies rely on decomposition techniques to ascertain how different factors of production—investments in information technology, expenditures on other capital assets, and changes in labour input—are associated with changes in labour productivity.[17] Research on the importance of technology assets has also focused on understanding differences in the intensity with which technology is being used in different sectors of the economy. These studies typically differentiate between investments in information technology and more traditional capital assets, and then correlate the intensity of technology use with various measures of industry performance (see Stiroh, 2001). In these exercises, information technology assets are often defined exogenously to capture expenditures on hardware, software and telecommunications equipment.

These studies shift the focus from technology-producing industries to the adoption of technology-based goods and services in different sectors. This distinction is critical when evaluating the dimensionality of the ICT economy—as one may be far more interested in the extent to which consumers, businesses and governments are using these technologies than in the extent to which domestic firms are bringing them to market, especially when a country is a net importer of ICT products.

In this chapter, we present statistics that can be used to assess the relative importance of technology use in the domestic economy. Unlike the production statistics presented in Chapter 3, these focus on the demand side of the technology market. They also take an open economy view, by incorporating data on both Canadian and foreign-produced ICT goods and services. Two summary indicators are examined in this chapter: (i) the share of final domestic demand accounted for by ICT goods and services, and (ii) the share of total domestic demand accounted for by ICT goods and services. We supplement these with more detailed tabulations that examine various aspects of aggregate technology use.

4.1 The final domestic demand for technology-based goods and services

In Chapter 3 we noted that the Canadian System of National Accounts (SNA) produces estimates of gross domestic product (GDP) from three distinct methods—the sum of value-added approach, the expenditure approach, and the distribution of income approach. The second of these, the expenditure approach, derives in principle from the familiar GDP equation

(1) $GDP = C + I + G + (X - M)$,

where C is consumer spending, I is business investment, G is government spending and $(X - M)$ is net exports (exports [X] minus imports [M]). Equation (1) depicts the final demand for (unduplicated) domestically produced goods and services, broken down into major expenditure categories. Within the SNA, these data are organized in a final demand matrix, which we present stylistically in the lower-right quadrant of Figure 1. This matrix provides detailed commodity data for each final expenditure category.[18]

Equation (1) forms the basis for our first summary indicator of domestic technology use—the share of final domestic demand that is accounted for by ICT goods and services. Final domestic demand is the sum of three general expenditure categories in Equation (1): C (consumer spending), I (business investment), and G (government investment and current expenditures). The portion accounted for by technology goods and services is obtained by summing all consumer spending, business investment and government spending on the ICT commodities listed in Table 2, and then dividing this ICT total by the sum of all consumer spending, business investment and government expenditure:

(2) $$\textit{ICT share of final domestic demand} = \frac{C^{ICT} + I^{ICT} + G^{ICT}}{C + I + G}.$$

This ratio can be obtained directly from the final demand matrix portrayed in Figure 1. This ICT expenditure share differs from the ICT GDP and gross output shares reported in Chapter 3 in several important respects. First, it measures the relative importance of technology in terms of domestic use, not domestic production. Second, while the ICT goods and services under study are, by design, important commodity outputs of domestic ICT industries, the expenditure shares reported in Table 4 are based on both goods and services produced in Canada and goods and services imported from abroad.[19] Third, while the ICT and gross output ratios reported in Table 3 encompass both industry output that is consumed in domestic markets and industry output that is exported abroad, the expenditure ratio described in Equation (2) excludes exports and focuses instead strictly on domestic use. All of these factors help underscore an important point—these final expenditure ratios are not GDP shares, as GDP is a measure of (unduplicated) domestic production, not domestic utilization. (We examine this issue in considerable detail in Appendix B).

It is worth stressing why the positive export term X and the negative import adjustment term M that appear in estimates of expenditure-based GDP (Equation [1]) are excluded from estimates of final domestic demand (the sum of the remaining terms C, I, and G). Exports are excluded from final domestic demand because these are domestic outputs that are consumed abroad. The negative import term in Equation (1) is excluded because foreign imports of goods and services (which are excluded from GDP because they are produced abroad) make up part of the domestic demand for these goods and services. The individual expenditure categories that together define final domestic demand (consumer spending, business investment and government expenditure) combine data on imports with data on domestically produced goods and services.[20]

Table 5 Share of final domestic demand accounted for by information and communications technology goods and services, 1997, 2000 and 2003

	1997	2000	2003
	percent		
Domestic expenditures on final ICT[1] goods and services relative to all domestic spending on final goods and services	4.2	5.1	4.4
Domestic expenditures on final ICT goods relative to all domestic spending on final goods	7.7	9.1	7.6
Domestic expenditures on final ICT services relative to all domestic spending on final services	1.0	1.4	1.6

1. Information and communications technology.
Source: Statistics Canada, final demand matrix, Canadian input-output accounts.

Table 5 reports the share of final domestic demand accounted for by the ICT goods and services listed in Table 2.

This first demand-side measure of technology use yields overall estimates of the size of the ICT economy that are qualitatively similar to the production ratios reported in Chapter 3. Final purchases of ICT goods and services accounted for 4.2% of final domestic spending in 1997. This grew to 5.1% by 2000, and subsequently fell to 4.4% in 2003. Substantial differences in these estimates are apparent when goods and services are examined separately. In each analysis year, final expenditures on ICT make up a much larger share of final goods spending than final services spending. In 2000, ICT products amounted to 9.1% of all final spending on goods. ICT services, by contrast, were only 1.4% of all final spending on services. These large qualitative differences between ICT goods and services were not apparent in the supply-based estimates examined earlier.

The above tabulations tell us how large ICT expenditures are in relation to all final spending on goods and services in Canada. Next, we examine the distribution of these final technology expenditures in 1997 and 2003. Table 6 reports how final purchases of ICT goods and services are distributed between the three domestic expenditure categories that together comprise final domestic demand (consumer spending, business investment and government expenditures). Table 7 presents the percentage of total spending within each of these expenditure categories that is accounted for by ICT goods and services.

Table 6 Distribution of information and communications technology final domestic expenditures, by expenditure category, 1997 and 2003

Year	Consumer spending	Business investment	Government investment[2]	Total domestic expenditures on final ICT[1] goods and services
	percent			
1997	45.8	44.6	9.5	100
2003	48.2	42.7	9.1	100

1. Information and communications technology.
2. Note that we have referred to government expenditures as government investment as all final government spending on ICT goods and services is limited exclusively to capital expenditures.
Source: Statistics Canada, final demand matrix, Canadian input-output accounts.

Table 7 Information and communications technology final domestic expenditure rates, by expenditure category, 1997 and 2003

Year	Consumer spending	Business investment	Government investment
		percent	
1997	3.3	10.4	17.2
2003	3.6	10.5	15.6

Source: Statistics Canada, final demand matrix, Canadian input-output accounts.

Consumer spending and business investment together account for about 90% of the final domestic demand for ICT commodities. Each represented about 45% of final technology sales in 1997; by 2003, business investments in ICT capital accounted for a slightly smaller share of final technology purchases (42.7%) than consumer spending (48.2%). Government spending on ICT capital—investment expenditures made in health, education and public administration industries—amount to only 9.1% of all final technology sales.

While consumer spending and business investment account for roughly the same percentage of final ICT sales, these technology-based goods and services make up a much larger share of investment spending than consumer spending (Table 7). In 1997, business acquisitions of ICT capital assets amounted to 10.4% of all investment spending; by contrast, personal expenditures on these goods and services represented only 3.3% of total consumer spending. Similar ICT expenditure rates were apparent in 2003. Technology accounted for 10.5% of business investment and 3.6% of consumer spending.

Technology purchases account for about one-sixth of all capital spending by government. It is important to stress that capital spending on goods and services represent only a small fraction of the government expenditures that are used in calculating GDP. Most of these expenditures are made up of wages and salaries. When wages and salaries are included along with capital investments, the ICT expenditure rates reported in Table 7 decline precipitously—to 1.8% in 1997 and 1.7% in 2003.

4.2 The total domestic demand for technology-based goods and services

The expenditure ratios reported in the previous section examine one particular aspect of domestic technology use—spending on final goods and services. But final spending is not equivalent to total spending—as businesses purchase both final ICT commodities (as capital investment) and intermediate ICT commodities (as production inputs). In this section, we report estimates of the total domestic demand for ICT goods and services. This is a more comprehensive measure of the use of these technologies and may be a more suitable indicator of domestic technology use in economies where large amounts of business spending are channelled into intermediate inputs.

We obtain estimates of total domestic demand by adding industry-level data on intermediate ICT spending (obtained from the use matrix in Figure 1) to our estimates of the final domestic demand for these products and services.[21] As before, we convert our estimates of technology spending into shares to obtain a measure of size. Table 8 reports on the share of total domestic demand accounted for by ICT products and services.

Table 8 Share of total domestic demand accounted for by information and communications technology goods and services, 1997, 2000 and 2003

	1997	2000	2003
		percent	
Domestic expenditures on all ICT[1] goods and services relative to all domestic spending on all goods and services	4.9	5.6	4.7
Domestic expenditures on all ICT goods relative to all domestic spending on all goods	7.7	8.4	6.6
Domestic expenditures on all ICT services relative to all domestic spending on all services	1.5	2.2	2.5

1. Information and communications technology.
Source: Statistics Canada, supply table and fiinal demand matrix, Canadian input-output accounts.

When using this more comprehensive indicator of domestic technology use, the relative importance of ICT spending increases. Purchases of ICT goods and services accounted for 4.9% of total spending in 1997, 5.6% in 2000, and 4.7% in 2003.

This more inclusive estimate of technology spending also masks substantial differences between goods and services. In 2000, total spending on ICT goods accounted for about 8% of all domestic spending on goods, while purchases of ICT services amounted to about 2% of total domestic spending on services.

The production and expenditure ratios reported in this and the previous chapter represent different approaches to measuring the size of the domestic ICT economy. On balance, each of these methods yields highly complementary results. On the supply-side, ICT industries in 2003 generated about 4% of total GDP—their contribution to the economy in terms of value-added, or unduplicated production. And the gross output associated with ICT products and services—effectively the total amount of technology product by firms operating in Canada—represented about 4% of the economy's productive output. On the demand-side, domestic purchases of final ICT products and services in 2003—which encompass both domestic and foreign-produced ICT goods and services—accounted for about 4% of final domestic demand. And the importance of ICT increases only modestly when the focus shifts from final to total domestic demand, which includes both final domestic expenditures and business spending on intermediate ICT inputs.

Endnotes

17. See, for example, Jorgenson, Ho and Stiroh (2005).
18. The actual final demand matrix includes a more detailed set of expenditure categories. For discussion, see Randall (1989).
19. Canada has a negative trade balance in ICT; see Beckstead and Gellatly (2003).
20. Consequently, the negative import term *M* excludes all imports from expenditure-based GDP "in order to remain true to the concept of domestic production." (Randall, 1989: 22). Separating imports from domestic output within specific expenditure categories (e.g., consumer spending, business investment) is not operationally feasible.
21. Inventory adjustments were also included in the estimation of total domestic demand.

Chapter 5. Total technology expenditures by industry

All of our descriptive tabulations to this point have focused on aggregate measures of technology production or technology use. In this chapter, we combine data on capital investment and input spending to present detailed estimates of technology spending in different sectors. Separate tabulations are reported for the 13 industry groups listed in Table 9.

Table 9 Industry definitions

Industry group	Detailed description (NAICS[1] code)
Agriculture, forestry, fishing and hunting	Agriculture, forestry, fishing and hunting (11)
Mining and oil and gas extraction	Mining and oil and gas extraction (21)
Utilities and construction	Utilities (22) and Construction (23)
Manufacturing	Manufacturing (31-33)
Distributive trades	Wholesale trade (41) and Retail trade (44-45)
Transportation and warehousing	Transportation and warehousing (48-49)
Information and cultural	Information and cultural industries (51)
Finance, insurance and real estate	Finance and insurance (52), Real estate and rental and leasing (53)
Professional, technical and management services	Professional, scientific and technical services (54), Management of companies and enterprises (55)
Administrative and support services	Administrative and support, waste management and remediation services (56)
Entertainment, accommodation and food services	Arts, entertainment and recreation (71), Accommodation and food services (72)
Non-market services	Education services (61), Health care and social assistance (62), Public administration (91)
Other services	Other services (except public administration) (81)

1. North American Industry Classification System.
Source: Statistics Canada, 1997 North American Industry Classification System.

Our discussion is organized around a related set of data tables. Table 10 examines how different industries apply information and communications technology (ICT) to their production systems—by distinguishing between capital spending and intermediate spending on production inputs. Table 11 reports ICT expenditure rates—the share of all industry spending that is accounted for by purchases of ICT goods and services. Separate ICT expenditure rates are reported for intermediate spending, capital investment, and total expenditures (the weighted sum of the first two categories). Table 12 examines how the total volume of technology spending is distributed across industries. Separate tabulations are reported for 1997 and 2003.

Table 10 Intermediate industrial expenditures on, and industrial capital investment in, information and communications technology, 1997 and 2003

Industry group	1997			2003		
	Intermediate expenditures	Capital investment	Total expenditures	Intermediate expenditures	Capital investment	Total expenditures
	percent					
Agriculture, forestry, fishing and hunting	69.8	30.2	100	73.3	26.7	100
Mining and oil and gas extraction	74.3	25.7	100	43.0	57.0	100
Utilities and construction	73.4	26.6	100	74.6	25.4	100
Manufacturing	88.8	11.2	100	82.4	17.6	100
Distributive trades	65.6	34.4	100	73.8	26.2	100
Transportation and warehousing	58.2	41.8	100	44.5	55.5	100
Information and cultural	38.1	61.9	100	58.3	41.7	100
Finance, insurance and real estate	63.5	36.5	100	60.4	39.6	100
Professional, technical and management services	58.8	41.2	100	73.6	26.4	100
Administrative and support services	54.1	45.9	100	63.0	37.0	100
Entertainment, accommodation and food services	67.2	32.8	100	45.7	54.3	100
Other services	62.3	37.7	100	47.8	52.2	100
Non-market services	51.6	48.4	100	54.0	46.0	100
All industries	**65.7**	**34.3**	**100**	**66.0**	**34.0**	**100**

Source: Statistics Canada, use table and final demand matrix, Canadian input-output accounts.

The majority of ICT purchases in Canadian industry are intermediate expenditures on technology that is consumed or transformed in production routines (Table 10). Purchases of technology inputs accounted for two-thirds of ICT purchases in 1997 and in 2003. This relative emphasis on input spending is most apparent in manufacturing—where intermediate purchases amounted to 89% of total ICT spending in 1997 and 82% in 2003. Over 90% of these ICT input purchases in manufacturing are for goods.

The relative importance of intermediate ICT spending is widespread. In 1997, only 1 of the 13 industry groups studied allocated more than 50% of their technology spending to capital assets; in 2003, 4 of the 13 reached this mark.

While most ICT spending is on intermediate inputs, these ICT inputs account for only a small fraction of total intermediate spending (Table 11). This is true in most of the sectors studied. In manufacturing, ICT inputs account for about 5% of total input spending in 1997 and 3% of input spending in 2003. Information and cultural industries have the highest rate of ICT spending as a portion of total inputs—at 18% in 1997 and 24% in 2003.

ICT expenditures make up a larger share of business spending on the investment side. In 1997 and 2003, some 15% and 16% of all investment spending involved the purchase of ICT capital assets respectively. There is substantial variation in ICT investment intensities across industries. In manufacturing, ICT capital expenditures constituted 9% of investment spending in manufacturing in 1997 and 14% of investment spending in 2003. The share of investment spending devoted to ICT is much larger in many of the service industries studied. Information and cultural industries stand out. In both periods, over 60% of investment

spending in these industries was on ICT capital. Two other service industries groups—professional, technical and management services, and administrative and support services—also make comparatively large expenditures on ICT as a percentage of their total investment outlays.

Table 11 Information and communications technology expenditure rates, by industry, 1997 and 2003

Industry group	1997			2001		
	Intermediate expenditures	Capital investment	Total expenditures	Intermediate expenditures	Capital investment	Total expenditures
	percent					
Agriculture, forestry, fishing and hunting	0.8	2.1	0.9	0.9	2.6	1.1
Mining and oil and gas extraction	1.8	0.6	1.2	1.9	2.7	2.3
Utilities and construction	3.5	9.8	4.2	3.2	7.7	3.8
Manufacturing	4.7	8.9	5.0	3.1	14.0	3.6
Distributive trades	6.5	20.4	8.5	6.9	17.6	8.2
Transportation and warehousing	2.9	6.0	3.7	2.6	9.0	4.3
Information and cultural	18.1	60.8	32.0	24.4	64.4	32.9
Finance, insurance and real estate	8.1	14.2	9.6	8.7	20.6	11.3
Professional, technical and management services	11.1	57.5	16.6	15.3	64.8	19.1
Administrative and support services	9.6	54.8	15.5	7.7	49.2	11.1
Entertainment, accommodation and food services	1.8	10.4	2.4	1.6	20.4	3.3
Other services	4.0	9.2	5.1	3.1	23.1	5.6
Non-market services	4.8	17.8	7.4	4.9	15.9	7.1
All industries	**5.1**	**14.9**	**6.6**	**5.0**	**16.2**	**6.6**

Source: Statistics Canada, use table and final demand matrix, Canadian input-output accounts.

Tables 10 and 11 report on how specific industries spend on technology—as intermediate inputs or capital investment—and how intensively this technology spending is in relation to their total outlays. The absolute size of these expenditures varies substantially across industries. We examine this in Table 12.

Manufacturing industries account for the largest share of total ICT spending, with 29% of ICT purchases in 1997 and 20% of ICT purchases in 2003. Manufacturing accounts for a higher share of all intermediate ICT spending—39% in 1997 and 25% in 2003—despite the relatively low expenditure rates for ICT inputs reported in Table 11. This underscores the fact that manufacturing industries spend much more on intermediate inputs than do most other sectors—both in terms of technology inputs and other production inputs.

Turning to capital investment, ICT spending is dominated by three service industry groups. Information and cultural industries accounted for 26% of total ICT investment spending in 1997, followed by non-market services (19%) and finance insurance and real estate industries (14%). Each of these three groups accounted for about 20% of ICT investment spending in 2003. By comparison, technology investments in the manufacturing sector represented 10% of ICT investment spending.

Table 12 Distribution of information and communications technology expenditures across industries, by expenditure type, 1997 and 2003

Industry group	1997			2001		
	Intermediate expenditures	Capital investment	Total expenditures	Intermediate expenditures	Capital investment	Total expenditures
	percent					
Agriculture, forestry, fishing and hunting	0.7	0.5	0.6	0.7	0.5	0.6
Mining and oil and gas extraction	1.0	0.7	0.9	1.2	3.1	1.8
Utilities and construction	6.4	4.4	5.7	6.3	4.2	5.6
Manufacturing	38.6	9.3	28.5	24.6	10.2	19.8
Distributive trades	8.9	8.9	8.9	10.5	7.2	9.4
Transportation and warehousing	2.1	2.9	2.4	1.7	4.1	2.5
Information and cultural	8.4	26.1	14.5	13.4	18.7	15.2
Finance, insurance and real estate	12.8	14.1	13.3	14.3	18.2	15.6
Professional, technical and management services	6.8	9.1	7.6	11.9	8.3	10.7
Administrative and support services	2.0	3.3	2.5	2.1	2.4	2.2
Entertainment, accommodation and food services	1.2	1.1	1.1	1.1	2.6	1.6
Other services	0.8	0.9	0.8	0.7	1.6	1.0
Non-market services	10.4	18.7	13.2	11.4	18.9	13.9
All industries	**100**	**100**	**100**	**100**	**100**	**100**

Source: Statistics Canada, use table and final demand matrix, Canadian input-output accounts.

Chapter 6. Conclusion

There is substantial demand for statistical information on what is often described as the technology-based economy. This has occasioned a steady flow of analytical studies on (1) the production characteristics of technology-based firms and industries and (2) the adoption of high-tech goods and services in different sectors of the economy. These two lines of research are often independent of one another. Consequently, estimates of technology production and technology use often derive from unrelated methods of classification. This paper demonstrates how the statistical architecture of Canada's System of National Accounts can be used to analyze the information and communications technology (ICT) sector. It develops an integrated set of ICT industry and commodity classifications and then uses these to examine the relative importance of ICT production and ICT use.

Our analysis of domestic technology production focused on two related but different measures: (1) the contribution to gross domestic product (GDP) made by ICT industries, and (2) the share of gross output accounted for by the production of ICT commodities. The first is a measure of the value-added created by technology producers; the second focuses, at a more basic level, on how much domestic production involves the creation of technology goods and services. These two indicators yield very similar estimates of the size of the economy's technology output. ICT industries contributed about 4% to total GDP during the years studied. The share of the economy's output made up of ICT products and services also stood at about 4%. Both measures show the same pattern of growth and decline in the relative importance of ICT goods, along with a steady increase in the importance of ICT services.

We then examined the demand side of the ICT economy by focusing on two measures of domestic technology use. These are conceptually broader measures of the ICT economy because they focus on the domestic utilization of both Canadian-produced and foreign-produced ICT goods and services. First, we ask what share of final domestic demand—all final domestic spending on goods and services—is accounted by ICT commodities. We then develop a more comprehensive measure of technology use by reporting the ICT share of total domestic demand, which incorporates both final ICT spending and intermediate purchases of ICT inputs.

These two indicators of ICT intensity yield qualitatively similar estimates of the size of the demand side of the domestic ICT economy.

Purchases of final ICT goods and services account for around 4% to 5% of all final spending—roughly the same ratio of ICT to total activity that we obtain from our estimates of domestic technology production. Some 90% of these final technology purchases is split evenly between household purchases and business investment. ICT purchases make up a much larger share of final spending on goods than of final spending on services.

Only one-third of business spending on ICT is investment (expenditures on durable capital assets). The remaining two-thirds is on intermediate inputs, technology-based goods and services that firms consume or transform in their production processes. These additional expenditures do not substantially alter our prior estimates of the relative importance of technology spending. ICT products and services accounted for about 5 to 6% of the total domestic demand for goods and services, depending on the year studied.

Appendix A. Coverage of the ICT commodity bundle—domestic goods versus imported goods

In this paper, we use related information and communications technology (ICT) industry and commodity classifications to examine the size and composition of the domestic ICT economy. Our ICT industry classification is a variant of the ICT standard of the Organisation for Economic Co-operation and Development (OECD), expressed in terms of input-output industries. We then derive an ICT commodity set based on the principal commodity outputs of these domestic ICT industries. This, in our view, represents a prudent classification strategy for undertaking an integrated analysis of domestic technology production and domestic technology use.

One limitation of our approach is that the ICT commodity classification may exclude large imports of technology-based goods and services which are not classified as important outputs of Canadian ICT industries. This could occur even when the dollar value of these imported commodities exceeds the gross output thresholds that are used to classify the individual goods and services in Table 2 as ICT-based. In all likelihood, this is a more critical issue for ICT goods.

One means of assessing how the exclusion of an import criterion from our selection method affects our estimates is to compare our ICT classification to the emerging ICT commodity standard developed by the OECD. As an international standard, the OECD commodity list may better account for basic differences in technology production amongst member countries, and hence, serve as a better indicator of the international trade in ICT goods. We examine the relationship between these classifications below.

Comparing the ICT goods in Table 2 with the OECD's ICT goods classification

The ICT goods classification proposed by the OECD is discussed in *ICT Manufacturing Goods* (OECD, 2001, especially Annex 1A). This set of ICT goods is defined in terms of the Harmonized System (HS) for both 1996 and 2002. Fortunately, the commodity classification system that supports the Canadian input-output accounts includes a concordance that allows us to compare HS commodities to the higher-level commodity aggregates maintained in the input-output tables. To support a longitudinal analysis of these commodities, the input-output commodity structure is based on the 1988 vintage of the HS (which distinguishes between some 563 goods).

Table A.1 Input-output information and communications technology goods, by classification source

Input-output commodity number and name		Relationship to the ICT[1] goods classification used this in study and to the ICT goods classification of the OECD.[2]
3235	Service industry machinery	Common to both classifications.
3291	Computers, video units, printers, etc.	
3571	Radio, stereo, cassette and CD players, and accessories	
3580	Telephone and related equipment, including facsimile	
3599	Broadcasting and radio communications equipment	
3600	Radar and radio navigation equipment	
3619	Semi-conductors	
3621	Printed circuits	
3622	Integrated circuits	
3700	Wire and cable, insulated, excluding aluminum	
3903	Optical fibre cables	
4989	Lab and scientific instruments, and flight simulators	
4999	Measuring and controlling instruments	
3090	Gas and water meters	Included in the OECD classification but excluded from the classification used in this study.
3292	Office equipment, excluding photocopy and fax machines	
35721	TV, VCR, and accessories	
35722	Unrecorded tapes (blanks)	
3623	Other electronic equipment components	
3630	Electronic alarm and signal systems	
3672	Transformers and converters	
3729	Wiring materials and electrical meters	
4970	Aircraft and nautical navigation instruments, excluding radio	
5001	Medical and dental equipment and supplies	
5031	Optical and photographic equipment	
52011	Recorded media, including music, movies and pre-packaged software	
5032	Photocopy and microfilm equipment	Included in the the ICT classification used in this study but excluded from the OECD classification.

1. Information and communications technology.
2. Organisation for Economic Co-operation and Development.
Source: Statistics Canada, Canadian input-output accounts.

To compare the OECD ICT goods definition with the ICT goods listed in Table 2, we converted the OECD HS codes to 1988 HS codes, and matched these to our input-output commodities. About one-half of the input-output commodities in the OECD list were included in our ICT goods classification. That said, a significant number of these OECD commodities are excluded from the ICT goods definition used in this study.

Table A.1 provides some detail on the relationship between these two classifications. It lists the 26 input-output goods that find expression either in our ICT commodity classification or in the OECD one. Thirteen of these commodities are common to both lists. These account for 88% of the output of the ICT goods industries selected for this study. Twelve other input-output commodities are linked to at least one ICT good in the OECD classification (as specified by its 6-digit HS code) but are not included in our ICT classification. Together, these 12 input-output commodities represent only 3.4% of the total output of domestic ICT goods-producing industries. The remaining commodity is part of our ICT list, but not included in the OECD classification. It represents only a small fraction of ICT industrial production.

Table A.2 Share of final domestic demand and total domestic demand for goods accounted for by ICT[1] products

	1997	2000	2003
		percent	
Share of the final domestic demand for goods			
ICT products based on current classification[2]	7.7	9.1	7.6
ICT products based on extended classification[3]	9.8	11.2	9.7
Share of the total domestic demand for goods			
ICT products based on current classification	7.7	8.4	6.6
ICT products based on extended classification	9.3	10.1	8.3

1. Information and communications technology.
2. Based on goods identified in Table 2.
3. Based on goods identified in Table 2 and additional goods identified in the Organisation for Economic Co-operation and Development classification.

Our set of ICT goods clearly relates to the OECD classification in one important respect—the principal commodity outputs that we identify as ICT-based are also classified as technology-based by the OECD. At issue is how the inclusion of the 12 additional commodities that are not part of our ICT goods list, but that are included in the OECD list, affects our estimates of technology expenditures.

We examine this below by revisiting the share of final domestic spending and total domestic spending accounted for by ICT goods. Table A.2 reports these shares, as presented in Tables 5 and 8 respectively. We then re-estimate these ICT shares based on an expanded goods definition—one that includes our set of ICT goods and the 12 additional ICT goods in the OECD list that are not included in our classification. Commodities in this latter group are not important outputs of domestic technology industries (as determined by our classification routine). However, if there are large imports of these goods, they can affect our estimates of the size of the demand side of the ICT economy.

In all years, the inclusion of these additional commodities has a measurable impact on the relative size of technology expenditures. In 2003, the share of all final domestic spending on goods accounted for by ICT products increases from 7.6% to 9.7% when moving to the broader classification, a 27% increase in size of the technology share. Similarly, the share of total domestic spending accounted for by technology products increases from 6.6% to 8.3%, a 26 % increase.

We should note that this broader approach to classification (albeit one that focuses exclusively on goods) does not qualitatively alter the conclusions presented herein concerning the overall magnitude of technology spending. When theses additional goods from the OECD classification are combined with the full set of ICT products and services listed in table 2, the technology share of final domestic demand in 2003 increases from 4.4% to 5.5%. Similarly, the technology share of total domestic demand increases from 4.7 to 5.6%.

Appendix B. The GDP contributions of technology producers and the share of final domestic demand accounted for by technology use

In our discussion of final expenditures in Section 4.1, we stated that the share of final domestic demand accounted for by technology-based goods and services should not be construed as the contribution these goods and services make to gross domestic product (GDP). The distinction between these commodity-based final expenditure ratios and the industry value-added ratios that capture the contribution of technology producers to total GDP (reported in Section 3.1) warrants some additional discussion.

As we noted in Chapter 4, the share of final domestic demand accounted for by technology-based goods and services can be derived from the final demand matrix—a matrix which classifies all commodity expenditures on final goods and services into the major expenditure categories that together constitute final expenditure GDP. The aggregate GDP estimates that derive from the final expenditure method (see Equation [1]) and the sum of value-added method used in Chapter 3 are equivalent, some differences in the treatment of taxes and subsidies notwithstanding. One may therefore be tempted to estimate the contribution that information and communications technology (ICT) commodities make to GDP by summing all final expenditures on ICT goods and services (which we depict stylistically in Figure 1 as a row in the final demand matrix) and dividing this figure by final expenditure GDP.

We should begin by noting that, in Chapter 4, we examined the final domestic demand for technology-based goods and services—one measure of the intensity with which technology is being used in the domestic economy. As we noted in Chapter 4, this is not a measure of all final expenditures on technology, of the sort that would presumably form the basis for the contribution to GDP ratio noted above. The final domestic demand for ICT excludes technology exports and includes technology imports—and thus do not accord with domestic production. But the above issue remains—is it sensible to use these final demand data to estimate the contribution that these technology-based goods and services make to total GDP, presumably by adding up all final expenditures on ICT goods and services (including exports and netting out imports) and dividing this by final expenditure GDP, the sum of all final spending (including exports net of imports) in the economy. Such a measure looks, at first blush, just to be an expenditure-based analogue to the contribution to GDP shares reported in Table 3, which measure the value-added associated with a particular industry (our amalgam of ICT producers) relative to total GDP, the sum of value-added across industries.

Computational similarities aside, the commodity-based expenditure ratio described above does not capture the contribution that these goods and services make to GDP in any meaningful sense. There are several reasons for this. Most fundamentally, within national accounting programs, the concept of a *contribution to GDP* is closely aligned with economic production: firms and industries contribute to GDP by generating value-added via the transformation of inputs into outputs. Commodity expenditures do not contribute to value-added in any analogous sense, whereby spending on final technology goods and services could be said to proxy the importance of these commodities to domestic production.

A different way of illustrating this point is to focus on the distinction between final and intermediate spending on technology commodities. Much of the business spending on the ICT goods and services listed in Table 2 does not go directly towards final demand, but instead involves the purchase of intermediate technology inputs that are consumed or transformed in production routines. As we report in Chapter 5, some two-thirds of total business spending on the commodities listed in Table 2 is on intermediate ICT inputs. Unlike business investments in technology-based assets, which are part of final demand, these intermediate expenditures are recorded in the use matrix of the System of National Accounts (see Figure 1). These intermediate expenditures (on ICT and all other commodity inputs) are aggregated to the industry level and then subtracted from industry gross output to obtain an industry's value-added contribution to GDP. This brings us to the central point: it would be misleading to infer that these intermediate expenditures on production inputs have no importance in the creation of GDP—they clearly do via their embodied importance to the production of industry output. Yet these same expenditures, by definition, have no presence in the final demand categories that are used when reporting expenditure-based GDP.

These distinctions have important implications for industry and commodity analysis. Consider a hypothetical case wherein technology industries create large amounts of value-added because of a sizable gap between the gross output of these industries and expenditures on intermediate inputs used to generate this output. This value-added is clearly a contribution to GDP in the conventional sense, as it captures the unduplicated value of producing technology-based goods and services. But what if this entire output of technology goods and services was purchased by other domestic industries in the form of intermediate inputs—with no sales to domestic governments, domestic consumers, or customers located abroad? These technology commodities would have no weight as a share of final demand because they are all purchased as intermediate inputs. Yet it seems nonsensical to conclude that these technology commodities make no *contribution* to GDP, as the zero final demand share would suggest. Rather, it is more the case that these products do not find expression in "the ultimate purpose of all economic productive activity" (Randall, 1989: 17) which is effectively what final demand data describe.

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