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CENTRE FOR THE STUDY OF LIVING STANDARDS

# CAN THE CANADA-U.S. ICT INVESTMENT GAP BE A MEASUREMENT ISSUE?

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# Can the Canada-U.S. ICT Investment Gap be a Measurement Issue?


## Abstract

In 2011, business sector investment per worker in information and communications technology (ICT) in Canada was only 57.8 per cent of the U.S. level, indicating an ICT investment per worker gap of 42.2 percentage points. Numerous explanations have been advanced to explain this gap, one of which is that the ICT investment data from Statistics Canada and the Bureau of Economic Analysis are not strictly comparable. The primary focus of this report is to analyze that hypothesis. We compare the methodology used to measure ICT investment in Canada and the United States and find that issues related to measurement account for approximately 4 percentage points (10 per cent) of the gap. Although software investment has been responsible for 90 per cent of the gap in recent years, seven out of 17 industries in Canada actually had greater investment per worker levels than the United States in both total ICT and software. A small number of ICT-intensive industries has been responsible for a substantial part of the gap. In particular, information and cultural industries accounted for 39.1 per cent of the total gap. This supports the conclusion that the Canada-U.S. ICT investment per worker gap is largely the result of industry-specific factors which affect software investment.

# Can the Canada-U.S. ICT Investment Gap be a Measurement Issue?

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# Can the Canada-U.S. ICT Investment Gap Be a Measurement Issue?

## Executive Summary

In 2011, business sector investment per worker in information and communications technology (ICT) in Canada was only 57.8 per cent of the U.S. level. Software investment, the largest component of ICT investment in both countries, was only 39.8 per cent of the U.S. level. These observations are part of a persistent phenomenon identified in a series of studies on ICT investment by the Centre for the Study of Living Standards (CSLS), which have consistently found that ICT investment per worker in Canada is significantly below the level in the United States. This low level of ICT investment per worker is troubling, as investment – and ICT investment in particular – increases labour productivity, an important determinant of potential economic growth and a measure by which the United States has also consistently outperformed Canada over the last decade.

Numerous explanations have been advanced to explain this gap, one of which is that the ICT investment data from Statistics Canada and the U.S. Bureau of Economic Analysis are not strictly comparable. The objective of this report is to determine to what extent differences in measurement methodology affect our ability to compare ICT investment per worker in Canada and the United States.

### The Canada-U.S. ICT Investment per Worker Gap

The key indicator in this report is the sum of investment in computers, communications equipment, and software per worker in Canada, adjusted for purchasing power parity (PPP), relative to the level of the same figure in the United States. This relative level can be computed by industry, and by each component of ICT investment (computers, communications equipment, and software). The gap is defined as 100 less the relative level.

Our analysis of the Canada-U.S. ICT investment per worker gap yields several important findings, which we summarize in this section.

First, the Canada-U.S. ICT investment per worker gap is now heavily concentrated in software investment. In 1987, the gap for ICT investment per worker was essentially the same in all three components of ICT, at approximately 40 percentage points. In 2011, software investment per worker in Canada was only 39.8 per cent of the level in the United States. In comparison, computer investment per worker in Canada is now 108.8 per cent of the level in the United States, while investment in communications equipment is 72.9 per cent of the level observed in the United States. This is a dramatic shift in the gap by component between 1987 and 2011. This is underscored by the fact that software investment accounted for nearly two-thirds of ICT investment in the United States in 2011, but just under half in Canada. Additionally, within software investment, the gap is the greatest for prepackaged software. Prepackaged software investment per worker in Canada was only 26.4 per cent of the U.S. level in 2009, the latest year for which data are available.

Second, we compare our key indicator to several other measures of relative ICT performance, and we find a large gap regardless of which measure we use. Additionally, the severity of the gap is greater for measures which use differences in labour input between Canada and the United States. For example, Canada's relative performance is worse for ICT investment per hour worked (52.5 per cent of the U.S. in 2011) than it is for ICT investment per worker (57.8 per cent), and worse for ICT capital stock per hour worked (40.1 per cent) than it is for ICT capital stock per worker (44.1 per cent). In contrast, measures which do not use labour input, such as the share of ICT investment in business sector GDP in Canada relative to the United States (71.2 per cent), identify a large, but somewhat smaller, gap.

Third, the Canada-U.S. ICT investment per worker gap is close to the average gap between the United States and most OECD countries. We compare Canada to a selected sample of 18 OECD countries using OECD data for the ICT investment share of private, fixed non-residential investment, ICT investment share of GDP, ICT investment per worker, and ICT investment per hour worked. We find that while Canada is generally in the bottom third of this selected sample in terms of its relative performance, its level is closer to the OECD average for each of these measures than it is to other countries in the bottom third. Our gap is with the United States, not other countries.

Fourth, using the same OECD data, we estimate non-business sector ICT investment per worker in Canada and the United States, and find that there is no gap outside the business sector. Canada and the United States invest essentially the same amount in ICT per worker outside the business sector. The gap therefore appears to be uniquely a business sector phenomenon.

Fifth, we perform decompositions by the components of ICT and by industry, the conclusions of which are extremely important. We find that in 2011, in U.S. dollars, business sector ICT investment per worker in Canada was $1,658 below the United States, while software investment per worker in Canada was $1,529 below software investment per worker in the United States, meaning that software investment accounted for 92.2 per cent of the difference in ICT investment per worker in 2011. If software investment per worker in Canada and the United States were the same, the gap would almost completely disappear.

In contrast, computer investment per worker in Canada was $61 greater than the U.S. level in 2011 (-3.7 per cent of the gap). The difference in telecommunications equipment investment per worker in Canada and the United States was equal to a modest share of the difference in total ICT investment per worker in 2011, at 11.5 per cent.[1] The decomposition by component has shifted dramatically since 1987. In 1987, the difference in ICT investment per worker for computers, communications equipment, and software constituted 31.6 per cent, 40.8 per cent, and 27.7 per cent, respectively, of the total difference in ICT investment per worker in Canada and the United States. These figures are now -3.7 per cent, 11.5 per cent, and 92.2 per cent.

The industry decomposition is also very important. Our analysis highlights that in addition to being concentrated largely in software investment, the Canada-U.S. ICT investment per worker gap is also heavily concentrated in a few industries. The difference between ICT investment per worker in Canada and the United States, after weighting by the employment share of each industry in the United States, is the largest for information and cultural industries. This industry was responsible for 39.1 per cent of the difference in ICT investment per worker in 2011. Information and cultural industries, and professional, scientific and technical services are consistently the largest contributors to the gap. In recent years, around 7 out of 17 industries in Canada actually had greater ICT investment per worker than their U.S. counterpart. This strongly suggests that the Canada-U.S. ICT investment per worker gap is largely due to industry-specific factors that affect software investment.

### Proximate Causes of the Gap

Many differences between the Canadian and U.S. economies contribute to the ICT investment per worker gap. While not the primary focus of this report, we explore a few of the factors contributing to the lower level of ICT investment per worker in Canada. We find that there is no compelling reason for the gap to be as large as it is.

- Comparing two countries with the same share of ICT investment in GDP but different labour productivity levels, the high level of labour productivity in one country means that a single worker will generate more GDP per capita. This, in turn, leads to more ICT investment per worker for a given ICT investment share of GDP, since the absolute level of ICT investment is determined by the absolute level of GDP. Assuming, initially, that ICT investment as a share of GDP is the same in two countries, then the difference in ICT investment per worker levels, i.e. the ICT gap, is explained *entirely* by the labour productivity differential between the two countries.
- Allowing the ICT investment share of GDP to be different, as it is for Canada and the United States, we find that the ICT investment per worker gap would be 12 percentage points (30 per cent) lower if Canada had the same level of labour productivity as the United States.
  - However, from the perspective of causality, we do note that investment is a determinant of productivity, and it is likely the case that U.S. labour productivity

[1] Statistics Canada refers to investment in telecommunications equipment, while the BEA refers to investment in communications equipment. We will generally use the term communications equipment.

is greater in part because of its greater level of ICT investment per worker. It is therefore not correct to say that higher labour productivity is a cause of the gap, when the reverse is also true to some extent.

- Industrial structure explains about 2.5 percentage points of the ICT investment per worker gap. The U.S. has greater relative employment in ICT-intensive industries.

### Differences in the Measurement of ICT Investment in Canada and the United States

The main contribution of this report is to examine the methodology used by Statistics Canada and the U.S. Bureau of Economic Analysis to prepare their estimates of investment in computers, communications equipment, and software. Our analysis of the measurement methodology yields several important findings, but we conclude that differences in measurement methodology explain at most only a small part of the gap. We highlight our important findings below.

- The methodology for data collection, quality control, and the entities surveyed are substantially the same for these data.
- The definition of the business sector in Statistics Canada’s Fixed Capital Flows and Stocks tables is inconsistent with the Fixed Asset Accounts in the United States. The Fixed Asset Accounts classifies investment as business sector based on the type of establishment making the investment, while the FCFS classifies investment as business sector based on the industry in which it occurs, excluding from total investment 3 out of 20 two-digit NAICS industries: health care and social assistance, educational services, and public administration. In contrast, the Fixed Asset Accounts estimates of ICT investment will exclude non-business sector investment in the remaining 17 two-digit NAICS industries, while including business sector investment in the 3 two-digit NAICS industries excluded from the business sector by the FCFS.
- Using estimates from the Canadian Productivity Accounts, which uses the same definition of the business sector as the U.S. Fixed Asset Accounts, we find that in 2008, the total Canada-U.S. ICT investment per worker gap had been underestimated by 5.5 percentage points due to inconsistencies in the definition of the business sector. Data to assess the effect of this definitional inconsistency in more recent years are not yet available.
- We identify no significant inconsistencies in the definition of ICT assets or the survey and data collection methodology for ICT investment data in Canada and the United States.
- The methodology used to account for intermediate purchases of pre-packaged and custom software differs in Canada and the United States. The United States assigns intermediate purchases of software to both pre-packaged and custom software, while Statistics Canada assigns all intermediate purchases of software to pre-packaged software. This does not affect the total level of ICT or software investment in either country, but it does mean

that Statistics Canada is slightly overestimating the share of custom software and underestimating the share of pre-packaged software.

- The treatment of purchases of used equipment differs in Canada and the United States. The estimates of investment in the United States include dealers' margins on the sale of used assets, while the estimates for Canada do not. This has the potential to have an impact, although perhaps a marginal one, on the comparability of investment in computers and communications equipment. This issue requires further study.
- Investment in internally developed or own account software is based primarily on the labour cost to employers of their software developers. This means that, even if two software developers spend the same amount of time developing the same software for internal use, a higher level of investment in the United States than in Canada would result due to higher salaries. We estimate that this conceptual challenge to valuing own account software results in the gap being overestimated by as much as 4 percentage points (10 per cent of the gap).
- On balance, we find that differences in measurement explain approximately 10 per cent of the gap in ICT investment per worker in Canada and the United States.

The following exhibit from the conclusion of this report summarizes our findings.

**Exhibit 3: Summary of Factors Contributing to the Canada-U.S. ICT Investment per Worker Gap**

| | | Contribution to the Gap in 2011 | |
|---|---|---|---|
| **Reference** | Factor | Percentage Points | Share |
| **Table 1** | Canada-U.S. ICT Investment per Worker Gap | 42.2 | 100.0 |
| **Non-Measurement Factors or Proximate Factors** | | | |
| **Table 31** | Labour Productivity | 12.6 | 29.8 |
| **Table 33** | Industry Structure | 2.4 | 5.7 |
| **Measurement-Related Factors** | | | |
| **Table 45** | U.S. Salary Premium for Software Developers | 3.7* | 8.8 |
| **Non-Quantifiable Factors Contributing to the Gap** | | | |
| Dealer's margins on sales of used ICT equipment (measurement) | | | |
| Firm Size | | | |
| Education of Managers | | | |
| Business Attitudes and Culture | | | |
| | | | |
| **Total Gap Explained by Factors** | | 18.5 | 44.3 |

*Refers to the effect on the gap in percentage points from in 2009, the last year for which data are available

Note: Inconsistencies in the definition of the business sector, which may also be considered a measurement issue, contributed to underestimating the gap by 5.5 percentage points in 2008, the last year for which data to measure this effect are available. This qualifies to some extent the proportion of the gap we have explained in this report.

## Other Factors Contributing to the Gap

There are a number of differences between the economies of Canada and the United States which are likely to have an effect on the ICT investment per worker gap that we are not able to quantify. Briefly, these factors are:

- Firm size favours greater ICT investment per worker in the United States. Canada has a larger share of employment in small and medium-sized enterprises (SMEs), which tend to invest less on a per worker basis.
- The education of managers favours greater ICT investment per worker in the United States. Managers have lower educational attainment overall in Canada, which means managers in charge of investment decisions are less likely to understand how ICT assets can improve the productivity of their firm's production process. Additionally, large Canadian corporations are less likely to be run by an MBA-educated CEO. As MBAs receive specific education on improving productivity and innovations in financing investment, research suggests that this factor also makes Canadian businesses less likely to invest in ICT.
- Finally, research and anecdotal evidence suggests that differences in business attitudes and culture, and the perception of ICT assets, is reducing ICT investment in Canada relative to the United States. Managers in Canada are more likely to report difficulty seeing or measuring the benefits of investing in ICT assets, and are more likely to decide not to invest in ICT assets based on cost.

These and other non-measurement factors all contribute to explaining the remainder of the Canada-U.S. ICT investment per worker gap. Based on our analysis in this report, it is likely that these and industry-specific factors relating to software investment are responsible for the remaining portion of the Canada-U.S. ICT investment per worker gap.

# Can the Canada-U.S. ICT Investment Gap be a Measurement Issue?[2]

## Introduction

In 2011, business sector investment per worker in information and communications technology (ICT) in Canada was only 57.8 per cent of the U.S. level. Software investment, the largest component of ICT investment in both countries, was only 39.8 per cent of the U.S. level. These observations are a part of a persistent phenomenon identified in a series of studies on ICT investment per worker by the Centre for the Study of Living Standards (CSLS), which have consistently found that ICT investment per worker in Canada is significantly below the level in the United States.[3] This low level of ICT investment per worker is troubling, as investment – and ICT investment particularly – increases labour productivity, an important determinant of potential economic growth and a measure by which the United States has also consistently outperformed Canada over the last decade.

Several factors have been posited as the source of the gap in ICT investment per worker, including differences in economic and industrial structure; relative costs and prices; attitudes and culture; framework variables such as education, taxes, and competitiveness; and, finally, measurement error in the level of investment in either or both countries. The primary focus of this report is to explore the extent to which differences in measurement methodology contribute to the observed gap in ICT investment per worker, in order to better inform policymakers concerned about the strength of investment in Canada. An understanding of the causes of the Canada-U.S. ICT investment per worker gap is essential for the development of policies to reduce the gap.

This study is organized as follows. The first section describes trends in the Canada-U.S. ICT investment gap over time, drawing from earlier CSLS studies and updating them to reflect the state of the gap in 2011, and provides an international comparison of ICT investment. The second section provides several decompositions of the ICT investment per worker gap,

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[2] This reported was prepared by Vikram Rai under the supervision of Andrew Sharpe, with contributions from Ricardo de Avillez, Etienne Grand-Maison, and Evan Capeluck. The views presented in this report are the views of the CSLS. We would like to thank Greg Peterson, Javier Oyarzun, Valerie Gaudreault, Art Ridgeway, Ziad Ghanem, Andreas Trau, Brenda Bugge, Wulong Gu, and Jean-Pierre Maynard from Statistics Canada for their cooperation and assistance in this project, as well as Michael Glenn, Christopher Mbu, Christina Hovland, Robert Corea, and David Wasshaussen from the U.S. Bureau of Economic Analysis, and Shawn Sprague from the U.S. Bureau of Labor Statistics. Finally, the CSLS would also like to thank Don Drummond, John Lester, Louis Marc Ducharme (Statistics Canada), Carlos Rosell (Department of Finance), Shutao Cao (Bank of Canada), Ben Dachis (C.D. Howe Institute), Barrie R. Nault (University of Calgary) for their detailed comments on earlier versions of this report.

[3] See CSLS, 2005; Sharpe, 2006; Sharpe and Arsenault, 2008a; Sharpe and Arsenault, 2008b; Sharpe and de Avillez, 2010; Sharpe and Moeller, 2011; and Sharpe and Andrews, 2012 for several detailed discussions of how the ICT investment per worker gap has evolved over time and some discussion of the factors underlying the gap.

identifying which components of ICT investment and which industries make the largest contributions to the gap. The third section provides an overview of non-measurement factors which contribute to the gap. The fourth section, the major contribution of this study, focuses on comparisons of different elements of the methodologies used to construct the ICT investment time series in Canada and the United States. It identifies differences in definitions, and provides estimates for the degree to which the gap is over- or under-estimated due to measurement error. The fifth section describes non-measurement factors which are also likely to contribute to the gap but are difficult to quantify. The sixth section identifies areas for further research motivated by our assessment of the relative importance of measurement methodology, while the seventh section contains recommendations for Statistics Canada and the U.S. Bureau of Economic Analysis (BEA) that would improve our ability to study this issue and reliably compare estimates of investment by asset type in Canada and the United States. The eighth and final section concludes.

This report is accompanied by a set of Appendix Tables, which provide more details on the estimates analyzed in this report. The Appendix Tables are available on the CSLS website at www.csls.ca/res_reports.asp. Additionally, the CSLS has maintained for several years a detailed database on ICT investment and capital stock in Canada and the United States based on publicly available data from Statistics Canada and the U.S. Bureau of Economic Analysis. This database is publicly available on the CSLS website at www.csls.ca/data/ict.asp.

## I. The Canada-U.S. ICT Investment per Worker Gap

The Canada-U.S. ICT investment per worker gap has fluctuated over time, but has not changed substantially over the 1987-2011 period.[4] Business sector ICT investment per worker was 57.8 per cent of the U.S. level in 2011; in 1987, we observed a similar relative level of 59.3 per cent. In the intervening years, it has been as high as 68.0 per cent (1991) of the U.S. level and as low as 53.9 per cent (2009). While the overall ICT investment per worker gap in 2011 is similar to the gap in 1987, the gap by component has shifted dramatically. In 1987, the gap for all three components was around 40 percentage points, but in 2011, software investment per worker in Canada was 39.8 per cent of the U.S. level, communications equipment investment per worker was 72.9 per cent, and computer investment per worker was 108.8 per cent. Our goal in this section is to highlight important features of the Canada-U.S. ICT investment per worker gap, such as the extent to which the gap is now significantly greater in software investment than the two other ICT components. To provide a complete understanding of the gap, we examine total ICT investment, investment by ICT component, business sector employment, and purchasing power parity estimates during the 1987-2011 period for Canada and the United States.

[4] For a detailed report on the state of the Canada-U.S. ICT investment per worker gap in 2011, see Capeluck (2013).

## A. The Canada-U.S. ICT Investment per Worker Gap

Our key indicator for comparing Canada's performance in ICT investment to the United States is the sum of business sector investment in computers, communications equipment, and software in Canada, per worker, converted to U.S. dollars, relative to the same figure in the United States. This is based on the generally accepted OECD definition of information and communications technology. To convert ICT investment per worker in Canada to U.S. dollars, we use purchasing power parity (PPP) estimates, which take into account differences in the prices of goods and services between Canada and the United States. For example, if ICT investment per worker were $1 CAD per worker in Canada, $2 USD per worker in the United States, and the purchasing power parity exchange rate indicated that to purchase the same basket of goods in Canada as the United States required 1.2 USD per CAD, then our key indicator would be:

$$\frac{\$\mathbf{1}\ \boldsymbol{CAD\ per\ worker}\ \times \mathbf{1.2}\frac{\boldsymbol{USD}}{\boldsymbol{CAD}}}{\$\mathbf{2}\ \boldsymbol{USD\ per\ worker}} = \mathbf{60}\%$$

Ideally, the PPP estimates used to calculate the Canada-U.S. ICT investment per worker gap would refer specifically to ICT investment. Unfortunately, such estimates do not exist. The closest alternative is the machinery and equipment (M&E) PPP calculated by Statistics Canada, which is the PPP used in this report to estimate the Canada-U.S. ICT investment per worker gap.[5] In general, ICT can be seen as a subcategory of M&E.[6] As such, using the M&E PPP instead of the ICT PPP (which is unavailable) provides a reasonable, albeit imperfect alternative to the more precise measure of the ICT gap. The reader should bear in mind, however, that divergences between the two PPPs can be a potential source of measurement error in the ICT gap.

The Canada-U.S. ICT investment per worker gap is calculated as 100 less this indicator. In this stylized example, the gap would be 40 per cent. This section provides an overview of the Canada-U.S. ICT investment per worker gap, including estimates of ICT investment per worker for total ICT investment and each component of ICT investment, for the purpose of informing and motivating our investigation into the measurement methodology of ICT investment in Canada and the United States. These estimates are shown for the business sector in current U.S. dollars for 1987 and the 2000-2011 period in Table 1. Table 2 provides estimates of business sector ICT investment per worker in Canada relative to the United States. The gap, calculated as 100 less the relative level was 42.2 percentage points in 2011, up from 40.8 percentage points in 1987. Over the total period, the gap has increased 1.46 percentage points.

[5] For more details on the PPP estimates produced by Statistics Canada, see Baldwin and Ryan (2009).

[6] This was strictly true before the recent SNA revision, since all three asset categories that compose ICT investment – namely: computer, software, and telecommunications investment – were part of M&E. With the SNA revision, however, software investment has been reclassified as part of intellectual property products (IPP). In 2012, ICT represented around 38 per cent of all M&E and software investment, with computer and telecom investment accounting for 23 per cent of M&E investment (excluding software).

We also note that the ICT investment per worker gap in 1987 was very similar across all three components, but this is no longer the case. Since 1987, relative to the United States, software investment per worker has declined significantly, from a high of 70.3 per cent of the U.S. level in 1994, to 39.8 per cent of the U.S. level in 2011. At the same time, computer investment per worker increased from 62.6 per cent in 1987 to 108.8 per cent of the U.S. level by 2011. Investment in communications equipment has only increased somewhat, from 55.9 per cent of the U.S. level in 1987 to 72.9 per cent of the U.S. level in 2011. Meanwhile, total ICT investment per worker has generally been close to 60.0 per cent during the entire period. The divergence in the ICT investment per worker gap by component begins in the mid-1990s, and continues to 2011. This is a very dramatic shift in the composition of the ICT investment per worker gap, from a relatively uniform gap across all components, to no gap at all in computers, an extremely large gap in software, and a substantial but smaller gap in communications equipment.

**Table 1: ICT Investment per Worker, Canada and the United States, business sector, current U.S. dollars, 1987 and 2000-2011**

| | Total ICT | | Computer | | Communications | | Software | |
|---|---|---|---|---|---|---|---|---|
| | CAN | U.S. | CAN | U.S. | CAN | U.S. | CAN | U.S. |
| **1987** | 668 | 1,127 | 243 | 388 | 238 | 425 | 187 | 314 |
| **…** | | | | | | | | |
| **2000** | 1,859 | 3,560 | 609 | 884 | 581 | 1,072 | 669 | 1,604 |
| **2001** | 1,834 | 3,343 | 509 | 751 | 600 | 956 | 725 | 1,636 |
| **2002** | 1,746 | 3,086 | 518 | 695 | 536 | 750 | 692 | 1,640 |
| **2003** | 1,766 | 3,128 | 554 | 677 | 497 | 731 | 715 | 1,719 |
| **2004** | 1,949 | 3,255 | 647 | 691 | 495 | 740 | 808 | 1,825 |
| **2005** | 2,131 | 3,292 | 704 | 667 | 496 | 725 | 930 | 1,899 |
| **2006** | 2,251 | 3,451 | 794 | 705 | 513 | 780 | 944 | 1,966 |
| **2007** | 2,296 | 3,642 | 747 | 718 | 455 | 844 | 1,095 | 2,080 |
| **2008** | 2,306 | 3,692 | 737 | 710 | 480 | 765 | 1,089 | 2,217 |
| **2009** | 1,993 | 3,693 | 662 | 651 | 456 | 694 | 875 | 2,348 |
| **2010** | 2,097 | 3,833 | 716 | 652 | 474 | 768 | 907 | 2,413 |
| **2011** | 2,273 | 3,931 | 752 | 691 | 510 | 700 | 1,011 | 2,540 |
| **Annual Average Growth Rate** | | | | | | | | |
| **1987-2011** | 5.24 | 5.34 | 4.82 | 2.43 | 3.23 | 2.10 | 7.28 | 7.63 |
| **1987-2000** | 7.48 | 8.08 | 5.43 | 4.83 | 6.84 | 5.97 | 10.15 | 8.48 |
| **2000-2011** | 2.17 | 1.63 | 3.98 | -0.83 | -1.61 | -3.07 | 3.38 | 6.45 |

Source: Appendix Tables 1a-c

Note: Figures for Canada converted to U.S. dollars using PPP for machinery and equipment available in CANSIM 380-0057. Data for 1988-1999 are available in Appendix Tables 1a and 1b.

Another key trend is  that the level of ICT investment per worker in Canada relative to the United States grew significantly faster from 2000-2011 than it did in the 1987-2000 period.

The relative level peaked in 2006 at 65.24 per cent, falling precipitously in 2009 during the recession. Since then, the level of ICT investment per worker in Canada has increased relative to the United States (Sharpe and de Avillez, 2010; Sharpe and Andrews, 2012; Capeluck, 2013). Chart 1 illustrates that the gap in total ICT investment per worker has fluctuated significantly over time but still remains relatively close to its level in 1987, and shows the dramatic evolution of the composition of the gap by component for the 1987-2011 period.

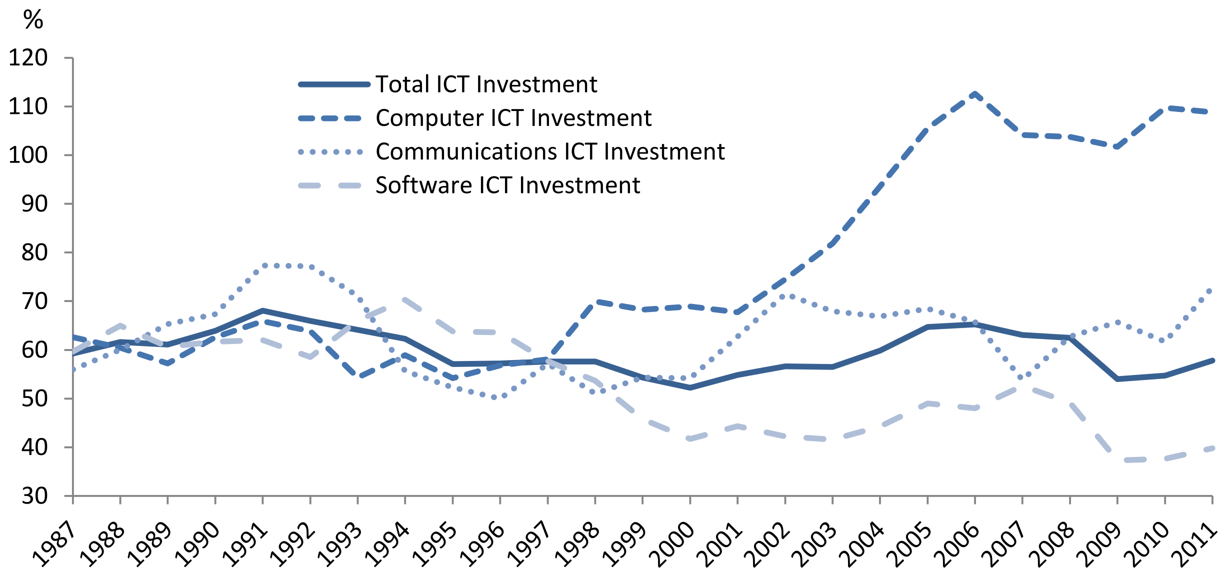
**Table 2: Business Sector ICT Investment per Worker in Canada (PPP adjusted) Relative to the United States, by component, 1987 and 2000-2011 (per cent)**

| | Total ICT | Computers | Communications | Software |
|---|---|---|---|---|
| **1987** | 59.3 | 62.6 | 55.9 | 59.6 |
| **...** | | | | |
| **2000** | 52.2 | 68.9 | 54.2 | 41.7 |
| **2001** | 54.9 | 67.8 | 62.8 | 44.3 |
| **2002** | 56.6 | 74.5 | 71.4 | 42.2 |
| **2003** | 56.5 | 81.9 | 68.0 | 41.6 |
| **2004** | 59.9 | 93.6 | 66.9 | 44.3 |
| **2005** | 64.7 | 105.5 | 68.5 | 49.0 |
| **2006** | 65.2 | 112.6 | 65.8 | 48.0 |
| **2007** | 63.1 | 104.1 | 53.9 | 52.6 |
| **2008** | 62.5 | 103.7 | 62.7 | 49.1 |
| **2009** | 54.0 | 101.7 | 65.7 | 37.3 |
| **2010** | 54.7 | 109.8 | 61.7 | 37.6 |
| **2011** | 57.8 | 108.8 | 72.9 | 39.8 |
| **Annual Average Growth Rates** | | | | |
| **1987-2000** | -0.97 | 0.74 | -0.24 | -2.72 |
| **2000-2011** | 0.93 | 4.24 | 2.73 | -0.42 |
| **1987-2011** | -0.10 | 2.33 | 1.11 | -1.67 |
| **Absolute Change** | | | | |
| **1987-2011** | 1.5 | -42.6 | -17.0 | 19.8 |

Source: Appendix Table 1c

Note: Data for 1988-1999 available in Appendix Table 1c

**Chart 1: ICT Investment per Worker in Canada Relative to the United States (per cent), business sector, 1987-2011**

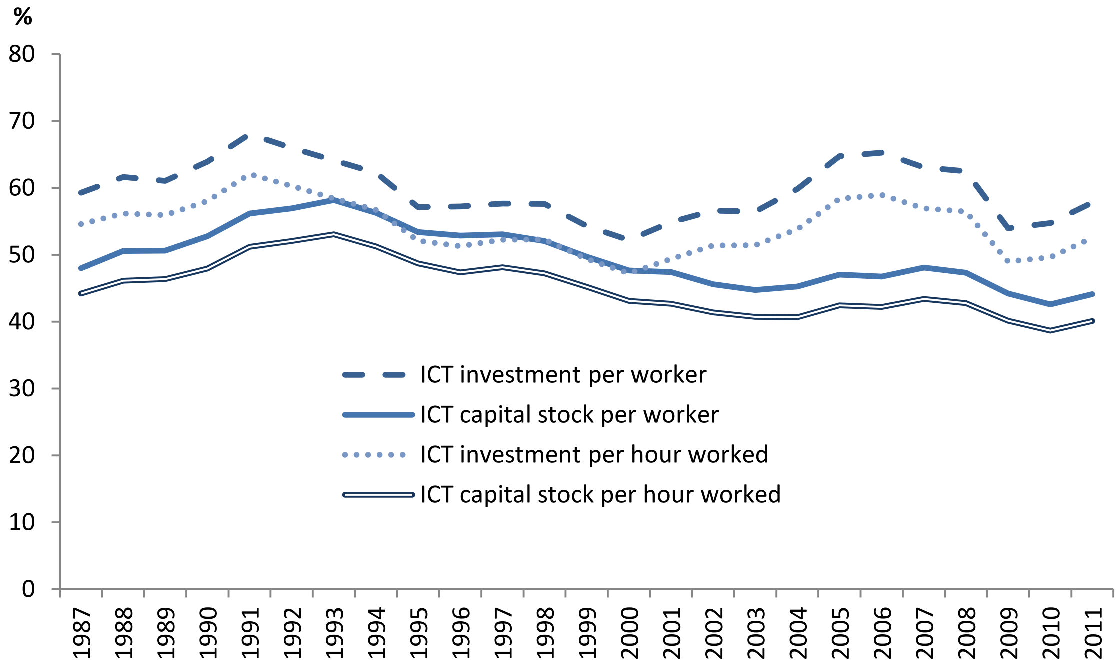



Source: Appendix Table 1c

Our finding of a large Canada-U.S. ICT investment per worker gap is robust across different measures of labour input, and a similar gap is present for ICT capital stock as well. We compare ICT investment and capital stock per worker and per hour worked in Chart 2, which shows that for each measure, the relative level in Canada is significantly lower than in the United States. Among these four measures of ICT investment intensity, ICT investment per worker is the measure by which Canada's performance is the greatest compared to the United States. Canada's performance is somewhat worse using ICT investment per hour worked, worse still using ICT capital stock per worker, and worse still using ICT capital stock per hour worked. Chart 2 also shows that these four different measures all tend to rise and decline together.

Canada's lower performance for capital stock is in part explained by lower ICT investment in Canada, but also by the higher rate of depreciation used by Statistics Canada to estimate capital stock (Tang, Rao, and Li, 2010). For the same level of investment, capital stock would be lower in Canada because of the greater depreciation rate. Additionally, the relative level of ICT intensity is lower for hours worked than per worker using both investment and capital stock.

**Chart 2: Business Sector ICT Intensity in Canada Relative to the United States, 1987-2011 (per cent)**




Source: Appendix Tables 1c and 1d

Note: Capital stock estimates for Canada and the United States are not strictly comparable. See Tang, Rao and Li (2010) a detailed discussion of this issue.

Finally, we note in Table 3 that the Canada-U.S. ICT investment per worker gap appears to be uniquely a business sector phenomenon. In the non-business sector, ICT investment per worker in the two countries was approximately the same in 2007. This is the only year for which OECD data on ICT investment allow us to perform this calculation; U.S. data do not uniquely identify non-business ICT investment in any year.

**Table 3: ICT Investment per Worker in Canada Relative to the United States by Sector, 2007**

| | Total ICT (millions of current NCU) | | | Employment (thousands of workers) | | | Per Worker (current U.S. dollars) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Economy | Business Sector | Non-Business Sector | Total Economy | Business Sector | Non-Business Sector | Total Economy | Business Sector | Non-Business Sector |
| **Canada** | 40,374 | 32,980 | 7,394 | 16,806 | 12,925 | 3,880 | 2,162 | 2,296 | 1,715 |
| **United States** | 475,966 | 428,900 | 47,066 | 146,271 | 117,763 | 28,508 | 3,254 | 3,642 | 1,651 |
| **Canada Relative to the United States** | | | | … | | | 66.45 | 63.05 | 103.87 |

Source: Appendix Table 15d

Note: Investment in Canada converted to U.S. dollars using 2007 PPP M&E of 0.90.

## B. Other Measures of Relative ICT Performance

There are, of course, ways to compare ICT investment in Canada and the United States without using labour input, and these measures also point to a large Canada-U.S. ICT investment gap. Table 4 shows the share of ICT investment in GDP and the share of ICT investment in private fixed non-residential investment for Canada and the United States. Although total investment as a share of GDP is higher in Canada than in the United State, ICT investment as a share of GDP has been consistently higher in the United States. Additionally, the ICT investment share of private fixed non-residential investment is greater in the United States than in Canada.

We also observe that, based on these two alternative measures, Canada's performance has declined significantly since 1987, in contrast to the relatively modest decline we observed using ICT investment per worker. The per worker and per hours worked measures all report a decline from 1987-2000, consistent with the significant decline we see for Canada relative to the United States using the ICT investment share of GDP or investment. However, ICT investment per labour input recovered in the 2000-2011 period, while this did not occur for the two alternative measures, which are neutral to labour input, in Table 4. This is in part because the shares of ICT are independent of changes in purchasing power parity, which favoured Canada in the 2000-2011 period, and in part because changes in labour input, using either hours worked or employment, favoured the United States over the same period.

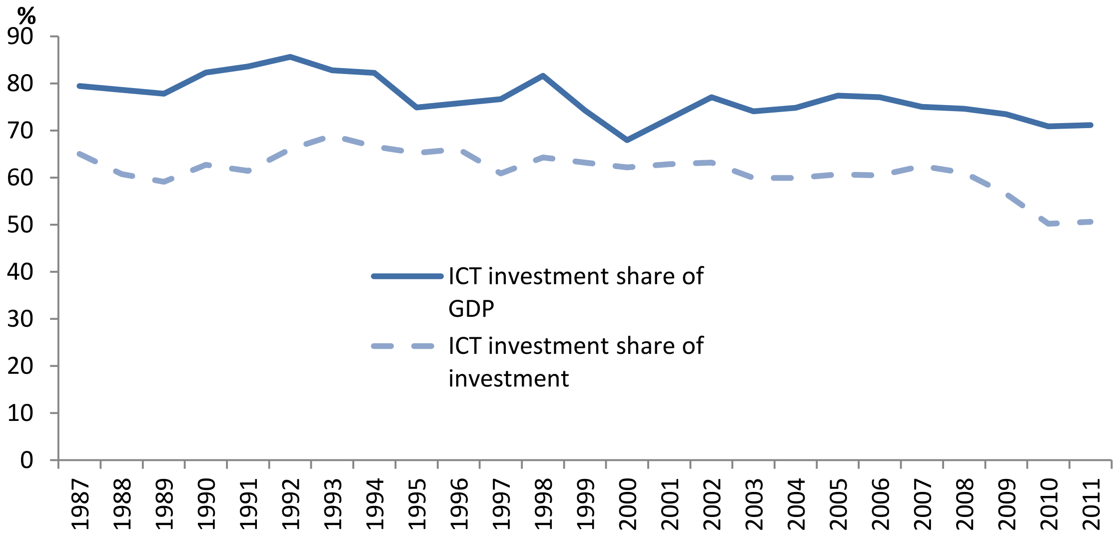
**Table 4: Investment and ICT Investment GDP Shares for Canada and the United States, selected years**

| | Share of ICT investment in GDP (per cent) | | | ICT investment share of private fixed non-residential investment (per cent) | | |
|---|---|---|---|---|---|---|
| | Canada | United States | Canada relative to the United States | Canada | United States | Canada relative to the United States |
| **1987** | 2.26 | 2.84 | 79.5 | 13.1 | 20.1 | 65.2 |
| **2000** | 3.61 | 5.31 | 68.0 | 20.3 | 32.6 | 62.3 |
| **2011** | 2.71 | 3.80 | 71.2 | 14.8 | 29.3 | 50.5 |

Source: Appendix Tables 2a-c.

Note: See Appendix Tables 2a-c for full period. All estimates refer to the business sector and shares always estimated in current dollars in domestic currency.

**Chart 3: Canada Relative to the United States, Business Sector ICT Investment Shares of GDP and Investment, 1987-2011**




Source: Appendix Table 2c
Note: Shares always estimated in current dollars.

## C. Determinants of the Canada-U.S. ICT Investment per Worker Gap

The Canada-U.S. ICT investment per worker gap, which we have described in the preceding section, is determined by three variables: business sector ICT investment, employment, and the relative value of the CAD and USD as measured by purchasing power parity. This section provides a brief description of the trends in those three underlying variables which have contributed to the evolution of the Canada-U.S. ICT investment per worker gap over time. Our key indicator, the level of ICT investment per worker in Canada relative to the United States, has generally fluctuated around a long-term mean of approximately 60 per cent, but the three inputs of this indicator have changed significantly.

We begin with nominal ICT investment, shown for Canada and the United States in Table 5 and Table 6. From this table, we can see that in Canada, total ICT investment growth averaged 5.62 per cent per year in the 1987-2011 period.  This has been slightly higher in the United States, at 6.11 per cent per year. We also report Canadian ICT investment converted to U.S. dollars using purchasing power parity (PPP) in Table 5, which grew at a substantially greater rate of 6.56 per cent per year in the 1987-2011 period.

**Table 5: ICT investment in Canada by Component in the Business Sector (millions of current dollars), 1987 and 2000-2011**

| | Current Canadian dollars | | | | Current U.S. dollars (PPP-adjusted) | | | |
|---|---|---|---|---|---|---|---|---|
| | Total ICT | Computers | Communications | Software | Total ICT | Computers | Communications | Software |
| **1987** | 8,864 | 3,224 | 3,154 | 2,486 | 6,825 | 2,482 | 2,429 | 1,914 |
| **...** | | | | | | | | |
| **2000** | 27,763 | 9,101 | 8,679 | 9,984 | 21,378 | 7,008 | 6,683 | 7,688 |
| **2001** | 27,710 | 7,691 | 9,068 | 10,952 | 21,337 | 5,922 | 6,982 | 8,433 |
| **2002** | 26,610 | 7,889 | 8,169 | 10,552 | 20,756 | 6,153 | 6,372 | 8,231 |
| **2003** | 26,138 | 8,206 | 7,355 | 10,577 | 21,433 | 6,729 | 6,031 | 8,673 |
| **2004** | 27,970 | 9,280 | 7,097 | 11,593 | 24,054 | 7,981 | 6,103 | 9,970 |
| **2005** | 29,862 | 9,869 | 6,957 | 13,036 | 26,577 | 8,783 | 6,192 | 11,602 |
| **2006** | 31,622 | 11,151 | 7,208 | 13,263 | 28,460 | 10,036 | 6,487 | 11,937 |
| **2007** | 32,980 | 10,731 | 6,530 | 15,719 | 29,682 | 9,658 | 5,877 | 14,147 |
| **2008** | 34,280 | 10,953 | 7,137 | 16,191 | 30,166 | 9,639 | 6,281 | 14,248 |
| **2009** | 30,602 | 10,165 | 6,996 | 13,441 | 25,400 | 8,437 | 5,807 | 11,156 |
| **2010** | 30,937 | 10,557 | 6,996 | 13,385 | 26,915 | 9,185 | 6,087 | 11,645 |
| **2011** | 32,890 | 10,879 | 7,382 | 14,630 | 29,601 | 9,791 | 6,644 | 13,167 |
| **Annual Average Growth Rates** | | | | | | | | |
| **1987-2011** | 5.62 | 5.20 | 3.61 | 7.66 | 6.56 | 6.14 | 4.54 | 8.63 |
| **1987-2000** | 9.18 | 8.31 | 8.10 | 11.29 | 9.67 | 8.80 | 8.59 | 11.79 |
| **2000-2011** | 1.55 | 1.64 | -1.46 | 3.53 | 3.00 | 3.09 | -0.05 | 5.01 |

Source: CSLS ICT Database Tables 5v, 9v, and S1

Comparing Table 5 and Table 6, we see that while nominal growth in national current units was greater in the 1987-2011 period in the United States, growth in nominal ICT investment actually favours Canada after converting the ICT investment figures to U.S. dollars using purchasing power parity (PPP) for machinery and equipment.[7] We also note that for total ICT and each component of ICT, growth was much faster from 1987-2000 than 2000-2011 in both countries.

[7] Purchasing power parity is an alternative method to market exchange rates of comparing different currencies. It is determined by selecting a common basket of goods and services in two countries and determining how much of each currency is needed to purchase that basket. Because of how it is calculated, PPPs can be estimated specifically for certain baskets of goods, such as machinery and equipment. In principle, PPP provides a more accurate reflection of the purchasing power of a currency than does the market exchange rate. The difference between market exchange rates and PPP will reflect the amount by which a currency is under- or over-valued.

### Table 6: ICT Investment in the United States by Component in the Business Sector (millions of current U.S. dollars), 1987 and 2000-2011

| | Total ICT | Computers | Communications | Software |
|---|---|---|---|---|
| 1987 | 104,000 | 35,800 | 39,200 | 29,000 |
| ... | | | | |
| 2000 | 409,500 | 101,700 | 123,300 | 184,500 |
| 2001 | 381,400 | 85,700 | 109,100 | 186,600 |
| 2002 | 344,200 | 77,500 | 83,700 | 183,000 |
| 2003 | 348,100 | 75,400 | 81,400 | 191,300 |
| 2004 | 367,000 | 77,900 | 83,400 | 205,700 |
| 2005 | 377,800 | 76,600 | 83,200 | 218,000 |
| 2006 | 403,400 | 82,400 | 91,200 | 229,800 |
| 2007 | 428,900 | 84,500 | 99,400 | 245,000 |
| 2008 | 428,400 | 82,400 | 88,800 | 257,200 |
| 2009 | 404,000 | 71,200 | 75,900 | 256,900 |
| 2010 | 414,500 | 70,500 | 83,100 | 260,900 |
| 2011 | 431,300 | 75,800 | 76,800 | 278,700 |
| **Annual Average Growth Rates** | | | | |
| 1987-2011 | 6.11 | 3.17 | 2.84 | 9.89 |
| 1987-2000 | 9.73 | 9.20 | 7.59 | 14.22 |
| 2000-2011 | 0.47 | -2.64 | -4.21 | 3.82 |

Source: CSLS ICT Database Table 18v

Chart 4 shows that total ICT investment growth over the entire period has been greater in the United States when compared to Canada, in national currencies, but greater in Canada after adjusting for PPP. We report both nominal and PPP-adjusted estimates for Canada, as nominal ICT investment is the appropriate measure of the trend in ICT investment growth in Canada, but the PPP-adjusted ICT investment is what will contribute to changes in the ICT investment per worker gap over time.

### Chart 4: Business Sector Investment in ICT Assets for Canada and the United States, Annual Average Growth Rates for 1987-2011 (per cent)

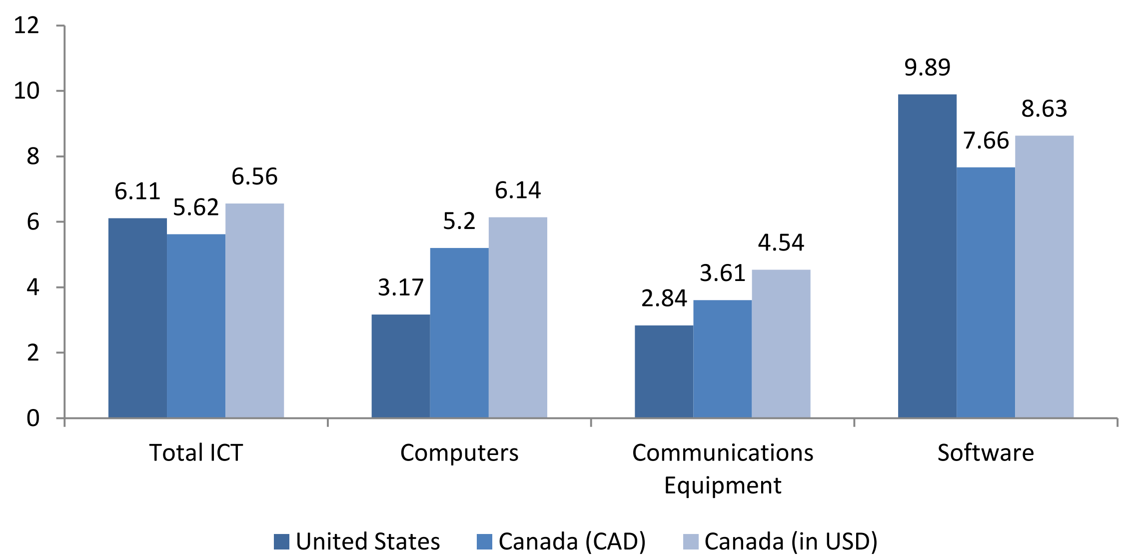


Table 7 gives the estimates of PPP and business sector employment used to compute business sector ICT investment per worker in both countries. PPP for machinery and equipment, in terms of United States dollars per Canadian dollar, increased more quickly than did ICT investment in the United States during the 2000-2011 period. The larger increase in PPP raises ICT investment in Canada when measured in U.S. dollars, decreasing, *ceteris paribus*, the gap over time.

On the other hand, business sector employment in the United States declined in the last decade, while ICT investment grew at a modest but positive rate. ICT investment grew in the United States at a much greater rate than business sector employment; the difference between these two growth rates was smaller in Canada, so trends in employment have increased the gap.

**Table 7: PPP for Machinery and Equipment in USD per CAD and Business Sector Employment for Canada and the United States (thousands of workers), 2001-2011**

| | Purchasing Power Parity for Machinery and Equipment | U.S. Business Sector Employment | Canada Business Sector Employment |
|---|---|---|---|
| **1987** | 0.73 | 92,301 | 9,639 |
| **…** | | | |
| **2000** | 0.77 | 115,016 | 11,499 |
| **2001** | 0.77 | 114,085 | 11,635 |
| **2002** | 0.78 | 111,554 | 11,886 |
| **2003** | 0.82 | 111,300 | 12,135 |
| **2004** | 0.86 | 112,743 | 12,343 |
| **2005** | 0.89 | 114,780 | 12,474 |
| **2006** | 0.90 | 116,907 | 12,643 |
| **2007** | 0.90 | 117,763 | 12,925 |
| **2008** | 0.88 | 116,033 | 13,082 |
| **2009** | 0.83 | 109,395 | 12,745 |
| **2010** | 0.87 | 108,142 | 12,836 |
| **2011** | 0.90 | 109,711 | 13,024 |
| **Annual Average growth (per cent)** | | | |
| **1987-2011** | 0.90 | 0.72 | 1.26 |
| **1987-2000** | 0.45 | 1.71 | 1.37 |
| **2000-2011** | 1.43 | -0.43 | 1.14 |

Source: CANSIM Table 380-0057 for PPP; Bureau of Labour Statistics Major Sector Productivity dataset for U.S. Business Sector employment, Statistics Canada Productivity Program for Canadian Business sector employment

It is worth recalling from the previous section that the level of ICT investment per worker in Canada relative to the United States fell dramatically between 2008 and 2009, from 62.5 to 54.0 per cent. This substantial drop provides an opportunity to demonstrate how changes in the three determinants of the Canada-U.S. ICT investment per worker gap, shown in Table 5, Table 6, and Table 7, affect the gap. From Table 5 and Table 6, we see that nominal ICT investment fell significantly in both countries, and that nominal ICT investment in U.S. dollars fell even more substantially in Canada, which increases the gap. The drop in PPP in 2009 shown in Table 7 also increases the gap. In addition to that, employment fell dramatically in the United States, but not in Canada. Each of these three changes favours the U.S. in a comparison of ICT investment per worker, resulting in the significant decline we observed in 2009.

Table 8 provides a summary of the trends in the determinants of the Canada-U.S. ICT investment per worker gap over the 1987-2011 period. The evolution of the gap over this period is explained by the offsetting developments of nominal investment, which grew at a rate of 6.11 per cent in the United States, compared to 5.62 per cent in Canada; the appreciation of the Canadian dollar relative to the U.S. dollar, as shown by the increase of PPP from 0.73 to 0.90; greater employment growth in Canada, at 1.26 per cent compared to 0.72 per cent in the United States, resulting in a slightly lower growth of ICT investment per worker in Canada of 5.24 per cent, compared to 5.34 per cent in the United States. This explains the modest decline in ICT investment per worker in Canada relative to the United States from 1987 to 2011 from 59.3 per cent to 57.8 per cent.

**Table 8: Growth Rates of Nominal ICT Investment, PPP, and Employment for Canada and the United States for 1987-2011**

| | Canada | United States | Difference |
|---|---|---|---|
| **Nominal ICT Investment** | 5.62 | 6.11 | -0.49 |
| **Purchasing Power Parity** | 0.90 | - | 0.90 |
| **Nominal ICT Investment in U.S. dollars** | 6.56 | 6.11 | 0.45 |
| **Business sector employment** | 1.26 | 0.72 | 0.54 |
| **Nominal ICT investment per worker in U.S. dollars** | 5.24 | 5.34 | -0.10 |

## D. International Comparisons of ICT Investment

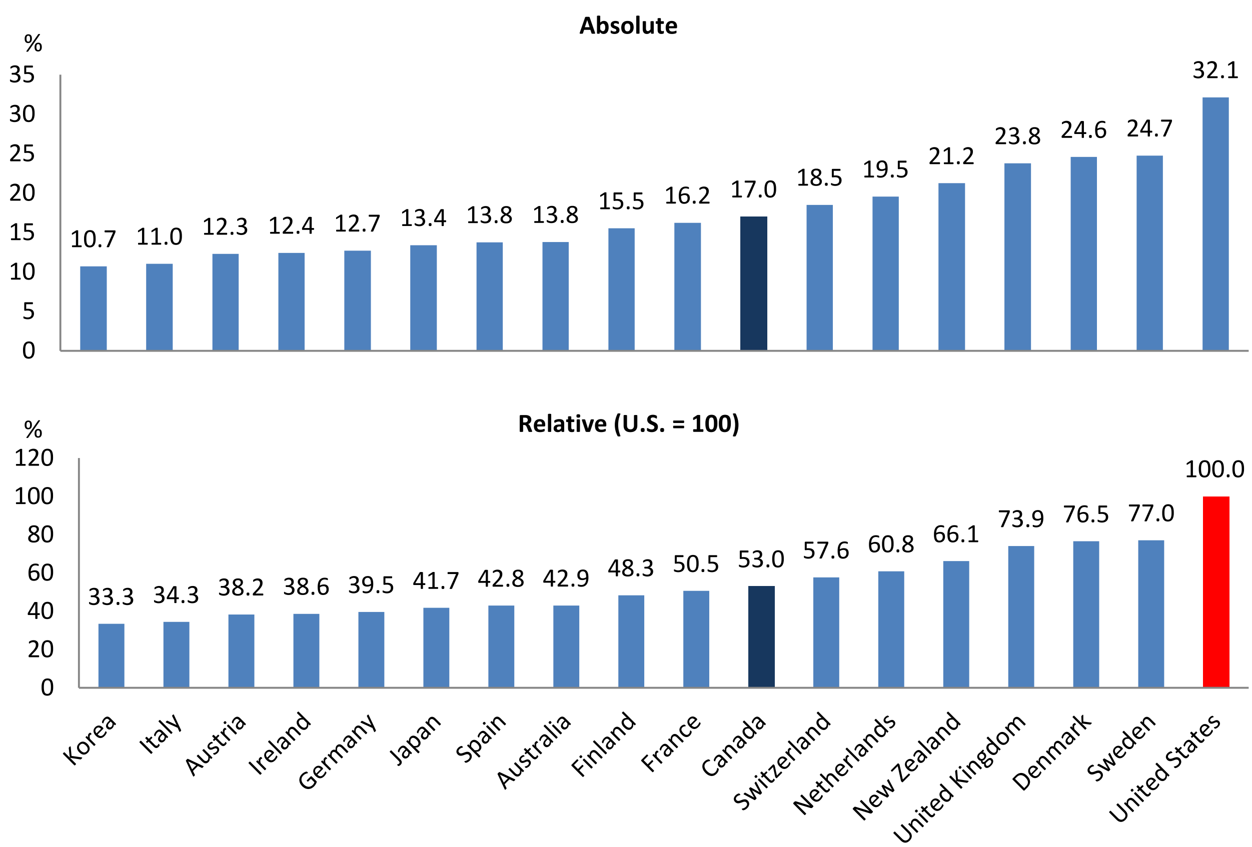
When we compare ICT investment in Canada and the United States, we can observe that Canada is largely under-investing in ICT assets relative to the United States. It is important to know if this situation is unique to Canada, or if other countries are similarly outperformed by the United States as well. This section provides a comparison of international ICT investment among a sample of OECD countries and finds that, although Canada's level of ICT investment is slightly below the average of the selected sample of OECD countries, the average of the countries we review is also well below the U.S. level. Canada’s performance on most measures of ICT investment is near the average of this sample of OECD countries.

Canada's performance is first assessed by examining the shares of ICT investment in non-residential gross fixed capital formation for 18 selected OECD countries in 2010, as given by the 2013 OECD Factbook. Using ICT investment data from the EU KLEMS database, we measured ICT investment performance across countries using three other indicators: ICT investment as a share of GDP, ICT investment per worker, and ICT investment per hour worked. For reasons of confidentiality and data availability, those measures were calculated for only 13 OECD countries for 2007. All those measures are calculated from data for total economy. A summary table of those measures for all countries in our sample can be found in Table 9.

### i. ICT investment as a share of non-residential investment

Out of a sample of 18 OECD countries, Canada ranked 8th in 2010 for its share of ICT investment in non-residential fixed investment in the total economy, at 17.0 per cent, compared to 32.1 per cent for the United States, which ranked first among the selected countries (Chart 5). Canada's share only represented 53.0 per cent of the United State share of ICT investment in non-residential investment. The U.S. share of ICT investment in non-residential investment is impressive in comparison to other OECD countries. Sweden ranked second with a share of ICT investment in non-residential investment of 24.7 per cent, which represented 77.0 per cent of the United State rate. To a large extent, the high share of ICT investment relative to non-residential investment in the United States is a consequence of the weak overall growth in U.S. non-residential investment.

**Chart 5: ICT Investment as a Share of Non-Residential Gross Fixed Capital Formation, Total Economy, 2010 or Latest Available Year**




Source: OECD Factbook 2013, OECD Statistics Database. See Appendix Table 4a.

There were significant differences in the share of ICT investment in total non-residential investment among these OECD countries in 2010. For Korea, Italy, Austria, Ireland, and Germany, ICT investment represented less than 13 per cent of their total non-residential investment whereas for Sweden, the United Kingdom, and Denmark, ICT investment represented more than 23 per cent of their total non-residential investment. According to these figures, Canada is in the top half of OECD countries for ICT investment as a share of non-residential investment. However, our three other indicators showed a different situation.

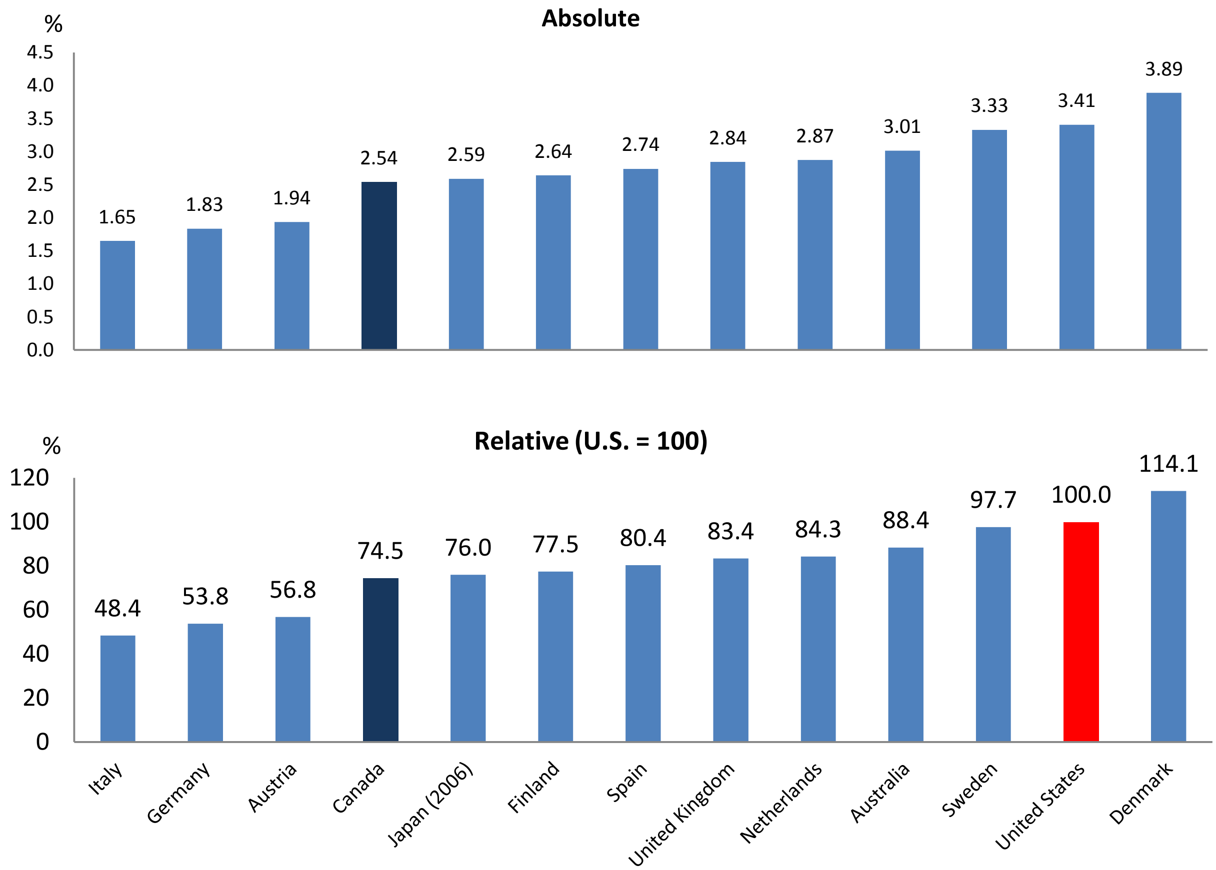
### ii. ICT investment as a share of GDP

When using ICT investment as a share of GDP as an indicator of ICT investment performance, Canada performed worse than most of the OECD countries in our sample. Canada ranked tenth out of 13 countries at 2.54 per cent, compared to 3.89 per cent for the leader, Denmark (Chart 6), slightly below the unweighted average of 2.71 per cent. However, Canada's ICT investment performance is far better than other countries found in the bottom third such as Austria at 1.94 per cent, Germany at 1.83 per cent or Italy at 1.65 per cent. While Canada ranks in the bottom third of countries in our sample, its performance in terms of ICT investment as a share of GDP is closer to countries positioned in the middle third such as Japan at 2.59 per cent, Finland at 2.64 per cent and Spain at 2.84 per cent.

Compared only to the United States, Canada's ICT performance in ICT investment as a share of GDP was stronger than its performance in ICT investment as a share non-residential investment. Canada's ICT investment share of GDP represented 74.5 per cent of the U.S. ICT investment share of GDP, whereas in ICT investment as a share of non-residential investment, Canada was only 53.0 per cent of the U.S. level. However, this improvement is not unique to Canada. All of the countries in our review had better results with ICT investment as a share of GDP relative to the United States than in ICT investment as a share of GDP relative to the United States.[8] In the first indicator, the average of ICT investment in non-residential investment as a share of United State for OECD countries was 54.0 per cent whereas for ICT investment in GDP, the average was 79.6 per cent. The United States ranked second, with an ICT investment share of GDP of 3.41 per cent. Most countries achieved a level of ICT investment in GDP more than 75.0 per cent of the United States rate.

[8] This is because investment represents a smaller share of GDP in the United States than it does for Canada and other OECD countries, despite ICT investment representing a greater share of GDP in the United States. If investment represented the same share of GDP in all countries, then there would be no difference between our comparisons of ICT investment as a share of GDP and ICT investment as a share of investment.

### Chart 6: ICT investment as a share of GDP (per cent), Selected OECD Countries in 2007

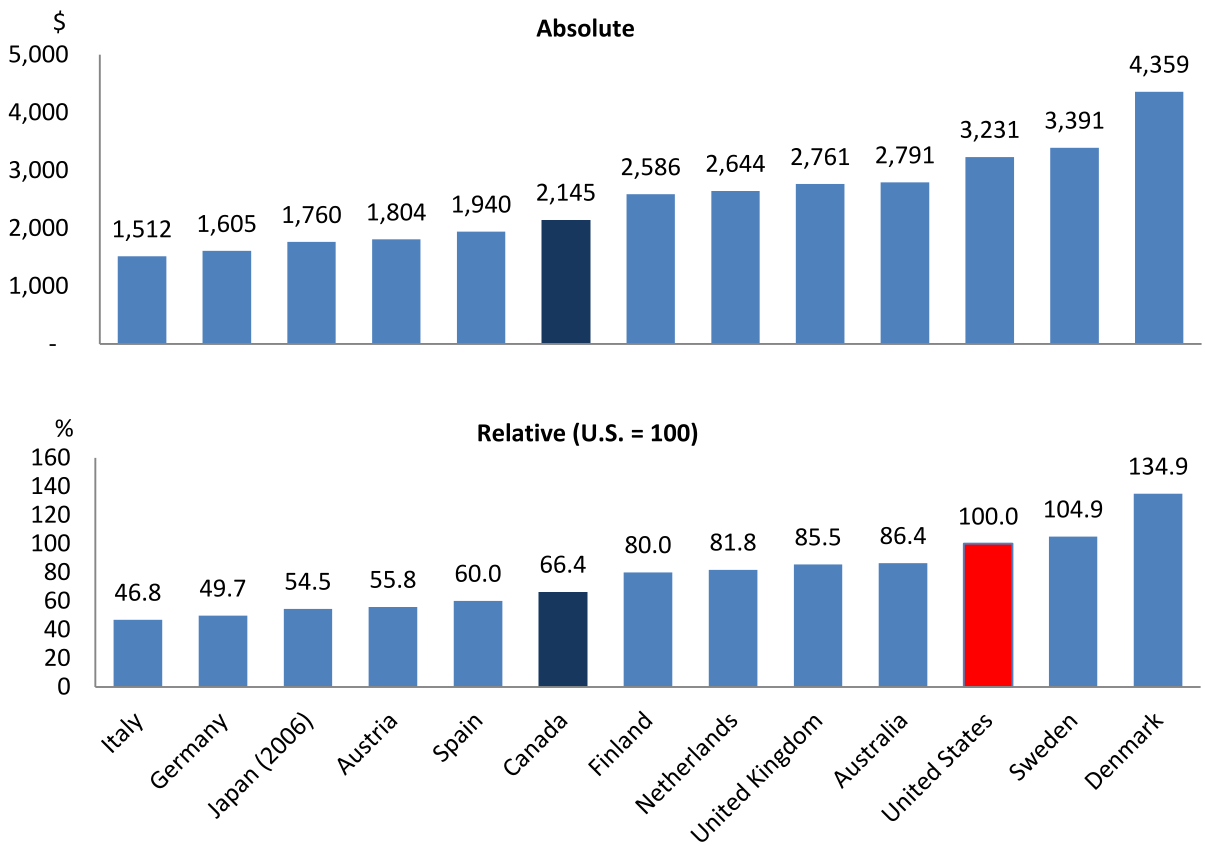



Source: EU KLEMS Database, 2009 release; OECD Statistics, National Accounts/Main Aggregates (Series: B1_GA). See Appendix Table 4b.

### iii. ICT investment per worker

The third indicator, ICT investment per worker, has a similar ranking to the one obtained using the ICT investment share of GDP. The indicator was calculated by adjusting ICT investment reported in current national currency to U.S. current dollars, using both the market exchange rate (Chart 7) and purchasing power parity for GDP for 2007. When we used market exchange rates, the United States was outperformed by both Denmark, with an ICT investment per worker of $4,359 or 134.9 per cent of the U.S. level, and Sweden, with an ICT investment per worker of $3,391 or 104.9 per cent of the U.S. level (Chart 7). Canada ranked ninth out of 13 countries with an ICT investment per worker of $2,145, equivalent to 66.4 per cent of the U.S. ICT investment per worker level in 2007.

**Chart 7: ICT Investment per Worker in Selected OECD Countries, Total Economy, 2007, U.S. Current Dollars, Market Exchange Rate Adjusted**

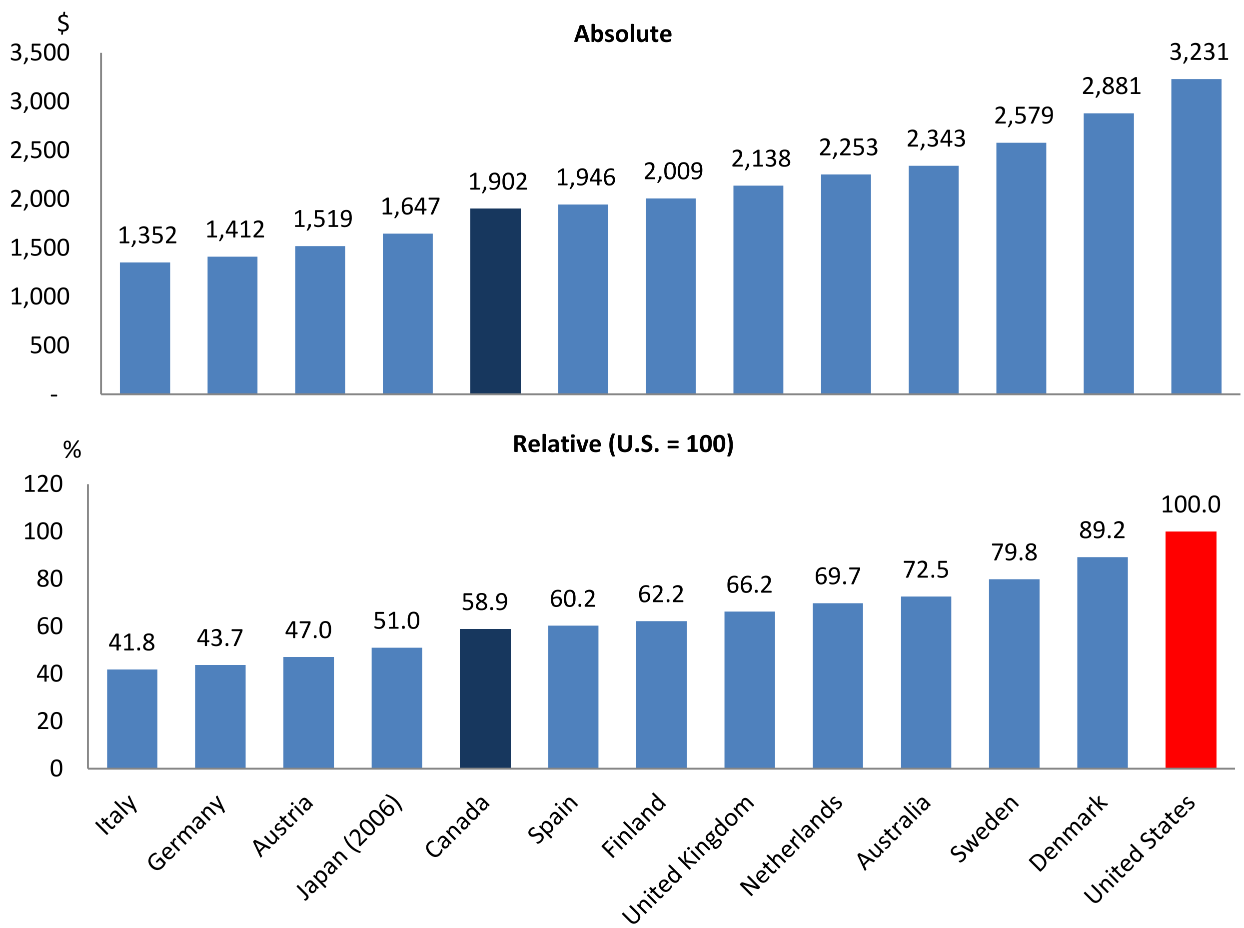



Source: EU KLEMS Database, 2009 release; OECD Statistics, Labour force statistics, ALFS Summary tables; OECD National Account, Main aggregate, PPPs and exchange rate. See Appendix Table 4c.

However, when we used PPPs, the more appropriate measure, to calculate the indicator, the United States was the strongest performer with ICT investment per worker of $3,231 (Chart 8). Denmark and Sweden followed, respectively, at $2,881 and $2,579, representing 89.2 per cent and 79.8 percent of U.S. investment per worker. Canada ranked ninth at ICT investment per worker of $1,902, representing 58.9 per cent of U.S. ICT investment per worker. According to the ranking, Canada held the last position of the middle third with a slightly below average performance in this indicator. Countries reporting lower ICT investment than Canada included Italy ($1,352 per worker), Germany ($1,412 per worker) and Japan ($1,647 per worker).

Comparing these results to those obtained using the previous indicator, we note that, for ICT investment as a share of GDP, Canada represented 74.5 per cent of U.S. level whereas for ICT investment per worker (converted to USD using PPP), Canada represented only 58.9 per cent of the U.S. level. Once again, this difference between the two indicators is not unique to Canada. The OECD average for the ICT investment share of GDP was 79.6 per cent of the U.S. level, while ICT investment per worker was 64.8 per cent of the United State level. These differences can largely be explained by lower levels of labour input, as measured by employment, in the United States.

**Chart 8: ICT Investment per Worker in Selected OECD Countries, Total Economy, 2007, U.S. Current Dollars, PPP Adjusted**




Source: EU KLEMS Database, 2009 release; OECD Statistics, Labour force statistics, ALFS Summary tables; OECD National Account, Main aggregate, PPPs and exchange rate. See Appendix Table 4c.

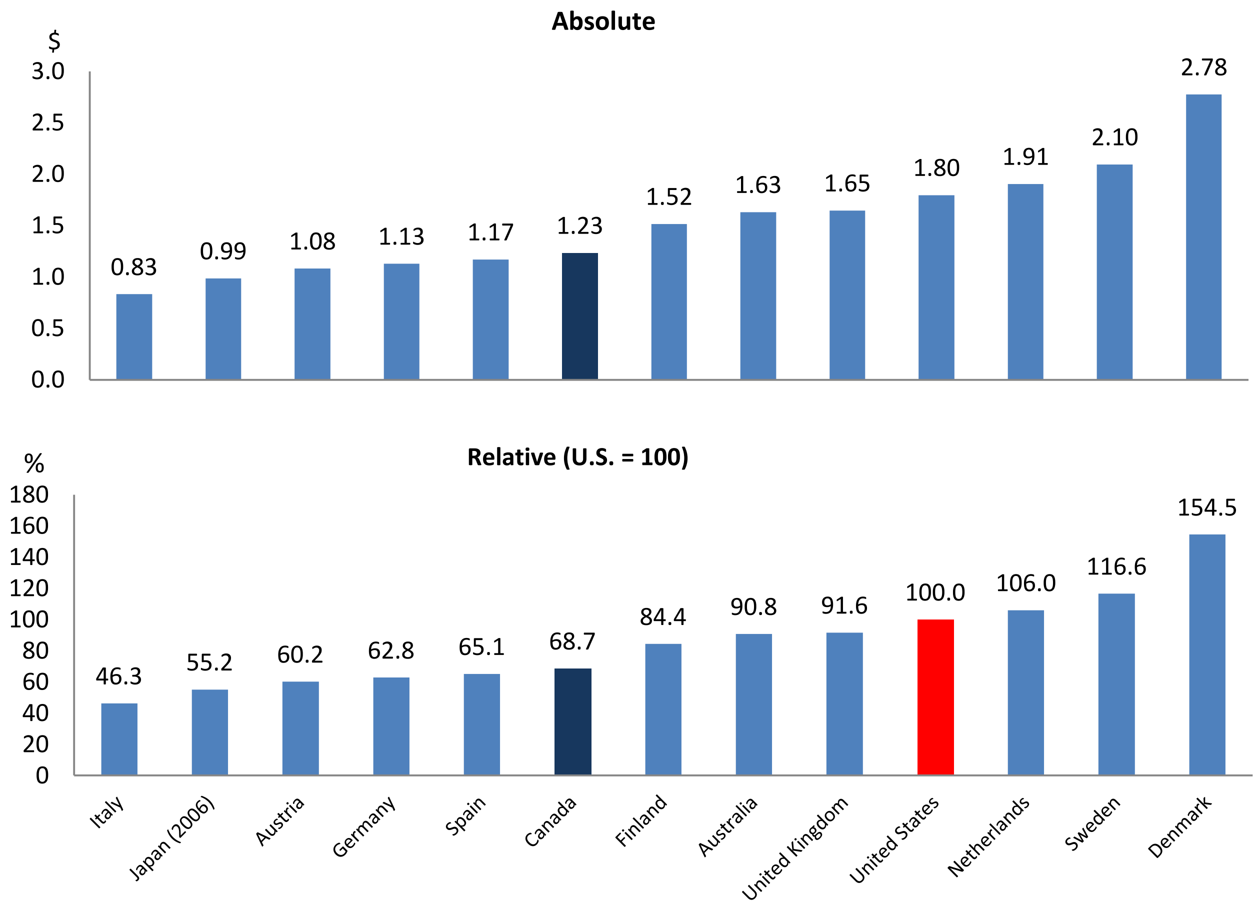
### iv. ICT investment per hour worked

Finally, the international ranking for ICT investment per hour worked was very similar to the one obtained for ICT investment per worker (Chart 9). Canada still ranked eighth using market exchange rates, with ICT investment per hour worked representing 68.7 per cent of the U.S. level.

Using PPP to obtain our indicator, Canada ranked ninth, the same position as ICT investment per worker, with an ICT investment of $1.09 per hour worked, which represented 60.9 of the U.S. level (Chart 10). On an international basis, this level of investment is once again below the OECD average of $1.23 per hour worked, with the OECD average representing 70.7

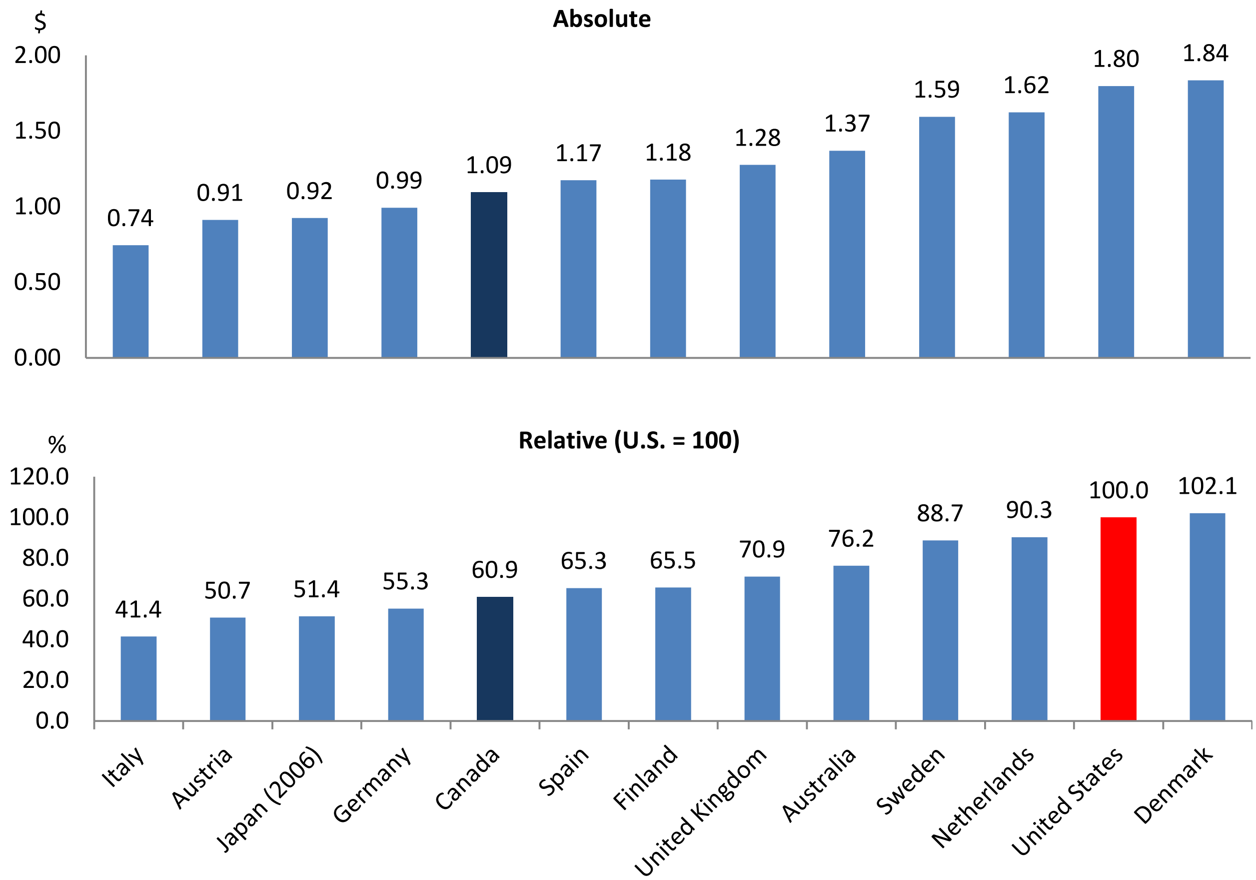
per cent of the United States level. In terms of ICT investment per worker, the best performer was Denmark, with $1.84 in ICT investment for every hour worked.

### Chart 9: ICT Investment per Hour Worked in Selected OECD Countries, Total Economy, 2007, US Current Dollars, Market Exchange Rate Adjusted




Source: EU KLEMS Database, 2009 release; OECD Statistics, Labour force statistics, Hours worked; OECD National Account, Main aggregate, PPPs and exchange rate. See Appendix Table 4d.

**Chart 10: ICT Investment per Hour Worked in Selected OECD Countries, Total Economy, 2007, US Current Dollars, PPP adjusted**




Source: EU KLEMS Database, 2009 release; OECD Statistics, Labour force statistics, Hours worked; OECD National Account, Main aggregate, PPPs and exchange rate. See Appendix Table 4d.

### v. Overview

Table 9 gives an overview of Canada's ICT investment performance on the international stage. With respect to the four indicators described in this exhibit, Canada is at the bottom of a group of countries characterized by an average ICT investment performance. This group includes countries like Finland, Spain, United Kingdom Australia and the Netherlands. Even though our first indicator, ICT investment as a share of non-residential investment, presents Canada's performance as average, in the other three indicators (ICT investment as a share of GDP, ICT investment per worker and ICT investment per hour worked), Canada had a below-average performance, ranking ninth (using PPP) or 10$^{th}$ out of a sample of 13 countries.

### Table 9: International Comparisons of ICT Investment

| | | Number of Countries | Canada | | | United States | | OECD Average | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Absolute | Rank | % of U.S. | Absolute | Rank | Absolute | % of U.S. |
| ICT Investment as a share of total non-residential investment, 2010 (per cent) | | 18 | 17.0 | 8th | 53.0 | 32.1 | 1st | 17.4 | 54.0 |
| ICT Investment as a Share of GDP, 2007 (per cent) | | 13 | 2.54 | 10th | 74.5 | 3.41 | 2nd | 2.71 | 79.6 |
| ICT Investment per Worker, 2007 (current U.S. dollars per worker) | Market exchange rate | 13 | 2,145 | 8th | 66.4 | 3,231 | 3rd | 2,503 | 77.5 |
| | PPP | 13 | 1,902 | 9th | 58.9 | 3,231 | 1st | 2,093 | 64.8 |
| ICT Investment per hour worked, 2007 (current U.S. dollars per hour worked) | Market exchange rate | 13 | 1.23 | 8th | 68.7 | 1.8 | 4th | 1.52 | 84.8 |
| | PPP | 13 | 1.09 | 9th | 60.9 | 1.8 | 2nd | 1.27 | 70.7 |

Countries such as Spain and Finland, which ranked lower than Canada for the first indicator, are in a better standing than Canada for all the other three ICT investment indicators. On the other hand, Sweden, Denmark and the United States formed a group of strong performers in terms of ICT investment, Denmark and the United States sharing the first position for all the indicators with Sweden following either second or third. Finally, Italy, and perhaps surprisingly, Germany formed a group of notably weak performers in terms of ICT investment, with ICT investment as a share of GDP per worker and per hour worked barely reaching 50 per cent of the numbers recorded by the United States for any of those three indicators.

When compared to the United States, Canada’s performance seems weak. Its ICT investment as a share of non-residential investment represented 53.0 per cent of the U.S. level, its ICT investment as a share of GDP was 74.5 per cent of the U.S. level, its ICT investment per worker and per hour worked were respectively 58.9 per cent and 60.9 per cent of the U.S. level. Yet, this gap between the United States level of ICT investment and Canada's was reflected in most of the OECD countries included in our sample (see Table 9). Therefore, Canada's level of ICT investment looks poor only because it lies in the shadow of exceptionally strong performances by the U.S. and Danish economies.

Compared to other OECD countries, Canada's ICT investment performance is below the average according to three indicators: ICT investment as a share of GDP, ICT investment per worker, and ICT investment per hour worked. Once again, this does not mean that Canada was a weak performer. The distance between Canada’s ICT investment performance and the performance of countries in the middle third of the international ranking is small, far smaller than the distance separating Canada from countries in the bottom third such as Germany, Austria and

Italy. On a better note, Canada performed well for ICT investment as a share of non-residential investment, making its way to the upper half of the ranking.

To conclude, it is important to note that, due to confidentiality issues and the lack of availability of capital input data, we lack information on many OECD countries such as France, Belgium and Ireland that would permit us to provide a more comprehensive overview of international ICT investment. Finally, the comparability of the data on ICT investment may be weakened by differences in the methodologies used to measure ICT investment (OECD, 2011).

## E. Canada-U.S. Comparisons of Non-ICT Investment per Worker

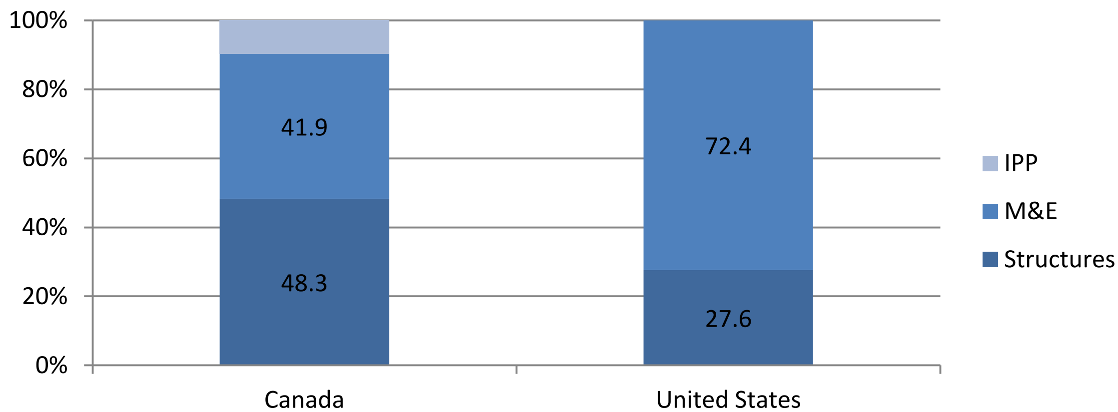
Our motivation for monitoring ICT investment per worker and understanding why it is so much lower in Canada than the United States is primarily that investment in machinery and equipment is widely understood to enhance labour productivity. ICT investment in particular may have significant productivity-augmenting properties. To fully understand the implications of Canada's investment performance compared to the United States and provide a point of comparison for ICT investment, we also compare other types of investment in Canada and the United States.

Investment consists of investment in machinery and equipment, and investment in structures.[9] Structures refer to large products, such as buildings and highways, which are constructed at the location where they will be used, and generally have very long service lives. Machinery and equipment (M&E) are assets with service lives greater than one year, and are generally stored in structures and used repeatedly. In this section, we look at total investment, investment in structures, and M&E investment in Canada and the United States

Chart 11 provides the shares of business sector investment in structures and machinery and equipment in Canada and the United States, revealing a very large difference in the composition of private fixed investment. Structures, which have a less direct impact on productivity than machinery and equipment, represented almost 50 per cent of investment in Canada in 2011, but only slightly more than 25 per cent of U.S. investment. This is very surprising given structural similarities between the Canadian and U.S. economies, and the fact that, as we discuss later on, industrial composition has only a small affect on the gap. Future research should focus on explaining why investment in structures is so much greater in Canada and the United States.

[9] The FCFS tables for Canada break investment into "buildings", "engineering," "machinery and equipment," and "intellectual property products," while the FAA tables for the United States break investment into "equipment and software," and "structures". In Canada, we combine "buildings" and "engineering" in Canada to produce an estimate of investment in structures. Machinery and equipment refers to "machinery and equipment" plus software investment in Canada, and "equipment and software" in the United States. Canada recently moved software out of machinery and equipment, and into intellectual property products, while the United States continues to classify software with equipment.

## Chart 11: Relative Importance of Business Sector Investment in Structures and Machinery & Equipment in Canada and the United States, 2011




Source: Appendix Table 15a

Notes: This includes only non-residential investment. Investment in Canada includes a third classification of investment, called intellectual property products (IPP), which is not used in the United States. This is a new addition to the investment and stocks program in Statistics Canada, instituted on December 6, 2012. The IPP category includes software (previously categorized as M&E), categorized as well spending in research and development (not capitalized prior to the 2012 SNA revision) and oil and gas exploration.

## Table 10: Total Investment per Worker and Investment in Structures and Machinery and Equipment per Worker in Canada, Business Sector, 2000-2011

| | Canada (current dollars) | | | | Canada (current US dollars) | | | |
|---|---|---|---|---|---|---|---|---|
| | Total Investment | Structures | Machinery and Equipment | Non-ICT M&E | Total Investment | Structures | Machinery and Equipment | Non-ICT M&E |
| **2000** | 11,904 | 3,828 | 6,922 | 4,508 | 9,999 | 3,484 | 5,330 | 3,471 |
| **2001** | 12,023 | 3,954 | 6,733 | 4,351 | 10,099 | 3,598 | 5,184 | 3,350 |
| **2002** | 11,387 | 3,742 | 6,408 | 4,169 | 9,565 | 3,368 | 4,998 | 3,252 |
| **2003** | 11,522 | 3,963 | 6,267 | 4,113 | 9,909 | 3,567 | 5,139 | 3,373 |
| **2004** | 12,420 | 4,478 | 6,551 | 4,285 | 10,929 | 4,075 | 5,634 | 3,685 |
| **2005** | 13,878 | 5,185 | 7,161 | 4,767 | 12,768 | 4,874 | 6,373 | 4,242 |
| **2006** | 15,240 | 6,093 | 7,577 | 5,076 | 15,088 | 6,459 | 6,819 | 4,568 |
| **2007** | 15,444 | 6,428 | 7,486 | 4,935 | 16,062 | 7,392 | 6,738 | 4,441 |
| **2008** | 16,490 | 7,323 | 7,525 | 4,904 | 17,809 | 9,081 | 6,622 | 4,316 |
| **2009** | 14,047 | 6,197 | 6,529 | 4,128 | 14,749 | 7,499 | 5,419 | 3,426 |
| **2010** | 15,443 | 7,265 | 6,702 | 4,292 | 15,907 | 8,572 | 5,831 | 3,734 |
| **2011** | 17,018 | 8,220 | 7,132 | 4,607 | 17,529 | 9,617 | 6,419 | 4,146 |
| **Annual Average Growth Rate** | | | | | | | | |
| **2000-2011** | 3.30 | 7.19 | 0.27 | 0.20 | 5.24 | 9.67 | 1.70 | 1.63 |

Source: Appendix Table 15b. See Appendix Table 15a and 15b for full period and total investment estimates.
Note: All figures refer to private, fixed, non-residential investment.

Table 10 contains estimates of total investment, investment in structures, and investment in machinery and equipment for Canada, all in per worker terms for the business sector, in both

CAD and USD. Table 11 provides the same estimates for the United States, while Table 12 provides the purchasing power parities used for comparison and shows Canada relative to the United States for each type of investment per worker.

### Table 11: Total Investment per Worker and Investment in Structures and Machinery and Equipment per Worker in the United States, Business Sector, 2000-2011

| United States (current US dollars) | | | | |
|---|---|---|---|---|
| | Total Investment | Structures | M&E | Non-ICT M&E |
| **2000** | 10,916 | 2,736 | 8,180 | 4,619 |
| **2001** | 10,604 | 2,858 | 7,746 | 4,403 |
| **2002** | 9,923 | 2,521 | 7,402 | 4,316 |
| **2003** | 10,028 | 2,535 | 7,492 | 4,365 |
| **2004** | 10,691 | 2,726 | 7,965 | 4,710 |
| **2005** | 11,582 | 3,068 | 8,515 | 5,223 |
| **2006** | 12,710 | 3,709 | 9,000 | 5,550 |
| **2007** | 13,767 | 4,461 | 9,304 | 5,662 |
| **2008** | 14,177 | 5,060 | 9,117 | 5,425 |
| **2009** | 12,210 | 4,139 | 8,071 | 4,378 |
| **2010** | 12,325 | 3,496 | 8,829 | 4,996 |
| **2011** | 13,414 | 3,703 | 9,710 | 5,779 |
| **Compound Annual Growth Rates, per cent** | | | | |
| **2000-2011** | 1.89 | 2.79 | 1.57 | 2.06 |

Source: Appendix Table 15a

### Table 12: Canada Relative to the United States, Investment per Worker in Total Investment, Structures, and Machinery and Equipment, Business Sector, 2000-2011

| | Purchasing Power Parities (USD per CAD) | | | Investment per worker in Canada relative to the United States (per cent) | | | |
|---|---|---|---|---|---|---|---|
| | GFCF | Construction | M&E | Total Investment | Structures | M&E | Non-ICT M&E |
| **2000** | 0.84 | 0.91 | 0.77 | 91.6 | 127.3 | 65.2 | 75.1 |
| **2001** | 0.84 | 0.91 | 0.77 | 95.2 | 125.9 | 66.9 | 76.1 |
| **2002** | 0.84 | 0.90 | 0.78 | 96.4 | 133.6 | 67.5 | 75.4 |
| **2003** | 0.86 | 0.90 | 0.82 | 98.8 | 140.7 | 68.6 | 77.3 |
| **2004** | 0.88 | 0.91 | 0.86 | 102.2 | 149.5 | 70.7 | 78.2 |
| **2005** | 0.92 | 0.94 | 0.89 | 110.2 | 158.9 | 74.9 | 81.2 |
| **2006** | 0.99 | 1.06 | 0.90 | 118.7 | 174.1 | 75.8 | 82.3 |
| **2007** | 1.04 | 1.15 | 0.90 | 116.7 | 165.7 | 72.4 | 78.4 |
| **2008** | 1.08 | 1.24 | 0.88 | 125.6 | 179.5 | 72.6 | 79.6 |
| **2009** | 1.05 | 1.21 | 0.83 | 120.8 | 181.2 | 67.1 | 78.3 |
| **2010** | 1.03 | 1.18 | 0.87 | 129.1 | 245.2 | 66.0 | 74.7 |
| **2011** | 1.03 | 1.17 | 0.90 | 130.7 | 259.7 | 66.1 | 71.8 |
| **Annual Average Growth Rate** | | | | | | | |
| **2000-2011** | 1.87 | 2.31 | 1.43 | 3.28 | 6.69 | 0.13 | -0.42 |

Source: Appendix Table 15b. PPPs from CANSIM 380-0037; calculations based on Table 10. See Appendix Table 15b for full period.

Note: PPP for Gross Fixed Capital Formation used for investment; PPP for construction used for structures; PPP for M&E used for M&E, ICT, and Non-ICT M&E.

Table 12 shows that investment per worker in Canada is actually greater than in the United States for total investment in the business sector entirely because of significantly greater investment per worker in structures in Canada. Investment per worker in machinery and equipment relative to the United States is only slightly greater than what we have seen for ICT investment per worker. Part of this is due to greater purchasing power parities for both gross fixed capital formation and construction compared to the M&E PPP, but the magnitude of the differences in relative investment per worker is much larger than the differences in PPP. It is also extremely important to note that Canada's ICT investment per worker performance is worse than its performance in structures and machinery and equipment.

Additionally, we note that the figures in Table 12 show a consistent trend toward higher total investment per worker and higher investment per worker in structures in Canada. Canada's level of investment per worker relative to the United States in both types of investment has increased substantially since 2000, while the gap for investment per worker in machinery and equipment has fluctuated over time, but not changed substantially, similar to the behaviour of ICT investment per worker.

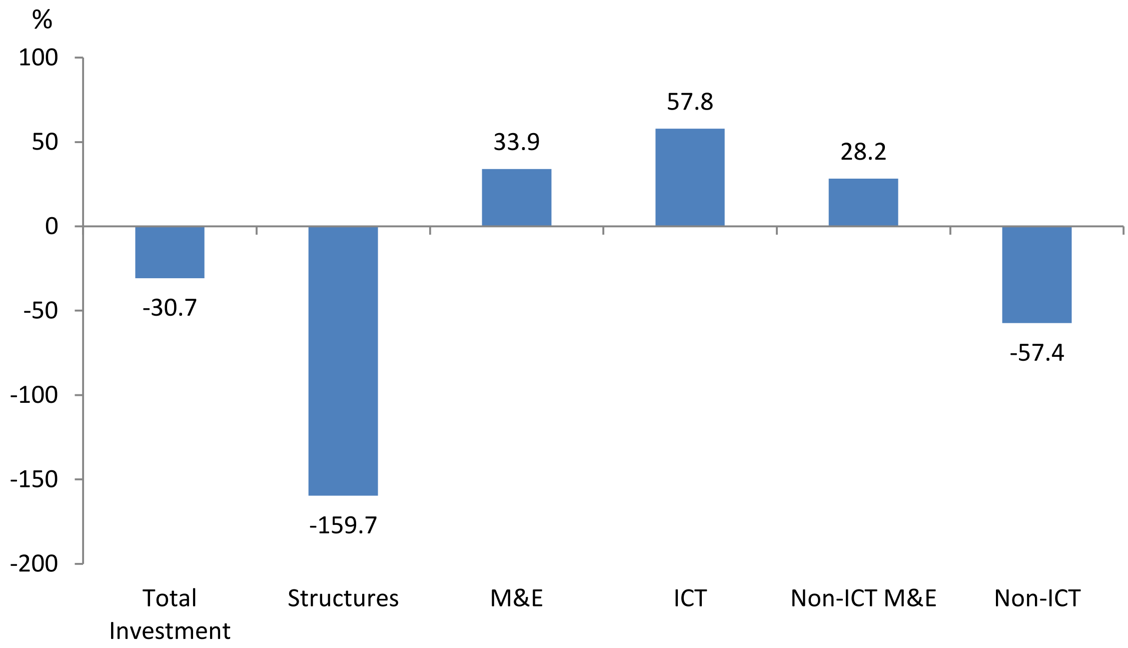
**Table 13: Non-ICT Canada-U.S. Investment per Worker Gap, Business Sector, 2000-2011**

| | Per Worker (current US dollars) | | | | Canada relative to the United States (per cent) | |
|---|---|---|---|---|---|---|
| | Canada | | United States | | | |
| | ICT Investment | Non-ICT Investment | ICT Investment | Non-ICT Investment | ICT Investment | Non-ICT Investment |
| **2000** | 2,414 | 9,490 | 3,560 | 7,355 | 52.2 | 108.4 |
| **2001** | 2,382 | 9,641 | 3,343 | 7,261 | 54.9 | 111.5 |
| **2002** | 2,239 | 9,148 | 3,086 | 6,838 | 56.6 | 112.4 |
| **2003** | 2,154 | 9,368 | 3,128 | 6,900 | 56.5 | 116.8 |
| **2004** | 2,266 | 10,154 | 3,255 | 7,435 | 59.9 | 120.2 |
| **2005** | 2,394 | 11,484 | 3,292 | 8,291 | 64.7 | 127.4 |
| **2006** | 2,501 | 12,739 | 3,451 | 9,260 | 65.2 | 136.2 |
| **2007** | 2,552 | 12,893 | 3,642 | 10,125 | 63.1 | 132.4 |
| **2008** | 2,620 | 13,870 | 3,692 | 10,485 | 62.5 | 142.9 |
| **2009** | 2,401 | 11,646 | 3,693 | 8,517 | 54.0 | 143.6 |
| **2010** | 2,410 | 13,033 | 3,833 | 8,493 | 54.7 | 158.1 |
| **2011** | 2,525 | 14,493 | 3,931 | 9,483 | 57.8 | 157.4 |
| **Annual Average Growth Rate** | | | | | | |
| **2000-2011** | 0.41 | 3.92 | 0.90 | 2.34 | 0.93 | 3.45 |

Note: PPP for GCFC used for Non-ICT Investment per Worker, PPP for M&E used for ICT Investment. See Appendix Table 15b for full period.

The figures in Table 13, which show Canada relative to the United States for ICT and non-ICT investment per worker, show that non-ICT investment per worker in Canada is substantially greater than in the United States, owing largely to Canada's greater level of investment in structures. This is consistent with our analysis of Table 12, which indicated that, relative to the United States, Canada's ICT investment per worker performance is worse than its performance for investment in both structures and machinery and equipment. The data from these three tables are summarized in Chart 12, which shows the Canada-U.S. investment per worker gap for each type of investment. A negative gap indicates that investment per worker in Canada is greater than in the United States for that type of investment.

**Chart 12: Canada-U.S. Investment per Worker Relative Gaps (per cent), Business Sector, 2011**




Source: Appendix Table 15a and 15b
Note: A negative gap indicates that investment per worker is greater in Canada for that type of investment.

What does this mean for our consideration of the Canada-U.S. ICT investment per worker gap? It is tempting to say that it is now less of a concern, given that Canada's investment per worker in other types of assets is much higher than in the United States, but this is not correct. A significant portion of Canada's investment in structures occurs in the natural resource sector. Investment in mining and oil and gas structures, for example, represented 19.2 per cent of total investment Canada in 2011, compared to just 9.2 per cent in the United States. The benefits of greater investment in structures in Canada will therefore be concentrated in those industries engaged in oil and gas extraction. Additionally, and more importantly, investment in machinery and equipment in particular is a significant determinant of labour productivity, as workers can use machinery and equipment regularly in their production process. Structures, on the other hand, are less significant as a determinant of labour productivity. Canada's low level of investment per worker in machinery and equipment overall confirms our concern that the composition of investment in Canada is less than optimal for maximizing productivity.

## II. Decomposition of the Canada-U.S. ICT Investment Gap by Component, Industry, and Province

The ICT investment per worker gap can be decomposed in three ways. First, it can be decomposed into the components of ICT: computers, software, and communications equipment. Second, it can be decomposed by industry, and by component within industry. Third, for Canada, ICT investment per worker can be decomposed by province, although it cannot be decomposed by state for the United States. Investment per worker in each province can be compared to investment per worker in the United States, but because U.S. ICT investment data are not available by state or region, we can only determine whether a particular province has a larger or smaller gap than the national gap. Decomposing the ICT investment per worker gap will direct our investigation of measurement issues to the most important sources of the gap.

### A. Decomposition by Component

In 2011, business sector ICT investment per worker in Canada was 57.8 per cent of the U.S. level (after adjusting for PPP), at $2,237 per worker, compared to $3,931 per worker in the United States. However, investment per worker in computer per worker was 108.8 per cent the U.S. level, at $752 per worker, compared to $691 per worker in the United States. Investment per worker in communications equipment was 72.9 per cent of the U.S. level, while software investment, at $1,011 per worker, was 39.8 per cent the U.S. level. These data are summarized in Table 14, which also provides a decomposition of the difference in investment per worker by component.

**Table 14: Decomposition of the Canada-U.S. ICT Investment gap by Component, Canada and the United States, Business Sector, 2011**

| | Canada (U.S. dollars) | United States (U.S. dollar) | Canada relative to the United States (per cent) | Difference (U.S. dollars) | Relative contribution to gap (per cent) |
|---|---|---|---|---|---|
| | A | B | C = A/B | D = A - B | E = D/-1658 |
| **Computers** | 752 | 691 | 108.8 | 61 | -3.7 |
| **Software** | 1,011 | 2,540 | 39.8 | -1,529 | 92.2 |
| **Communications** | 510 | 700 | 72.9 | -190 | 11.5 |
| **Total** | 2,273 | 3,931 | 60.1 | -1,658 | 100.0 |

Source: Calculations based on CSLS ICT Investment Database Tables S1-4

Software investment is the largest component of ICT investment – in Canada, software investment was 48.5 per cent of total ICT investment in 2011, while in the United States it represented 64.5 per cent of total ICT investment.[10] The difference in software investment per

[10] Note that, since the Canada-U.S. ICT investment per worker gap is calculated by taking the Canadian per-worker level relative to the U.S. per-worker level, the U.S. shares across components are the weights for the relative contribution of each component to the total gap. This means that the software investment per-worker gap is weighted by the U.S.-share of software investment in ICT investment. The decomposition, however, is identical regardless of which country is used as the base.

worker accounted for 92.2 per cent of the gap, meaning that software investment is almost wholly responsible for Canada's low level of ICT investment per worker relative to the United States. This observation will motivate our investigation later in this report of the methods used to measure different types of software investment.

We perform the same calculation used to produce the decomposition in Table 14 for each year, which gives the absolute and relative contributions to the total ICT investment per worker gap for 1987 and 2000-2011. These contributions are shown in Table 15 and they show that, in 1987, the relative contribution of each component to the gap was very similar. There has been a consistent long-term trend beginning in 1995, as shown in Chart 13, which has concentrated the gap almost entirely in software in 2011.

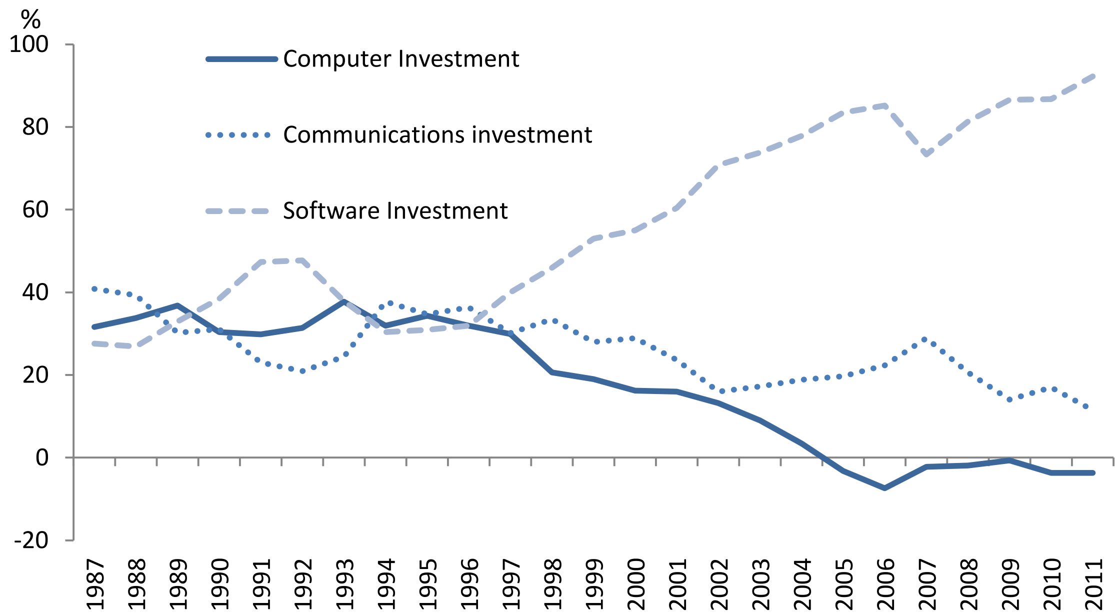
**Table 15: Absolute and Relative Difference Between ICT Investment per Worker in Canada and the United States by Component, Business Sector, 1987 and 2000-2011**

| | Total ICT | Computer | Communications | Software | Computer | Communications | Software |
|---|---|---|---|---|---|---|---|
| | Absolute difference between ICT investment per worker in Canada and the United States (U.S. dollars) | | | | Relative contribution to the total ICT investment per worker gap (per cent) | | |
| **1987** | -459 | -145 | -187 | -127 | 31.6 | 40.8 | 27.6 |
| **...** | | | | | | | |
| **2000** | -1,701 | -275 | -491 | -936 | 16.2 | 28.9 | 55.0 |
| **2001** | -1,509 | -242 | -356 | -911 | 16.0 | 23.6 | 60.4 |
| **2002** | -1,339 | -177 | -214 | -948 | 13.2 | 16.0 | 70.8 |
| **2003** | -1,361 | -123 | -234 | -1,004 | 9.0 | 17.2 | 73.8 |
| **2004** | -1,306 | -44 | -245 | -1,017 | 3.4 | 18.8 | 77.8 |
| **2005** | -1,161 | 37 | -228 | -969 | -3.2 | 19.7 | 83.5 |
| **2006** | -1,199 | 89 | -267 | -1,022 | -7.4 | 22.3 | 85.2 |
| **2007** | -1,346 | 30 | -389 | -986 | -2.2 | 28.9 | 73.3 |
| **2008** | -1,386 | 27 | -285 | -1,127 | -1.9 | 20.6 | 81.3 |
| **2009** | -1,700 | 11 | -238 | -1,473 | -0.7 | 14.0 | 86.6 |
| **2010** | -1,736 | 64 | -294 | -1,505 | -3.7 | 17.0 | 86.7 |
| **2011** | -1,658 | 61 | -190 | -1,529 | -3.7 | 11.5 | 92.2 |

Source: Appendix Table 3a

Note: Relative contribution of total ICT investment to the gap will always be 100 per cent.

**Chart 13: Relative Contribution to the Total ICT investment Per Worker Gap by Component, per cent, 1987-2011**




Source: Appendix Tables 1a-c, 2a-c, 3a

### i. Decomposition by type of software investment

Given the importance of software investment in the total Canada-U.S. ICT investment per worker gap, we devote this section to analyzing the software investment per worker gap by type of software. Statistics Canada's Input-Ouput tables contain estimates of investment in the three components of software: own-account, custom-designed, and pre-packaged software. This analysis is based on Input-Output (IO) estimates for 2009, and unpublished IO data for 1998-2008, which we received from Statistics Canada by request. We provide the detailed tables showing the relative proportion of the components of software investment in Canada and the United States in Table 16 and Table 17.

## Table 16: Software Investment by Type from Input-Output Tables for Canada, Business Sector, 1998-2009

| | Investment (millions of current dollars) | | | | Shares of total software (per cent) | | |
|---|---|---|---|---|---|---|---|
| | Total Software | Pre-packaged | Custom Design | Own Account | Pre-packaged | Custom Design | Own Account |
| **1998** | 8,961 | 2,518 | 3,942 | 2,405 | 28.4 | 44.5 | 27.1 |
| **1999** | 9,392 | 2,033 | 4,651 | 2,623 | 21.8 | 50.0 | 28.2 |
| **2000** | 9,984 | 1,984 | 4,697 | 2,733 | 21.1 | 49.9 | 29.0 |
| **2001** | 10,952 | 1,990 | 5,377 | 3,518 | 18.3 | 49.4 | 32.3 |
| **2002** | 10,552 | 1,969 | 5,044 | 3,213 | 19.3 | 49.3 | 31.4 |
| **2003** | 10,577 | 2,437 | 5,686 | 2,683 | 22.6 | 52.6 | 24.8 |
| **2004** | 11,593 | 2,528 | 6,515 | 2,946 | 21.1 | 54.3 | 24.6 |
| **2005** | 13,036 | 2,684 | 6,862 | 4,008 | 19.8 | 50.6 | 29.6 |
| **2006** | 13,263 | 2,588 | 7,170 | 4,283 | 18.4 | 51.1 | 30.5 |
| **2007** | 15,719 | 2,796 | 8,149 | 4,794 | 17.8 | 51.8 | 30.5 |
| **2008** | 16,191 | 2,553 | 8,722 | 4,919 | 15.8 | 53.9 | 30.4 |
| **2009** | 13,441 | 2,823 | 6,758 | 4,945 | 19.4 | 46.5 | 34.0 |

Source: CANSIM Table 031-0003 for total software (Fixed Capital Flows and Stocks); CANSIM Table 381-0023 for software components for 2009, unpublished data consistent with CANSIM Table 381-00023 for software components for 1998-2008 obtained from Statistics Canada (Input-Output Tables)

Note: Because data by software type treats margins and taxes slightly differently and classifies investment as business sector using different criteria from the estimates in the FCFS tables, the sum of investment by software type is not equal to total software. Shares are calculated as shares of the sum of software investment by type, not the share of total software.

## Table 17: Software Investment Components from Detailed Fixed Asset Tables for the United States, business sector, 1998-2009

| | Investment (millions of current dollars) | | | | Shares of total software (per cent) | | |
|---|---|---|---|---|---|---|---|
| | Total Software | General Purpose Software | Custom Software | Own Account Software | General Purpose Software | Custom Software | Own Account Software |
| **1998** | 125,994 | 42,864 | 45,185 | 37,945 | 34.0 | 35.9 | 30.1 |
| **1999** | 157,331 | 49,662 | 53,611 | 54,058 | 31.6 | 34.1 | 34.4 |
| **2000** | 184,453 | 54,683 | 63,925 | 65,845 | 29.6 | 34.7 | 35.7 |
| **2001** | 186,592 | 55,885 | 63,436 | 67,271 | 30.0 | 34.0 | 36.1 |
| **2002** | 183,040 | 60,260 | 56,490 | 66,290 | 32.9 | 30.9 | 36.2 |
| **2003** | 191,276 | 64,185 | 55,433 | 71,658 | 33.6 | 29.0 | 37.5 |
| **2004** | 205,677 | 68,903 | 57,192 | 79,582 | 33.5 | 27.8 | 38.7 |
| **2005** | 218,007 | 72,213 | 63,257 | 82,537 | 33.1 | 29.0 | 37.9 |
| **2006** | 229,783 | 73,172 | 69,551 | 87,060 | 31.8 | 30.3 | 37.9 |
| **2007** | 245,007 | 75,621 | 77,232 | 92,154 | 30.9 | 31.5 | 37.6 |
| **2008** | 257,217 | 76,575 | 83,438 | 97,204 | 29.8 | 32.4 | 37.8 |
| **2009** | 256,880 | 76,227 | 81,654 | 98,999 | 29.7 | 31.8 | 38.5 |

Source: BEA Detailed Fixed Asset Table 2.5

We note from these two tables that own-account software investment represents a similar share of software investment per worker in Canada and the United States, but Canada has a significantly greater share of investment in custom software, and a significantly smaller share in prepackaged software.

### Table 18: Software Investment per Worker by Component, Canada and the United States in current U.S. dollars, business sector, 1998-2009

| | Canada | | | | United States | | | |
|---|---|---|---|---|---|---|---|---|
| | Total Software | Prepackaged Software | Custom Software | Own Account Software | Total Software | Prepackaged Software | Custom Software | Own Account Software |
| 1998 | 601 | 171 | 267 | 163 | 1,132 | 385 | 406 | 341 |
| 1999 | 631 | 138 | 315 | 178 | 1,391 | 439 | 474 | 478 |
| 2000 | 630 | 133 | 315 | 183 | 1,604 | 475 | 556 | 572 |
| 2001 | 720 | 132 | 356 | 233 | 1,636 | 490 | 556 | 590 |
| 2002 | 671 | 129 | 331 | 211 | 1,641 | 540 | 506 | 594 |
| 2003 | 730 | 165 | 384 | 181 | 1,719 | 577 | 498 | 644 |
| 2004 | 835 | 176 | 454 | 205 | 1,824 | 611 | 507 | 706 |
| 2005 | 967 | 192 | 490 | 286 | 1,899 | 629 | 551 | 719 |
| 2006 | 1,000 | 184 | 510 | 305 | 1,966 | 626 | 595 | 745 |
| 2007 | 1,096 | 195 | 567 | 334 | 2,081 | 642 | 656 | 783 |
| 2008 | 1,089 | 172 | 587 | 331 | 2,217 | 660 | 719 | 838 |
| 2009 | 946 | 184 | 440 | 322 | 2,348 | 697 | 746 | 905 |
| **Canada relative to the United States (per cent)** | | | | | | | | |
| | Total Software | Prepackaged Software | Custom Software | Own Account Software | | | | |
| 1998 | 53.1 | 44.3 | 65.9 | 47.8 | | | | |
| 1999 | 45.3 | 31.4 | 66.5 | 37.2 | | | | |
| 2000 | 39.3 | 27.9 | 56.6 | 32.0 | | | | |
| 2001 | 44.0 | 26.9 | 64.0 | 39.5 | | | | |
| 2002 | 40.9 | 23.9 | 65.4 | 35.5 | | | | |
| 2003 | 42.5 | 28.6 | 77.1 | 28.2 | | | | |
| 2004 | 45.8 | 28.8 | 89.5 | 29.1 | | | | |
| 2005 | 50.9 | 30.4 | 88.8 | 39.8 | | | | |
| 2006 | 50.9 | 29.4 | 85.8 | 40.9 | | | | |
| 2007 | 52.7 | 30.3 | 86.5 | 42.7 | | | | |
| 2008 | 49.1 | 26.0 | 81.6 | 39.5 | | | | |
| 2009 | 40.3 | 26.4 | 59.0 | 35.6 | | | | |

Source: Author's calculations based on CSLS ICT Database Tables 1v, 9v, 18v, 26v, and S1; CANSIM Table 381-0023; and BEA Detailed Fixed Asset Table 2.5

Table 18 shows investment per worker in Canada and the United States in current U.S. dollars for each type of software investment, and their level relative to the United States. Custom software is the only software component for which the gap is not only smaller than the gap for software, but also smaller than the gap for total ICT investment per worker. In 2009, after adjusting for PPP, total ICT investment per worker in Canada was 54.0 per cent of the U.S. level, while custom software investment per worker was 59.0 per cent of the U.S. level. Furthermore, we note that custom software investment per worker fell abruptly in 2009, from 81.6 per cent of the U.S. level – this is worth further study after the Input-Output tables are next revised. Own-account software investment per worker was just 35.6 per cent of the U.S. level, while general purpose software investment per worker was just 26.4 per cent of the U.S. level, much further below the U.S. level than any other component of ICT investment.

Finally, we can perform our decomposition of the Canada-U.S. ICT investment per worker gap for 2009, as done in Table 14 for 2011, but this time including a second-order decomposition of software components. This is done in Table 19, including a new column for the relative contribution of each component of software investment to the software investment per worker gap.

### Table 19: Relative Contribution to the Canada-U.S. ICT Investment Per Worker Gap of Software Investment Components, 2009

| | Canada Investment per worker (PPP adjusted) | U.S. investment per worker | Canada relative to U.S. | Difference | Relative contribution to software investment per worker gap | Relative contribution to total ICT investment per worker gap |
|---|---|---|---|---|---|---|
| | A | B | C = A/B | D = A - B | E = D/-1473 | F = E/-1700 |
| Software | 875 | 2,348 | 37.3 | -1,473 | 100 | 86.6 |
| Own-account software | 323 | 919 | 35.1 | -597 | 40.5 | 35.1 |
| Custom | 568 | 746 | 76.10 | -178 | 12.1 | 10.5 |
| Pre-packaged | 166 | 697 | 23.9 | -531 | 36.0 | 31.2 |
| Computers | 662 | 651 | 101.7 | 11 | n.a. | -0.7 |
| Telecommunications equipment | 480 | 694 | 69.2 | -214 | n.a. | 12.6 |
| Total ICT | 1,993 | 3,693 | 54.0 | -1,700 | n.a. | 100.0 |

Source: Appendix Table 3a.

Note: The estimates of own-account software, custom software, and pre-packaged software come from the I/O Tables, which currently produce an estimate of total software investment somewhat greater than does the Fixed Capital Flows and Stocks Table, the source of the other estimates of ICT investment in this table. As a result, the relative contributions for software will sum to less than 100 per cent.

We note that based on these data, own-account software investment is responsible for fully 35.1 per cent on the total ICT investment per worker gap in 2009. Pre-packaged software makes a slightly smaller contribution of 31.2 per cent to the gap in 2009, despite exhibiting a much larger gap itself – the Canada-U.S. investment per worker gap for pre-packaged software was 74.6 percentage points in 2009, compared to a gap of 64.6 percentage points in own account software investment. The contribution of prepackaged software to the gap is below that of own account software despite this, because pre-packaged software represents a smaller share of software investment, as shown before in Table 16. The contribution of custom software is significantly smaller than is the contribution of the other two software components – at 10.5 per cent, its contribution is about the same as the contribution made by communications equipment investment per worker. As the measurement of own account software is a challenging methodological issue, we address this issue in-depth later in the section on measurement methodology.

## B. Decomposition by Industry of Total ICT Investment per Worker Gap

The ICT investment per worker gap can be decomposed by industry in Canada and the United States for a direct comparison between industries.[11] Furthermore, we can also compare the gap in each industry by ICT components to determine whether the large gap in software investment per worker is a persistent trend across industries, or whether it is concentrated in several particular industries.

We perform the industry composition for total ICT investment per worker twice, as we use two sets of data for industry-level comparisons. Our first decomposition is done using estimates from the Fixed Capital Flows and Stocks (FCFS) tables, which are missing data for many industries, particularly in recent years. Data availability in the FCFS tables is discussed in more detail in Appendix A. The second decomposition is done using data we have estimated for the missing industries, based primarily on ICT investment data from the Canadian Productivity Accounts (CPA).

The FCFS data are preferable because they provide the most recent estimates up to 2011 and allow us to decompose ICT investment into its three components. However, the FCFS industry data are limited by confidentiality restrictions in communications equipment investment, which prevent us from estimating total ICT investment in 13 out of 17 business sector industries in 2010 and 2011. The CPA data, on the other hand, by sacrificing investment data at the component level allows us to obtain coverage for all industries.

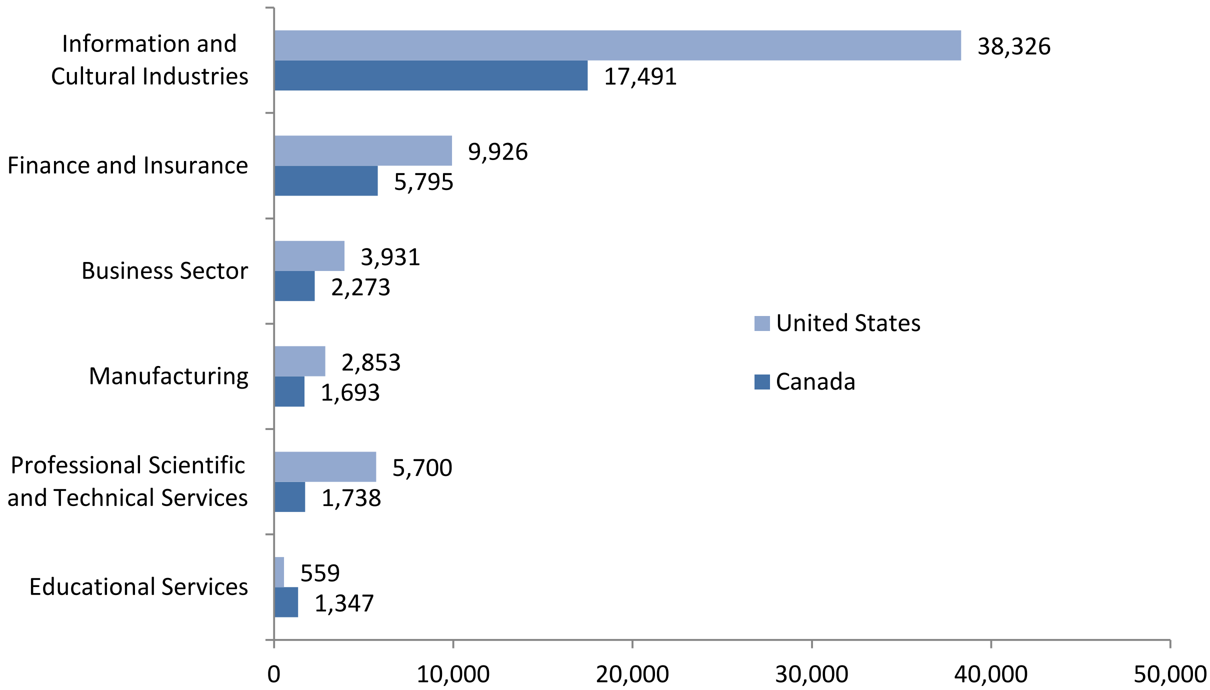
### i. Canada-U.S. Industry-level Comparisons Based on FCFS Data

Chart 14 shows total ICT investment per worker by industry in Canada and the United States for the five two-digit industries that we have data for in 2011. ICT investment per worker is greater in the United States by the largest amount in information and cultural industries[12]. In 2011, U.S. ICT investment per worker was $38,326 in this industry, compared to $17,491 in Canada after adjusting for PPP, making ICT investment per worker in Canada just 45.6 per cent of the U.S. level in information and cultural industries. The gap was also large in professional, scientific, and technical services, and finance and insurance.

[11] Statistics Canada's Fixed Capital Flows and Stocks program defines the business sector as all industries excluding health care and social assistance, educational services, and public administration. Consequently, investment by private establishments in health care is not captured in these data.

[12] Information and cultural industries include: publishing industries (except Internet); motion picture and sound recording industries; broadcasting (except Internet); telecommunications; data processing, hosting and related services; and other information services. In practice, ICT investment in broadcasting and telecommunications represents between 85 and 90 per cent of total ICT investment in information and cultural industries.

**Chart 14: Total ICT investment per worker by industry in Canada and the United States, current U.S. dollars, 2011**




Note : Industries without data for both Canada and the United States are not shown.
Source : CSLS ICT database Table S17

The industry-level data can be decomposed in the same way as the component contributions were, although the industry differences must be weighted by their relative employment in order to determine their contribution to the gap, shown in Table 20. We use the employment shares from the United States as weights for the relative contribution. The greatest contribution is in the category of information and cultural industries, which are responsible for 39.1 per cent of the gap despite accounting for only 2.4 per cent of employment. Professional, scientific, and technical services made the next largest contribution, at 22.3 per cent. These two industries together comprise nearly half of the gap in ICT investment per worker. Finance and insurance, and professional, scientific, and technical services are the only other industries estimated that make disproportional contributions to the gap.

**Table 20: Decomposition of Total ICT Investment per Worker Gap by Business Sector Industry, 2011**

| | ICT Investment per worker | | | | U.S. Employment shares (per cent) | Weighted contribution to the total ICT gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the United States (per cent) | Absolute Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/-1570 |
| **Business sector** | 2,273 | 3,931 | 57.8 | -1,570 | 100.00 | 100.00 |
| **Manufacturing** | 1,693 | 2,853 | 59.3 | -1,160 | 10.8 | 9.9 |
| **Information and cultural industries** | 17,491 | 38,326 | 45.6 | -20,835 | 2.4 | 39.1 |
| **Finance and insurance** | 5,795 | 9,926 | 58.4 | -4,131 | 5.0 | 16.3 |
| **Professional scientific and technical Services** | 1,738 | 5,700 | 30.5 | -3,962 | 7.1 | 22.3 |
| **Educational Services** | 1,347 | 559 | 241.0 | -559 | 9.8 | 0 |
| **Health care and social assistance** | n.a. | 630 | n.a. | -630 | 14.2 | 0 |
| **Total allocated** | | | | | 35.0 | 88.7 |
| **Unallocated (calculated as residual)** | | | | | 65.0 | 12.3 |

Source: Appendix Tables 6a-d.

Note: We assign a share of zero to health care and education for the purpose of the decomposition, as they are not included in the business sector in Canada, but still provide the data we have for these industries.

We can further see that these industries for which we have data collectively make a disproportional contribution to the gap based on their employment shares. They represent only 35.0 per cent of business sector employment in the United States, but account for 65.5 per cent of the Canada-U.S. ICT investment per worker gap. The remaining industries account for nearly two-thirds of business sector employment in the United States, and explain only a third of the gap.

Due to the lack of availability of 2011 estimates of communications investment for many industries, we also perform this decomposition for the 2009, in which six more business sector industries are available –the industries included in this decomposition comprise 82.0 per cent of industry employment in the United States, compared to 35.0 per cent in the previous decomposition. The results of this decomposition, shown in Table 21, agree broadly with the results of Table 20. Information and cultural industries remains the largest contributor to the gap after weighting by employment share in the United States. Finance and insurance and professional, scientific, and technical services are also the next largest contributors. The gap is somewhat less concentrated in these industries in 2009 compared to 2011, but other than that, the decomposition yields similar results.

## Table 21: Decomposition of Total ICT Investment per Worker Gap by Business Sector Industry, 2009

| | ICT Investment per Worker | | | | U.S. Employment shares (per cent) | Weighted contribution to the total ICT gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the United States (per cent) | Absolute Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/-1700 |
| **Business Sector** | 1,993 | 3,693 | 54.0 | -1,700 | 100.0 | 100.0 |
| **Agriculture Forestry Fishing and Hunting** | 311 | 192 | 162.1 | 119 | 1.9 | -0.1 |
| **Mining and Oil and Gas Extraction** | 1,240 | 5,430 | 22.8 | -4,190 | 0.7 | 1.6 |
| **Manufacturing** | 1,167 | 2,580 | 45.2 | -1,413 | 13.0 | 10.8 |
| **Wholesale Trade** | 2,576 | 5,037 | 51.1 | -2,461 | 3.5 | 5.0 |
| **Retail Trade** | 729 | 881 | 82.8 | -151 | 14.5 | 1.3 |
| **Information and Cultural Industries** | 16,530 | 30,742 | 53.8 | -14,212 | 3.0 | 24.8 |
| **Finance and Insurance** | 6,290 | 10,168 | 61.9 | -3,878 | 6.2 | 14.2 |
| **Real Estate Rental and Leasing** | 6,124 | 2,192 | 279.4 | 3,933 | 2.6 | -5.9 |
| **Professional Scientific and Technical Services** | 1,416 | 5,340 | 26.5 | -3,924 | 4.9 | 11.3 |
| **Educational Services** | 0 | 529 | 0.0 | -529 | 12.1 | 3.8 |
| **Health Care and Social Assistance** | 0 | 610 | 0.0 | -610 | 17.0 | 6.1 |
| **Arts Entertainment and Recreation** | 915 | 450 | 203.3 | 465 | 2.8 | -0.8 |
| **Total allocated** | | | | | 82.0 | 70.8 |
| **Unallocated (calculated as a residual)** | | | | | 28.0 | 29.2 |

Note: Weighted relative contribution is the difference in each industry relative to the business sector difference in total ICT investment per worker, weighted by the employment shares of that industry in the United States. Industries for which data were not available for both countries are omitted. Total allocated industries refer to the sum of the weighted relative contribution; unallocated industries are calculated as the residual. Investment in health care and educational services in Canada are treated as zero for the purpose of this decomposition, because the Fixed Capital Flows and Stocks program in Canada defines this investment as not occurring in the business sector

### ii. Canada-U.S. Industry-Level Comparisons Based on CPA Data

As mentioned earlier, Statistics Canada's Fixed Capital Flows and Stocks (FCFS) program, which is the main data source of the CSLS ICT Database, does not publish communications investment data for a number of industries due to confidentiality issues. For some industries, only estimates for recent years are missing, while for others the entire series is deemed confidential, even at the national level. This makes it difficult to accurately assess the role of individual industries on the Canada-U.S. ICT investment per worker gap. In the absence of communications equipment investment estimates for a particular industry, we cannot construct a total ICT investment estimate.

In order to circumvent this problem, the CSLS has constructed telecom and total ICT investment estimates for the missing industries using historical trends in industry-level ICT investment and a second official data source, Statistics Canada's Canadian Productivity Accounts (CPA). Broadly speaking, this was a two step process:

1. In the case of industries where telecom investment was missing only for the most recent years, we assumed that the share of telecom investment in total ICT investment remained at its average level in the past five years for which data were available. This allowed us to compute estimates for total ICT investment and telecom investment. In the case of agriculture, for instance, investment in computers and software represented, on average, approximately 85 per cent of total ICT investment in the 2005-2009 period. Assuming that this relationship held for 2010 and 2011, we were able to produce total ICT estimates for that industry and then, residually, construct estimates for telecom investment.

| Industries included in this case | Missing Data |
|---|---|
| **Agriculture, Forestry, Fishing and Hunting** | 2010-2011 |
| **Mining and Oil and Gas Extraction** | 2010-2011 |
| **Wholesale Trade** | 2010-2011 |
| **Retail Trade** | 2010-2011 |
| **Transportation and Warehousing** | 2007-2011 |
| **Management of Companies and Enterprises** | 2010-2011 |
| **Arts, Entertainment and Recreation** | 2009-2011 |

2. For industries which had no telecom investment data available, we used the total ICT investment series produced by Statistics Canada's Canadian Productivity Accounts (CPA) (CANSIM Table 383-0025). The CPA has total ICT investment data at the two-digit and three-digit NAICS industry level, up to 2008. Thus, for those particular industries, total ICT investment was assumed to be equal to the CPA estimate, and telecom investment was determined residually using computer and software investment estimates from the Fixed Capital Flow and Stocks series (CANSIM Table 031-0003). The industries included in this case are: utilities; construction; administrative support, waste management and remediation services; accommodation and food services; and other services.

Using these alternative estimates, we calculated the industry contributions to the Canada-U.S. ICT investment per worker gap in 2011. Although the estimates shown in Table 22 are slightly different from those in Table 20 and Table 21,[13] the two sets of estimates tell basically

[13] This difference is due to the two tables using different estimates for U.S. employment shares. The employment shares used here are calculated with industry-level CPS data and exclude health care and education services. This small adjustment makes them directly comparable to the Canadian employment shares (see Appendix Tables).

the same story. The industries that contributed the most to the gap were information and cultural industries, which explained 39.2 per cent of the gap, and professional services, which was responsible for 22.3 per cent of the gap. In the case of information and cultural industries, the level of ICT investment per worker in Canada (US$17,491) was less than half of the U.S. level (US$38,326). For professional services, the difference between the two countries was even greater: the Canadian level of ICT investment per worker was approximately a third of the U.S. level (US$1,738 versus $5,700).

### Table 22: Industry Contributions to the Canada-U.S. ICT Investment per Worker Gap, 2011

| | Employment Shares | | ICT Investment per Worker | | Difference Between Canada and U.S. | Industry Contributions to Canada-U.S. ICT Investment per Worker Gap | |
|---|---|---|---|---|---|---|---|
| | **Canada** | **United States** | **Canada** | **United States** | | | |
| | **A** | **B** | **C** | **D** | **E=C-D** | **F=(B/100)*E** | **$G=(E_{ind}/E_{tot})*100$** |
| | (per cent) | | (U.S. dollars) | | (U.S. dollars) | (U.S. dollars) | (per cent) |
| Business Sector | **100.0** | **100.0** | **2,273** | **3,931** | **-1,658** | **..** | **100.0** |
| **Agriculture** | 2.9 | 2.2 | 324* | 216 | 108 | 3 | -0.2 |
| **Mining and Oil** | 2.1 | 0.8 | 2,158* | 5,130 | -2,971 | -24 | 1.4 |
| **Utilities** | 1.1 | 1.2 | 11,892* | 5,853 | 6,040 | 74 | -4.5 |
| **Construction** | 9.7 | 8.9 | 230* | 248 | -19 | -2 | 0.1 |
| **Manufacturing** | 13.5 | 14.2 | 1,693 | 2,853 | -1,160 | -164 | 9.9 |
| **Wholesale Trade** | 4.9 | 3.8 | 3,510* | 5,834 | -2,324 | -87 | 5.3 |
| **Retail Trade** | 15.6 | 15.7 | 923* | 1,066 | -143 | -23 | 1.4 |
| **Transportation** | 6.5 | 5.9 | 2,220* | 1,095 | 1,125 | 66 | -4.0 |
| **Information Industries** | 2.9 | 3.1 | 17,491 | 38,326 | -20,835 | -649 | 39.1 |
| **Finance and Insurance** | 5.8 | 6.5 | 5,795 | 9,926 | -4,131 | -270 | 16.3 |
| **Real Estate** | 2.5 | 2.7 | 5,300* | 2,317 | 2,983 | 82 | -4.9 |
| **Professional Services** | 10.1 | 9.4 | 1,738 | 5,700 | -3,962 | -371 | 22.3 |
| **MCE** | 0.0 | 0.2 | 22,615* | 195,964 | -173,349 | -334 | 20.2 |
| **ASWMRS** | 5.1 | 6.1 | 1,464* | 3,173 | -1,710 | -104 | 6.3 |
| **Arts** | 3.0 | 2.9 | 1,232* | 415 | 818 | 24 | -1.4 |
| **Accommodation** | 8.4 | 9.7 | 320* | 116 | 204 | 20 | -1.2 |
| **Other Services** | 5.8 | 6.6 | 1,453* | 685 | 769 | 51 | -3.1 |

* These figures are CSLS estimates constructed using data from two different Statistics Canada series (Fixed Capital Flows and Stocks, CANSIM Table 031-0003, and Canadian Productivity Accounts, CANSIM Table 383-0025). For details on how these estimates were calculated, refer to Appendix Tables 10a-c.

Notes: 1) ASWMRS – Administrative and support, waste management and remediation services; MCE – Management of companies and enterprises; 2) Business sector is defined here as total economy minus public administration; health care and social assistance; and education. Source: CSLS calculations based on the CSLS ICT database.

Table 22 also highlights a number of important facts about the Canada-U.S. ICT investment gap in 2011:

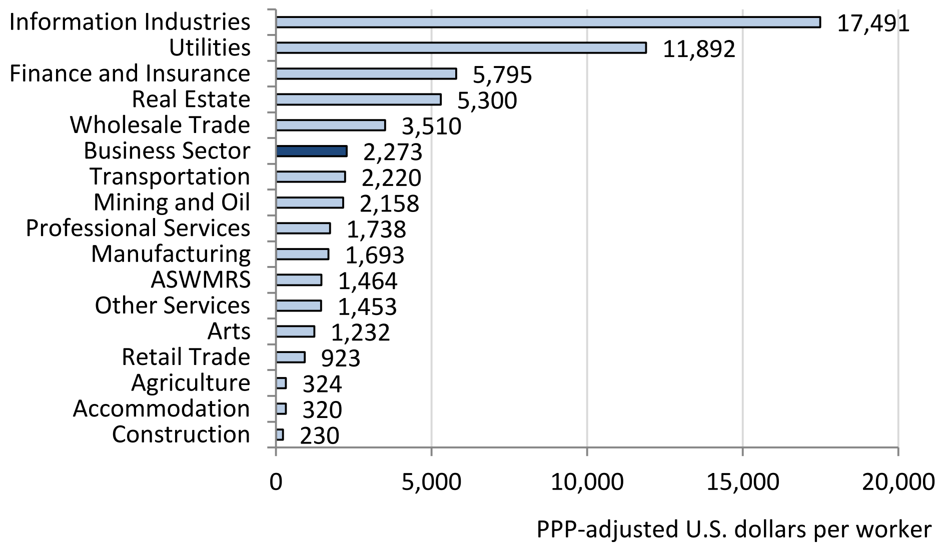
- There is a massive variation in ICT investment per worker at the two-digit NAICS level for both Canada (Chart 15) and the United States. Focusing our attention on Canada, the industry with the lowest level of ICT investment per worker is construction ($230), while the industry with the highest level is information and cultural industries ($17,491) (note that we are excluding MCE). Because of the very high values in some industries, the business sector average ($2,273) is actually higher than the levels of 11 industries (out of a total of 16). As noted earlier, these industries drive the gap.

- The extremely high level of ICT investment per worker in management of companies and enterprises (MCE) in both countries is an allocation issue, and thus quite misleading. MCE investment represents investments made by head offices. In reality, a significant part of that investment will be assigned to activities other than MCE, which means that MCE investment is actually investment used by other industries. In the United States, even more so than in Canada, MCE investment is overestimated, producing an extremely large (and implausible) gap between MCE ICT investment in the two countries.

- For two-digit NAICS industries, there is a large variation in the Canada-U.S. relative levels of ICT investment per worker, which range from 30.5 per cent in the case of professional, scientific and technical services to 297.4 per cent in the case of arts, entertainment and recreation. In 6 industries, Canada's ICT investment per worker levels were more than double of the U.S. levels (Chart 16).

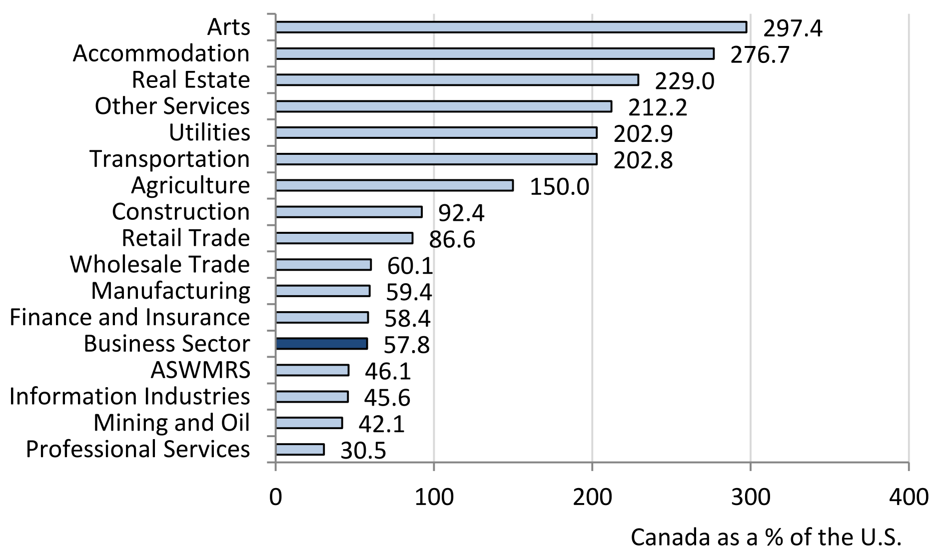
- Although the Canada-U.S. relative level of ICT investment per worker for the business sector was 57.8 per cent, only four out of 17 industries had relative levels below the business sector average. Two of these industries were, however, ICT-intensive industries: information and cultural industries, where Canada's ICT investment per worker level relative to the U.S. was 45.6 per cent; and professional, scientific and technical services were the Canada-U.S. relative was only 30.5 per cent.

### Chart 15: ICT Investment per Worker by Industry in Canada, 2011




Note: ASWMRS – Administrative and support, waste management and remediation services.
Source: CSLS calculations based on the CSLS ICT database.

### Chart 16: ICT Investment per Worker in Canada as a Share of the United States, 2011




Note: ASWMRS – Administrative and support, waste management and remediation services.
Source: CSLS calculations based on the CSLS ICT database.

## C. Decomposition by Industry of Computer Investment per Worker

As previously shown, this is the only component of ICT investment with a greater level of investment per worker in Canada. Computer investment per worker in Canada actually exceeds that of the United States in 10 out of 17 business sector industries. Table 23 shows that

Canada has substantially greater computer investment per worker in utilities ($3,571), transportation and warehousing ($581), real estate rental and leasing ($1,957), arts, entertainment, and recreation ($401), and accommodation and food services ($132). However, information and cultural industries, finance and insurance, and professional, scientific, and technical services - all industries with larger shares of ICT investment and business sector employment - are significantly below the U.S. level of computer investment per worker. This means that the computer investment per worker in Canada is only slightly greater than it is in the United States, even though ICT investment per worker in several industries is substantially above the U.S. level.

We perform the same decomposition for computer investment per worker as done previously for total ICT; the decomposition is shown in Table 23. There are no unallocated industries and, unlike the rest of ICT investment, the gap is positive (i.e., computer investment per worker is greater in Canada), so a positive relative contribution means that an industry performs better than the United States on the basis of computer investment per worker.

The decomposition (column F) yields the result we would expect based on the estimated gaps by industry (column C) – industries with a large absolute gap tend to make a large relative contribution to the gap. Manufacturing and real estate rental and leasing make large contributions to the gap. It is worth noting that many industries are being estimated to make offsetting contributions. This is not the case for our analysis of the remaining components of ICT investment.  The precise figures are secondary to the observation that three industries are largely responsible for Canada's strong performance in computer investment per worker.

**Table 23: Decomposition of Computer Investment per Worker Gap by Industry, 2011**

| | Investment per worker | | | | Industry employment shares for the United States (per cent) | Weighted contribution to the computer investment per worker gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the U.S. (per cent) | Absolute Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/61 |
| **Business Sector** | 752 | 691 | 108.8 | 61 | 100.00 | 100.0 |
| **Agriculture Forestry Fishing and Hunting** | 167 | 68 | 244.3 | 99 | 1.7 | 3.6 |
| **Mining and Oil and Gas Extraction** | 959 | 683 | 140.4 | 276 | 0.6 | 3.7 |
| **Utilities** | 4,372 | 801 | 545.6 | 3,571 | 0.9 | 72.1 |
| **Construction** | 175 | 90 | 193.8 | 85 | 6.8 | 12.5 |
| **Manufacturing** | 612 | 435 | 140.9 | 178 | 10.8 | 41.4 |
| **Wholesale Trade** | 836 | 1,250 | 66.8 | -415 | 2.9 | -25.6 |
| **Retail Trade** | 375 | 325 | 115.6 | 51 | 12.0 | 13.1 |
| **Transportation and Warehousing** | 804 | 224 | 359.4 | 581 | 4.5 | 56.2 |
| **Information and Cultural Industries** | 2,410 | 3715 | 64.9 | -1,305 | 2.4 | -66.8 |
| **Finance and Insurance** | 1,721 | 2262 | 76.1 | -541 | 5.0 | -58.1 |
| **Real Estate Rental and Leasing** | 2,905 | 948 | 306.3 | 1957 | 2.1 | 88.1 |
| **Professional Scientific and Technical Services** | 988 | 1,389 | 71.1 | -401 | 7.1 | -61.7 |
| **Management of Companies and Enterprises** | 8,775 | 18,821 | 46.6 | -10,046 | 0.1 | -31.8 |
| **Administrative and Support** | 679 | 467 | 145.2 | -98 | 4.6 | 21.1 |
| **Educational Services** | 370 | 110 | 0.0 | -110 | 9.7 | .. |
| **Health Care and Social Assistance** | 156 | 170 | 0.0 | -170 | 14.2 | .. |
| **Arts Entertainment and Recreation** | 532 | 131 | 406.6 | 401 | 2.2 | 19.0 |
| **Accommodation and Food Services** | 175 | 43 | 405.3 | 132 | 7.3 | 21.0 |
| **Other Services (except Public. Admin.)** | 342 | 201 | 170.1 | 141 | 5.1 | 15.4 |

Source: Appendix Table 7d.

Note: We assign a share of zero to health care and education for the purpose of the decomposition, as they are not included in the business sector in Canada, but still provide the data we have for these industries.

## D. Decomposition by Industry of Communications Equipment Investment per Worker

Table 24 provides a comparison of communications investment per worker by industry in Canada and the United States in 2011 – as previously noted, communications equipment investment is only available for six industries, two of which (educational services and public administration) are entirely or almost entirely public sector industries and therefore not part of the Canadian business sector. Since data for so many industries are missing, we cannot fully understand the gap in communications equipment investment per worker. We do note that, with the exception of educational services which is not in the business sector, communications equipment investment per worker was lower in Canada than the United States in all industries.

**Table 24: Decomposition of Communications Investment Per worker in Canada and the United States, Current U.S. dollars, 2011**

| | Communications equipment investment per worker | | | | Industry employment shares for the United States (per cent) | Weighted contribution to the communications investment per worker gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the U.S. (per cent) | Absolute Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/-190 |
| **Business Sector** | 510 | 700 | 72.9 | -190 | 100.0 | 100.0 |
| **Manufacturing** | 97 | 293 | 33.1 | -196 | 10.8 | 14.6 |
| **Information and Cultural Industries** | 12,025 | 14,243 | 84.4 | -2,218 | 2.4 | 36.4 |
| **Finance and Insurance** | 322 | 992 | 32.4 | -670 | 5.0 | 22.9 |
| **Professional Scientific and Technical Services** | 118 | 382 | 30.8 | -265 | 7.1 | 20.7 |
| **Educational Services** | 97 | 51 | 191.2 | -51 | 9.8 | 0.0 |
| **Total allocated** | | | | | 35.0 | 94.6 |
| **Unallocated (calculated as residual)** | | | | | 65.0 | 5.4 |

Note: We assign a share of zero to health care and education for the purpose of the decomposition, as they are not included in the business sector in Canada, but still provide the data we have for these industries. Relative contributions do not sum up to 100 per cent due to missing data.

However, as is the case for total ICT investment, we can examine the communications equipment investment per worker gap for 2009, in which we have data for six more business sector industries in Canada (Table 25). The decomposition yields similar results to our findings for total ICT investment per worker – the industry with the greatest contribution to the gap is information and cultural industries, despite communications equipment investment per worker being greater in this industry than in the Canadian business sector. The contribution is large despite performing better than most industries because the U.S. level of communications equipment investment per worker is also very high in this industry.

**Table 25: Decomposition of the Canada-U.S. Communications Equipment Investment Per Worker, 2009**

| | Communications equipment investment per worker | | | | Industry employment shares for the United States (per cent) | Weighted contribution to the communications investment per worker gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the U.S. (per cent) | Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/-238 |
| **Business Sector** | 456 | 694 | 65.7 | -238 | 100.0 | 100.0 |
| **Agriculture Forestry Fishing and Hunting** | 49 | 63 | 77.1 | -14 | 1.9 | 0.1 |
| **Mining and Oil and Gas Extraction** | 224 | 1,218 | 18.4 | -994 | 0.7 | 2.7 |
| **Manufacturing** | 64 | 297 | 21.6 | -233 | 13.0 | 12.7 |
| **Wholesale Trade** | 128 | 245 | 52.2 | -117 | 3.5 | 1.7 |
| **Retail Trade** | 31 | 124 | 25.2 | -93 | 14.5 | 0.0 |
| **Information and Cultural Industries** | 11,363 | 13,220 | 86.0 | -1857 | 3.0 | 23.1 |
| **Finance and Insurance** | 377 | 1,063 | 35.5 | -686 | 6.2 | 18.0 |
| **Real Estate Rental and Leasing** | 289 | 775 | 37.4 | -485 | 2.6 | 5.2 |
| **Professional Scientific and Technical Services** | 103 | 381 | 27.0 | -278 | 4.9 | 5.7 |
| **Educational Services** | n.a. | 51 | 191.2 | -51 | 12.1 | 2.6 |
| **Health Care and Social Assistance** | n.a. | 80 | 0.0 | -80 | 17.0 | 5.7 |
| **Arts Entertainment and Recreation** | 78 | 153 | 50.8 | -75 | 2.8 | 0.9 |
| **Total allocated** | | | | | 82.0 | 78.4 |
| **Unallocated** | n.a. | | | | 28.0 | 21.6 |

Note: Weighted relative contribution is the difference in each industry relative to the business sector difference in total ICT investment per worker, weighted by the employment shares of that industry in the United States. Industries for which data was not available for both countries are omitted. Total allocated industries refer to the sum of the weighted relative contribution; unallocated industries is a residual. Data does not sum to 100.0 per cent because business sector employment is less than total industry employment. Health care and education are entered as zero for Canada as this investment does not occur in the business sector.

## E. Decomposition by Industry of Software Investment per Worker

Our main finding from the previous decompositions by industry is that information and cultural industries makes the largest contribution to the Canada-U.S. ICT investment per worker gap; our decomposition of software investment per worker is consistent with this finding. Industries that were found to be drivers of the total ICT investment per worker gap are generally found to be the drivers of the software investment per worker gap as well. The exception is real estate rental and leasing, which again has greater software investment per worker in Canada than the United States in 2011.

Software investment per worker in information and cultural industries was $20,368 in the United States in 2011, while it was just $3,055 in Canada. Software investment per worker in Canada relative to the United States was just 15.0 per cent in this industry, compared to 39.8 per cent across all industries. Perhaps surprisingly, given Canada's overall low level of software investment per worker, we find that software investment per worker was significantly greater in Canada than in the United States in seven industries: utilities; transportation and warehousing; real estate rental and leasing; educational services;[14] arts, entertainment, and recreation services; and accommodation and food services.

As software investment is the most important ICT component to the gap by far, contributing 92.2 per cent in total, it is important to determine in which industry this gap is the greatest. We therefore follow the same methodology used to decompose the ICT investment per worker gap by component. This is reported in Table 26.

[14] This figure will include non-business sector investment in Canada, so this is not a perfect comparison. Educational services are also almost entirely public in Canada, while there is significant private activity in education services in the United States.

## Table 26: Decomposition of Software Investment Per Worker by Industry, 2011

| | Communications equipment investment per worker | | | | Industry employment shares for the United States (per cent) | Weighted contribution to the communications investment per worker gap (per cent) |
|---|---|---|---|---|---|---|
| | Canada (current U.S. dollars) | United States (current U.S. dollars) | Canada relative to the U.S. (per cent) | Difference | | |
| | A | B | C = A/B | D = A - B | E | F = E x D/-1529 |
| **Business Sector** | 1,011 | 2,540 | 39.8 | -1,529 | 100.00 | 100.0 |
| **Agriculture Forestry Fishing and Hunting** | 108 | 77 | 141.1 | 32 | 1.69 | 0.0 |
| **Mining and Oil and Gas Extraction** | 984 | 3,366 | 29.2 | -2,382 | 0.61 | 1.1 |
| **Utilities** | 5,737 | 4,133 | 138.8 | 1,604 | 0.93 | -1.1 |
| **Construction** | 37 | 101 | 36.4 | -65 | 6.80 | 0.3 |
| **Manufacturing** | 984 | 2,126 | 46.3 | -1,142 | 10.78 | 9.0 |
| **Wholesale Trade** | 2,499 | 4,310 | 58.0 | -1,811 | 2.86 | 3.8 |
| **Retail Trade** | 502 | 605 | 82.9 | -103 | 11.97 | 0.9 |
| **Transportation and Warehousing** | 1,194 | 473 | 252.6 | 721 | 4.48 | -2.4 |
| **Information and Cultural Industries** | 3,055 | 20,368 | 15.0 | -17,313 | 2.37 | 30.1 |
| **Finance and Insurance** | 3,752 | 6,672 | 56.2 | -2,920 | 4.97 | 10.7 |
| **Real Estate Rental and Leasing** | 2,130 | 566 | 376.4 | 1,564 | 2.08 | -2.4 |
| **Professional Scientific and Technical Services** | 633 | 3,929 | 16.1 | -3,296 | 7.11 | 17.2 |
| **Management of Companies and Enterprises** | 13,275 | 171,431 | 7.7 | -158,156 | 0.15 | 17.0 |
| **Administrative and Support** | 639 | 2,368 | 27.0 | -1,730 | 4.63 | 5.9 |
| **Educational Services** | 339 | 398 | 221.0 | -398 | 9.75 | .. |
| **Health Care and Social Assistance** | 578 | 381 | 88.9 | -381 | 14.21 | .. |
| **Arts Entertainment and Recreation** | 578 | 150 | 386.2 | 428 | 2.20 | -0.7 |
| **Accommodation and Food Services** | 112 | 41 | 277.3 | 72 | 7.35 | -0.4 |
| **Other Services (except Public. Admin.)** | 452 | 325 | 138.9 | 126 | 5.06 | -0.5 |

Source: Appendix Table 9a-d

Notes: Weighted relative contribution is the difference in each industry relative to the business sector difference in total ICT investment per worker, weighted by the employment shares of that industry in the United States. Industries for which data was not available for both countries are omitted. Education and health care in Canada are treated as zero for the decomposition as in the previous tables, and we also provide the value of investment per worker in those industries for informational purposes. Finally, the relative weighted contribution will not sum to 100 per cent exactly, as we use only the U.S. employment weights to calculate the contribution, but the total gap depends on a blend of U.S. and Canadian employment and ICT component shares. U.S. employment is simply the most important of these weights.

The decomposition from Table 26 shows that the industries for which Canadian software investment per worker in 2011 was substantially greater than the U.S. level make small negative contributions to the gap, while industries with a large gap had a very large impact after being weighted by employment. Despite a 2.4 per cent employment share, information and cultural industries was responsible for 30.1 per cent of the software investment per worker gap; this is a very disproportionate contribution, and the single largest contribution of any industry to the gap in software investment per worker. We also find large contributions in professional, scientific, and technical services. The large contribution to the software investment per worker gap of information and cultural industries and professional, scientific, and technical services is consistent with our analysis of the other two components of ICT; for both of those components, these industries also performed the worst.

Additionally, we note that not only is the software investment per worker heavily concentrated in a few industries, but software investment per worker in Canada is actually greater in seven out of 17 industries. This is an extremely important finding. It means that the Canada-U.S. ICT investment per worker gap is not the result of a broad, macroeconomic phenomenon, but instead is primarily the result of industry-level differences in software investment.

## F. Decomposition by Province

Decomposing the ICT investment per worker gap by province will allow us to identify which provinces make the greatest contribution to the ICT investment per worker gap, and determine whether provinces are contributing proportionally to the gap by their size. Provincial data for ICT investment are not available at the business sector level, so we compare ICT investment per worker in the total economy in Canada and the provinces to the U.S. business sector. As such, these data are not strictly comparable; the Canadian total economy has lower levels of investment per worker than the Canadian business sector, on average; we would expect the same to be true of the United States, so these figures overstate slightly the extent of the gap by province.

**Table 27: ICT investment Per Worker for Canadian provinces and the United States, 2011**

| | ICT Investment per worker (current U.S. dollars) | Relative to U.S. business sector investment per worker (per cent) |
|---|---|---|
| **Business Sector (United States)** | 3,931 | 100.0 |
| **Business Sector (Canada)** | 2,273 | 57.8 |
| **Non-Business Sector (Canada)** | 1,912 | 48.7 |
| **Total Economy (Canada)** | 2,184 | 55.6 |
| **NFLD** | n.a. | n.a. |
| **PEI** | n.a. | n.a. |
| **NS** | 1,908 | 48.5 |
| **NB** | n.a. | n.a. |
| **QC** | 1,926 | 49.0 |
| **ON** | 2,418 | 61.5 |
| **MN** | 1,571 | 40.0 |
| **SK** | 2,204 | 56.1 |
| **AB** | 2,370 | 60.3 |
| **BC** | 1,838 | 46.8 |

Source: Author's calculations based on CANSIM Tables 282-0008, 031-0003, and 031-0004

Note: Telecommunications investment for Newfoundland, Prince Edward Island, and New Brunswick was suppressed by Statistics Canada for the years 2010 and 2011, so total ICT investment cannot be computed. All figures for the provinces are for total economy. Converted to U.S. dollars using PPP for M&E.

The relevant measure from Table 28 is whether or not a province's gap is above or below the national gap; this indicates whether the province is bringing the gap up or down. The ICT investment gap per worker is somewhat smaller for Ontario and Alberta, while all other provinces have significantly lower ICT investment per worker relative to the U.S. business sector than does Canada as a whole. The gap is particularly large in Manitoba, British Columbia, and Nova Scotia; the large gap in Nova Scotia suggests that the gap would likewise be large for Prince Edward Island and New Brunswick, two provinces for which this calculation is not possible.

We also decompose the ICT investment per worker gap by province to determine whether the provinces contribute proportionally to the ICT investment per worker gap. Note that, as in the case of the decomposition by industry, a province with a below-average gap still contributes to the gap in absolute dollar terms, as long as its level of ICT investment per worker is below the level of the United States. This decomposition, shown in Table 28, is performed for 2011 in current dollars for the total economy, as those are the only estimates available at the provincial level. This is compared to the gap between the Canadian total economy and U.S. business sector, weighted by each province's share of employment, and reported only for those provinces where total ICT investment per worker is known.

### Table 28: Decomposition of Total ICT Investment per Worker by Province, Current Dollars, Total economy, 2011

| | ICT investment per worker (PPP adjusted) | Difference between U.S. level | Share of total employment | Contribution (per cent) |
|---|---|---|---|---|
| | A | B | C | D = B/-1747 x C |
| **NS** | 1,908 | -2,023 | 2.66 | 3.08 |
| **QUE** | 1,915 | -2,016 | 22.92 | 26.45 |
| **ON** | 2,536 | -1,395 | 39.05 | 31.18 |
| **MN** | 1,536 | -2,395 | 3.53 | 4.84 |
| **SK** | 1,944 | -1,987 | 2.96 | 3.37 |
| **AB** | 2,374 | -1,557 | 11.85 | 10.56 |
| **BC** | 1,766 | -2,165 | 13.14 | 16.29 |
| **Other provinces** | | | 3.90 | 4.24 |
| **Canada** | 2,184 | -1,747 | 100 | 100.00 |

Source: Author's calculations based on CANSIM Tables 031-0003, 031-0004, and 282-0010

The results of the decomposition in Table 28 are unsurprising, and consistent with our expectations. Table 28 shows that Ontario, the province with the greatest share of employment, also makes the largest absolute contribution to the gap. However, the relevant measure is not whether its relative contribution is the greatest of all provinces, but whether it is greater or lesser than its share of employment. On this measure, it is clear that Ontario performs quite well – its contribution to the gap is nearly 8 percentage points below its share of ICT investment. Alberta is the only other province that had a contribution to the gap smaller than its employment in 2011. The contribution of all other provinces to the gap is greater than their share of ICT investment. Furthermore, though we do not know what total ICT investment is in the unreported provinces of New Brunswick, Prince Edward Island, and Newfoundland, we do note that the unallocated contribution to the gap is somewhat greater than the unallocated share of employment.

Provincial ICT investment can also be decomposed into its components of computers, software, and communications equipment, as shown in Table 29. The provincial decomposition reflects the overall trend of software investment exhibiting the largest gap, and computer investment per worker roughly equal across the two countries. About half of Canadian provinces have greater levels of computer investment per worker than the United States, while the remainder have a level of computer investment per worker below the United States by varying amounts. Quebec, Saskatchewan, and British Columbia are fairly close to the U.S. level, while the Maritime Provinces are substantially below the U.S. level of computer investment per worker.

**Table 29: ICT Investment per Worker in Canada and the Provinces Relative to U.S. by Component, Total Economy, 2011**

| | Investment per worker (current CAD per worker) | | | Relative to the U.S. (per cent, PPP adjusted) | | |
|---|---|---|---|---|---|---|
| | Computers | Communications Equipment | Software | Computers | Communications Equipment | Software |
| **Canada** | 650 | 434 | 1,099 | 94.2 | 92.6 | 46.6 |
| **NFLD** | 659 | n.a. | 541 | 95.5 | n.a. | 22.9 |
| **PEI** | 464 | n.a. | 930 | 67.2 | n.a. | 39.4 |
| **NS** | 583 | 675 | 648 | 84.5 | 144.1 | 27.5 |
| **NB** | 521 | n.a. | 750 | 75.4 | n.a. | 31.8 |
| **QC** | 660 | 308 | 957 | 95.6 | 65.7 | 40.5 |
| **ON** | 667 | 428 | 1,322 | 96.6 | 91.3 | 56.0 |
| **MN** | 579 | 458 | 532 | 83.9 | 97.7 | 22.6 |
| **SK** | 636 | 799 | 767 | 92.2 | 170.6 | 32.5 |
| **AB** | 734 | 425 | 1,209 | 106.4 | 90.7 | 51.2 |
| **BC** | 546 | 433 | 858 | 79.1 | 92.5 | 36.3 |

Source: Author's calculations based on CANSIM Tables 282-0008, 282-0010, 031-0003, 031-0003, and CSLS ICT Database

Note: Telecommunications investment for Newfoundland, Prince Edward Island, and New Brunswick was suppressed by Statistics Canada for the years 2009, 2010, and 2011, and so total ICT investment cannot be computed.

Most provinces have lower levels of communications investment per worker than the United States, and no province does particularly well in the category of software investment. Curiously, Saskatchewan is well above the U.S. level of investment in communications equipment per worker, despite being far below the U.S. level overall. Since software is the greatest contributor to the gap, the differences between provinces are a relatively small factor compared to the overall phenomenon of software investment per worker in Canada being dramatically below the U.S. level.

# III. Proximate Causes of the Canada-U.S. ICT Investment per Worker Gap

There are important differences between the Canadian and U.S. economies which have led, directly or indirectly, to the greater level of ICT investment per worker in the United States. These differences are measurable and their effect on the gap, holding all else constant, is also measurable. We identify two such features of the two economies, labour productivity and industrial structure, and provide estimates of their affect on the gap.

Note that, as is the case for most economic variables, it is not strictly correct to claim that either labour productivity or industrial structure are causal factors of the gap based on the analysis in this section. It is likely true that, to some extent, ICT investment per worker is also a causal factor of Canada's lower labour productivity and industrial structure. However, we do believe that each variable is related to ICT investment, and we would expect, for example, that policies designed to improve labour productivity will also be likely to improve ICT investment per worker, just as policies designed to improve ICT investment per worker will be likely to improve labour productivity.

## A. Labour Productivity

Labour productivity is an important determinant of income per capita, which in turn affects ICT investment per worker. In this sense, differences in labour productivity explain part of the Canada-U.S. ICT investment per worker gap. Holding constant ICT investment as a share of GDP, a country with higher labour productivity (defined here as PPP-adjusted nominal GDP per worker)[15] will have a higher level of ICT investment per worker compared to a country with a lower labour productivity level. A stylized example can help clarify why this happens.

For simplicity, we compare two countries, X and Y, with country Y having twice the labour productivity level of country X. Assuming, initially, that ICT investment as a share of GDP is the same in both countries, Table 30 (Panel A) shows that Country X's level of ICT investment per worker is only half of country Y's level. This difference in ICT investment per worker levels, i.e. the ICT gap, is explained *entirely* by the labour productivity differential between the two countries. The high level of labour productivity in country Y means that a single worker will generate more GDP per capita. This, in turn, leads to more ICT investment per worker for a given ICT investment share of GDP, since the absolute level of ICT investment is determined by the absolute level of GDP.[16]

[15] The reader should keep in mind that labour productivity levels are sometimes defined in real terms – either as real GDP per hour worked or real GDP per worker. In this section, however, we defined it in nominal terms because we are interested in the *level* of nominal income being generated per worker.

[16] Note that, if the greater income per capita had been generated solely by country Y having a higher employment share (compared to country X), both countries would have the same ICT investment per worker level, because the effect of the higher income per capita in country Y would be completely offset by the higher employment share (i.e., employment increases proportionately to the increase in income per capita).

### Table 30: Effect of Labour Productivity Differences on the ICT Gap, Stylized Example

**A) Same ICT shares of GDP; different labour productivity levels**

| | | Country X | Country Y | Country X / Country Y |
|---|---|---|---|---|
| | | | | (per cent) |
| (i) | GDP | 100 | 400 | 25 |
| (ii) | ICT Investment | 5 | 20 | 25 |
| (iii) | Workers | 2 | 4 | 50 |
| (iv)=(ii)/(i) | ICT Investment as a Share of GDP | 5.0% | 5.0% | 100 |
| (v)=(i)/(iii) | Labour Productivity | 50 | 100 | 50 |
| **(vi)=(ii)/(iii)** | **ICT Investment per Worker** | **2.5** | **5.0** | **50** |

**B) Different ICT shares of GDP; different labour productivity levels**

| | | Country X | Country Y | Country X / Country Y |
|---|---|---|---|---|
| | | | | (per cent) |
| (i) | GDP | 100 | 400 | 25 |
| (ii) | ICT Investment | 4 | 20 | 20 |
| (iii) | Workers | 2 | 4 | 50 |
| (iv)=(ii)/(i) | ICT Investment as a Share of GDP | 4.0% | 5.0% | 80 |
| (v)=(i)/(iii) | Labour Productivity | 50 | 100 | 50 |
| **(vi)=(ii)/(iii)** | **ICT Investment per Worker** | **2.0** | **5.0** | **40** |

**C) Effect of Labour Productivity Differences on the ICT Gap**

| | | | Panel A | Panel B |
|---|---|---|---|---|
| (i) | Relative Level of ICT Investment per Worker | (per cent) | 50 | 40 |
| (ii) | Labour Productivity Ratio | (ratio) | 2 | 2 |
| (iii)=(ii)*(i) | Adjusted Relative Level of ICT Investment per Worker | (per cent) | 100 | 80 |
| (iv)=(iii)-(i) | Part of the Gap Explained by Labour Productivity Differential | (percentage points) | 50 | 40 |
| **(v)=100-(iii)** | Part of the Gap Explained by Differences in the ICT share of GDP | (percentage points) | 0 | 20 |

In practice, however, it is unlikely that both countries will have the same level of ICT investment as a share of GDP. When the shares differ, only *part* of the overall ICT gap will be explained by the labour productivity differential between the two countries. Table 30 (Panel B) describes this scenario, with country X investing less on ICT. Now, the ICT gap is explained by two (proximate) factors: differences in labour productivity and differences in the ICT investment share. Can we disentangle the two effects?

A straightforward way to separate the two effects is adjusting the ICT gap by the labour productivity ratio between the two countries (Table 32, Panel C). By doing this, we are measuring what the relative level of ICT investment per worker would be *if* both countries had the same labour productivity level. Thus, the adjusted ICT gap now reflects only differences in the ICT investment share between countries X and Y. In our example in Panel B, adjusting the country X-country Y relative level of ICT investment per worker by the labour productivity ratio increased the level from 50 per cent to 80 per cent. We can thus infer that this labour productivity differential accounted for 30 percentage points of the ICT gap, with differences in ICT shares accounting for the remaining 20 points of the gap.

An important limitation of the decomposition described above is that its accuracy depends on: 1) the labour productivity ratio between the two countries $\left(\frac{LP_{US}}{LP_{CAN}}\right)$ being fairly close to one; 2) the ratio of ICT investment as a share of GDP between the two countries $\left(\frac{ICT\_S_{US}}{ICT\_S_{CAN}}\right)$ being close to one. The reason for this is that the relationship between these two ratios and the relative level of ICT investment per worker $\left(\frac{ICT\_W_{CAN}}{ICT\_W_{US}}\right)$ is *multiplicative*:

$$\left(\frac{LP_{US}}{LP_{CAN}}\right) * \left(\frac{ICT\_S_{US}}{ICT\_S_{CAN}}\right) * \left(\frac{ICT\_W_{CAN}}{ICT\_W_{US}}\right) = 1$$

When the ratios are close to one, however, the relationship becomes *approximately* additive.[17]

With the stylized example described above in mind, we can now turn to the actual Canada-U.S. ICT investment per worker gap. Panels A and B in Table 31 provide details on business sector GDP, ICT investment, workers, as well as a number of ratios, for Canada and the United States during the 1987-2011 period. The Canadian GDP and ICT investment estimates are PPP adjusted, so as to make them directly comparable to the U.S. figures. Using data from these two panels, panel C presents the Canada-U.S. labour productivity ratios; the ratios of ICT investment as a share of GDP; the Canada-U.S. relative level of ICT investment per worker (both actual and adjusted by the labour productivity ratio); and the overall contribution of the Canada-U.S. labour productivity ratio to the ICT gap. There is no column on panel C for the contribution of the ICT share ratio to the Canada-U.S. ICT gap simply because this contribution is equal to the adjusted ICT gap. In other words, for equal levels of productivity, the ICT per worker gap is just 1.0 minus the Canada-U.S. ratio of ICT investment as a share of GDP.

[17] Note that in a log scale, the relationship is *always* perfectly additive.

## Table 31: ICT Investment per Worker Adjusted for Labour Productivity in Canada and the United States, Business Sector, 1987-2011

**A) Canada**

| | GDP | ICT Investment | Workers | ICT Investment as a Share of GDP | Labour Productivity | ICT Investment per Worker |
|---|---|---|---|---|---|---|
| | (millions, current PPP-adjusted U.S. dollars) | | (thousands) | (per cent) | (current PPP-adjusted U.S. dollars) | |
| | (i) | (ii) | (iii) | (iv)=(ii)/(i)*100 | (v)=(i)/(iii)*1000 | (vi)=(ii)/(iii)*1000 |
| 1987 | 318,087 | 6,437 | 9,639 | 2.02 | 33,000 | 668 |
| 1988 | 344,777 | 7,450 | 9,922 | 2.16 | 34,749 | 751 |
| 1989 | 361,308 | 8,189 | 10,133 | 2.27 | 35,657 | 808 |
| 1990 | 373,532 | 8,686 | 10,118 | 2.33 | 36,918 | 858 |
| 1991 | 367,516 | 9,389 | 9,836 | 2.55 | 37,364 | 955 |
| 1992 | 379,450 | 9,821 | 9,653 | 2.59 | 39,309 | 1,017 |
| 1993 | 394,446 | 10,183 | 9,677 | 2.58 | 40,761 | 1,052 |
| 1994 | 424,502 | 10,831 | 9,933 | 2.55 | 42,737 | 1,090 |
| 1995 | 456,244 | 11,369 | 10,160 | 2.49 | 44,906 | 1,119 |
| 1996 | 482,132 | 12,689 | 10,308 | 2.63 | 46,773 | 1,231 |
| 1997 | 514,175 | 15,063 | 10,614 | 2.93 | 48,443 | 1,419 |
| 1998 | 528,509 | 16,959 | 10,910 | 3.21 | 48,443 | 1,554 |
| 1999 | 574,144 | 18,963 | 11,217 | 3.30 | 51,185 | 1,691 |
| 2000 | 638,836 | 21,378 | 11,499 | 3.35 | 55,556 | 1,859 |
| 2001 | 665,783 | 21,337 | 11,635 | 3.20 | 57,222 | 1,834 |
| 2002 | 677,027 | 20,756 | 11,886 | 3.07 | 56,960 | 1,746 |
| 2003 | 723,825 | 21,433 | 12,135 | 2.96 | 59,648 | 1,766 |
| 2004 | 775,860 | 24,054 | 12,343 | 3.10 | 62,858 | 1,949 |
| 2005 | 850,058 | 26,577 | 12,474 | 3.13 | 68,146 | 2,131 |
| 2006 | 918,247 | 28,460 | 12,643 | 3.10 | 72,629 | 2,251 |
| 2007 | 1,001,524 | 29,682 | 12,925 | 2.96 | 77,487 | 2,296 |
| 2008 | 1,087,344 | 30,166 | 13,082 | 2.77 | 83,118 | 2,306 |
| 2009 | 983,053 | 25,400 | 12,745 | 2.58 | 77,132 | 1,993 |
| 2010 | 1,049,558 | 26,915 | 12,836 | 2.56 | 81,767 | 2,097 |
| 2011 | 1,105,842 | 29,601 | 13,024 | 2.68 | 84,908 | 2,273 |

Note: Business sector GDP in Canada is adjusted to exclude the value of imputed rent for owner-occupied dwellings, to be consistent with the U.S. definition of business sector GDP. See Appendix Table 11c for details on this calculation.

**B) United States**

| | GDP | ICT Investment | Workers | ICT Investment as a Share of GDP | Labour Productivity | ICT Investment per Worker |
|---|---|---|---|---|---|---|
| | (millions, current U.S. dollars) | | (thousands) | (per cent) | (current U.S. dollars) | |
| | (vii) | (viii) | (ix) | (x)=(viii)/(vii) | (xi)=(vii)/(ix) | (xii)=(viii)/(ix) |
| **1987** | 3,662,000 | 104,000 | 92,301 | 2.84 | 39,675 | 1,127 |
| **1988** | 3,940,200 | 115,900 | 95,119 | 2.94 | 41,424 | 1,218 |
| **1989** | 4,235,700 | 128,600 | 97,171 | 3.04 | 43,590 | 1,323 |
| **1990** | 4,453,900 | 131,400 | 97,810 | 2.95 | 45,536 | 1,343 |
| **1991** | 4,558,600 | 135,100 | 96,287 | 2.96 | 47,344 | 1,403 |
| **1992** | 4,829,200 | 147,700 | 95,743 | 3.06 | 50,439 | 1,543 |
| **1993** | 5,084,100 | 160,500 | 97,760 | 3.16 | 52,006 | 1,642 |
| **1994** | 5,425,200 | 177,000 | 101,060 | 3.26 | 53,683 | 1,751 |
| **1995** | 5,677,800 | 203,600 | 103,902 | 3.59 | 54,646 | 1,960 |
| **1996** | 6,030,200 | 228,400 | 106,191 | 3.79 | 56,786 | 2,151 |
| **1997** | 6,442,800 | 268,500 | 109,043 | 4.17 | 59,085 | 2,462 |
| **1998** | 6,810,800 | 300,200 | 111,286 | 4.41 | 61,201 | 2,698 |
| **1999** | 7,249,000 | 352,100 | 113,088 | 4.86 | 64,101 | 3,114 |
| **2000** | 7,715,500 | 409,500 | 115,016 | 5.31 | 67,082 | 3,560 |
| **2001** | 7,913,600 | 381,400 | 114,085 | 4.82 | 69,366 | 3,343 |
| **2002** | 8,132,800 | 344,200 | 111,554 | 4.23 | 72,905 | 3,086 |
| **2003** | 8,502,800 | 348,100 | 111,300 | 4.09 | 76,395 | 3,128 |
| **2004** | 9,070,100 | 367,000 | 112,743 | 4.05 | 80,449 | 3,255 |
| **2005** | 9,680,100 | 377,800 | 114,780 | 3.90 | 84,336 | 3,292 |
| **2006** | 10,262,400 | 403,400 | 116,907 | 3.93 | 87,783 | 3,451 |
| **2007** | 10,738,300 | 428,900 | 117,763 | 3.99 | 91,186 | 3,642 |
| **2008** | 10,787,800 | 428,400 | 116,033 | 3.97 | 92,972 | 3,692 |
| **2009** | 10,367,000 | 404,000 | 109,395 | 3.90 | 94,767 | 3,693 |
| **2010** | 10,836,000 | 414,500 | 108,142 | 3.83 | 100,201 | 3,833 |
| **2011** | 11,341,200 | 431,300 | 109,711 | 3.80 | 103,373 | 3,931 |

Source: Investment and net stock figures from Statistics Canada, CANSIM Table 031-0003; GDP data also from Statistics Canada, CANSIM Table 379-0023 and 384-0001 for 2009 and 2010 for total economy GDP; and CANSIM 379-0027 for business sector. US Data from BEA NIPA Table 1.3.5.

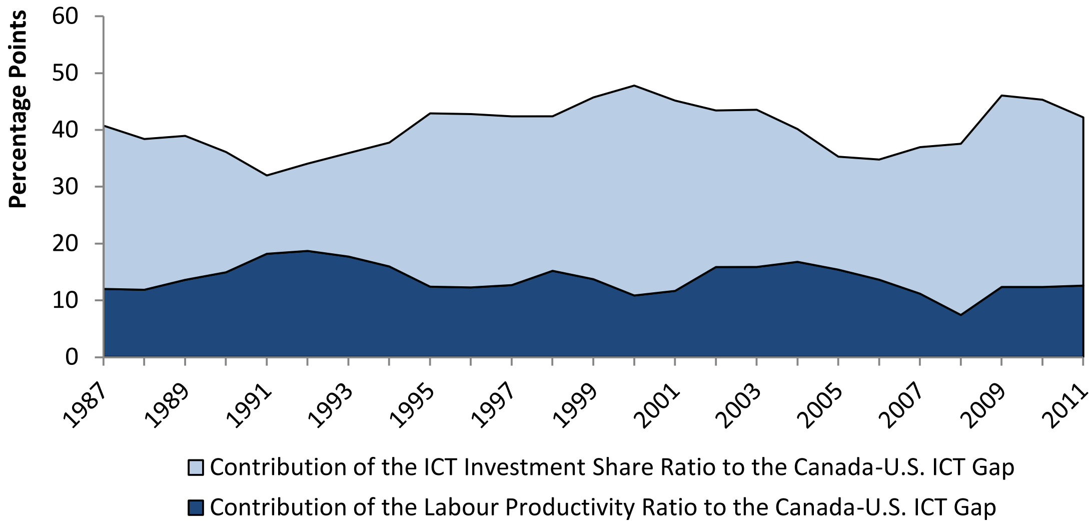
### C) Labour Productivity and ICT Shares Contributions to the Canada-U.S. ICT Investment per Worker Gap

| | Canada as a Share of the United States | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Labour Productivity Ratio | ICT Investment as a Share of GDP Ratio | ICT Investment per Worker | ICT Gap | Adjusted ICT Investment per Worker | Adjusted ICT Gap | Contribution of the Labour Productivity Ratio to the ICT Gap | |
| | (ratios) | | (per cent) | | | | (percentage points) | (per cent) |
| | (xiii)=(v)/(xi) | (xiv)=(iv)/(x) | (xv)=(vi)/(xii)*100 | (xvi)=100-(xvi) | (xvii)=(xiii)/(xv) | (xviii)=100-(xvii) | (xix)=(xvi)-(xviii) | (xx)=(xix)/(xvi)*100 |
| **1987** | 0.83 | 0.71 | 59.3 | 40.7 | 71.3 | 28.7 | 12.0 | 29.4 |
| **1988** | 0.84 | 0.73 | 61.6 | 38.4 | 73.5 | 26.5 | 11.8 | 30.8 |
| **1989** | 0.82 | 0.75 | 61.1 | 38.9 | 74.7 | 25.3 | 13.6 | 34.9 |
| **1990** | 0.81 | 0.79 | 63.9 | 36.1 | 78.8 | 21.2 | 14.9 | 41.3 |
| **1991** | 0.79 | 0.86 | 68.0 | 32.0 | 86.2 | 13.8 | 18.2 | 56.8 |
| **1992** | 0.78 | 0.85 | 66.0 | 34.0 | 84.6 | 15.4 | 18.7 | 54.8 |
| **1993** | 0.78 | 0.82 | 64.1 | 35.9 | 81.8 | 18.2 | 17.7 | 49.2 |
| **1994** | 0.80 | 0.78 | 62.3 | 37.7 | 78.2 | 21.8 | 15.9 | 42.3 |
| **1995** | 0.82 | 0.69 | 57.1 | 42.9 | 69.5 | 30.5 | 12.4 | 28.9 |
| **1996** | 0.82 | 0.69 | 57.2 | 42.8 | 69.5 | 30.5 | 12.3 | 28.6 |
| **1997** | 0.82 | 0.70 | 57.6 | 42.4 | 70.3 | 29.7 | 12.7 | 29.9 |
| **1998** | 0.79 | 0.73 | 57.6 | 42.4 | 72.8 | 27.2 | 15.2 | 35.8 |
| **1999** | 0.80 | 0.68 | 54.3 | 45.7 | 68.0 | 32.0 | 13.7 | 30.0 |
| **2000** | 0.83 | 0.63 | 52.2 | 47.8 | 63.0 | 37.0 | 10.8 | 22.7 |
| **2001** | 0.82 | 0.66 | 54.9 | 45.1 | 66.5 | 33.5 | 11.6 | 25.8 |
| **2002** | 0.78 | 0.72 | 56.6 | 43.4 | 72.4 | 27.6 | 15.8 | 36.5 |
| **2003** | 0.78 | 0.72 | 56.5 | 43.5 | 72.3 | 27.7 | 15.9 | 36.4 |
| **2004** | 0.78 | 0.77 | 59.9 | 40.1 | 76.6 | 23.4 | 16.8 | 41.7 |
| **2005** | 0.81 | 0.80 | 64.7 | 35.3 | 80.1 | 19.9 | 15.4 | 43.6 |
| **2006** | 0.83 | 0.79 | 65.2 | 34.8 | 78.8 | 21.2 | 13.6 | 39.2 |
| **2007** | 0.85 | 0.74 | 63.1 | 36.9 | 74.2 | 25.8 | 11.1 | 30.2 |
| **2008** | 0.89 | 0.70 | 62.5 | 37.5 | 69.9 | 30.1 | 7.4 | 19.7 |
| **2009** | 0.81 | 0.66 | 54.0 | 46.0 | 66.3 | 33.7 | 12.3 | 26.8 |
| **2010** | 0.82 | 0.67 | 54.7 | 45.3 | 67.0 | 33.0 | 12.3 | 27.2 |
| **2011** | 0.82 | 0.70 | 57.8 | 42.2 | 70.4 | 29.6 | 12.6 | 29.8 |

Notes: 1) Labour productivity is defined here as nominal GDP per worker; 2) Nominal GDP in Canada adjusted by GDP-PPP, nominal ICT investment adjusted by M&E-PPP.

Source: CSLS calculations based on Appendix Tables.

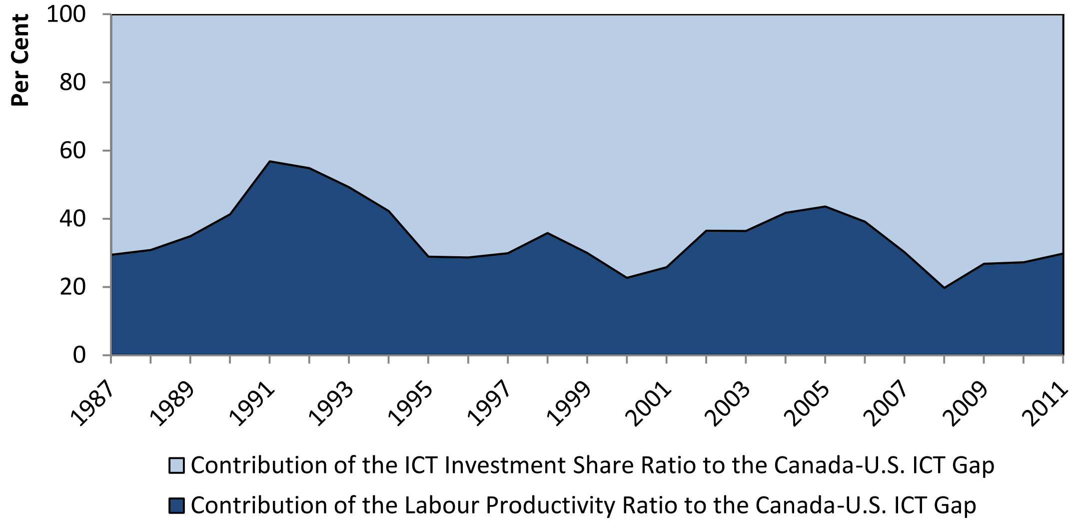
**Chart 17: Labour Productivity and ICT Share Contributions to the Canada-U.S. ICT Investment per Worker Gap, percentage points, 1987-2011**




Source: CSLS calculations based on Appendix Tables.

In 2011, the Canada-U.S. ICT investment per worker gap would have been 12.6 percentage points lower *if* the two countries had the same labour productivity level. This represents slightly less than a third of the ICT gap of 42.2 per cent in 2011, in line with the average contribution of labour productivity to the ICT gap throughout the 1987-2011 period. The higher ICT share of GDP in the United States accounted for the remaining two-thirds of the Canada-U.S. ICT gap. Chart 17 plots the contribution of each of these two factors during the past 25 years. Despite some significant fluctuations over the period (especially in the early 1990s), the contribution of labour productivity differentials to the Canada-U.S. ICT gap has remained fairly stable over time.

**Chart 18: Labour Productivity and ICT Share Contributions to the Canada-U.S. ICT Investment per Worker Gap, per cent, 1987-2011**




Source: CSLS calculations based on Appendix Tables.

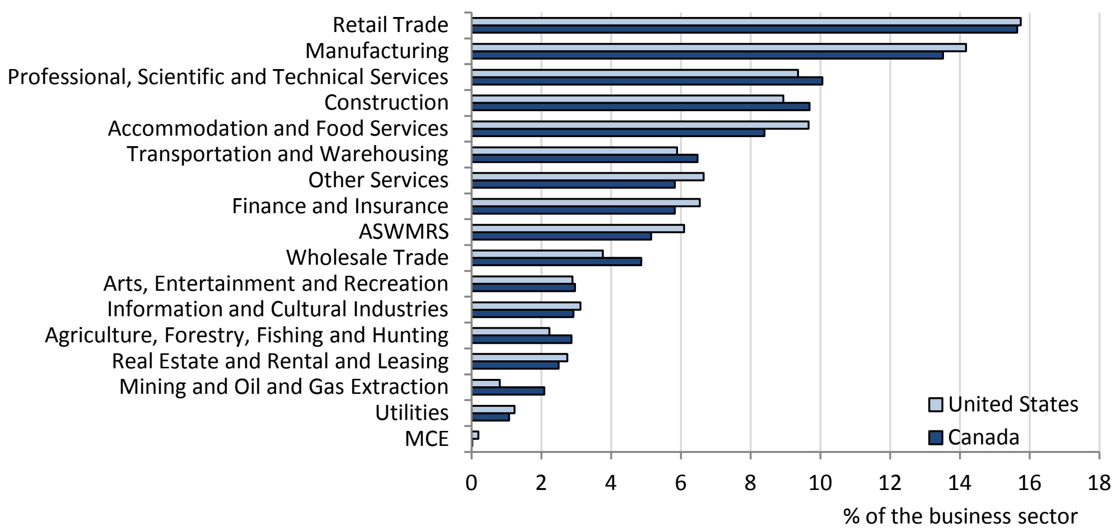
It is important to highlight that the decomposition of the Canada-U.S. ICT investment per worker gap into these two factors offers only a *proximate* explanation of the gap. After all, it does not answer the question as to what exactly is causing labour productivity differences between the two countries or why Canada invests less in ICT (as a share of GDP) than the United States. It is also true that the difference in labour productivity is not entirely an exogenous phenomenon. It may well be the case that Canada's lower ICT investment per worker partially explains its lower labour productivity when compared to the United States, rather than the reverse. Nonetheless, the above decomposition is valuable in its own right and can be used to inform the direction of future research.

## B. Industrial Structure

Differences between the industrial structures in Canada and in the United States can, potentially, explain part of the Canada-U.S. ICT investment per worker gap. At the business sector level, ICT investment per worker is simply the weighted average of ICT investment per worker at the *industry level*, where the weights are employment shares. If, compared to Canada, the U.S. economy favours ICT-intensive industries, i.e. industries with above-average levels of ICT investment per worker, this will increase the gap compared to a baseline scenario where both countries have the same industrial structure.

To estimate the effect of industrial structure on the Canada-U.S. ICT investment per worker gap, the CSLS calculated how much Canada's business sector ICT investment per worker would be if Canada's employment shares were equal to those of the United States. As Chart 19 shows, the two countries have a fairly similar employment share structure at the business sector level. In both countries, the largest sector was retail trade, which accounted for 15.6 per cent of employment in Canada's business sector versus 15.7 per cent in the United States. Manufacturing came close second, representing 13.5 per cent of the business sector in the Canada and 14.2 per cent in the United States. This was followed by professional, scientific and technical services (10.1 per cent in Canada versus 9.4 per cent in the United States); construction (9.7 per cent versus 8.9 per cent); and accommodation and food services (8.4 per cent versus 9.7 per cent). Overall, these five industries accounted for approximately 57-58 per cent of business sector employment in both countries.

**Chart 19: Employment Shares by Industry in the Business Sector, Canada and the United States, 2011**




Notes: 1) ASWMRS – Administrative and support, waste management and remediation services; MCE – Management of companies and enterprises; 2) Business sector is defined here as total economy minus public administration; health care and social assistance; and education. Sources: Statistics Canada, Labour Force Survey (CANSIM Table 282-0008); U.S. Bureau of Labor Statistics, Current Population Survey (CPS Table 18).

Table 32 presents the simulated level of ICT investment per worker in Canada using U.S. employment shares as weights, and compares it to the actual level in 2011. Using U.S. weights, business sector ICT investment per worker in Canada was $2,629, 4.1 per cent higher than the actual level of $2,525. Converting these figures to PPP-adjusted U.S. dollars, we find that if Canada had the U.S. employment shares, its business sector ICT investment per worker level would have been 60.2 per cent of the U.S. level, while its *actual* level was only 57.8 per cent that of the United States, a difference of 2.4 percentage points.[18]

[18] CSLS (2005) also finds a difference of 2.4 percentage points between actual and simulated Canada-U.S. ICT investment per worker gap in 2004. The data used in that report has been updated, however, and the new estimates point to a difference of 2.7 percentage points for that year.

**Table 32: Canada-U.S. ICT Investment per Worker Relative (PPP-adjusted U.S. dollars), Actual x Simulated (U.S. employment share weights), 2011**

| | | Variable | Unit | Value |
|---|---|---|---|---|
| Canada | A | ICT Investment per Worker, actual | (dollars) | 2,525 |
| | B | ICT Investment per Worker, simulated | (dollars) | 2,629 |
| | C=B-A | Difference between Simulated and Actual | (dollars) | 104 |
| | D=(C/A)*100 | | (per cent) | 4.1 |
| | E | Canada-U.S. Purchasing Power Parity | | 0.90 |
| | F=A*E | ICT Investment per Worker, actual | (PPP-adjusted U.S. dollars) | 2,273 |
| | G=B*E | ICT Investment per Worker, simulated | (PPP-adjusted U.S. dollars) | 2,366 |
| United States | H | ICT Investment per Worker | (U.S. dollars) | 3,931 |
| Canada as a Share of the United States | I=(F/H)*100 | ICT Investment per Worker, actual | (per cent) | 57.8 |
| | J=(G/H)*100 | ICT Investment per Worker, simulated | (per cent) | 60.2 |
| | M=K-L | Difference between Simulated and Actual | (percentage points) | **2.4** |

Notes: For details on how the simulated estimates were calculated, refer to Appendix Tables.
Source: CSLS calculations based on data from the CSLS ICT database.

Given that Canada and the United States share a fairly similar profile in terms of employment shares, what explains this non-trivial contribution of industrial structure to the Canada-U.S. ICT investment per worker gap? Despite its many similarities, there are small, but significant differences in the way the two countries allocate labour. Note, for instance, that mining and oil and gas extraction in Canada represents 2.1 per cent of business sector employment versus 0.8 per cent in the United States, a difference of 1.3 percentage points. Accommodation and food services, on the other hand, represents a higher employment share in the United States than in Canada (9.7 per cent versus 8.4 per cent, respectively), again a difference of 1.3 percentage points.

Table 33 shows how each industry contributed to the overall effect of industrial structure on the Canada-U.S. ICT investment per worker gap in 2011. Recall from Table 32 that the simulated ICT investment per worker level (using U.S. weights) in 2011 was greater than the actual level by $104. The industries that contributed the most to this difference were: finance and insurance ($46); management of companies and enterprises ($45);[19] and information and cultural industries ($38). Note that these three industries had above-average ICT investment per worker levels, which magnified their overall contribution to the total industrial structure effect. Conversely, the industries that contributed the most to *closing* the difference between actual and

[19] This significant contribution of management of companies and enterprises (MCE) is caused by an allocation issue. MCE investment represents investment made by head offices. In reality, a significant part of that investment will be assigned to activities other than MCE, which means that MCE investment is actually investment to other industries.

simulated levels all had below-average ICT investment per worker levels: wholesale trade (-$43); mining and oil and gas extraction (-$31); and transportation and warehousing (-$14). Overall, ten out of the seventeen industries played a role in *increasing* the difference between actual and simulated levels of ICT investment per worker.

### Table 33: Industry Contributions to the Difference between Actual and Simulated ICT Investment per Worker Level in Canada, 2011

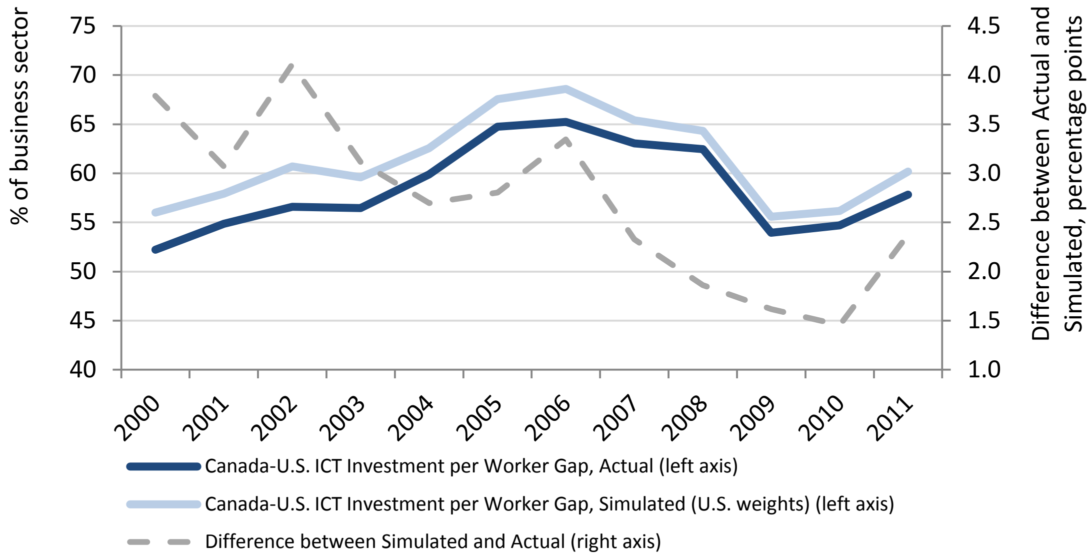
| | Employment Shares | | | ICT Investment per Worker | | Industry Contributions to Difference Between Simulated and Actual | |
|---|---|---|---|---|---|---|---|
| | Canada | United States | Canada-U.S. | Level, Actual | Compared to Business Sector | | |
| | (per cent) | | | (dollars) | | (dollars) | (per cent) |
| | A | B | C=B-A | D | E | F=(C/100)*D | $G=(F_{ind}/F_{tot})*100$ |
| **Business Sector** | **100.0** | **100.0** | **0.0** | **2,525** | **=** | **104** | **100.0** |
| **Agriculture** | 2.9 | 2.2 | -0.6 | 360* | < | -2 | -2.2 |
| **Mining and Oil** | 2.1 | 0.8 | -1.3 | 2,398* | < | -31 | -29.4 |
| **Utilities** | 1.1 | 1.2 | 0.2 | 13,214* | > | 20 | 19.6 |
| **Construction** | 9.7 | 8.9 | -0.8 | 255* | < | -2 | -1.8 |
| **Manufacturing** | 13.5 | 14.2 | 0.7 | 1,882 | < | 12 | 12.0 |
| **Wholesale Trade** | 4.9 | 3.8 | -1.1 | 3,900* | > | -43 | -41.5 |
| **Retail Trade** | 15.6 | 15.7 | 0.1 | 1,026* | < | 1 | 1.0 |
| **Transportation** | 6.5 | 5.9 | -0.6 | 2,467* | < | -14 | -13.9 |
| **Information Industries** | 2.9 | 3.1 | 0.2 | 19,434 | > | 38 | 36.8 |
| **Finance and Insurance** | 5.8 | 6.5 | 0.7 | 6,439 | > | 46 | 44.5 |
| **Real Estate** | 2.5 | 2.7 | 0.2 | 5,888* | > | 14 | 14.0 |
| **Professional Services** | 10.1 | 9.4 | -0.7 | 1,931 | < | -13 | -13.0 |
| **MCE** | 0.0 | 0.2 | 0.2 | 25,128* | > | 45 | 42.9 |
| **ASWMRS** | 5.1 | 6.1 | 0.9 | 1,626* | < | 15 | 14.9 |
| **Arts** | 3.0 | 2.9 | -0.1 | 1,369* | < | -1 | -1.0 |
| **Accommodation** | 8.4 | 9.7 | 1.3 | 355* | < | 5 | 4.4 |
| **Other Services** | 5.8 | 6.6 | 0.8 | 1,615* | < | 13 | 12.7 |

* These figures are CSLS estimates constructed using data from two different Statistics Canada series (Fixed Capital Flows and Stocks, CANSIM Table 031-0003, and Canadian Productivity Accounts, CANSIM Table 383-0025). For details on how these estimates were calculated, refer to appendix tables.

Notes: 1) ASWMRS – Administrative and support, waste management and remediation services; MCE – Management of companies and enterprises; 2) Business sector is defined here as total economy minus public administration; health care and social assistance; and education. Source: CSLS calculations based on the CSLS ICT database.

Although the impact of industrial structure on the Canada-U.S. ICT investment per worker gap was still significant, it is interesting to note that its magnitude declined from its pre-2007 levels. Chart 20 plots Canada's ICT investment per worker level relative to that of the United States from 2000 to 2011. The difference between the two series reached a peak in 2002, when the Canada-U.S. ICT investment per worker relative was 56.6 per cent versus the simulated value of 60.7 per cent, a difference of 4.1 percentage points. There was an increase in the difference between the two series in 2011, but it is still too early to tell if this represents a change in trend or simply reflects temporary fluctuations.

**Chart 20: Canada-U.S. ICT Investment per Worker Relative (PPP-adjusted U.S. dollars), Actual x Simulated, 2000-2011**




Source: CSLS calculations based on the CSLS ICT database.

The key take away from this simulation exercise is that Canada's somewhat lower employment share in ICT-intensive industries caused the Canada-U.S. ICT investment per worker gap to be 2.4 percentage points higher than it would be if Canada had the same industrial structure as the United States; this is equal to 5 per cent of the gap. A small number of industries contributed disproportionately to this effect – finance and insurance and information and cultural industries, in particular. In the case of the latter, even though Canada's employment share was only 0.2 percentage points below that of the United States, the extremely high level of ICT investment per worker amplified the effect that differences in industrial structure had on the Canada-U.S. ICT investment gap.

# IV. Contribution of Differences Measurement Methodology to the Canada-U.S. ICT Investment per Worker Gap

Our analysis in the preceding section has explained a significant portion of the ICT investment per worker gap, but approximately 65 per cent of the gap still remains unexplained. Of the factors that we reviewed, we explain approximately one-fifth of the gap through quantifiable differences between Canada and the United States, particularly greater U.S. labour productivity (12 percentage points or 30 per cent) and differences in industrial structure (2.5 percentage points or 5 per cent. Because much of the gap is still not explained, in this section, we turn our attention to comparing measurement methodologies in Canada and the United States to determine to what degree the estimates we use to compute the gap are comparable. We look both for inconsistencies in what the two countries are estimating, and sources of error in how they produce their estimates that could affect our estimate of the ICT investment per worker gap. This section proceeds as follows. First, we begin with a discussion of definitions of ICT commodities, business sector investment in ICT, and business sector employment. We include a discussion based on the reporting guides of the surveys used to collect data on ICT investment in both countries, and discuss differences in the definitions of business sector employment and investment. We also discuss differences in the composition or size of the business sector in Canada and the United States, which is a measurement issue for the purposes of comparing business sector ICT investment per worker. Second, we review the design of the surveys used in the two countries and compare sample methodology and coverage, response rates, and coefficients of variation. Third, we discuss in great detail the estimation of own-account software, software developed by the employees of a firm for internal use, and compare the estimates of own-account software in the two countries. Own-account software is the most difficult component of software to estimate, and as software investment accounted for 92.2 per cent of the ICT investment per worker gap in 2011, this is an important area of research.

## A. Differences in Definitions

There are two sets of definitions which are important to our estimates of the business sector ICT investment per worker gap. First, there are the definitions of ICT components, that is, computers, communications equipment, and software. We examine the reporting guides accompanying the surveys used by statistical agencies in both countries to determine to what degree the definitions of these components differ, if at all. Second, the definition of the business sector used by Statistics Canada's Fixed Capital Flows and Stocks program is important in the calculation of business sector ICT investment per worker, both for investment and employment. We discuss any differences in the definition of the business sector for the purposes of comparing investment or employment in Canada and the United States.

### i. ICT Component Definitions

The North American economies have harmonized definitions of commodities for trade commodities, and have a harmonized industry classification system, the North American Industry Classification System (NAICS); these classifications are used in Canada, the United States, and Mexico. However, the definitions of commodity classes for private fixed investment are not harmonized; the Bureau of Economic Analysis' (BEA) Fixed Asset Accounts and Statistics Canada's Fixed Capital Flows and Stocks program report private non-residential fixed investment for asset types that do not follow exactly the same definition. It is therefore possible that the values reported for investment for a particular ICT asset type will not refer to the same groups of commodities in the two countries. We examine the definitions of the assets that comprise ICT in order to determine whether the definition of these assets is a challenge for comparing ICT investment in Canada and the United States.

The definition of ICT components is indicated in the U.S. Information and Communication Technology Survey (ICT) reporting guide and Statistics Canada's Capital and Repair Expenditure Survey (CES). Both establishment surveys provide respondents with a reporting guide, which describes the asset types they should report and how they are classified. In Table 34, we provide a side-by-side comparison of the asset type descriptions respondents are asked to report.

**Table 34: ICT Equipment Expenditure Reporting Descriptions**

| ICT Component | U.S. Reporting Description | Canada Reporting Guide |
|---|---|---|
| **Computer and related equipment** | - Mainframes; personal computers, laptops, workstations, terminals, computer servers, printers, plotters, monitors, storage devices, personal digital assistants (PDAs), automatic teller machines (ATMs), point of sale (POS) terminals, etc. | - Computers and related machinery and equipment (exclude software purchased separately) |
| **Information and Communications Technology Equipment, Excluding Computer Software and Peripheral Equipment** | Central office switching equipment, telephones (wired/wireless) and telephone apparatus, facsimile equipment, bridges, routers, gateways, portable transmitting and receiving antennas, communications satellites, cable television equipment, global positioning system (GPS) equipment, radio and television studio broadcasting equipment, fire detection and alarm systems, intercom systems, etc. | Broadcasting and radio communication equipment (exclude transmission equipment), radar and navigational instructions (e.g., radar and sonar equipment, radio navigational aid apparatus, GPS receivers), terminal equipment (e.g., PBXs, telephone, handsets, cellular phones, key systems, modems, palm pilots, fax machines, pagers, satellite terminals/dishes, decoders, set-top boxes), transmission equipment (e.g., transponders, receivers, cross connects, multiplexes, optical electronics, satellite earth stations, cell site equipment, antennas, cable head end equipment and components, cable distribution systems, plant equipment) |
| **Computer Software** | Prepackaged (off-the-shelf), vendor customized, and internally developed software; costs related to software development (for internal use and/or resale) including loaded payroll (salaries, wages, benefits, and bonuses), excluding other IT payroll | Off-the-shelf prepackaged; custom software (for internal use); and internally developed |

Sources: 2011 Information and Communication Technology Reporting Instructions and Industry Codes for the United States and Survey on Capital and Repair Expenditures, Form A8 Reporting Guide for Canada

There are three possible types of differences or inconsistencies in these definitions. First, we check to see if any item, which appears in a component for one country, appears in a different component for the other country. Second, we check to see if an item appears in the definition of a component for one country, but does not appear at all in the definition of any component for the other country. Third, we note any commodities which are vague or unclear in one country while specific in the other; this may lead to uncertainty on the behalf of respondents. The first type of difference will have an impact on the distribution of ICT investment by component, but not the level of total ICT investment in either country. The second type of difference will have an impact on the level of total ICT investment. The impact of the third type of error is ambiguous – it may lead to establishments broadly or narrowly construing assets, which would have an unknown impact on ICT investment and consequently the gap.

With regard to the first type of inconsistency, we find no commodity classified as a different type of ICT component in either country. However, we do note that in the U.S. reporting guide, respondents are instructed to report networking equipment as computer equipment if they cannot separately account for it. This is primarily an allocation issue, but it may mean that computer investment in the United States is somewhat overestimated while communications investment is somewhat underestimated.

For the second type of inconsistency, we note that the definition of computer investment in the U.S. survey is broader than the definition of computer investment in the Canadian survey; ATMs and POS terminals are not obviously a computer related asset, and it is unclear how the purchase of those commodities are classified in Canada – they do not appear specifically anywhere else on the Capital Repair and Expenditure Survey reporting guide. However, upon further investigation and inquiry to the BEA, we see that these commodities are not reported in the detailed fixed asset tables despite their inclusion in the survey. They are not classified as computer investment in either the United States or Canada, despite being listed under computers in the reporting guide for the ICT survey.

The only instance of the third type of inconsistency is also in regards to computer investment. The reporting guide for Canada only identifies asset code 8001 as "computers and related machinery and equipment," and it is not clear that this would be understood by respondents to include everything identified in the U.S. definition, such as direct access storage devices (DASDs) and personal digital assistants (PDAs). Nevertheless, considering that computer investment per worker is greater in Canada than the United States and that computer investment per worker is the smallest component of ICT investment per worker, we find it unlikely that this ambiguity is a major source of error.

The other important definitional issue for assets is own-account software. We discuss the methodology in a following section, but both reporting guides define own-account software in the same way. They instruct establishments to value own-account software based on labour cost, including salaries, wages, benefits, and bonuses related to all software development. Stock options are explicitly excluded, as are inventory and payroll for any IT function not explicitly related to software development; for example, payroll associated with running a help desk for an IT function would be excluded. Both surveys explicitly define and ask for the cost of own account software following this definition, and include the payroll costs of adapting software to existing software as own-account software as well. We also note that, according to interviews with Statistics Canada and our review of methodology papers, Statistics Canada's methodology for estimating own account software is largely based on the BEA's methodology. Therefore, we conclude that own-account software follows the same definition in Canada and the United States.

Despite some ambiguities, we find no major definitional differences that would cause ICT estimates from Canada and the United States to not be comparable.

### ii. Business sector definitions

Our interest in ICT investment per worker has been confined to the business sector because business sector investment is an important determinant of productivity.[20] In order for our estimates of the Canada-U.S. business sector ICT investment per worker gap to be accurate, it must be the case that the definition of the business sector in Canada and the United States is the same. Unfortunately, this is not the case – Statistics Canada's Fixed Capital Flows and Stocks (FCFS) tables, our primary source of investment data in Canada, does not use the same definition of the business sector as the BEA Fixed Asset Accounts, our primary source of investment data in the United States. This section provides a discussion of the complications resulting from the definition of the business sector in the Fixed Capital Flows and Stocks tables, and the implications of different definitions on our measure of labour input or employment and our estimate of the Canada-U.S. ICT investment per worker gap.

From an expenditure perspective, Statistics Canada classifies establishments into one of four institutional sectors: the household sector, the government sector, the business sector, and non-residents. Non-residential investment in the business sector investment is defined as all non-residential investment made by establishments operating in the business sector, which according to Statistics Canada includes the following types of establishments (Sharpe and de Avillez, 2012):

- Incorporated businesses
- Unincorporated businesses (the self-employed and proprietors)
- Government business enterprises
- Associations of individuals
- Owners who occupy their own dwellings[21]

#### *a) Investment*

In addition to classifying economic activity by the business and non-business sectors, Statistics Canada also classifies economic activity by NAICS. These two classifications are intended to be independent; within the business and non-business sector, economic activity is also classified by NAICS.[22] This is the definition of the business sector used by the Canadian System of National Accounts (CSNA) in estimating fixed capital formation. If this practice of

[20] In addition to business sector activity being the most important determinant of productivity, estimates for non-business sector ICT investment are not available in the United States. BEA estimates for government fixed assets are less detailed than for private fixed assets, and do not uniquely identify ICT assets. It is therefore only possible to produce the detailed comparisons which form the basis of this report for the business sector.

[21] This group is not an issue for measuring investment, as the only activity from owner-occupied dwellings in final demand is imputed rent. Imputed rent is not considered investment, so the inclusion of owner-occupied dwellings in the business sector has no effect on ICT investment. Their inclusion in the business sector does affect business sector GDP, however.

[22] In practice, of course, many NAICS industries will consist of establishments primarily or only in one institutional sector, but some NAICS industries will include establishments in different institutional sectors. Health care and education are examples of NAICS industries in which establishments may fall into any institutional sector.

classifying investment were followed for ICT investment, we would have access to ICT investment estimates for both the business and non-business sector in every two-digit NAICS industry.

Unfortunately, the FCFS, the primary source of data for private non-residential investment in Canada, does not classify investment by institutional sector. Instead, it only identifies investment by two-digit NAICS industries, and defines business sector investment as total investment excluding investment in three two-digit NAICS industries: health care and social assistance, educational services, and public administration. This industry-based definition of the business sector used by the FCFS is not consistent with Statistics Canada's definition of the business sector above. The U.S. data, which follows the correct practice of classifying private investment by both institutional sector and two-digit NAICS industry, is, however, consistent with the practice of classifying investment by the institutional sector of the establishment described above.

This means that the business sector aggregate found in Statistics Canada's FCFS tables does not accurately identify investment by business sector establishments; it will omit business sector investment that occurs in the three excluded industries, and it will include non-business sector investment in the 17 two-digit NAICS industries defined as the business sector. In practice, this likely means the FCFS improperly excludes private investment in health care and social assistance, while improperly including fixed ICT investment by non-profits and charities operating in the 17 two-digit NAICS industries defined as the business sector in the FCFS tables.

Despite this limitation, the FCFS has several advantages over the Canadian Productivity Accounts (CPA), the other source of ICT investment data in Canada. First, the FCFS tables contain investment estimates for computers, communications equipment, while the CPA tables contain only an ICT aggregate. Second, the FCFS tables publish more recent estimates; generally, the FCFS will publish estimates for the current year, while the CPA tables are delayed for several years. Currently, the CPA data for ICT investment end in 2008, while the FCFS data for 2012 are currently available. These two features of the FCFS are essential in estimating ICT investment per worker, so we continue to use this source to estimate ICT investment in Canada despite its shortcomings with respect to classifying investment by the business and non-business sectors. Statistics Canada is currently engaged in a two-year project to enhance the coherence of the FCFS with other estimates of fixed capital formation in Canada. We are hopeful that at the end of this process, the FCFS will classify investment by institutional sector as well as two-digit NAICS industries.

Table 35 provides some indication of the magnitude of this consistency, comparing the share of business sector ICT investment in total investment, as estimated by the FCFS and Canadian Productivity Accounts (CPA), which use the two competing definitions of the business sector discussed in this section. The CPA share, reported in column E, which is based on the correct classification of investment by institutional sector, has generally been several percentage points below the share resulting from the FCFS estimates of ICT investment. This means that, on balance, the inclusion of investment by non-profits and charities in the 17 two-digit NAICS industries which are improperly included in the FCFS business sector aggregate, more than offsets the exclusion of investment by private health care establishments. The FCFS business sector definition therefore results in overestimating business sector ICT investment and underestimating of the Canada-U.S. ICT investment per worker gap.

**Table 35: Business Sector Shares of Total ICT Investment in Canada, 1997-2008**

| | FCFS Business Sector ICT (millions of current dollars) | CPA Business Sector ICT (millions of current dollars) | Difference (millions of current dollars) | FCFS Total ICT (millions of current dollars) | FCFS Business Sector Share of Total (per cent) | CPA Business Sector Share of total (per cent) | Difference between business sector shares (percentage points) |
|---|---|---|---|---|---|---|---|
| | A | B | C = B - A | D | E = A/D | F = B/D | G = F - E |
| **1997** | 19,562 | 19,640 | 78 | 23,468 | 83.36 | 83.69 | 0.33 |
| **1998** | 22,917 | 22,365 | -552 | 26,787 | 85.55 | 83.49 | -2.06 |
| **1999** | 24,951 | 24,656 | -295 | 30,427 | 82.00 | 81.03 | -0.97 |
| **2000** | 27,763 | 27,666 | -97 | 33,245 | 83.51 | 83.22 | -0.29 |
| **2001** | 27,710 | 26,759 | -951 | 33,291 | 83.24 | 80.38 | -2.86 |
| **2002** | 26,610 | 24,826 | -1,784 | 31,152 | 85.42 | 79.69 | -5.73 |
| **2003** | 26,138 | 24,777 | -1,361 | 31,491 | 83.00 | 78.68 | -4.32 |
| **2004** | 27,970 | 26,767 | -1,203 | 33,692 | 83.02 | 79.45 | -3.57 |
| **2005** | 29,862 | 28,671 | -1,191 | 36,273 | 82.33 | 79.04 | -3.28 |
| **2006** | 31,622 | 30,280 | -1,342 | 38,684 | 81.74 | 78.28 | -3.47 |
| **2007** | 32,980 | 31,882 | -1,098 | 40,374 | 81.69 | 78.97 | -2.72 |
| **2008** | 34,280 | 33,111 | -1,169 | 41,524 | 82.55 | 79.74 | -2.82 |

Source: A) Sum of business sector investment in computers, communications equipment and software from CANSIM 031-0003 (FCFS tables); B) Business sector ICT investment in CANSIM 383-0025 (CPA); D) Sum of total economy investment in computers, communications equipment and software from CANSIM 031-0003 (FCFS tables); C,E-G) CSLS calculations.

Note: The business sector share of ICT investment in the United States cannot be calculated because the BEA Fixed Asset Accounts do not uniquely identify government investment in ICT assets. CPA data are only available for 1997-2008; this calculation is performed for all possible years.

### *b) Employment*

In estimating ICT investment per worker, our aim is to provide an estimate of new capital formation in ICT on a per worker basis. Estimates of employment classified by the business and non-business sectors are available in Canada and the United States, but as we have described, the FCFS ICT investment data for Canada are not classified in this way. It is important that the measure of employment we use to estimate ICT investment per worker is consistent with our measure of ICT investment; that is, our measure of business sector ICT investment per worker should be based on investment and employment from the same establishments or it will not truly represent ICT investment per worker.

For this reason, we chose our business sector employment data for Canada to conform to the industry-based definition of the business sector used to classify investment in the FCFS, preserving the one-to-one correspondence between establishments and employment in our estimate of ICT investment per worker. We define business sector employment as the total level of employment reported by the Labour Force Survey (LFS) less employment in three industries: health care and social assistance, educational services, and public administration. The LFS is a household survey, thus taking into account full- and part-time, self-employed, domestic, and unpaid family workers. We are unable to exclude workers on the basis of the sector in which they are employed, but this is by design; this definition of the business sector employment is the most consistent with the FCFS of those available.

In the United States, the Bureau of Labor Statistics (BLS) produces a business sector employment series based on an amalgamation of data from both their household survey (the Current Population Survey), and their establishment survey (Current Employment Statistics). This is available from their Major Sector Productivity (MSP) dataset, which classifies a worker as in the business sector if they are employed by an establishment that operates in the business sector. This measure includes all private nonfarm employees, in addition to the employees of government enterprises, nonfarm proprietors or the self-employed, unpaid family workers, and farm workers, while excluding the employees of non-profit enterprises and general government. This is what we use for U.S. business sector employment to estimate ICT investment per worker in the U.S. business sector.

An important difference between the Canadian LFS data and the U.S. MSP data is that Statistics Canada measures employment based on the number of people employed, whereas the BLS measures employment based on the number of jobs. Since some people are actually multiple job holders, this introduces a bias in our measure of the Canada-U.S. ICT investment gap. The magnitude of this bias is quite small, however; multiple job holders in the U.S. represent only around 5 per cent of the total employed population in the United States.

To use the terminology we have used for Canada, the U.S. business sector employment measure provided by the BLS is classified by institutional sector. This is consistent with the fixed asset accounts estimates of private fixed investment produced by the BEA, which are also classified by institutional sector. Consequently, our estimates of business sector ICT investment per worker in the United States are entirely based on the correct definition of the business sector, while our estimates of business sector ICT investment per worker in Canada do not strictly refer to the business sector as defined by Statistics Canada.

Table 36 show how the measures of business sector employment differ as a share of total employment. The first column shows the share of total employment by business sector industries from the LFS, which we use to calculate the gap; the second column shows the share of total employment by business sector establishments from the Canadian Productivity Accounts, which classifies employment by institutional sector. The establishment-based or institutional sector definition places the business sector share of total employment in Canada greater than the industry-based share of total employment by between 2 and 6 percentage points in most years.

The business sector share of total employment classified by institutional sector (columns E and F) is normally between four and five percentage points greater when using CPA data.

**Table 36: Business Sector Employment Shares for Canada, 1997-2011**

| | LFS Business Sector Employment | CPA Business Sector Employment | CPA Total Employment | LFS Total Employment | LFS Business Sector Share | CPA Business Sector Share | Difference |
|---|---|---|---|---|---|---|---|
| | A | B | D | E | F = A/E | G = B/D | G = G -F |
| **1997** | 10,614 | 11,203 | 14,028 | 13,708 | 77.43 | 79.86 | 2.43 |
| **1998** | 10,910 | 11,521 | 14,345 | 14,047 | 77.67 | 80.31 | 2.65 |
| **1999** | 11,217 | 11,882 | 14,720 | 14,402 | 77.89 | 80.72 | 2.84 |
| **2000** | 11,499 | 12,185 | 15,048 | 14,760 | 77.91 | 80.97 | 3.07 |
| **2001** | 11,635 | 12,292 | 15,199 | 14,941 | 77.87 | 80.87 | 3.00 |
| **2002** | 11,886 | 12,580 | 15,568 | 15,298 | 77.70 | 80.81 | 3.11 |
| **2003** | 12,135 | 12,816 | 15,902 | 15,663 | 77.48 | 80.59 | 3.12 |
| **2004** | 12,343 | 13,046 | 16,166 | 15,922 | 77.52 | 80.70 | 3.18 |
| **2005** | 12,474 | 13,232 | 16,405 | 16,125 | 77.36 | 80.66 | 3.30 |
| **2006** | 12,643 | 13,432 | 16,677 | 16,410 | 77.04 | 80.54 | 3.50 |
| **2007** | 12,925 | 13,721 | 17,047 | 16,806 | 76.91 | 80.49 | 3.58 |
| **2008** | 13,082 | 13,871 | 17,330 | 17,087 | 76.56 | 80.04 | 3.48 |
| **2009** | 12,745 | 13,495 | 17,036 | 16,813 | 75.80 | 79.21 | 3.41 |
| **2010** | 12,836 | 13,747 | 17,339 | 17,041 | 75.32 | 79.28 | 3.96 |
| **2011** | 13,024 | 14,007 | 17,625 | 17,306 | 75.26 | 79.47 | 4.22 |

Source: A) Author's calculations based on LFS data in CANSIM Table 282-0008; business sector is total employment excluding employment in educational services, health care and social assistance, and public administration; B and D) CANSIM Table 383-0009 for Canadian Productivity Accounts data; share of business sector employment classified by institutional sector in total employment; rest are CSLS calculations.

Recall from Table 35 that this inconsistency in the definition of the business sector resulted in overestimating business sector ICT investment. Here, we can see that this same inconsistency results in underestimating business sector employment. Both of these sources of error indicate that the Canada-U.S. ICT investment per worker gap has been underestimated.

### c) *Alternative Estimates of the Canada-U.S. ICT investment per Worker Gap*

The Canada-U.S. ICT investment per worker gap is the key indicator used in this report of Canada's ICT investment performance. As we have described, this indicator, is constructed using nominal investment estimates from Statistics Canada's Fixed Capital Flow and Stocks (FCFS) program and employment estimates from the Labour Force Survey. The previous two sections have described how both of these inputs are not properly classified by the business and non-business sectors, and do not accurately identify the business sector – though they are broadly consistent with each other in terms of their coverage. There are alternative ways of constructing this indicator, based on Statistics Canada data consistent with an establishment-based definition of the business sector. In this section, we look at other estimates of business sector ICT investment per worker in Canada and discuss how they differ from the main measure used in this report.

The Canadian Productivity Accounts (CPA) provides business sector estimates for total ICT investment and employment. Taking into account these estimates, the employment estimates from the LFS, and the ICT investment numbers from the FCFS, we can construct four series for ICT investment per worker in the Canadian business sector, which lead to four series of the Canada-U.S. ICT investment per worker gap:

- *FCFS/LFS (Benchmark estimates)*: ICT investment data from the FCFS and employment data from the LFS;
- *FCFS/CPA*: ICT investment data from the FCFS and employment data from the CPA;
- *CPA/LFS:* ICT investment data from the CPA and employment data from the LFS;
- *CPA/CPA*: ICT investment and employment data from the CPA.

The estimates produced by the CPA have two advantages over our benchmark estimates. The definition of the business sector used by the FCFS program is not consistent with the definition used by U.S. statistical agencies (or even, for that matter, with the definition used by other Statistics Canada programs). In the FCFS, the business sector encompasses the total economy minus public administration; health care and social assistance; and education services. In the CPA, the business sector is defined on an establishment basis, rather than on an industry basis. It includes the corporate sector (incorporated businesses); the unincorporated sector (self-employed and proprietorships); and government business enterprises. In this sense, the CPA business sector includes the business components of health care and social assistance and education services, while excluding the non-business components of other industries. This is the same definition of business sector used by U.S. statistical agencies, including the BEA, in compiling the Fixed Asset Accounts, from which we have obtained our data for U.S. ICT investment.

A second advantage of the CPA data over our benchmark estimates is that it has total ICT investment estimates for *all* two-digit NAICS industries. In the FCFS, telecom estimates are not available for a significant number of industries due to confidentiality or data quality concerns. Sometimes the data are unavailable only for the most recent years; other times they are unavailable for the entire time series. Missing telecom estimates make it impossible for us to calculate total ICT investment for specific industries.

Despite these two advantages of CPA data, two considerations led the CSLS to use the FCFS/LFS estimates as its benchmark estimates. First, the CPA has data only for total ICT investment, while the FCFS program has data on ICT components (i.e. computers, software, and telecom), which allows for a better understanding of specific areas where Canada's ICT performance might be lacking. Second, the FCFS data go up to 2011, while the CPA estimates currently only go to 2008. This lag in the CPA data makes it impossible to analyse the impact of recent events on business sector ICT investment in Canada.

Table 37 looks at how the use of different data affects Canada's business sector ICT investment per worker level relative to the U.S. level. It is immediately clear that, using the FCFS/LFS (benchmark) estimates, Canada's relative levels are somewhat higher than if we had used the CPA/CPA estimates. In fact, for the 2000-2008 period, the average level of ICT investment per worker in Canada was 59.5 per cent of the U.S. level according to the FCFS/LFS estimates versus 54.0 per cent according to the CPA/CPA estimates, a difference of 5.5 percentage points. Thus, according to the CPA data, the Canada-U.S. ICT investment per worker gap is significantly *higher* than the gap implied by the CSLS benchmark measure.

### Table 37: Alternative Measures of ICT Investment per Worker in Canada Relative to the United States, 2000-2008

| | Canada-U.S. Relatives | | | | Difference Relative to Benchmark (FCFS/LFS) | | |
|---|---|---|---|---|---|---|---|
| | **CPA/CPA** | **CPA/LFS** | **FCFS/CPA** | **FCFS/LFS** | **CPA/CPA** | **CPA/LFS** | **FCFS/CPA** |
| | (Canada as a Share of the U.S., per cent) | | | | (percentage point difference) | | |
| **2000** | 49.1 | 52.0 | 49.3 | 52.2 | -3.1 | -0.2 | -2.9 |
| **2001** | 50.1 | 53.0 | 51.9 | 54.9 | -4.7 | -1.9 | -2.9 |
| **2002** | 49.9 | 52.8 | 53.5 | 56.6 | -6.7 | -3.8 | -3.1 |
| **2003** | 50.7 | 53.5 | 53.5 | 56.5 | -5.8 | -2.9 | -3.0 |
| **2004** | 54.2 | 57.3 | 56.6 | 59.9 | -5.7 | -2.6 | -3.2 |
| **2005** | 58.6 | 62.2 | 61.0 | 64.7 | -6.1 | -2.6 | -3.7 |
| **2006** | 58.8 | 62.5 | 61.4 | 65.2 | -6.4 | -2.8 | -3.8 |
| **2007** | 57.4 | 61.0 | 59.4 | 63.1 | -5.6 | -2.1 | -3.7 |
| **2008** | 56.9 | 60.3 | 58.9 | 62.5 | -5.6 | -2.1 | -3.5 |
| | Average, per cent | | | | Average, percentage points | | |
| **2000-2008** | 54.0 | 57.2 | 56.2 | 59.5 | -5.5 | -2.3 | -3.3 |

Sources: CSLS calculations based on: 1) Statistics Canada data (Canadian Productivity Accounts, CANSIM Table 383-0025; Labour Force Survey, CANSIM Table 282-0008; Fixed Capital Flows and Stocks, CANSIM Table 031-0003); 2) U.S. ICT investment data from the U.S. Bureau of Economic Analysis; 3) U.S employment data from the U.S. Bureau of Labor Statistics (Major Sector Productivity tables).

Analysing the CPA/LFS and FCFS/CPA estimates provides insights as to what exactly is driving the differences between the CSLS benchmark estimates of the ICT gap and the CPA estimates. The CPA/LFS estimates are only 2.3 percentage points below the CSLS benchmark estimates, while the FCFS estimates are 3.3 percentage points below our benchmark estimates. This means that differences between the CPA and LFS employment series account for approximately 40 per cent of the total difference of 5.5 percentage points, while differences in the CPA and FCFS ICT investment numbers are responsible for the remaining 60 per cent of the total difference. In other words, on average, *overestimating* business sector ICT investment has resulted in underestimating the gap by 2.3 percentage points, while *underestimating* business sector employment has resulted in underestimating the gap by 3.3 percentage points.

In principle, the CPA/CPA estimates provide the closest comparison to the data for the United States, and the most accurate identification of business sector ICT investment and employment. Data are currently not available to estimate the gap using CPA measures of ICT investment and employment for 2009-2011, but we can infer from the estimates for 2000-2008 in Table 37 that the Canada-U.S. ICT investment per worker gap has been significantly underestimated in the most recent years as well. By using the FCFS estimates, we have made a trade-off in this report, underestimating the gap in order to provide estimates using the most recent data.

### iii. Difference in Data Collection Methodologies

Our analysis of the investment surveys used in Canada and the United States did not find any significant differences in the surveys themselves that would affect our estimate of the gap. We detail briefly our investigation across four elements of data collection: survey sample frame, sample size, sample stratification, quality control and analysis, and non-sampled entities. The surveys we discuss are the same three we have been referring to throughout this paper: the Capital and Repair Expenditure Survey for Canada; and the Annual Capital and Expenditure (ACES) and Information Communications Technology (ICT) surveys for the United States.

In regards to survey sample frame, all three surveys consist of a random sample drawn from the respective business registry. In both countries, the business registry covers approximately 97 per cent of all businesses. One important difference, however, is that in Canada, all government entities as well as private entities are included in the sample frame; in the United States, government estimates do not contain the same detail as private data. The government fixed assets data do not support as detailed a breakdown as the private fixed assets data and do not allow for the identification of ICT investment. This is not a measurement issue for comparing the business sector in the two countries, but it does mean that it is not possible to produce comparable estimates of ICT investment for the total economy in Canada and the United States, meaning that our focus on the business sector is also necessary.

In regards to sample size, we did not expect to uncover anything unusual, and we did not. The sample size is somewhat larger in the United States, but both countries use samples in the tens of thousands of establishments, with more than a sufficient number of respondents completing the long- and short-form variants of each survey. Our findings for stratification were similar; Statistics Canada uses an algorithm based on revenue to determine which strata are fully surveyed and which strata are sampled, while the Census Bureau also employs a revenue-based mechanism to assign establishments into strata. These algorithms are essentially the same.

Quality control and analysis methods were also similar in both countries. We conducted detailed interviews with individuals from Statistics Canada and the BEA to determine that similar efforts were being made at both agencies to ensure the reliability of survey data. Explicit measurement error were dealt with in the initial data collection phases using ratio estimators and other methods to identify reported values that were out of bounds or inconsistent with previous estimates, and follow-up calls to respondents were routine in both agencies. Likewise, both agencies report a response rate in excess of 70 per cent.

Finally, in regards to non-sampled entities, we found that both agencies had several methods of dealing with the challenges they posed. Non-sampled entities would explicitly be excluded from Statistics Canada's estimates, which exclude very small establishments that cannot be sampled with certainty. Statistics Canada estimates the investment values for these entities using administrative data, including tax data. The BEA similarly uses administrative data for non-employer establishments; where establishment level data are not possible to estimate, the BEA uses activity-level data for any non-manufacturing establishment as a proxy. Overall, both agencies reported that this issue would only affect establishments comprising between 2.5 and 3.0 per cent of firm revenue, leading us to conclude that the impact of collection on the estimates is negligible.

### B. Purchases of Used Equipment

Computers and communications equipment are assets with relatively long service lives, and their ownership can be expected to change multiple times throughout their service lives. The treatment of these purchases can therefore be expected to have some impact on investment. Furthermore, purchases of used equipment can be either intrasectoral, meaning within the business or non-business sector, or intersectoral, meaning between the business and non-business sector. It is therefore necessary for the purpose of accurately estimating capital stock by the business and non-business sectors to track purchases of used equipment by government and households from business.

Statistics Canada does not define the purchase of used equipment as part of investment, and these purchases are not represented at all in the FCFS tables. The Bureau of Economic Analysis' approach is similar, with one important difference: the BEA considers the margins of dealers of used assets to be a part of final investment. These margins are included in the estimates of investment by asset type and will, when present, increase investment in computers and communications equipment. This is not done by Statistics Canada.

The BEA instituted this methodology primarily to accurately estimate investment and capital stock in motor vehicles and, in practice, dealers' margins will be most significant for motor vehicles; for many asset types, they may be quite small. The Bureau of Economic Analysis could not make available detailed data on dealers' margins by asset type for the purpose of this report, but could confirm that they are present for other asset types. Even if this data were available for the United States, there would be no reason to believe a priori that the volume of purchases of used ICT equipment and the size of the margins on those purchases would be similar in Canada. It would not be possible to make reliable inferences for Canada based on the U.S. data, although with the U.S. data on margins we could directly compare ICT investment in Canada and the United excluding dealers' margins on the sale of used equipment.

Additionally, it is likely that the total value of margins on dealers' sales of used computers and communications equipment are relatively small. The margins themselves are not likely to be large, and it is also unlikely that there would be a large number of transactions via a dealer in used ICT equipment, both of which mean that the total value of margins for used ICT equipment would be relatively small. Nevertheless, this is an issue Statistics Canada should consider exploring in more depth. The effect of transactions involving used equipment on the gap is not possible to determine without data on those transactions.

## C. Differences in Software Investment Measurement Methodology

Software investment was responsible for 92.2 per cent of the gap in 2011, and has been responsible for a similar share of the gap for much of the last decade. Software is furthermore the most difficult component of ICT investment to accurately measure. Business accounting practices are generally inadequate for investment surveys to accurately capture software investment, and so software investment in Canada and the United States is estimated using indirect methods. In this section, we compare the indirect methods used by Statistics Canada and the Bureau of Economic Analysis to estimate investment in the three types of software.

### i. Measurement of Pre-Packaged Software

Investment per worker in pre-packaged software in Canada, which was just 26.4 per cent of the U.S. level, was responsible for 31.2 per cent of the total gap in business sector ICT investment per worker on its own in 2009, the most recent year for which detailed data are available. The discussion of measurement methodology in this section should provide a better understanding of the accuracy of these estimates. We review the methodology used by Statistics Canada and the Bureau of Economic Analysis to estimate investment in pre-packaged software, and discuss any differences thereof.

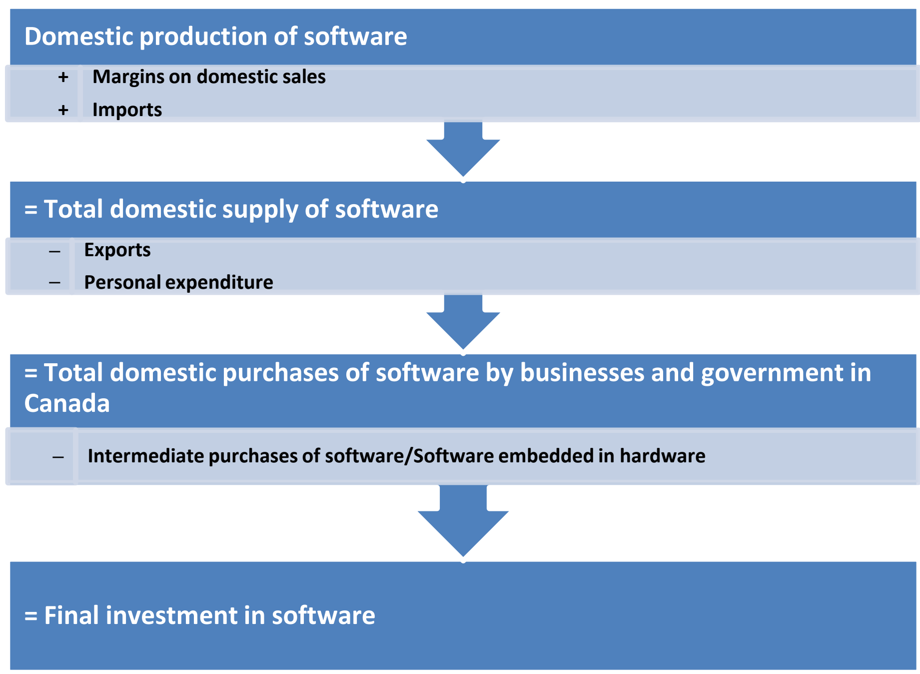
#### *a) Commodity-flow methodology for pre-packaged software investment*

In Canada and the United States, estimates of software investment do not rely exclusively on the survey data from the CES, ACES, and ICT surveys we have previously discussed due to challenges in business accounting which make it difficult for businesses to report data in sufficient quality or detail. Instead, an indirect method of estimating pre-packaged software investment is used. In Canada, these estimates are constructed by Statistics Canada's Canadian System of National Accounts (CSNA) and then used by FCFS to produce estimates of final investment in software. In the United States, the three divisions within the Bureau of Economic Analysis (BEA) are involved in this estimation.

The CSNA uses a commodity-flow method to estimate pre-packaged software investment, shown in Figure 1. First, the CSNA determines total domestic production of pre-packaged software, based on the value of total sales of the producers of software. In Canada, pre-packaged software is produced almost entirely in the software publishing industry (NAICS 511210), sales data for which are taken from Statistics Canada's annual surveys of Computer Services, and International Transactions in Commercial Services.

To this amount, CSNA adds the margins on domestic sales,[23] based on IO benchmarks, and the value of imports, using Balance of Payments (BOP) and merchandise trade data. This new figure is equal to the total domestic supply of software. From total domestic supply, the CSNA subtracts the value of exports, again from trade data, and the value of personal expenditure by households on software, from Statistics Canada's Annual Survey of Household Spending. This new figure is total domestic expenditure on software – the only remaining adjustment before arriving at final investment in software is to remove intermediate spending, which is largely software purchased to be embedded in hardware. To estimate intermediate spending on pre-packaged software, the CSNA deducts the input expense of the software publishing industries based on IO estimates.

**Figure 1: Commodity-Flow Method for the Estimation of Pre-packaged Software Investment in the CSNA**




Source: CSLS based on Jackson (2002)

The methodology used by the BEA in the United States is essentially the same. The BEA begins with total domestic production, based on data from the Census Bureau's quinqennial Census of Services Industries and Census of Manufacturers in its benchmark year; in non-benchmark years, the BEA uses receipts of industries involved in producing software from survey data. From this total, they deduct intermediate purchases and changes in inventory. Data on intermediate purchases are based on input-output estimates from the computer manufacturing industry based on the census of manufacturers; in non-benchmark years, the shares are assumed

[23] Margins reflect the value of purchaser prices, which will include distribution costs, taxes, and other costs not reflected in the producer or "at-the-gate" factory price.

to be the same as the most recent benchmark year. Inventory changes are based on IO estimates in benchmark years only; the value of inventory changes in non-benchmark years is assumed to be zero due to a lack of data. This adjustment is equal to the total domestic supply of software for final use; the BEA deducts exports from and adds imports to domestic supply, to produce an estimate of total final investment in software. Table 38 summarizes the methodology and data sources for the commodity-flow estimation of software investment in Canada and the United States.

**Table 38: Commodity-Flow Method and Data Sources for Software Investment Estimates in Canada and the United States**

| Component | Data Source in Canada | Data Source in United States | |
|---|---|---|---|
| | | Benchmark Years | Non-Benchmark Years |
| **Total domestic production (Canada) or shipments (United States)** | Survey of Computer Services and Survey of International Transactions in Commercial Services (production) | Census Bureau's quinqennial Census of Service Industries and Manufacturers (shipments) | Receipts of programming industries from annual survey data (shipments) |
| + | | | |
| **Imports** | BOP and merchandise trade data | | |
| **Margins on Sales** | Estimates based on IO margins for producers | n.a. | |
| - | | | |
| **Exports** | BOP trade data | | |
| **Inventory changes** | n.a. | IO estimates | Assumed to be zero |
| **Personal consumption** | Survey of Household Consumption | Census Bureau retail sales | Census Bureau retail trade surveys |
| **Intermediate purchases** | Input expense of software publishes | IO estimates for the computer manufacturing industry. | Benchmark year share of intermediate purchases in total purchases. |
| **= Total final investment in software** | | | |

Note: n.a. indicates that a step is not performed in that country.

### *b) Differences in the estimation of pre-packaged software investment*

Table 38 shows two differences in the commodity-flow methods in Canada and the United States.

First, Statistics Canada and the BEA arrive at their initial value of total domestic software production via slightly different methods. Statistics Canada begins with producer prices prior to shipment, and adds margins on sales based on estimates from IO data, while the U.S. methodology is based on receipts and is at purchaser prices. In principle, margins on sales should be equal to the difference in producer and purchaser prices, so these methodologies are equivalent.

Second, the BEA explicitly adjusts for changes in inventory in benchmark years, while the CSNA at Statistics Canada makes no adjustment for inventory changes in any year. Data from U.S. benchmark years indicates that inventory changes have traditionally been very small, below 0.2 per cent of the value of purchased software in benchmark years, so the magnitude of this discrepancy is likely to be extremely small. This is unsurprising, considering that when designing their methodology, the BEA believed it was valid to omit this step for every non-benchmark year.[24] This is because most changes in inventory will already be accounted for through production and sales data.

The most important adjustment, the deduction for intermediate purchases of pre-packaged software, is estimated using essentially the same methodology in Canada and the United States.

There is an additional complication in regards to the estimation of business sector software investment. In Canada and the United States, business sector software investment is calculated as a residual by deducting government purchases of software, which are known from administrative data. The business sector data therefore cannot uniquely identify and exclude software investment by non-profit organizations and charities. This is not an issue for comparing the data, since we are comparing software investment by the same establishments in both countries. However, if the software investment per worker and relative size of the non-profit sectors in Canada and the United States are not comparable, then estimates of the gap based on these data will differ from the true business sector gap. This bias cannot be quantified without uniquely identifying software investment, which is the very same reason it exists. Nevertheless, the non-profit sector is likely small enough in both countries that the contribution to the total gap of software investment by those establishments is relatively small.

Having reviewed these factors, it appears very unlikely that measurement differences account for any significant portion of the extremely large gap in pre-packaged software investment per worker. This means that Canada's very low level of investment per worker in pre-packaged software, which was just a quarter of the United States in 2009, is largely unexplained.

### ii. Measurement of Custom Designed Software

The measurement methodology of custom design software in Canada and the United States is exactly the same as for pre-packaged software. The description of the commodity-flow method in Figure 1 and the sources in Table 38 apply to custom software as well, and there are no major differences in the overall methodology. There is, however, one key difference in the calculation of intermediate purchases. Statistics Canada is able to identify all intermediate purchases of software, but is not able to uniquely identify pre-packaged and custom software; all intermediate software purchases are therefore assigned to pre-packaged software. The BEA, in contrast, only identifies intermediate purchases of pre-packaged software, and reduces custom software by the same amount. In general, these intermediate purchases are difficult to measure, and so a fair amount of judgment was required to develop these methodologies. The estimates of

[24] Benchmark years are based on the quinqennial censuses, and so they occur every five years.

intermediate purchases are always continually revised based on benchmark shares and software investment estimates.

The difference in the methods used to account for intermediate purchases cannot affect the overall gap or the gap in software investment, but it will affect the gap by software type and the share of software investment in each type of software. This is because Statistics Canada, by explicitly assigning all intermediate purchases of software to pre-packaged software, reduces the share of software investment in pre-packaged software, and increases the share of investment in custom software. This explains some of the difference in the composition of software investment in Canada and the United States, shown in Table 39.

**Table 39: Shares of Software Investment by Type of Software, Canada and the United, 2009**

| | Pre-packaged | Custom | Own Account |
|---|---|---|---|
| **Canada** | 19.4 | 46.6 | 34.0 |
| **United States** | 29.7 | 31.8 | 38.5 |

Source: CANSIM Table 381-0023 and BEA Fixed Asset Account detailed table 2.5
Note: All figures refer to business sector investment in current dollars.

However, total intermediate purchases of purchased – meaning both pre-packaged and custom design -- software comprised only 4.6 per cent of software investment in 2009, according to IO input estimates from Statistics Canada. Even reducing the share of custom software and increasing the share of pre-packaged software by this amount only makes a modest difference to the distribution software investment in Canada. This explains only a small percentage of Canada's large gap in pre-packaged software investment per worker.

More to the point, however, this difference in the treatment of intermediate purchases does not affect total software investment. Based on our analysis in this section, we conclude that measurement differences in custom designed software cannot account for a significant portion of the Canada-U.S. ICT investment per worker gap. The methodology used by Statistics Canada and the Bureau of Economic Analysis for both categories of purchased software is in fact essentially the same.

### iii. Non-Capitalized Purchases of Software

Investment data in Canada and the United States only include capitalized purchases of software. For the two categories of software investment considered, this refers to two types of purchases: (1) leases or licensed software, which are considered investment made by the lessee in both countries, and (2) purchases of either pre-packaged or custom software. In recent years, cloud computing has emerged as a new technology, but its use is generally governed by Software-as-a-Service (SaaS) agreements, which are not included in either of the preceding categories. SaaS agreements are considered services, not assets, and so will not be classified as fixed capital formation. From the perspective of capital use, however, SaaS agreements are an example of extracting capital services from existing capital stock.

The potential measurement issue is that cloud computing agreements may be more appropriately considered investment, as they do increase the amount of software available to a worker. SaaS agreements therefore have the potential to affect the allocation of software investment estimates in two ways. First, domestic production of cloud computing software will be considered investment by the owner of the software, while the expenditure of the establishment using the software as part of a SaaS agreement is engaging in trade in services. This means that the allocation of investment on an ownership basis, rather than a use basis, may be misrepresenting ICT investment per worker by industry. Second, the same allocation problem exists with respect to trade; SaaS agreements with non-residents will not affect estimates of software investment, even though they may increase or decrease the software available for domestic use. A third issue, arising from the second, is that if the capital services extracted from cloud computing software held by non-residents are better considered investment, then it is possible that software investment is currently under- or overestimated.

Detailed domestic data and international trade data on the trade in computer and information services trade, however, are not capable of uniquely identifying SaaS agreements to allow us to quantify to what degree this may affect estimates of software investment. As the vast majority of ICT-related imports in both countries tend to be for data processing services, it is unlikely that a large number of SaaS agreements are crowding out capitalized purchases of software in Canada or the United States.

In 2011, for example, the share of computer and information services imports in computer and data processing services in the United States was 92 per cent, according to U.S. Trade in Services data. The same detailed data are not available on CANSIM, but the data on trade in services (available in CANSIM 376-0033) indicate that Canada has a trade surplus in computer and information services. A trade surplus means Canada is a net exporter of computer services, which is not consistent with the hypothesis that a significant volume of SaaS imports are leading to software investment in Canada being underestimated. We find that it is very unlikely that this complication has a significant impact on the gap, but as cloud computing grows, more detailed data measuring purchases of these services is warranted.

### iv. Measurement of Own Account Software

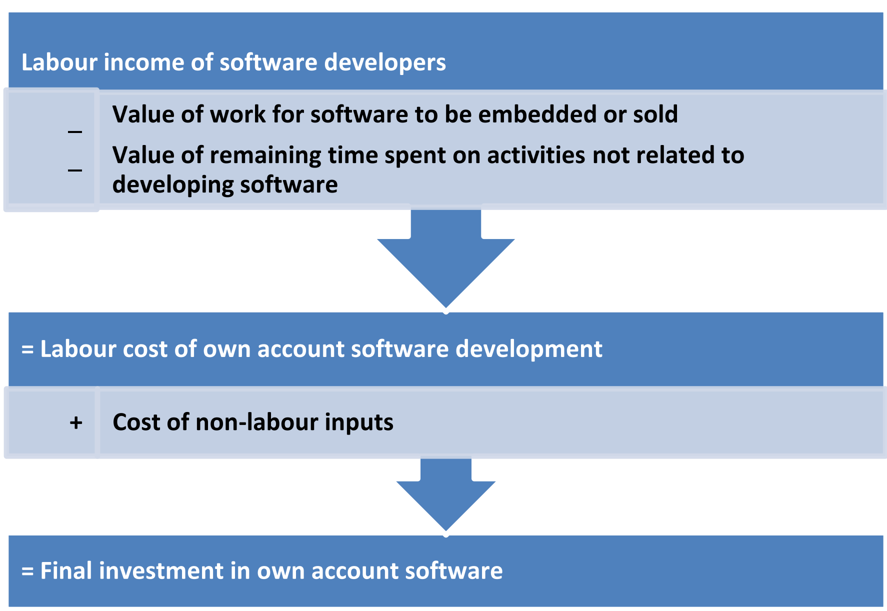
We focus now on own-account software investment, motivated by the fact that it was responsible for 35.1 per cent of the Canada-U.S. ICT investment per worker gap in 2009, and that it tends to account for approximately a third of software investment in both Canada and the United States. Business accounting practices are even more inadequate for investment survey data to accurately measure own-account software, compared to pre-packaged and custom software. Indeed, in our interviews with Statistics Canada, the staff administering the CES indicated that while the response rate for the survey overall was more than satisfactory, the response rate for the section for own-account software was extremely low. This challenge has led to the development of indirect methods for estimating own-account software in Canada and the United States, which we describe in this section. We have previously identified that own-account software investment was responsible for 35.1 per cent of the total Canada-U.S. ICT investment per worker gap in 2009; this extraordinary contribution to the gap motivates our investigation into how estimates of own account software investment are produced.

At the outset, we note that the methodology to measure own account software used by the CSNA in Canada was largely based on the methodology used by the BEA in the United States. Any sources of measurement error are therefore likely to be symmetrical – they will introduce the same bias into the estimates of both countries, which will not have a clear effect on the gap. It is also therefore unlikely that differences in measurement methodology will account for a significant portion of the Canada-U.S. gap in software investment per worker. Nevertheless, we provide an explanation of the methodology and note where they differ in this section.

### a) *Cost-based methodology for own-account software investment*

Own-account software is not bought or sold on a market, and as a result, it has no market value comparable to the purchaser price values we use for determining final investment in purchased software. Consequently, the CSNA and BEA use a cost-based approach to measuring investment in own-account software. The cost-based methodology used by Statistics Canada is shown in Figure 2.

**Figure 2: Methodology for own-account software investment at the Canadian System of National Accounts**




The CSNA methodology uses labour and non-labour costs of own-account software development to estimate the value of own-account software. The process begins with the total labour income of software developers, deducting the labour costs of other activities software developers are engaged in, and adding the non-labour cost of own-account software development. Non-labour costs include the depreciation of machinery and equipment, utilities, travel, property and other taxes, and overhead, including personnel, accounting, and procurement.

From Figure 2, there are four values which must be computed for the methodology used in Canada: (1) the labour cost of software developers, (2) the proportion of their labour cost that produces software for sale or embedding in hardware, (3) the proportion of their labour cost not spent on developing own-account software, and (4) the cost of other inputs. The methodology and data required in the United States are essentially the same.[25]

### Table 40: Data Sources for Own Account Software Estimates in Canada and the United States

| | Data source in Canada | Data source in the United States |
|---|---|---|
| **Labour cost of programmers** | Census of population | BLS occupational employment survey |
| **–** | | |
| **Deduction for embedded software and software for sale** | Cap of 1 per cent of the labour income of employees in software producing industries | Cap of 1 per cent of the employment of computer programmers |
| **Time spent not developing software** | 50 per cent reduction of remaining income assumed | 50 per cent reduction of remaining income assumed |
| **+** | | |
| **Non-labour inputs** | Estimate non-labour inputs from labour inputs, based on cost structure of custom software production from Survey of Computer Services | Estimate non-labour inputs from labour inputs, based on cost structure of custom software production from Census of Service Industries |
| **=** | | |
| **Final investment in own account software** | | |

Note: the labour cost in both countries is adjusted to include benefits, employment insurance, public and private pensions, performance pay, etc., to provide a comprehensive reflection of the cost to employers.

Each step in this process is based on data from either the census or surveys, except for the two deductions. The first deduction, for embedded software and software for final sale, is slightly different in the two countries; we leave this issue for the next section. The second deduction subtracts 50 per cent of the remaining labour income of software developers, on the basis that software developers only work on developing own-account software for about half of their time. This is based on a study in the United States from 1981 of how software developers use their time, which found that software developers use 62 per cent of their time to develop software.[26] The BEA and Statistics Canada arbitrarily reduced the share to 50 per cent, on the basis that this is an approximate exercise. They were also motivated by a belief, when this

[25] The BEA methodology for current-year quarterly estimates is different from what is described here, but our focus is on the annual estimates, which follow this methodology.
[26] The study in question is: Boehm, B (1981). Software Engineering Economics (Englewood Cliffs, NJ: Prentice-Hall). 533-35, 548-50.

methodology was developed following the 1981 study this share is taken from (Boehm, 1981), that own account software was becoming less important.

### b) *Differences in the estimation of own account software investment*

Table 40 reveals one difference in the methodologies used to estimate own account software investment in Canada and the United States. This is the deduction for embedded software and software for final sale: in Canada, this deduction is based on an estimate that software developers account for roughly 1 per cent of all wages, salaries and supplementary income in industries not engaged in producing software for sales or embedding it in hardware. The CSNA uses this percentage to cap the labour cost of software developers in software producing and developing industries, on the basis that any labour cost above this amount must be for the purpose of producing software to be embedded or sold. The BEA performs the same adjustment, but it is based on 1 per cent of the employment of software developers, not 1 per cent of their income. Given different average wages, this will result in a different share of income being excluded. However, both Canada and the United States have verified and adjusted these shares using survey data, so any inconsistency resulting from this difference in methodology will reflect a real difference in the production of own account software in Canada and the United States.

As this is the only apparent difference in the methodologies used by Statistics Canada and the BEA to estimate own account software, we conclude that there are no significant differences in the methodology used to measure own-account software in Canada and the United States.

## v. Impact of Wages on Own Account Software Investment Estimates

The previous section discussed the cost-based methodology for estimating own-account software in Canada and the United States, which relies heavily on the labour income of software developers, and determined that the methodologies are largely the same.

However, the fact that U.S. salaries are greater for software developers is a conceptual challenge to this cost-based approach to valuing own-account software. In theory, a software developer with the same skill level could earn more, and contribute to a greater level of own-account software investment, simply by virtue of being employed in the United States. This could occur even if a software developer in each country produced precisely the same software for their employer to use. In this case, the greater level of investment in the United States does not reflect differences in software investment, but instead only reflects the fact that software developers in the United States earn a salary premium relative to their counterparts in Canada. This section explores this conceptual challenge, examining how own-account software investment in Canada changes if software developers in Canada earned U.S. wages.

Our methodology in this section to produce an estimate of how this wage gap has affected the Canada-U.S. ICT investment per worker gap will be as follows. We use employment and wage data from 2005 to establish a wage gap; 2005 is chosen because it was a census year in

Canada, so we have the greatest level of detail for employment and average earnings in this year. Second, we use the wage gap and the data we have for own-account software investment for 1998-2009 to see what impact the difference in wages between Canada and the United States for software developers had based on that data. This will allow us to provide an estimate of the difference in wages of software developers on the Canada-U.S. ICT investment per worker gap.

### a) Differences in labour cost of software developers

Statistics Canada and the Bureau of Economic Analysis use a cost-based methodology described in the previous section to estimate own-account software. The labour cost of software developers is the primary input – some of this cost is deducted for time spent on other work, and the remaining cost is increased using the ratio of operating expenses to labour costs. All of these relationships are proportional, so an increase in labour costs would, in this methodology, also result in an increase in the estimated non-labour inputs.

Our estimate of the wage is shown in Table 41. The software developers in Statistics Canada's cost-based methodology consist of NOC 2006 C071-75, so we include these occupational codes.

**Table 41: Average Salary of Software Developers in Canada, 2005**

| NOC Code(s) | Occupation | Employment | Share of Employment | Average Salary | Relative to All Occupations |
|---|---|---|---|---|---|
| **NOC 0** | All Occupations | 17,146,135 | 100.00 | 37,855 | 100.00 |
| **C071** | Information systems analysts and consultants | 142,400 | 0.83 | 61,448 | 162.33 |
| **C072** | Database analysts and data administrators | 13,630 | 0.08 | 54,474 | 143.90 |
| **C073** | Software engineers and designers | 30,740 | 0.18 | 71,486 | 188.84 |
| **C074** | Computer programmers and interactive media developers | 100,365 | 0.59 | 52,375 | 138.36 |
| **C075** | Web designers and developers | 20,550 | 0.12 | 31,618 | 83.53 |
| | Total Software Developers | 307,685 | 1.79 | 57,190 | 151.08 |

Source: 2006 Census, see Appendix Table 16a for detailed calculations.
Note: Average salary for all software developers is weighted average of NOC codes C071-5.

The same data for the United States is provided in 2006, for the Standard Occupation Classification (SOC) codes that the BEA informed us they use in their cost-based methodology. The BLS Occupation Employment Statistics, which we have taken these estimates from, is also the source of data used by the BEA to estimate own account software. The SOC code numbers have changed since 2006, but they are substantially the same otherwise.

**Table 42: Average Salary of Software Developers in the United States, 2006**

| SOC Code (2006) | Occupation | Employment | Average Salary | Share of Employment | Salary Relative to All Occupations | Relative to Canada |
|---|---|---|---|---|---|---|
| **00-0000** | All Occupations | 130,307,840 | 37,870 | 100.00 | 100.00 | 116.33 |
| **15-1021** | Computer Programmers | 389,090 | 67,400 | 0.30 | 177.98 | .. |
| **15-1031** | Computer Software Engineers, Applications | 455,980 | 79,540 | 0.35 | 210.03 | .. |
| **15-1032** | Computer Software Engineers, Systems Software | 320,720 | 84,310 | 0.25 | 222.63 | .. |
| **15-1051** | Computer Systems Analysts | 492,120 | 70,430 | 0.38 | 185.98 | .. |
| **Total Software Developers** | | 1,657,910 | 74,910 | 1.27 | 197.81 | 152.31 |

Source: BLS Occupational Employment Statistics.
Note: Relative to Canada is estimated using GDI PPP of 0.86 in 2005.

Based on these data and GDI PPP of 0.86 in 2005, software developers earned 52.31 per cent more in the United States, $74,910 in the United States compared to $49,183 in Canada. We use GDI PPP to convert instead of exchange rates because PPP reflects differences in prices, and provides a more accurate comparison of the labour cost to firms in Canada and the United States of employing software developers.

Before applying this estimate of the wage gap to our data on own account software investment, we note three important differences between Table 41 and Table 42. First, software developers earn much more relative to the national average in the United States than Canada. Software developers in the United States earn nearly twice as much as the average salary for all occupations, compared to around 50 per cent more in Canada. Second, Statistics Canada includes web developers in their definitions of software developers, while the BEA does not. Web developers make up a relatively small share of employment, but we still note that the two countries have different definitions of software developers for the purpose of estimating own-account software. Third, software developers make up a significantly smaller share of total employment in the United States than Canada. Their employment share of 1.79 per cent is 40.9 per cent higher than the U.S. share of 1.27 per cent.[27]

It is surprising that own-account software investment per worker is so much lower in Canada than the United States given that there are relatively more software developers in Canada. This difference could be explained in part by a larger share of software developers in

[27] Software developers in Canada represented 1.78 per cent of the working-age population in 2005, compared to 0.73 per cent in the United States, based on LFS and CPS data. The proportion of software developers is even greater based on WAP.

Canada working in industries which only sell or embed software in hardware. The wage difference, of course, also explains part of this discrepancy, but not all of it. Further research is required to determine precisely why own-account software investment per worker is so much lower in Canada than the United States despite greater employment of software developers.

We also note that the U.S. salary premium estimate of 52.31 per cent in Table 42 depends on the value of PPP for GDI, which we used to convert CAD to USD. Given similar growth rates of nominal salaries in Canada and the United States, the U.S. salary premium will change over time depending on the relative value of the CAD and USD as measured by PPP. To allow our estimate of the U.S. salary premium to change over time, we assume that the growth rates of nominal salaries in Canada and the United States are close enough that changes in the U.S. salary premium will depend only on changes in PPP. This estimation is shown in Table 43.

**Table 43: Salary Premium of U.S. Software Developers Relative to Canada, 1998-2009**

| | U.S. Salary Premium in 2005 in domestic currency (per cent) | GDI for PPP (USD per CAD) | U.S. Salary Premium Adjusted for PPP (per cent) |
|---|---|---|---|
| | A | B | C = A/B |
| **1998** | 130.98 | 0.83 | 157.81 |
| **1999** | 130.98 | 0.83 | 157.81 |
| **2000** | 130.98 | 0.83 | 157.81 |
| **2001** | 130.98 | 0.84 | 155.93 |
| **2002** | 130.98 | 0.83 | 157.81 |
| **2003** | 130.98 | 0.84 | 155.93 |
| **2004** | 130.98 | 0.84 | 155.93 |
| **2005** | 130.98 | 0.86 | 152.31 |
| **2006** | 130.98 | 0.88 | 148.84 |
| **2007** | 130.98 | 0.91 | 143.94 |
| **2008** | 130.98 | 0.94 | 139.34 |
| **2009** | 130.98 | 0.92 | 142.37 |

Source: Appendix Table 16a

### *b) Contribution of salary differences to the gap*

Using the data we have for own account software investment from the Input-Output tables, we can use the U.S. salary premium for software developers shown in Table 43 to estimate own-account software investment in Canada adjusting for the Canada-U.S. wage differential for software developers. This will allow us to produce an estimate of the contribution of wages to the Canadian-U.S. ICT investment per worker gap for the 1998-2009 period, based on data for own-account software investment in Canada. This depends on our previous assumption that nominal growth of salaries of software developers in Canada and the United States is similar.

### Table 44: Simulated Canada-U.S. Investment per Worker Gap Based on U.S. Salaries for Canadian Own Account Software Investment, 1998-2009

| | U.S. Salary Premium (per cent) | Actual Investment per Worker in Canada (U.S. dollars) | | | Simulated Investment per Worker in Canada (U.S. Dollars) | | |
|---|---|---|---|---|---|---|---|
| | | Own Account | Software | Total ICT | Own Account | Software | Total ICT |
| | A | B | C | D | E = A x B | F = C – B + E | G = D – B + E |
| 1998 | 157.8 | 163 | 608 | 1,554 | 257 | 702 | 1,649 |
| 1999 | 157.8 | 178 | 636 | 1,691 | 280 | 739 | 1,793 |
| 2000 | 157.8 | 183 | 669 | 1,859 | 289 | 774 | 1,965 |
| 2001 | 155.9 | 233 | 725 | 1,834 | 363 | 855 | 1,964 |
| 2002 | 157.8 | 211 | 692 | 1,746 | 333 | 814 | 1,868 |
| 2003 | 155.9 | 181 | 715 | 1,766 | 283 | 816 | 1,868 |
| 2004 | 155.9 | 205 | 808 | 1,949 | 320 | 923 | 2,064 |
| 2005 | 152.3 | 286 | 930 | 2,131 | 436 | 1,080 | 2,280 |
| 2006 | 148.8 | 305 | 944 | 2,251 | 454 | 1,093 | 2,400 |
| 2007 | 143.9 | 334 | 1,095 | 2,296 | 480 | 1,241 | 2,443 |
| 2008 | 139.3 | 331 | 1,089 | 2,306 | 461 | 1,219 | 2,436 |
| 2009 | 142.4 | 322 | 875 | 1,993 | 458 | 1,012 | 2,129 |

Source: Appendix Tables 16a and 16b

### Table 45: Canada-U.S. ICT Investment per Worker Gap at U.S. Salaries for Software Developers, 1998-2009

| | Actual Canada Relative to the United States (per cent) | | | Simulated Canada Relative to the United States (per cent) | | | Difference (percentage points) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Own Account | Software | Total ICT | Own Account | Software | Total ICT | Own Account | Software | Total ICT |
| | A | B | C | D | E | F | G = D - A | H = E - B | I = F - C |
| 1998 | 47.8 | 53.7 | 57.6 | 75.5 | 62.0 | 61.1 | 27.7 | 8.33 | 3.50 |
| 1999 | 37.2 | 45.8 | 54.3 | 58.7 | 53.1 | 57.6 | 21.5 | 7.39 | 3.30 |
| 2000 | 32.0 | 41.7 | 52.2 | 50.5 | 48.3 | 55.2 | 18.5 | 6.60 | 2.97 |
| 2001 | 39.5 | 44.3 | 54.9 | 61.6 | 52.3 | 58.8 | 22.1 | 7.96 | 3.90 |
| 2002 | 35.5 | 42.2 | 56.6 | 56.0 | 49.6 | 60.6 | 20.5 | 7.43 | 3.95 |
| 2003 | 28.2 | 41.6 | 56.5 | 43.9 | 47.5 | 59.7 | 15.8 | 5.90 | 3.24 |
| 2004 | 29.1 | 44.3 | 59.9 | 45.3 | 50.6 | 63.4 | 16.3 | 6.29 | 3.53 |
| 2005 | 39.8 | 49.0 | 64.7 | 60.6 | 56.9 | 69.3 | 20.8 | 7.88 | 4.54 |
| 2006 | 40.9 | 48.0 | 65.2 | 60.9 | 55.6 | 69.6 | 20.0 | 7.58 | 4.32 |
| 2007 | 42.7 | 52.6 | 63.1 | 61.4 | 59.7 | 67.1 | 18.7 | 7.05 | 4.03 |
| 2008 | 39.5 | 49.1 | 62.5 | 55.0 | 55.0 | 66.0 | 15.5 | 5.87 | 3.53 |
| 2009 | 35.6 | 37.3 | 54.0 | 50.7 | 43.1 | 57.7 | 15.1 | 5.81 | 3.69 |

Source: Appendix Tables 16a and 16b

We can see from Table 44 and Table 45 that, using the adjusted values of own-account software, the total Canada-U.S. ICT investment per worker gap shrinks by approximately 4 percentage points in each year. This represents for about 10 per cent of the total Canada-U.S. ICT investment per worker gap.

# V. Review of Factors Contributing to the Canada-U.S. ICT Investment per Worker Gap

The Canada-U.S. ICT investment per worker gap has been decomposed into several factors over the course of this report. These include proximate causes of the Canada-U.S. ICT investment per worker gap, the effect of which we are able to quantify, and measurement-related factors, only some of which we are able to quantify. Together, these factors explain 18.5 percentage points (43.8 per cent) of the 42.2 percentage point gap in 2011.

This leaves a considerable portion of the gap unexplained. There are, of course, non-measurement factors which are difficult to quantify, but are expected to affect ICT investment in Canada and the United States. The list of such factors is numerous, but we briefly highlight three which we believe are important to consider. First, we note differences in firm size in Canada and the United States, which may affect ICT investment per worker. Second, we note differences in the education of managers in Canada and the United States, which may affect investment decisions that relate specifically to ICT. Third, we also note differences in business attitudes and culture between Canada and the United States that may also have an effect on ICT investment decisions.

It is important to note that this is only a selection of remaining factors which may contribute to the gap. Prior research has identified other differences between Canada and the United States that may affect the Canada-U.S. ICT investment gap, such as the regulation of telecommunications firms and the fact that businesses in Canada have become net savers in recent years (Dachis and Robson, 2012).

## A. Firm Size

Firm size is positively correlated with investment per worker – large firms invest more per worker than small firms, because larger firms have more resources, in terms of both financial and human capital. It is also easier for larger firms to spread the cost of adoption across a larger number of employees, and to retain and diffuse within the firm the necessary human capital required to enjoy the benefits of new technology. Therefore, we would expect that if the share of employees in small firms were greater in Canada, then ICT investment per worker in the Canada would be smaller. We examine firm size in Canada and the United States to determine if Canada does in fact have a greater share of employment in smaller firms, which may in turn affect ICT investment per worker.

**Table 46: Employment Shares (per cent) by Firm Size, Canada and the United States, 2010**

| | Share of Firms | | Share of Total Employment | |
|---|---|---|---|---|
| | Canada | U.S. | Canada | U.S. |
| **Small ( 0-99)** | 98.9 | 98.3 | 48.3 | 34.9 |
| **Medium (100-499)** | 0.9 | 1.4 | 15.6 | 14.2 |
| **Large (500+)** | 0.2 | 0.3 | 36.1 | 50.9 |

Source: Appendix Table 14. Original data from Statistics Canada Business Register and U.S. Census Bureau

As shown in Table 46, according to the Statistics Canada business register, in 2010, 98.3 per cent of Canadian companies had less than 100 employees while according to US Census Bureau 98.9 per cent of US firms had less than 100 employees. However, as we have noted, the distribution of employment by firm size differs significantly between the two countries. A greater number of employees work for firms with less than 100 employees in Canada than in the United States: 48.3 per cent compared to 34.9 per cent.

Researchers at the Bank of Canada also found differences not only in the proportion of small and large business in the Canadian and American economy, but also in the absolute size of small and medium business in themselves. In the Canadian economy, "nearly three-quarters of Canadian SMEs have only 0-4 employees, while the number for the U.S. is slightly less than 60 per cent" (Leung, Meh and Terajima, 200: 7-8). The Bank of Canada also found that the average number of employees for an American SME is 9.2 employees, well above the Canadian average of 5.7 employees.

Furthermore, Martin and Milway (2007a) find that managers of small and medium-sized enterprises (SMEs) generally report difficulty seeing quantifiable benefits from investing in ICT. These difficulties are related to a lack of specialized staff and the adoption cost of integrating new ICT into a firm’s operations. Martin and Milway (2007a) find significant gaps in the use of advanced business applications of ICT, such as a company website, and online purchases and sales, between SMEs and larger firms. This is consistent with evidence in our original study, Sharpe (2005), which draws on international studies from Australia, Italy, and the UK to show that SMEs are less likely to adopt ICT.

Because investment data are collected at the establishment and not firm level, we cannot compare ICT investment per worker in the two countries by firm size to quantify what effect this might have. We would nevertheless expect this difference to explain some, although perhaps small, part of the Canada-U.S. ICT investment per worker gap.

## B. Education of Managers

The adoption of ICT assets requires specific human capital and some expertise or experience to understand how ICT investment can enhance productivity. In most firms, investment decisions are centralized, made by a manager or owner. It is therefore important that managers and owners be able to understand the benefits of investing in ICT and how to integrate ICT assets into their firm's production process in order to enjoy the associated productivity gains. Research has shown that less-educated management tends to be less demanding of innovation, which would lead to lower investment in ICT. We therefore investigate the education of managers in Canada and the United States and find several important differences.

First, we note that managers in general are less educated in Canada than the United States, purely on the basis of educational attainment. In Canada, only 32 per cent of managers possessed a university degree compared to 48 per cent in the United States from an average over 1997-2004. The complete breakdown of managers' education is shown in Table 47, which also shows that a greater share of managers in Canada have less than a high school education. This lower level of human capital at the management level is itself troubling, and may also explain part of Canada's lower ICT investment per worker.

**Table 47: Education Attainment of Managers in Canada and the United States, average from 1997-2004 (per cent)**

| | Canada | United States |
|---|---|---|
| **Less than high school** | 9 | 3 |
| **High school** | 19 | 21 |
| **Some post-secondary** | 40 | 28 |
| **Bachelor's degree** | 21 | 32 |
| **Advanced degree** | 11 | 16 |

Source: Martin and Milway (2007b).

Second, in addition to U.S. managers having more education on average, the type of education possessed by managers in the United States is also more likely to be conducive to higher ICT investment. A 2004 comparison of the CEOs of Fortune 500 companies to the 100 largest corporations identified by Canada's Financial Post 100 found that 37 per cent of large U.S. firms were run by someone with an MBA, compared to 24 per cent in Canada (Martin and Milway, 2007b). MBAs typically possess management expertise designed specifically to increase productivity, which may make MBA-educated CEOs more likely to prioritize ICT investment. MBA-educated CEOS may also be more knowledgeable of financing, or willing to engage in financing to a greater degree, which makes higher investment in ICT more likely.

We also note that, while they are separate issues both with a distinct effect on ICT investment, firm size and the education of managers are also interrelated issues. Canada not only has a larger share of SMEs and less educated managers, but also has less educated managers in SMEs (Martin and Milway, 2007b). This combination has the potential to compound the tendency of SMEs and less-educated managers to invest less in ICT.

There is an important qualification to be made with regards to education, however. In general, the Canadian workforce has a similar share of scientists and engineers as the United States (Martin and Milway, 2007b). Technical expertise overall is not lacking in the Canadian workforce – this appears to be a problem confined to management. The degree to which better-educated managers encourage greater ICT investment per worker in the United States is not quantifiable, but we do believe that differences between Canada and the United States in the education of managers increase the Canada-U.S. ICT investment per worker gap.

## C. Corporate Tax Policy

Investment in machinery and equipment, including ICT, is affected by direct and indirect taxes, which influence businesses' incentives to invest and their overall demand for capital. Corporate income taxes may reduce investment, as some of the income which is used to pay taxes may have been used to invest in machinery and equipment instead. Likewise, indirect taxes such as sales taxes or value-added taxes can reduce investment by making goods and services more expensive. Finally, both Canada and the United States allow business to reduce their taxable income by claiming the depreciation of capital as an expense; this can increase investment, by reducing the cost of acquisition of capital to businesses. There are significant differences between Canada and the United States for all three of these framework variables, which may have had an effect on the relative level of ICT investment per worker in the two countries.

This section analyzes a number of tax policy indicators for Canada and the United States, including: statutory corporate tax rates; corporate income tax receipts as a share of GDP; corporate income tax receipts as a share of total business receipts; corporate income tax receipts as a share of taxable income; and marginal effective tax rates (METRs). Among these indicators, METRs are arguably the most important, since they take into account the three framework variables highlighted in the previous paragraph (statutory rates, depreciation, and indirect taxes). Ideally, for a complete comparison of the relative tax treatment of ICT in Canada and the United States, we would use specific METRs for ICT and non-ICT M&E. We could not, however, find such estimates. Thus, the METRs discussed here are "general" METRs. The United States has a progressive corporate income tax, increasing gradually to a flat rate of 35 per cent on income above $18.3 million. Canada, in contrast, has a tax rate of 11 per cent for income up to $500,000, and 15 per cent for income above that amount for Canadian-controlled corporations. For general corporations, Canada has a flat tax rate of 15 per cent. These statutory federal rates clearly favour Canada in a direct comparison with the United States. The corporate income tax rate was reduced in Canada a number of times in the last decade. It stood at 28 per cent in 2000, still below the statutory federal corporate income tax rate in the United States at that time.

In Canada and the United States, provinces and states also collect corporate income tax, and there is considerable variation in the combined corporate income tax rate. The provincial corporate income tax rates in Canada range from 10 per cent to 16 per cent (KPMG, 2012).[28]. Of the 50 states, four have no corporate income tax, while 32 have a flat corporate income tax rate below 10 per cent.[29] The remaining 14 states in 2012 had a progressive corporate income tax schedule (Tax Policy Center, 2012a).[30] The combined statutory rates still favour Canada in this comparison, although the difference would be smaller in some jurisdictions.

However, statutory rates are not the most accurate basis for comparison. Both countries allow businesses to reduce their taxable income by deducting expenses, the treatment of which has a significant effect on average effective tax rates. As an exhaustive analysis of the rules governing how all deductions reduce corporate income tax liabilities is well beyond the scope of this report, we compare Canada and the United States using three summary measures of the relative corporate tax burden, to determine whether Canada or the United States has higher average effective tax rates. We also compare marginal effective tax rates in Canada and the United States, which affect the incentive of corporations to invest.

First, corporate income tax receipts as a share of GDP are higher in Canada, even in 2012 after a decade of falling statutory corporate income tax rates in Canada and relative rate stability in the United States. In 2011, corporate income tax receipts were 3.09 per cent of GDP in Canada, compared to 2.60 per cent in the United States, shown in Chart 21. Corporate income tax receipts have always represented a smaller share of GDP in the United States, despite statutory rates favouring Canada for this entire period. Note that this measure is sensitive to structural differences between Canada and the United States. For example, the relatively larger natural resource sector in Canada may result in higher economic rents and hence a higher corporate tax receipt share of GDP, even with the same statutory tax rates.

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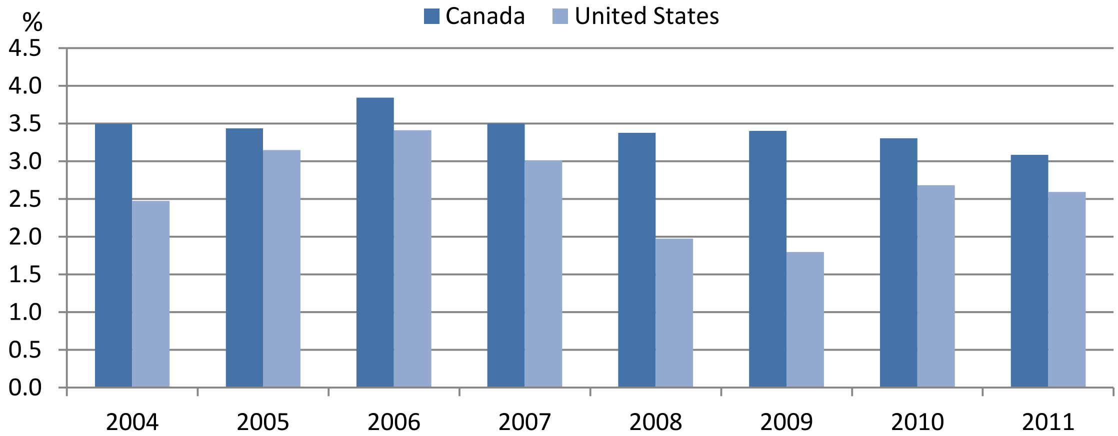
[28] The lowest corporate income tax rate in Canada in 2012 was 10 per cent in Alberta; the highest was 16 per cent in Nova Scotia. There is also a parallel income tax schedule for small businesses, the rates for which are much lower. Manitoba, for example, has no small business income tax, while the highest small business income tax rate among the provinces is in Quebec, at 8 per cent

[29] The four states without a corporate income tax are Nevada, South Dakota, Washington, and Wyoming.

[30] In every state with a progressive corporate income tax schedule, the highest rate is below 10 per cent.

### Chart 21: Corporate Income Tax Receipts as Share of GDP, Canada and the United States, 2004-2011



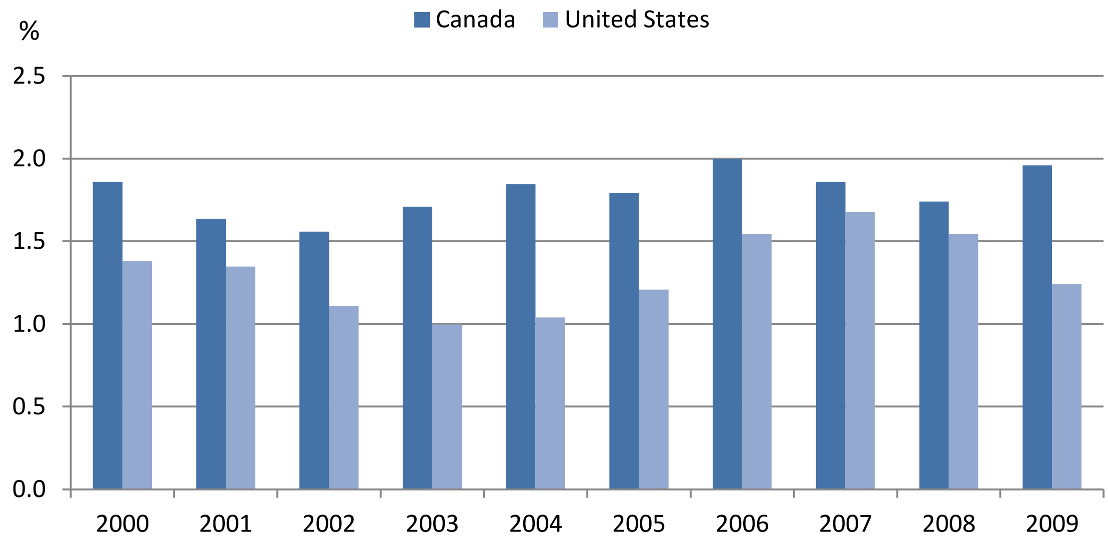

Source: OECD Statistics, Taxation

Second, we compare the corporate tax receipts share of GDP to two measures of the average effective tax rate: the share of corporate taxes in total business receipts, and the share of corporate taxes in taxable corporate income. The corporate tax receipt share of business receipts, shown in Chart 22, favours the United States. In 2009, the latest year for which data are currently available for comparison, the shares for Canada and the United States were, respectively, 1.96 and 1.24 per cent. In 2000, corporate income taxes were 1.86 per cent of total business receipts in Canada, compared to 1.38 per cent in the United States, very similar to 2009. Tax rates in Canada fell substantially from 2000-2009, so it is surprising that tax receipts as a share of total business receipts as shown in Chart 22 did not decline over this period.

For the second measure, shown in Chart 23, the average effective tax rate was 28.2 per cent in Canada in 2009, somewhat lower than the rate of 29.9 per cent in the United States. Since this measure of corporate income taxes is highly sensitive to differences in rules governing deductions which determine taxable income, it may not be the most accurate measure of average tax rates.

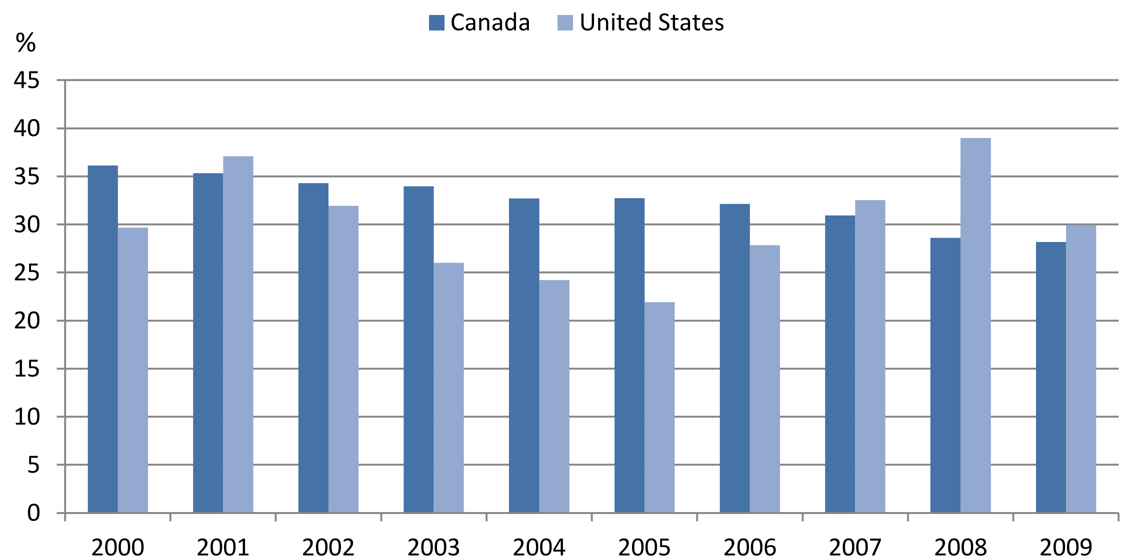
Statutory corporate tax rates continued to fall in Canada in the 2010-2012 period, from 18 per cent in 2010 to the current rate of 15 per cent, so it is possible that in 2012, Canada's performance relative to the United States is better than it was in 2009, as shown in Chart 22 and Chart 23.

### Chart 22: Corporate Tax Receipts as a Share of Total Business Receipts, Canada and the United States, 2000-2009




Source: Appendix Table 17c for detailed calculation; CANSIM Table 180-0003 for Canada; IRS Statistics on Income Integrated Business Data for U.S. business receipts and federal taxes; U.S. Census Bureau Annual Survey of State Government Tax Collections for U.S. State CIT

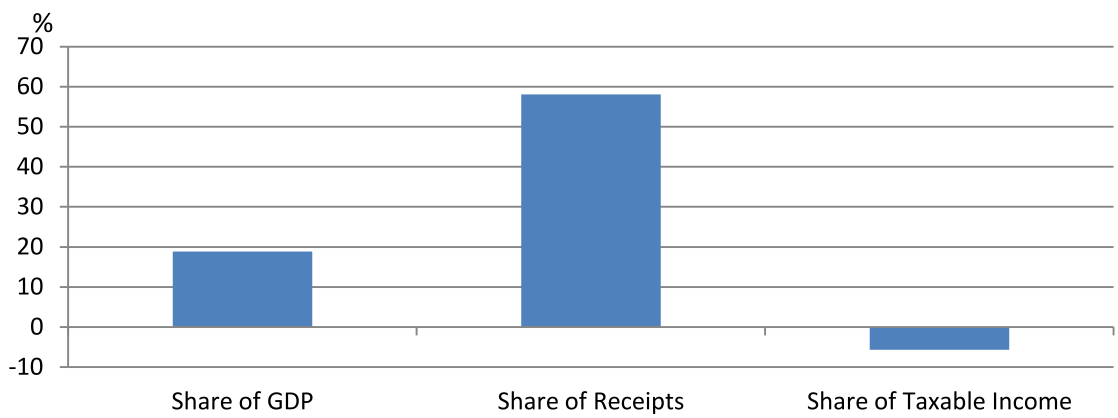
### Chart 23: Corporate Tax Receipts as a Share of Taxable Income, Canada and the United States, 2000-2009




Source: Appendix Table 17c for detailed calculation; CANSIM Table 180-0003 for Canada; IRS Statistics on Income Integrated Business Data for U.S. business receipts and federal taxes; U.S. Census Bureau Annual Survey of State Government Tax Collections for U.S. State CIT

Underscoring this analysis is the fact that the corporate income tax is not distributed uniformly among corporations in the United States. A 2008 study by the Government Accountability Office (GAO) motivated by concerns about transfer pricing abuse in the United States found that, among companies with $50 million or more in gross receipts or $250 million or more in assets, many did not pay any corporate income tax for one or more years from 1998-2005. For example, in this period, 54.9 per cent of foreign-controlled US corporations and 71.7 per cent of US-controlled corporations reported no tax liabilities for at least one year. Furthermore, about 80 per cent of such corporations in 2005 established no tax liabilities prior to claiming any net operating loss (GAO, 2008). These corporations reduced their tax liabilities, largely by claiming deductions in the category of "other deductions," reinforcing our observation that deductions have a significant impact on average effective tax rates for corporations in the United States.

**Chart 24: Per Cent Tax Share in Canada Relative to the United States, 2009**

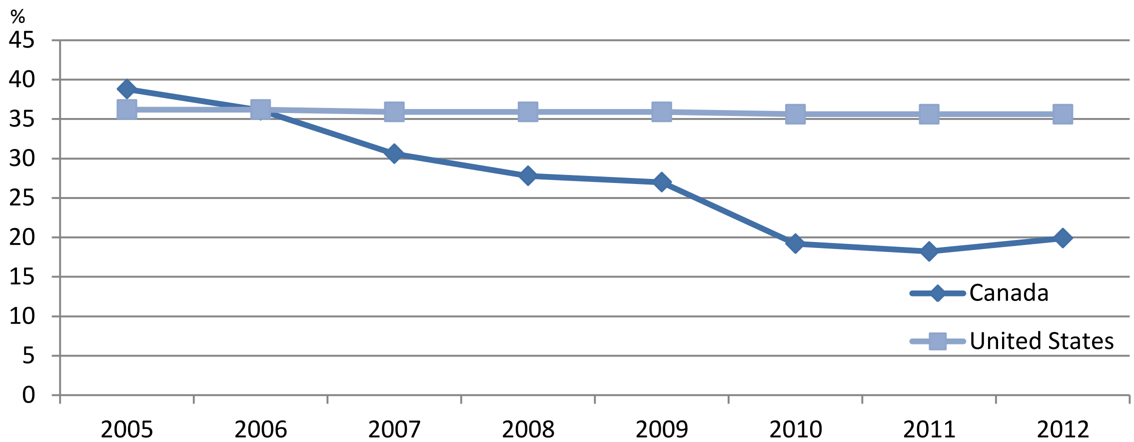



Based on this analysis, it is unclear which country has greater average tax rates, despite statutory rates being much lower in Canada relative to the United States. For two of the three measures we have used, average corporate income taxes were lower in the United States. This is summarized in Chart 24, which shows that corporate income tax receipts constitute a larger share of GDP and a much larger share of business receipts in Canada, but take up a smaller share of taxable income in relative terms. Some of this difference is likely due to the larger natural resource sector in Canada, as we previously noted, but it is a surprising result given that statutory rates are much lower in Canada.

Chen and Mintz (2012) conducted a study of 90 countries, including all G7 countries, and found that on the basis of marginal effective tax rates (METRs), Canada has the lowest METR of all G7 countries. Compared to all 34 OECD nations, the study found that Canada had the 15$^{th}$ highest METR, making it the 20$^{th}$ most tax competitive nation based after accounting for other features, such as the presence of value-added taxes and taxes on income earned from capital. It is worth noting that Canada's relative performance among the G7 is much better than its performance compared to all OECD countries.

In a direct comparison with the United States, shown in Chart 25, Canada's METR on capital investment was 19.9 in 2012, compared to 35.6 in the United States (Chen and Mintz, 2012). Furthermore, Canada's METR has declined dramatically since 2005, when it stood at 38.8 per cent. The United States had a METR on capital investment of 36.2 per cent in 2005, actually below Canada's 2005 METR.[31] This implies that the substitution effect substantially favours Canada, while it is unclear which country gains an advantage through the income effect. The decline in Canada's METR is attributable to harmonization of the GST/HST and falling statutory corporate income tax rates.

**Chart 25: Marginal Effective Tax Rates, Canada and the United States, 2005-2012**



Source: Chen and Mintz (2012)

One the factors driving METRs estimated in Chen and Mintz (2012) is sales taxes. In Canada, the national and provincial sales taxes are harmonized, which means it functions like a value-added tax, excluding spending on intermediate goods from taxation. [32] This is positive for investment. In the United States, there is no national sales tax, but 45 states have a sales tax of their own (Tax Policy Center, 2012b).[33] Although no state has implemented a value-added tax, it is reasonable to assume that the negative impact of state sale taxes is not particularly large due to low tax rates (in particular when compared to Canada).

[31] Average tax rates appear to be much more similar in Canada and the United States than METRs, even after statutory rates fell in Canada. This is likely because many deductions and credits in the United States function as lump-sum transfers (e.g., refundable tax credits), which do not affect METRs and will not have any associated substitution effect. Lump-sum transfers only effect average effective tax rates and therefore only have an income effect. Transfer pricing rules may also lower average tax rates in ways which do not appear in METRs.

[32] Harmonization is in effect in most provinces, but notably not in Prince Edward Island, Manitoba, and Saskatchewan. Quebec does not have a harmonized provincial sales tax, but instead has a value-added tax which is similar to harmonization. The British Columbia legislature harmonized its sales tax in 2010, but harmonization was repealed by referendum in 2011 and replaced with a provincial sales tax, effective in 2013. Alberta has no provincial sales tax.

[33] Alaska, Delaware, Montana, New Hampshire, and Oregon do not have a state sales tax. The state sales tax rates vary from a low of 2.9 per cent in Colorado to a high of 7.25 per cent in California.

Additionally, the METR on capital investment will not be the same for all types of capital because both Canada and the United States allow businesses to deduct the cost of capital from their income differently based on the type of assets purchased.[34] For computers and software, the capital cost allowance (CCA) in Canada varies depending on the intended use of the asset and the date of acquisition. For assets acquired in 2007 or later, there are several classes of (CCAs) which include computers and software. The rate at which their cost be used as an expense ranges from 25 per cent to 100 per cent per year, beginning in the year the asset is placed in service, and ending when the total cost of acquisition is exhausted.

Exhibit 1 shows the description of these assets and their capital cost allowances (CCAs). Prior to 2007, the prescribed rate ranged from 25 to 50 per cent per year, generally meaning that it would take a business three years to fully deduct the expense of acquiring an ICT asset. General purpose computer hardware and software acquired after 2007 is subject to a rate of 100 per cent if acquired between 2009 and 2011, and a rate of 55 per cent otherwise. The CCA of 100 per cent from 2009 and 2011 was a part of the federal government's stimulus program during the recession (Warda, 2010). The CCA for computer hardware and software was allowed to fall back to 55 per cent when the stimulus program ended. Meanwhile, network infrastructure equipment is always subject to a capital cost allowance rate of 30 per cent.

### Exhibit 1: Capital Cost Allowance for ICT Assets in Canada

| Class | Rate (per cent) | Eligible period of acquisition | Description |
|---|---|---|---|
| 29 | 25 in 1st year<br>50 in 2nd year<br>25 in 3rd year | March 28, 2007 to January 28, 2009 | Machinery and equipment used in Canada to manufacture and process goods for sale or lease, including computers and software |
| 46 | 30 | After March 22, 2004 | General purpose network infrastructure equipment and systems software |
| 50 | 55 | After March 18, 2007 | General-purpose computer hardware and systems software for that hardware, not included in class 52 or 29 (based on date of acquisition) |
| 52 | 100 | January 27, 2009 to February 2011 | General-purpose computer hardware and systems software for that hardware, not included in class 29 |

Source: Canada Revenue Agency, Business and Professional Income Guide; Includes Form T2125 2012

In the United States, firms are able expense up to $500,000 of the total cost of new and used depreciable assets the year they are placed into service, according to Section 179 of the Internal Revenue Code (IRC) (Guenther, 2013). Additionally, Section 168(k) includes a provision which is referred to as "bonus depreciation" in the United States; this provision adds up to 50 per cent of the value of eligible assets, which includes software. The bonus depreciation provision has been in place since 2002, and was recently renewed for 2013 (Guenther, 2013).

[34] See Warda (2005) for a more complete analysis of the tax incentives for businesses to adopt ICT in Canada and the United States.

Similar to the 100 per cent CCA in place in Canada from 2009 to 2011, bonus depreciation was originally introduced as economic stimulus (Warda, 2010). The United States, however, has kept this provision in place. Guenther (2013) presents some evidence that the bonus depreciation provisions have not had a significant impact on investment, citing surveys which point to low take-up rates and evidence that much of the capital expense claimed under these deductions would have occurred anyway.

The Section 179 and 168(k) allowances are in addition to the general depreciation expense allowance system in the United States, the modified accelerated cost recovery system (MACRS).[35] Under the MACRS, computers and information systems are classified as having a 5-year service life, with depreciation rates of 20, 32, 19.2, 11.52, 11.52, and 5.76 per cent in each year.[36] Businesses would only have to use the MACRS if they were unable or unwilling to use the Section 179 and 168(k) allowances, or if these two allowances did not cover the full cost of their new equipment.

Exhibit 2 provides a stylized example of how these three deductions would all be used on investment greater than $500,000. In this example, for capital investment of $700,000, all but $80,000 is deducted in the first year, regardless of what type of equipment is purchased through this capital expense. Note that the Section 179 deduction is also currently subject to a phase-out threshold of $2 million; once a business reaches $2 million in capital investment, its Section 179 allowance is reduced by the amount of capital investment over $2 million. Additionally, the Section 179 deduction allowance has historically been much smaller and was only increased to its current level of $500,000 in 2010. In 2001, the Section 179 deduction was just $24,000. It was increased to $100,000 in 2003 and to $500,000 in several steps between 2003 and 2010 (Guenther, 2013). The remaining years in this example show the depreciation expense allowance for assets with a 5-year service life in the MACRS, which will encompass ICT assets (Warda, 2010).

[35] Businesses also have the option of electing for straight-line depreciation (equal rates in each year) under the Alternative Depreciation System, if the rates prescribed in the MACRS are not to their liking.
[36] In the MACRS, it takes six years to depreciate fully an asset with a 5-year service life. The sixth year reduces the value of the asset to zero, which is why this is considered a 5-year service life.

**Exhibit 2: Example of Deduction Allowances and the Modified Accelerated Cost Recovery System in the United States**

| Tax Item | Amount |
|---|---|
| Capital Expense | 700,00 |
| Section 179 deduction | -500,000 |
| Remaining Capital Expense | 200,000 |
| Section 168(k) deduction | -100,000 |
| Remaining Capital Expense | 100,000 |
| MACRS deductions | |
| Year 1: | 20,000 |
| Remaining Capital Expense | 80,000 |
| Year 2 | -32,000 |
| Year 3 | -19,200 |
| Year 4 | -11,520 |
| Year 5 | -11,520 |
| Year 6 | -5,760 |
| Remaining Capital Expense | 0 |

Source: CSLS based on Guenther (2013)

As many businesses will not have capital expenses greater than $500,000 per year in most years, the Section 179 allowance, which allows for the immediate deduction of any new equipment put into service, has the potential to have a considerable impact on investment, by reducing the METR on capital investment to 0 for some businesses. Guenther (2013) notes, however, that businesses are more likely to elect to use the Section 179 allowance for equipment with longer service lives, because on the net present value of the recovered cost is greater for assets depreciated over a longer period of time. This means that the Section 179 allowance would have had a very limited effect on ICT assets, which have service lives of 5 or 7 years in MACRS, compared to assets with service lives of 10, 15, or 20 years in MACRS. ICT investment is therefore unlikely to benefit from a substitution effect created by the Section 179 allowance. Beyond this limitation, Guenther (2013) also notes that the take-up rates for the Section 179 allowance are much lower than would have been expected – C Corporations (large corporations) had take-up rates ranging from 54-61 per cent in the 2002-2004 period, for example, severely discounting the potential for this allowance to encourage additional investment.

The rules allowing businesses to depreciate capital spending in Canada are generally more favourable to ICT investment than in the United States, although there is some uncertainty because it is not clear to what extent the bonus depreciation provisions in the United States would be used for ICT investment.

We conclude that corporate income tax policy cannot serve as an explanation for the ICT investment per worker gap. Average tax rates in Canada and the United States appear to be very similar, while marginal effective tax rates are substantially lower in Canada. Furthermore, statutory corporate income tax rates have fallen relative to the United States dramatically since the year 2000. If anything, these policies should advantage Canada relative to the United States. In addition, the decline in statutory rates and METRs should be very favourable to ICT investment in Canada, but we are unable to identify any significant increase in ICT investment as a result of these changes. ICT investment in Canada actually increased at a slower rate from 2000-2011 than it did from 1987-2011. Nevertheless, given the importance of marginal effective tax rates, we believe differences in corporate tax policy should favour Canada. The overall effect of corporate tax policy on ICT investment remains a fruitful subject for future research.

## D. Business Attitudes and Culture

In previous research reports, the CSLS has identified several attitudes and beliefs that may affect business decisions related to the adoption of new technologies. Different attitudes towards technology or investment may explain some of the ICT investment per worker gap. Beliefs that encourage the adoption of technology will tend to increase ICT investment, and perhaps investment overall, and so they are an important consideration for the ICT investment per worker gap. We examine previous research which has identified beliefs and attitudes which may encourage or discourage the adoption of technology in Canada and the United States.

Several studies point to certain beliefs and attitudes which encourage the adoption of technology being more prevalent in the United States. Prior research has identified that Canadian businesses are more likely to identify increased efficiency as a reason for adopting new technologies, while U.S. businesses are more likely to identify any other reason, including faster access to information and keeping up with progress, for adopting new technologies (Sharpe, 2005). Furthermore, research has also identified that U.S. businesses are more likely to believe they need to adopt new technologies to keep up with their competitors. It is challenging for businesses to determine prior to adoption whether a new technology will increase efficiency or not, so if this is the key reason for investing in ICT as seen by businesses, it may lead to businesses postponing the adoption of new technologies longer than they otherwise would. U.S. beliefs which view the adoption of ICT as more of a race with progress or against their competitors will tend to encourage earlier adoption.

In regards to attitudes that directly discourage the adoption of technologies, we find little difference between Canada and the United States. Both countries perceive cost as the greatest barrier of adopting ICT (Sharpe, 2005). This persists even though ICT prices have fallen dramatically, because the total cost of adoption is often many multiples of the cost of purchasing an ICT asset. ICT assets require specific human capital to operate and maintain, which the employees of an establishment may not possess. The time and cost of adopting an ICT asset and integrating it into a business' operations are both barriers to adoption, and evidence suggests that managers of small and medium-sized enterprises in Canada are more likely to have difficulty identifying the benefits of investing in ICT (Martin and Milway, 2007a).

To assess potential differences in business attitudes between Ontario and the United States as a factor behind the productivity gap, the Institute of Competitiveness & Prosperity (2003) conducted a cross-border survey of Ontario's public, business community, and business leadership with their counterparts from the United States. The Institute found that "attitudinal differences between the public and business in Ontario and the peer states are not significant roadblocks to closing the prosperity gap." This suggests that Ontario's (and Canada's) lower ICT investment per worker relative to the United States does not reflect differences in attitudes. Anecdotal evidence suggests that there are attitudinal differences in business culture in Canada and the United States, but research has not conclusively determined this is the case.

Attitudes and beliefs about ICT investment may impact the ICT investment per worker gap by some small degree, but the evidence indicates that in both Canada and the United States, businesses consider adopting ICT based on factors affecting cost and competitiveness. We find no cultural barrier to investment in ICT and do not believe this is a significant factor in the gap. Nevertheless, future study is required to confirm the role played by business attitudes on ICT investment.

### E. Other Factors

There are several other factors that can affect the Canada-U.S. ICT investment per worker gap that have not been discussed in this report. Here are some of these other factors that deserve attention:

- The degree of protection of the Canadian market and openness to foreign investment;
- The possibility that Canadian workers lack the necessary skills required to use state-of-the-art software;
- Barriers to foreign ownership;
- Tariffs;
- The regulatory environment.

## VI. Issues for Further Research

Our analysis thus far has explained some of the Canada-U.S. ICT investment per worker gap, but we are only able to quantify approximately 18.5 percentage points or 43.8 per cent of the gap. The remainder of the gap must be due to some combination of qualitative non-measurement differences between Canada and the United States that affect ICT investment. We believe further study of these issues will contribute to our understanding both of the ICT investment per worker gap and the importance of ICT assets in the modern economy, and we present them in the hopes that this important issue will continue to receive the attention it merits from policymakers and experts alike.

- **What explains the low level of investment in pre-packaged software investment in Canada?**

For the last decade, pre-packaged software investment per worker in Canada has generally been only a quarter of the U.S. level after adjusting for PPP. This is a very low level, far below the relative level of investment per worker in any other component of ICT. Possible explanations could include reluctance or unwillingness to upgrade to new versions of widely used software, a greater reliance on freeware and open source software, less use of software, and differences in the relative prices of pre-packaged software in Canada compared to the United States. Differences in the treatment of intermediate purchases explain some, but not all, of this difference. Given the very large size of this gap, we consider this a surprising finding and believe the issue warrants further research.

- **What is the reason for the concentration of the Canada-U.S. ICT investment per worker gap in software investment?**

One curious feature of the Canada-U.S. ICT investment per worker gap is that Canada and the United States use very different mixes of ICT assets. Software investment comprised just under half of Canadian ICT investment, for example, while it was nearly two-thirds of U.S. ICT investment in 2011. We find this interesting because most ICT assets are complementary goods – computers and software tend to be used together and, indeed, you cannot normally use one without the other. It is surprising that Canada invests a similar amount in computers (108.8 per cent of the U.S. level), but substantially less in telecommunications equipment (72.9 per cent), and even less in software (39.8 per cent). This may relate to different common use of particular assets, or different attitudes with respect to software in particular. We believe an investigation of this issue could shed significant light on the ICT investment per worker gap.

- **What is the reason for the concentration of the Canada-U.S. ICT investment per worker gap by industry?**

A key finding of our report is that the gap is heavily concentrated in software investment, and heavily concentrated in a small number of industries. In particular, information and cultural industries was responsible for 39.1 per cent of the gap in 2011, much of this due to software investment per worker in this industry being just 15.0 per cent of the U.S. level. The gap is not a uniform Canada-wide phenomenon across industries and types of ICT: in fact, seven out of 17 industries had greater ICT investment per worker and greater software investment per worker than the United States in 2011. Together, information and cultural industries and professional, scientific, and technical services account for approximately half of the gap. We believe a deeper understanding of why this is the case is the key to understanding the Canada-U.S. ICT investment per worker gap.

- **How does employment and time use of software developers and computer programmers in Canada differ from those in the United States?**

Software investment per worker in Canada is approximately 40 per cent of the U.S. level, and own-account software investment per worker is around one-third of the U.S. level, despite greater relative employment of software developers in Canada. This must be explained by differences in the industries which employ software developers; that is, it must be the case that a larger share of software developers in Canada are employed by firms producing software to be embedded in hardware or sold, rather than used internally. A comparative analysis of the employment of software developers in Canada and the United States could verify that this is true, and provide a deeper understanding of the Canada-U.S. software investment per worker gap.

- **How do private businesses in Canada and the United States perceive ICT technology and what are the prevailing attitudes to investing in ICT, particular in software, compared to non-ICT investments?**

Much of the data and studies that we draw on when discussing attitudes and beliefs come from international studies; there are several studies on the investment behaviour of private companies which have been conducted by industry groups or other private companies, but few that address the attitudes and beliefs underlying ICT. In our own initial study in 2005, our most important source of research for discussing the impact of culture was a study prepared by a government department in the United Kingdom. While there has been more Canadian research activity in this field in the intervening years, there is still room to improve our understanding of how businesses perceive ICT investment. In particular, we believe it is worth studying how important businesses believe ICT investments are comparatively; what role businesses see ICT assets playing in their operations; and why businesses in Canada are more likely to abstain from ICT investment due to cost.

- **How effective are tax incentives and subsidies to encourage ICT adoption?**

The last several federal budgets, and the budgets of many provinces, have increasingly included measures to encourage investment in ICT, including tax incentives and accelerated depreciation, yet the effect on the gap has been very modest. We believe enough time has passed that it is worth studying these issues in detail, analyzing both how appropriately they were designed and whether or not they have achieved their goal. We are unable to identify any significant improvement in the gap from a decade ago when few such measures were in place and the conversation surrounding ICT investment in Canada had far fewer participants, and believe this area of research deserves significant attention, as governments are now spending significantly more time and resources on encouraging ICT investment.

## VII. Recommendations

There are several possible areas of improvement for Statistics Canada and the Bureau of Economic Analysis, which would enhance the ability of researchers to study investment and other business sector activity. We list these recommendations in this section for the consideration of staff at Statistics Canada and the Bureau of Economic Analysis. We also include recommendations for researchers studying ICT investment in Canada and the United States.

- **Statistics Canada's Fixed Capital Flows and Stocks program should produce an establishment-based estimate of business sector investment.**

The Fixed Capital Flows and Stocks (FCFS) is an ideal source for following an issue like the Canada-U.S. ICT investment per worker gap for many reasons. Unlike other possible sources in CANSIM, it always produces up-to-date estimates; it provides its data in current and real dollars; it provides a detailed industry breakdown not available in other sources; and it provides a detailed asset breakdown including estimates of investment in computers, telecommunications equipment, and software. There is no alternative data source which accomplishes all of these goals. However, the FCFS tables define business sector investment as total investment excluding investment in three industries: health care and social assistance, educational services, and public administration. This is in contrast to the definition of business sector used in the Canadian Productivity Accounts and the Income and Expenditure Accounts, which includes all business sector establishments regardless of which industry they operate in; as a non-trivial proportion of health care establishments are private in Canada, this underestimates business sector investment, albeit to a small degree. It would improve the ability of researchers to compare investment in Canada to investment in the United States if the primary source of ICT investment estimates used an establishment-based definition of business sector. This should be possible for Statistics Canada to do, as the data for this program is collected on an establishment basis.

- **The Bureau of Economic Analysis should investigate ways to produce estimates of government fixed assets comparable to their estimates of private fixed assets.**

The BEA uses different data sources for public and private establishments, and the data sources for public establishments do not support estimates as detailed as their estimates for private establishments. Currently, it is not possible to estimate ICT investment in government fixed assets in the United States using the BEA Fixed Asset Accounts; ICT assets are part of "software and equipment" in the government fixed assets. No further breakdown is published, and so it is not possible to uniquely identify ICT investment in the government fixed assets. This is a significantly lower level of detail than the one available for private fixed assets. It would improve the ability of researchers to compare public and private investment, particularly ICT investment, if the data on government fixed assets were revised so as to support the same detailed asset data that the BEA publishes for private fixed assets, which include estimates of investment in computers, communications equipment, and software.

- **Canada and the United States should begin investigating ways to harmonize investment data by asset class, or to develop a concordance**.

Comparisons between Canada and the United States are common for researchers in Canada because of the geographic proximity and cultural and economic similarities between the two countries. The potential for different definitions of assets, in particular ICT assets, casts some uncertainty on research comparing investment, and places a burden on users to investigate definitions, which can leave users of data unable to address their research questions. While we do not believe there are currently any significant inconsistencies between asset definitions in the two countries, we do believe a common set of definitions – either in the form of a harmonization, as is currently done for trade commodities, or a concordance – for investment in private fixed non-residential investment would aid users of data published by the BEA Fixed Asset Accounts and Statistics Canada's Fixed Capital Flows and Stocks program, and provide researchers with greater certainty in their comparisons.

- **Statistics Canada and the Bureau of Economic Analysis should collaborate on a new survey of software developers to determine how much of their time is devoted to own-account software and which occupations are engaged in own-account software development.**

The value of own-account software in the Canadian System of National Accounts and the National Income and Product Accounts in the United States is largely based on a macro-estimate derived from the salaries of software developers. Both agencies base their estimates of own-account software investment on the labour cost of software developers, reduced by 50 per cent to account for time spent on non-development activities. The 50 per cent reduction is based on a 1981 study (Boehm), and the definition of software developers is benchmarked to both countries' national occupation classification. We believe it is time to renew both benchmarks. Significant changes in the last several years, including increased prevalence of social media and mobile cellular phones, may have altered the time use of software developers and the occupations which regularly engage in software development. We recommend that Statistics Canada and the Bureau of Economic Analysis collaborate on establishing new benchmarks for the occupations engaged in own-account software, and the appropriate share of their time to count toward the development of own-account software.

- **Statistics Canada should adjust its methodology for transactions involving used assets to enhance their comparability with U.S. investment and capital stock estimates.**

In regards to investment, the BEA measures the margins of dealers on sales of used equipment, while Statistics Canada does not, except for motor vehicles. This means that ICT investment in the United States includes dealers' margins on the sale of used assets, while it does not in Canada. Though the effect of this difference is likely to be small, it does mean that ICT investment in Canada and the United States are not directly comparable. Additionally, the BEA adjusts its estimates of the ownership of capital stock for all assets to account for the transfer of capital stock between industries and institutional sector (i.e., business and government), based on the sale of used equipment. Statistics Canada currently does not track transactions involving used assets for this purpose, except for motor vehicles. We believe bringing both methodologies in line with the BEA would improve the comparability of investment estimates in Canada and the United States.

- **The management of companies and enterprises (MCE) industry should be categorized with Finance, Insurance, Real Estate and Leasing (FIRE), or with the primary industry of the firm.**

The MCE industry poses a significant allocation problem in the Fixed Capital Flows and Stocks Tables and likely in other tables where it appears as well. Due to the nature of this industry as it is currently estimated, it appears to be an industry with a tiny employment share and a massive share of investment. This is a problem as managers are effectively managing companies and enterprises operating in a particular industry, and engaged in business activities pertaining to more than simply management. We believe that either placing the investment that occurs in this industry in FIRE or, alternatively, in the primary industry of the firm that employs these managers are more appropriate choices.

- **Statistics Canada should consider investigating the possibility of providing investment in telecommunications equipment for a greater number of industries in its Fixed Capital Flows and Stocks Tables consistent with their confidentiality rules.**

Suppressions due to confidentiality are in principle made to protect the confidentiality of large firms, which can be identified in the Fixed Capital Flows and Stocks tables if only a small number of firms is operating in an industry. In recent years, the number of industries for which telecommunications equipment investment by industry has been labelled confidential has severely limited the ability of researchers to study ICT investment per worker by industry. Given that the Canadian Productivity Accounts are able to provide total ICT investment by industry for years in which the FCFS labels telecommunications equipment confidential in those industries, we believe that it may be possible to increase the number of industries for which estimates of investment in telecommunications equipment are available in recent years. We recommend that Statistics Canada investigate the possibility of providing investment in telecommunications equipment by industry for a greater number of industries in recent years, consistent with their confidentiality rules.

- **Statistics Canada should consider producing purchasing power parity (PPP) estimates specifically for ICT.**

Since there are no official estimates of an ICT PPP, our headline measure of the Canada-U.S. ICT investment per worker gap is constructed using the machinery and equipment (M&E) PPP. Although ICT represents a sizeable part of M&E, it is possible for ICT prices in the two countries to diverge from the overall M&E price trends. In this sense, official ICT PPP estimates (for total ICT and for ICT components as well) could potentially improve the accuracy of our estimates of the Canada-U.S. ICT investment per worker gap.

- **Researchers and policymakers should direct greater attention to ICT investment as a share of GDP rather than ICT investment per worker when comparing ICT investment trends between Canada and the United States.**

One of our most interesting findings in this report has been that the ICT investment gap measured using the ICT investment share of GDP has always been smaller than the gap for ICT investment per worker due to labour productivity differences. We believe that ICT investment as a share of GDP is a more appropriate metric for comparing the two countries. This is a more accurate measure of ICT investment performance in Canada and the United States. Most research on this topic has focused on ICT investment per worker because of the productivity implications that can be drawn from investment per worker, but it is our conclusion that this measure of ICT investment understates Canada's ICT performance.

## VIII. Conclusion

The main conclusion of this report is that measurement issues, defined as differences in definitions or methodologies used in the construction of ICT investment estimates by the Canadian and U.S. statistical agencies, are not an important part in the explanation for the Canada-US ICT investment gap. According to our estimates, measurement issues, and in particular the treatment of the estimation of the value of own-account software, only account for 4 percentage points of the gap, or about one tenth of the gap, and some measurement issues may actually contribute to underestimating the gap. The Canada-US ICT investment gap is *not* a statistical artifact.

The report is able to quantify a significant proportion of the gap. In 2011, ICT investment in the business sector in Canada was 57.8 per cent of the U.S. level, a gap of 42.2 percentage points. The largest proximate cause of the gap is higher level of labour productivity in the United States; ceteris paribus, the gap would be 12 percentage points (30 per cent) lower if Canada had the same level of labour productivity as the United States. Canada's industrial structure, with smaller employment share in information and finance industries, which have very high levels of ICT investment per worker, accounts for about 2 percentage points or 5 per cent of the gap. We summarize these findings in Exhibit 3.

Together, these factors allow us to quantify approximately 18.5 percentage points or 44.3 per cent of the gap in 2011. In addition to this, differences in the treatment of transactions involving used equipment also affect the gap, but data are not available to quantify this measurement factor.

### Exhibit 3: Summary of Factors Contributing to the Canada-U.S. ICT Investment per Worker Gap

| Reference | Factor | Contribution to the Gap in 2011 | |
|---|---|---|---|
| | | Percentage Points | Share |
| **Table 1** | Canada-U.S. ICT Investment per Worker Gap | 42.2 | 100.0 |
| **Non-Measurement Factors or Proximate Factors** | | | |
| **Table 31** | Labour Productivity | 12.6 | 29.8 |
| **Table 33** | Industry Structure | 2.4 | 5.7 |
| **Measurement-Related Factors** | | | |
| **Table 45** | U.S. Salary Premium for Software Developers | 3.7* | 8.8 |
| **Non-Quantifiable Factors Contributing to the Gap** | | | |
| Dealer's margins on sales of used ICT equipment (measurement-related) | | | |
| Firm Size | | | |
| Education of Managers | | | |
| Business Attitudes and Culture | | | |
| | | | |
| **Total Gap Explained by Factors** | | 18.5 | 44.3 |

*Refers to the effect on the gap in percentage points in 2009, the last year for which data on own account software investment in Canada are available

Note: These estimates are based on the most recent ICT data for Canada. However, the most recent estimates in Statistics Canada's FCFS tables are not consistent with the definition of the business sector used in the BEA Fixed Asset Accounts. According to the most recent ICT investment data from the Canadian Productivity Accounts, an alternate source of ICT investment data, the gap was 5.5 percentage points larger than estimated using the data sources this exhibit is based on for the year 2009. This qualifies to some extent the proportion of the gap we have explained in this report. If this effect persisted, the total gap would be 47 percentage points in 2011.

The remaining 24 percentage points or 55 per cent of the gap cannot be easily quantified. It likely reflects such factors as the smaller average firm size in Canada, and the fact that since the United States is the world technology leader form are more aware of the benefits of ICT investment, as well as noted differences in the education of managers and potential differences in business attitudes and culture. It is important to recognize that Canada's ICT investment per worker is comparable to that of most other OECD countries. Our gap is with the United States, not other countries. It is also important to note that, by a variety of other measures, including the ICT investment share of GDP, ICT investment share of investment, ICT investment per hour worked, ICT capital stock per worker, and ICT capital stock per hour worked, we still have a large gap with the United States. The gap is robust across different measures of relative ICT investment performance.

Future research on this subject should be motivated by two key findings in this report.

First, for total ICT investment per worker in the business sector in 2011, we estimated that ICT investment per worker in Canada was greater in 7 of 17 industries. For computers, this figure was 12 of 17 industries, as computer investment per worker is actually greater overall in Canada. Even for software investment, 7 of 17 industries possessed a greater level of software investment per worker, despite business sector software investment in Canada being only 39.8 per cent of the U.S. level in 2011. Furthermore, we consistently find that informational and cultural industries and professional, scientific, and technical services make the largest contributions to the gap. This strongly implies that the Canada-U.S. ICT investment per worker gap is the result of industry-specific factors. Any explanation for the gap must include an explanation for why ICT investment per worker, and software investment per worker in particular, in these two industries is so much lower in Canada than in the United States.

Second, the lion's share (92.2 per cent in 2011) of Canada's ICT investment per worker gap with the United States is in software investment. A better understanding of this software deficit, and the reasons for its concentration in only a few industries, is the key to explaining the Canada-U.S. ICT investment gap.

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## Appendix A: Data Sources

For a number of years, the Centre for the Studying of Living Standards staff has maintained a large database on ICT investment in Canada and the United States based on publicly available data from Statistics Canada and the Bureau of Economic Analysis.[37] The purpose of this database is to monitor trends in ICT investment in Canada and the United States, and produce annual estimates of the Canada-U.S. ICT investment per worker gap. The estimates in our database are given in this report, and our findings based on those data motivate our investigation of the methods used by Statistics Canada and the BEA to estimate ICT investment. This report is based largely on the estimates in the CSLS ICT Investment Database, but we also include alternative estimates of investment and employment in Canada for comparative purposes. In this section, we describe all of the data sources used in this report and provide a brief explanation of the methodology used by Statistics Canada and the BEA to produce them.

For both Canada and the United States, comparing ICT investment per worker requires estimates of (A) business sector ICT investment; (B) employment in the business sector, and by industry; and (C) purchasing power parity (PPP), which is used to compare investment per worker levels in Canada and the United States. Table 48 provides an overview of all of the data sources discussed in this section. For ICT investment and employment, we indicate which sources are used for the estimates in our database, and which are used to produce supplementary estimates for analytic purposes in this report.

[37] The database is freely accessible at www.csls.ca/data/ict.asp.

### Table 48: Data Sources for ICT Investment

| | Canada | United States |
|---|---|---|
| **ICT Investment** | **Sources for Database:**<br>Fixed Capital Flows and Stocks:<br>CANSIM Tables 031-0003 and 031-0004 | Fixed Asset Accounts: Detailed Fixed Asset Table 2.5 and Fixed Asset Account Tables 2.1, 2.7 |
| | **Additional Sources:**<br>Canadian Productivity Accounts:<br>CANSIM Table 383-0025<br><br>Input-Output Tables:<br>CANSIM Table 381-0023 | |
| **Employment** | **Sources for Database:**<br>Labour Force Survey:<br>CANSIM Tables 282-0008 and 282-0010 | Major Sector Productivity dataset (business sector employment) and Current Population Survey (CPS) Table 18 (industry employment) |
| | **Additional Sources:**<br>Canadian Productivity Accounts:<br>CANSIM 383-0009 | |
| **Gross Domestic Product** | CANSIM Tables 379-0023, 379-0027, and 380-0056 | NIPA Table 1.3.5 |
| **Purchasing Power Parity** | CANSIM Table 380-0057 | |

## A. Investment

We collect data for ICT investment in Canada from three different Statistics Canada programs: the Fixed Capital Flows and Stocks (FCFS) tables, the Canadian Productivity Account (CPA), and the Input-Output (IO) tables.

The first, the FCFS, is used in the CSLS ICT Investment Database to calculate ICT investment per worker in Canada. The estimates produced by this program are found in CANSIM Tables 031-0003 (for Canada) and 031-0004 (for the provinces). These tables provide investment data for four major asset categories: buildings, engineering, machinery and equipment (M&E), and intellectual property products. Two of the assets under the category of M&E investment are "computers" and "telecommunication equipment";[38] one of the assets under the category of intellectual property products is "software". Investment in these three asset types comprise total ICT investment in Canada.

For each asset type in the FCFS, investment and capital stock is available for 20 two-digit NAICS industries, as well as for the business and non-business sectors. This program defines "business sector" investment as total investment excluding investment in three industries: health

[38] Statistics Canada refers to "telecommunications" equipment, while the BEA refers to "communications" equipment. These refer to the same assets and we generally refer to them as communications equipment or simply communications.

care and social assistance, educational services, and public administration, as opposed to investment by private establishments; our estimate of ICT investment per worker gap is for the business sector, so this definition of business sector investment is an inconsistency we discuss later. CANSIM Table 031-0004 provides the same data for provinces, but industry-level and business sector estimates are not available at the provincial level. Our database includes estimates for the three ICT asset types, which we use to calculate total ICT investment, and total non-residential fixed investment, for the period 1981-2011, in nominal and real dollars.[39]

Canada's Capital and Repair Expenditure Survey (CES) is the primary data source used by Statistics Canada to estimate investment by asset type in CANSIM Tables 031-0003 and 031-0004. The survey uses a random sample of 30,000 units of all business and government entities in Canada, maintained by Statistics Canada's Business Registry. The sample frame is divided into homogenous subgroups by industry and province so as to ensure the sample is representative; from there, the sample of 30,000 units is divided into two strata, which are referred to as the "take-all" strata, in which every member is sampled with certainty, and the "take-some" strata, where a minimum of 1 per cent or 3 units, whichever is greater, is required for the sample. Of these, 8,000 sampled establishments report detailed capital expenditure by asset type, which is used to establish the asset type investment levels reported in 031-0003. The FCFS also uses data from the Canadian System of National Accounts (CSNA) and administrative data, in cases where survey data are insufficient.

The Canadian Productivity Accounts (CPA), the second source of ICT investment data in Canada, contains estimates of total ICT investment for 20 two-digit NAICS industries, for the period 1961-2008 in real and nominal dollars. These estimates can be found in CANSIM Table 383-0025. They differ from the FCFS estimates in three important ways: first, ICT investment is assigned to the business sector in this table based on whether the establishment in question is a private establishment or not, not on the basis of which industry the establishment operates in; second, this series ends in 2008 while the FCFS publishes recent estimates, currently up to 2011; and third, this data source does not provide estimates of investment by component; it only publishes estimates of total ICT, which means we cannot calculate investment per worker in computers, communications equipment, or software using CPA data.

It is the first difference that motivates us to use the CPA as a supplementary source of estimates of ICT investment in Canada. An establishment-based assignment of business sector ICT investment is preferable to an industry-based assignment for two reasons: first, there will be some private establishments in the three industries identified as non-business in the FCFS, particularly in health care, and there will also be some non-business sector investment in the 17 industries which it includes in the business sector. The industry-based definition may therefore

[39] For real dollars, total ICT investment is calculated by the CSLS using a Fisher chain index which accounts for the relative price changes of the components of ICT. As a result, total ICT in real dollars is equal to the sum of its components only in the base year. This is necessary because Statistics Canada only produces estimates by component of ICT. All estimates of total ICT based on the FCFS are CSLS calculations.

under- or overestimate ICT investment; second, the establishment-based definition of the business sector is also used by the Bureau of Economic Analysis in the United States in the investment data for the United States, making the CPA estimates a more direct comparison. The data in the CPA is drawn from multiple sources, including the CES, administrative data, and estimates produced by the CSNA.

The third and final source of data we use for ICT investment in Canada is the Input-Output (IO) tables. These tables contain estimates of expenditure by detailed asset type for 2009 only at basic prices (excluding taxes and margins on sales); in particular, the IO tables contain detailed data on investment in the three types of software: pre-packaged software, custom designed software, and internally developed or own-account software, which can be found in CANSIM Table 381-0023. Our motivation for using this data source is primarily to provide analysis on investment in the different types of software. To conduct this analysis, we requested unpublished data on expenditure by type of software for 1998-2009 from Statistics Canada at purchaser prices (which includes taxes and margins). We also note that the IO tables use a definition of the business sector consistent with the CPA definition, which assigns activity to the business sector based on whether or not the establishment in question is a business sector establishment. We discuss this issue in depth in a later section on the definition of the business sector.

For the United States, the ICT asset types by industry for the business sector from the detailed Fixed Asset Table 2.5 are shown in Table 49. The BEA Asset Codes are listed under the corresponding asset type from CANSIM Table 031-0003. Just as for Canada, we collect total non-residential investment and investment for each ICT asset type from this database. The database reports total private fixed non-residential investment, ICT investment, and investment in computers, telecommunications equipment, and software, for the business sector.

### Table 49: BEA Asset Categories and NIPA Asset Types

| BEA Asset Codes | NIPA Asset Types |
|---|---|
| **Computers** | |
| EP1A | Mainframes |
| EP1B | PCs |
| EP1C | DASDs |
| EP1D | Printers |
| EP1E | Terminals |
| EP1F | Tape drives |
| EP1G | Storage devices |
| EP1H | System integrators |
| **Software** | |
| ENS1 | Prepackaged software |
| ENS2 | Custom software |
| ENS3 | Own account software |
| **Telecommunications equipment** | |
| EP20 | Communications |

The BEA primarily uses the Annual Capital Expenditure Survey (ACES) and the Information Communication Technology Survey (ICT) to collect data on the ICT assets reported in the Fixed Asset Accounts (FAA). The BEA additionally uses a number of supplementary sources for benchmarking investment, estimating capital stock, computing price indices, and other secondary purposes. These sources include the Bureau of the Census economic censuses, the BEA capital flow tables and Input-Output accounts, and two Census Bureau surveys: the Annual Survey of Manufacturers, and the Plant and Expenditure Survey.

Of these surveys, the ICT survey is the most important; it is used to establish asset type shares by industry for non-capitalized expenditure on private fixed assets;[40] the ACES is used for all capitalized expenditure. The ICT survey is based on one sample of 46,483 companies, while the ACES is based on two random, stratified samples of 46,427 and 14,981 companies. Both survey samples were developed using the Business Registry, and include only private, non-farm, domestic companies.

For both Canada and the United States, survey coverage does not include non-employer businesses, the data for which are estimated using administrative data. Non-employer businesses account for approximately 3 per cent of total revenue by businesses in both countries, so it is unlikely that any issues would arise as a result of using administrative data to estimate private non-residential investment by non-employer businesses.

### i. ICT Investment Data Availability for Canada

Confidentiality restrictions and data quality play a significant role in the availability of investment estimates by industry for some ICT assets in Canada, although not in the United States. This is because Canada is a much smaller country than the United States, and consequently it is much easier for investment data to inadvertently identify specific firms.

Prior to December 6, 2012, Statistics Canada published estimates for all three components of ICT investment for 12 out of 20 industries in 2010 and 2011. As of the December 6, 2012 revision, investment in telecommunications equipment has been suppressed for 6 of those industries due to confidentiality reasons, meaning that total ICT investment is now unavailable for 14 out of 20 industries.[41] Specifically, the following industries, for which it was possible to compute the gap prior to revisions, no longer have telecommunications equipment investment in the revised table: agriculture, forestry, fishing, and hunting; mining and oil and gas extraction; wholesale trade; retail trade; real estate rental and leasing; arts, and entertainment and recreation.

[40] For example, the ICT survey collects data on non-capitalized purchases, operating leases, and rental payments by businesses for every asset class, as well as data on capitalized purchases. Certain types of expenditure on ICT assets is not capitalized by businesses but is considered investment; as well, operating leases are reassigned by the BLS on an ownership basis, but this expenditure is also not capitalized by lessees.

[41] There are two issues here: in 6 of 20 industries, telecommunications equipment investment is confidential for the entire length of the series; in 8 of 20 industries, data for telecommunications equipment investment in 2010 and 2011 are not available. Prior to the most recent revision, only 2 of those 8 industries were subject to confidentiality suppressions in 2010 and 2011.

For most of these industries, estimates of telecommunications investment are not available for 2010 and 2011; for some, they are not available as far back as 2007.

Table 50 shows how the data availability of communications equipment investment – and consequently total ICT investment – changed after the December 6, 2012 revision. The first column indicates industries for which communications equipment estimates for 2010 and 2011 were available prior to December 6, 2012; the second column indicates for which industries these estimates are no longer available. In each case, the CANSIM table indicates that the data has been suppressed due to confidentiality. The lack of data for communications equipment investment in each of these industries means that total ICT investment in these industries is unknown for the years 2010 and 2011.

**Table 50: Availability of Total ICT Investment Estimate by Industry in Old and Revised Series, 2010-2011**

| | Available in old estimates | Available in revised estimates |
|---|---|---|
| **Agriculture, Forestry, Fishing and Hunting** | ✓ | × |
| **Mining and Oil and Gas Extraction** | ✓ | × |
| **Utilities** | × | × |
| **Construction** | × | × |
| **Manufacturing** | ✓ | ✓ |
| **Wholesale Trade** | ✓ | × |
| **Retail Trade** | ✓ | × |
| **Transportation and Warehousing** | × | × |
| **Information and Cultural Industries** | ✓ | ✓ |
| **Finance and Insurance** | ✓ | ✓ |
| **Real Estate Rental and Leasing** | ✓ | × |
| **Professional Scientific and Technical Services** | ✓ | ✓ |
| **Management of Companies and Enterprises** | × | × |
| **Administrative and Support** | × | × |
| **Educational Services** | ✓ | ✓ |
| **Health Care and Social Assistance** | × | × |
| **Arts Entertainment and Recreation** | ✓ | × |
| **Accommodation and Food Services** | × | × |
| **Other Services(except Public. Admin.)** | × | × |
| **Public Administration** | ✓ | ✓ |
| **# Industries Available** | 12/20 | 6/20 |

While all of the suppressed data points for 2010 and 211 in these industries are labelled as confidential, some may actually be suppressed due to low quality, according to the procedures Statistics Canada described to us. When suppressing data to ensure that confidential data cannot be calculated as a residual, Statistics Canada will label any data that has been suppressed due to low quality as confidential, instead of suppressing additional high quality data to preserve confidentiality. This preserves the confidentiality of respondents without unnecessarily reducing the amount of available data. Because of this, some of the missing data above, all of which are labelled confidential, may also be low quality.

To mitigate the challenges posed by the lack of data availability for recent years in the FCFS tables, the CSLS has used historical shares from both sources of ICT investment data, particularly the CPA data which is not subject to any confidentiality restrictions, to produce estimates of telecommunications equipment by industry in 2009, 2010, and 2011 for the missing industries. This allowed us to estimate total ICT by industry for these years; this was done primarily so we could measure the effect of industrial structure on the ICT investment per worker gap. The methodology for this estimation is described in Appendix Tables 10a and 10b, which decompose the Canada-U.S. ICT investment per worker gap by industry using CPA data. While these estimates are subject to certain limitations, they allow us to analyze ICT investment per worker in all industries and mitigate the challenges posed by data availability of ICT investment in Canada.

## B. Employment

We use two sources of employment data in Canada: the Labour Force Survey (LFS), and the CPA, which is based on the LFS and the Survey on Employment, Payroll, and Hours (SEPH). The first is used in the CSLS ICT database, while the second is used in this report to produce additional estimates of the Canada-U.S. ICT investment per worker gap.

The employment data for Canada in the CSLS ICT Investment Database comes from the LFS and can be found in CANSIM Tables 282-0008 (Canada) and 282-0010 (the provinces). These employment data are based on the Labour Force Survey, a survey of 54,000 households which covers approximately 100,000 individuals. We use this table to produce an estimate of business sector employment consistent with the estimate of business sector investment in the FCFS, by subtracting employment of educational services, health care and social assistance, and public administration industries from total employment. Total employment will include employees of all public and private establishments, as well as domestic workers and the self-employed. We also collect employment data for 20 two-digit NAICS industries from the LFS, for the period 1981-2011.

Just as for investment, we also use the CPA for employment data, which produces an establishment-based estimate of business sector employment, to provide additional estimates of ICT investment per worker in Canada in this report. Business sector employment is available from the CPA for 19 two-digits NAICS industries for the period 2000-2008, and can be found in CANSIM Table 383-0009.

For the United States, we use the Bureau of Labor Statistics (BLS) Labour Productivity and Costs Program measure of business sector employment, which can be found in their Major Sector Productivity program dataset. The employment aggregate is based on both the Current

Employment Statistics (CES), a survey of all public and private establishments in the United States, and the Current Population Survey (CPS), a household survey comparable to the LFS in Canada. This measure includes all private employees, the self-employed, private farm workers, and domestic workers, and excludes the employees of non-profits and charities and general government employees.

For industry level employment data in the United States, we use the detailed industry employment as shown in CPS Table 18. We collect business sector employment data for the 1987-2011 period and industry-level employment data for the period 2000-2011 for the CSLS ICT Investment Database. The industry employment levels in the CPS are not business sector employment and in some industries, will include workers who are not in the business sector; this does lead to business sector employment being over-estimated in some industries, but it will only affect our estimate of ICT investment per worker by industry, and not business sector ICT investment per worker.

We obtained by request from the BLS unpublished estimates of business sector employment by three-digit NAICS industries from the Major Sector Productivity dataset, in an attempt to resolve this discrepancy. However, in 2011, 11 per cent of U.S. business sector employment was unclassified by NAICS industry,[42] so this data source poses the opposite problem as the CPS tables. It would lead to employment in each industry being somewhat underestimated, but it will not affect our estimate of business sector employment. We therefore chose to continue using the data from CPS Table 18 to estimate ICT investment per worker by industry in the United States.

## C. Gross Domestic Product

In our database, we use the official estimates of business sector gross domestic product for both countries, the sources of which are listed in Table 48. We use gross domestic product primarily for the purpose of calculating the share of ICT investment in GDP, an important indicator of the intensity of ICT investment. We make one adjustment, which is described in more detail in Appendix Table 11c, to remove the value of imputed rent for owner-occupied dwellings from business sector GDP in Canada, as the BEA does not include imputed rent in business sector GDP.

## D. Purchasing power parity

The ICT investment data for Canada and the United States are compared using PPP for machinery and equipment (M&E). The use of PPP is important, as it makes it possible to compare directly the level of ICT investment in Canada and the United States. PPP is preferable to market exchange rates as a method of comparison because market exchange rates do not fully capture price differences between the two countries. Ideally, a PPP specifically for ICT would be used, but no such PPP is estimated by Statistics Canada. Of the available PPP estimates, the PPP

[42] Some business sector employment in the United States is only classified at the major sector level, which is less detailed than 2-digit NAICS.

for M&E is the most appropriate, as ICT is largely a subset of M&E. Both telecommunications equipment and computers are classified as M&E, and software was as well until the most recent SNA revision, which now classifies it under "Intellectual Property Products"; software is still classified as M&E in the United States.