March 2016

151 Slater Street, Suite 710
Ottawa, Ontario K1P 5H3
Tel: 613-233-8891
Fax: 613-233-8250
csls@csls.ca

CENTRE FOR THE STUDY OF LIVING STANDARDS

EXPLAINING INDUSTRY DIFFERENCES IN IT INVESTMENT PER WORKER BETWEEN CANADA AND THE UNITED STATES, 2002-2013

Jasmin Thomas

CSLS Research Report 2016-01

March 2016

Prepared for Industry Canada

Explaining Industry Differences in IT Investment Per Worker Between Canada and the United States, 2002-2013

Abstract

In 2013, Canadian firms invested only about one half as much per worker in information and communications technologies (ICT) compared to their US counterparts. Many studies have shown that lower ICT investment per worker in Canada compared to the United States is responsible for weaker productivity growth in Canada. In the past, attention has been focused on the aggregate gap, but 49.8 per cent of lower business sector IT investment in Canada relative to the United States in 2013 was explained by two industries: information and cultural industries and professional, scientific and technical services, which accounted for only 13.0 per cent of employment (IT investment is composed of computers and software investment, while ICT investment is composed of computers, communications, and software investment).

The main objective of this report is to shed light on the possible reasons for the gap in these sectors even though other industries contributing to the gap are also analyzed. A number of explanations will be examined, including data measurement and comparability issues stemming from methodological differences between statistical agencies in Canada and the United States, and differences in potential explanatory variables of IT investment, such as human capital, taxation, profits, firm creation rates, industrial structure, and regulation, among others.

This report finds that software investment in information and cultural industries and professional, scientific and technical services is responsible for 45.9 per cent of the total IT investment per worker gap between Canada and the United States. The report also finds that measurement issues likely account for a significant share of the software investment gap in professional, scientific and technical services, and subsequently, account for a large share of the total IT investment per worker gap. Other explanations, such as human capital, regulation, firm size, managerial education, and labour compensation likely play a smaller role in this industry. In contrast, measurement issues likely account for much less of the information and cultural industries software gap between Canada and the United States, meaning that explanations such as human capital, managerial education, labour compensation and firm size, are more likely to play a larger role in this industry.

Explaining Industry Differences in IT Investment Per Worker Between Canada and the United States, 2002-2013

Table of Contents

Explaining Industry Differences in IT Investment Per Worker Between Canada and the United States, 2002-2013

Executive Summary

The level of information technology (IT) investment per worker[1] in the Canadian business sector in 2013 was 52.0 per cent of that in the US business sector, which implies a gap of 48.0 percentage points. Previous CSLS research found that only a small part of this gap was due to differences in industry structure (at the two-digit level) between the two countries. Rather industry-specific differences in IT investment per worker, such as those in information and cultural industries and professional, scientific and technical services, accounted for the lion's share of this gap. An explanation for these industry differences is required in order to understand the reasons behind the Canada-US IT investment gap. The objective of this study is to identify which, if any, industries in Canada contribute disproportionately to the Canada-US IT investment gap and to shed light on the factors behind this situation.

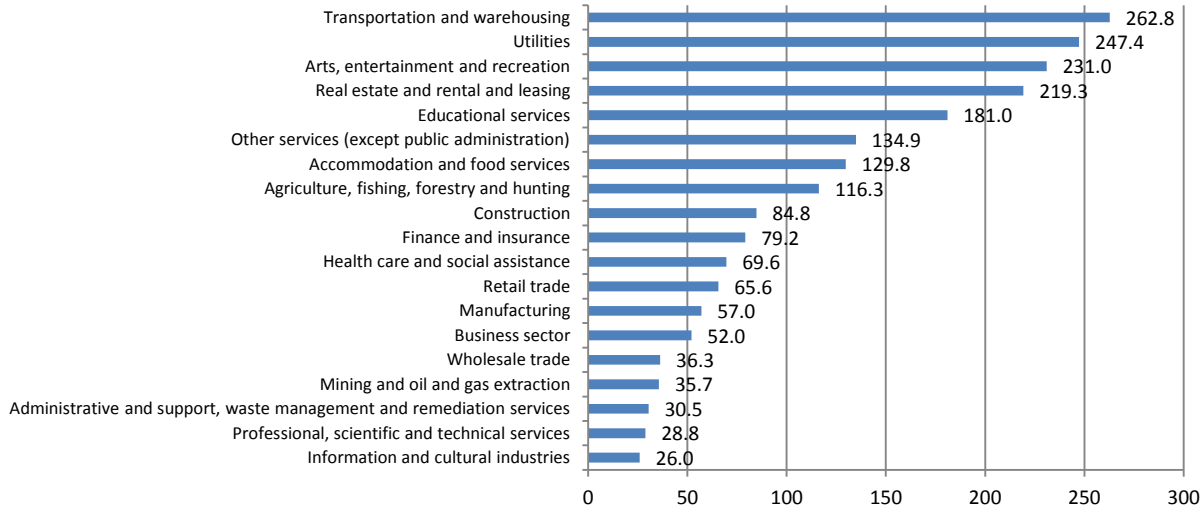
In line with previous CSLS research, this report has shown that 11 of 19 industries in Canada had less information technologies (IT) investment per worker than their US counterparts in 2013, with 8 of 19 industries with higher levels of IT investment per worker. Given that there is a 48.0 percentage point gap in IT investment per worker in the business sector, it is somewhat surprising that 8 industries in Canada show higher IT investment per worker levels than the United States.

Of the 11 industries with less IT investment per worker in Canada relative to the United States, professional, scientific and technical services and information and cultural industries have the largest gaps. In particular, Canada invested US$5,309 in IT per worker in 2013 in information and cultural industries, while the United States invested a massive US$20,417 in IT per worker.

The professional, scientific and technical services industry also showed large gaps with US$1,520 in IT investment per worker in Canada in 2013 compared to US$5,272 in the United States. These figures lead to extremely small relative Canada-US IT investment per worker levels: 26.0 per cent in information and cultural industries and 28.8 per cent in professional, scientific and technical services. No other two-digit NAICS industries had a relative level of Canada-US IT investment per worker below 30.0 per cent.

[1] It is important to note that in this report we have switched from the use of information and communication technologies (ICT) investment, which is an aggregate of computers, communications and software investment, to the use of IT, which is an aggregate of only computers and software, because of data limitations related to the availability of communications investment data at the industry level in Canada.

Exhibit 1: Nominal Total IT Investment Per Worker in Canada Relative to the United States, Per Cent, 2013



Source: CSLS ICT by Industry database.

Decompositions

Exhibit 2 provides three different decompositions of the IT investment per worker gap between Canada and the United States in the business sector in 2013 from three mutually exclusive perspectives, namely income differentials, industries and IT components, and simultaneously by industry and IT component.

Income Differentials

The business sector gap in IT investment per worker is largely due to differences in income per capita between Canada and the United States. In particular, we do not expect the absolute level of IT investment per worker in Canada to be the same as IT investment per worker in the United States because Canada has a lower GDP per capita than the United States. For example, if we hold constant IT investment as a share of GDP, a country with a higher level of income will have a higher level of IT investment and hence IT investment per worker.

It is possible to roughly control for income by using IT investment as a share of GDP instead of IT investment per worker. If we do this, we find that IT investment as a share of GDP in the United States was 2.40 per cent in 2013 compared to 1.80 per cent in Canada. If Canada had an IT investment share in GDP of 2.40 per cent, IT investment per worker in US dollars would be US$2,322 (up from US$1,744), leading to relative Canada-US IT investment per worker of 69.3 per cent (up from 52.0 per cent). This means that roughly 17.2 percentage points of the 48.0 percentage point gap is the result of lower income in Canada (i.e. 35.9 per cent).

Exhibit 2: Contributions to the Canada-US Business Sector IT Investment Gap by Income Differentials, Industry, and IT Component, Per Cent and Percentage Points, 2013

	Percentage Points	Per Cent
Canada-US IT Investment Per Worker Business Sector Gap	48.0	100.0
Impact of Income Controls on Canada-US Business Sector IT Investment Per Worker Gap	17.2	35.9
Industry Contributions to the Canada-US Business Sector IT Investment Per Worker Gap		
Information and cultural industries and professional, scientific and technical services	23.9	49.8
Wholesale trade and manufacturing	11.9	24.8
Other positive contributors*	14.5	30.2
Other negative contributors**	-20.1	-41.9
Software and Computer Contributions to the Canada-US Business Sector IT Investment Per Worker Gap		
Software	44.2	92.1
Computers	3.8	7.9
Software and Computer Contributions at the Industry Level to the Canada-US Business Sector IT Investment Per Worker Gap		
Information and cultural industries	12.8	26.7
Software	11.5	24.0
General purpose software	1.9	4.0
Custom design software and development services	4.4	9.2
Own-account software design and development services	5.2	10.8
Computers	1.3	2.7
Professional, scientific and technical services	11.1	23.1
Software	10.5	21.9
General purpose software	2.0	4.2
Custom design software and development services	4.3	9.0
Own-account software design and development services	4.2	8.8
Computers	0.6	1.3

* Other positive contributors includes management of companies and enterprises; administrative and support, waste management and remediation services; mining and oil and gas extraction; finance and insurance; construction; and retail trade. These are industries with relative Canada-US IT investment per worker levels that are below 100.0 per cent.

** Other negative contributors includes agriculture, fishing, forestry and hunting; accommodation and food services; other services (except public administration); arts, entertainment and recreation; real estate and rental and leasing; utilities; and transportation and warehousing. These are industries with relative Canada-US IT investment per worker levels that are above 100.0 per cent.

Source: CSLS calculations based on the CSLS ICT by Industry database, Statistics Canada data, Bureau of Economic Analysis data, and the CSLS ICT database from January 2015.

Industry Contributions

Given the strikingly low relative Canada-US IT investment per worker levels in information and cultural industries and professional, scientific and technical services, it is not surprising that they accounted for approximately 49.8 per cent of the business sector IT investment per worker gap in 2013, even though they only accounted for 13.0 per cent and 17.9 per cent of employment and IT investment in the business sector respectively.

Manufacturing and wholesale trade contributed an additional 24.8 per cent to the Canada-US total IT business sector gap, although they accounted for 17.6 per cent of employment and 21.1 per cent of IT investment in Canada.

Given the large contributions from professional, scientific and technical services and information and cultural industries, this report has attempted to develop explanations for the IT investment per worker gap in these two industries.

Component Contributions

Of the two components of IT, software investment was the largest contributor to the Canada-US IT investment per worker gap in the business sector in 2013. In particular, software was responsible for 92.1 per cent of the overall gap, while computer investment was responsible for only 7.9 per cent.

Component Contributions by Industry

In 2013, 45.9 per cent of the Canada-US business sector IT investment per worker gap (or 22.0 percentage points) was due to low relative software investment per worker in information and cultural industries and professional, scientific and technical services.

More specifically, software in information and cultural industries and professional, scientific and technical services was responsible for 24.0 per cent and 21.9 per cent of the overall gap in IT investment per worker between Canada and the United States in the business sector, respectively.

Software investment has three subcomponents: general purpose software; custom design software and development services; and own-account software design and development services. In the two industries of interest, own-account and custom design software are equally important.

In particular, in information and cultural industries and professional, scientific and technical services, own-account software design and development services accounted for 19.6 per cent of the overall Canada-US IT investment per worker gap in 2013. Custom design software and development services were responsible for 18.2 per cent.

Measurement Issues

Previous CSLS research investigated the impact of differences in definitions or measurement methodologies on the ICT investment per worker gap between Canada and the United States and found that measurement issues were responsible for around 10 per cent of the business sector gap in 2011. This report undertakes similar research concerning information and cultural industries and professional, scientific and technical services. The findings suggest that for computers, differences in definitions and methodologies are unlikely to explain the computer investment per worker gap. However, the methodology used to estimate software investment, particularly own-account software investment, does present a serious challenge for measurement of the IT investment per worker gap.

Own-Account Software

Own-account software expenditures are generated by using the compensation of computer programmers and computer systems analysts. Since investment in internally developed software (or own-account software) is based primarily on the labour cost to employers of their software developers, even if two software developers spend the same amount of time developing the same software for internal use, there would be a higher level of investment in the United States than in Canada due to higher salaries in the United States. Thus, software measurement issues could potentially explain some of the IT investment per worker gap in information and cultural industries and professional, scientific and technical services, especially if own-account software represents a large portion of software investment.

This report finds that 46.6 per cent of software investment in professional, scientific and technical services is in own-account software, compared to the business sector average of 35.0 per cent. This large contribution of own-account software is especially important since software investment accounts for about 95 per cent of the IT investment per worker gap in this industry. Hence, measurement differences may explain part of this gap in professional, scientific and technical services. In contrast, measurement differences are less likely to explain the gap in information and cultural industries, since it has only 22.7 per cent of its software investment in own-account software.

Drivers and Determinants of IT Investment

This report finds evidence for a number of explanations for the Canada-US IT investment per worker gap in information and cultural industries and professional, scientific and technical services, which had IT investment per worker gaps of 74.0 percentage points and 71.2 percentage points and accounted for 49.8 per cent of the business sector IT investment per worker gap in 2013:

- three-digit industrial structure;
- input prices and unexpected costs;
- regulation;
- managerial education; and

- firm size.

These drivers and their evidence are discussed in more detail below.

Three-Digit Industrial Structure

IT investment per worker in information and cultural industries and professional, scientific and technical services is a weighted average of IT investment per worker in the sub-industries of which they are composed. Thus, it is possible that different industrial structures and different levels of IT investment at the three-digit level between Canada and the United States could explain differing levels of IT investment per worker in these two industries. Unfortunately, IT investment data at the three-digit level is not available for Canada. Since employment distributions within information and cultural industries and professional, scientific and technical services show significant differences between Canada and the United States, the different employment composition between the two countries could explain part of the gap.

For example, 16.0 per cent of employment in professional and business services (which includes management of companies and enterprises) in the United States was in legal services, compared to only 10.8 per cent in Canada in 2014. Similarly, 21.4 per cent of employment in professional and business services in Canada was in architectural, engineering, and related services, compared to only 14.2 per cent in the United States. Thus, suppose that legal services use relatively high levels of IT investment per worker. Since the United States has a larger share of employment in this subsector, IT investment per worker would be driven upward relative to IT investment per worker in Canada.

In information and cultural industries, radio and television broadcasting and cable subscription programming consisted of 18.8 per cent of employment in this industry in the United States compared to only 11.2 per cent in Canada in 2014, while telecommunications carriers accounted for 31.5 per cent in the United States and 41.1 per cent in Canada.

These differences could greatly affect the level of IT investment per worker in both professional, scientific and technical services and information and cultural industries, even if all sub-industries within these two industries in both Canada and the United States had the same IT investment per worker. Since it is unlikely that they do, these differences could be important. However, until IT investment data is provided at the three-digit level, the importance of this factor in explaining IT investment per worker differences at the industry level in Canada and the United States will be entirely impossible to determine.

Input Prices

Different input prices, namely nominal labour compensation per hour, may also explain the IT investment per worker gap in these two industries because employers have different incentives to substitute IT capital for labour: the IT capital-labour substitution hypothesis. In particular, labour compensation per hour in Canada was US$31.52 (exchange rate adjusted) compared to US$58.47 in the United States in information and cultural industries in 2013 (resulting in a relative of 53.9 per cent compared to 70.2 per cent in the business sector). This

would suggest that employers in the United States have a greater incentive to substitute IT investment for labour than employers in Canada. If this is the case, then IT investment per worker is likely higher in the United States than in Canada because of the substitution hypothesis. Professional, scientific and technical services in Canada also showed lower nominal labour compensation per hour than the United States in 2013, but only by US$1.56 (a relative of 95.2 per cent).

Regulation

High levels of regulation can impede the creation of businesses, access to capital, and limit competition in the marketplace, which are all linked to IT investment per worker. According to OECD product and labour market indicators and professional services regulation indicators, this may be a potential explanation for relatively low levels of IT investment per worker in Canada compared to the United States in professional, scientific and technical services. In particular, these OECD data suggest that Canada has much stricter regulatory policies in accounting, engineering, legal and architectural services.

Managerial Education

Managers with a higher level of educational attainment are more likely to be aware of the productivity-enhancing benefits of IT investment and more likely to have staff that can make effective use of IT investment.

Thus, the relative under-education of managers in Canada compared to the United States could have negative implications for IT investment per worker. The validity of the explanation is especially strong in professional, scientific and technical services, where only 48.7 per cent of managers had obtained a Bachelor's or Master's degree in Canada in 2011 relative to 71.2 per cent in the United States. In information and cultural industries, 41.1 per cent of managers in Canada had a Bachelor's or Master's degree, while 52.9 per cent in the United States had this level of education. This compares to the total economy, where 31.0 per cent of managers in Canada had a Bachelor's or Master's degree relative to 49.0 per cent in the United States.

Firm Size

Large firms tend to invest and adopt more IT capital than do smaller firms because they have greater financial resources and may be more aware of the benefits of IT. In particular, employment in information and cultural industries is more likely to be concentrated in large firms in the United States (72.5 per cent in firms over 500 people) compared to Canada (65.1 per cent). A similar story applies to professional, scientific and technical services: 87.3 per cent of employment in the United States is in firms with over 500 employees compared to 46.4 per cent in Canada. Hence, it is quite possible that firm size can explain lower IT investment per worker levels in Canada in information and cultural industries and professional, scientific and technical services.

Additional data will need to be developed and further research will need to be undertaken in order to confirm these findings and verify the likelihood of the other explanations that were

put forward, such as foreign direct investment, taxes, risk aversion, profits, and firm creation rates.

In summary, this report finds that information and cultural industries and professional, scientific and technical services accounted for approximately 49.8 per cent of the business sector IT investment per worker gap in 2013, when they only accounted for 13.0 per cent and 17.9 per cent of employment and IT investment in the business sector respectively. Moreover, it was found that software investment in information and cultural industries and professional, scientific and technical service was responsible for 46.1 per cent of the total IT investment per worker gap between Canada and the United States in 2013.

Measurement issues likely account for a significant share of the software investment gap in professional, scientific and technical services and subsequently for a large share of the total business sector IT investment per worker gap. Other explanations, such as human capital, regulation, firm size, managerial education, and labour compensation likely play a smaller role in this industry. In contrast, measurement issues likely account for much less of the information and cultural industries software gap between Canada and the United States. Hence, explanations such as human capital, managerial education, labour compensation and firm size, are more likely to play a larger role in this industry.

Explaining Industry Differences in IT Investment Per Worker Between Canada and the United States, 2002-2013[2]

I. Introduction

It is widely recognized that information and communication technologies (ICTs)[3] are crucial for productivity growth and that Canadian firms lag their American counterparts in this area. The Canada-US ICT investment gap has been identified as a key factor explaining the Canada-US productivity gap. Consequently, it is important from both an analytical and policy perspective to monitor developments and trends in ICT investment in Canada and the United States.

The primary objective of this report is to shed light on the reasons for differences in the levels of IT investment per worker in information and cultural industries and professional, scientific and technical services in Canada and the United States, the main culprits behind low Canada-US IT investment per worker in 2013. This report will explore a variety of reasons for these differences, including measurement errors and data comparability issues stemming from differences between statistical agencies in Canada and the United States, and differences in potential explanatory variables of IT investment, such as human capital, taxation, profits, firm creation rates, three-digit industrial structures, and regulation, among others.

The report will also highlight reasons for differences in the levels and growth rates of IT investment per worker across industries within Canada, although this is a secondary objective.

A. Background and Motivation

Since 2000, Corrado (2015) estimates that ICT has accounted for approximately 55 per cent of the growth in output per hour in the United States. Furthermore, according to her estimates, ICT could contribute as much as 0.3 to 1.3 percentage points to labour productivity growth going forward.

Given the importance of ICT for productivity growth, the Centre for the Study of Living Standards (CSLS) has been monitoring and analyzing ICT investment in Canada and the Canada-US ICT investment gap at the aggregate level for over a decade, beginning with a request from the Information Technology Association of Canada (ITAC) in the mid-2000s. This activity included the construction of a comprehensive ICT investment and capital stock database

---

[2] This report was written by Jasmin Thomas under the supervision of Andrew Sharpe, CSLS Executive Director. The CSLS would like to thank Industry Canada for financial support.

[3] ICTs are defined in accordance with the 1993 System of National Accounts (SNA). ICT investment covers the acquisition of equipment and computer software that is used in production for more than one year. ICT has three components: information technology equipment (computers and related hardware); communications equipment; and software (OECD, 2015). Software investment includes the acquisition of pre-packaged software, customized software, and software developed in-house (OECD, 2015).

for 20 two-digit NAICS industries in Canada and the United States from 1987 to the most recent year for which data were available (currently 2013 in Canada and 2014 in the United States). Since the creation of this database, updates have been made on an annual basis and a series of reports have been produced highlighting the latest developments (Sharpe and Arsenault, 2008; Centre for the Study of Living Standards, 2008; Sharpe and De Avillez, 2010; Sharpe, 2010; Sharpe and Moeller, 2011; Sharpe and Andrews, 2012; Capeluck, 2012; Capeluck, 2013a; Capeluck, 2013b). In the most recent update, Thomas (2015) found that nominal ICT investment per worker in the business sector increased at a rate of 0.1 per cent per year in Canada and 0.9 per cent per year in the United States between 2000 and 2013, which caused the nominal ICT investment per worker gap in the business sector between Canada and the US to increase to 51.1 per cent in 2013 from 48.9 per cent in 2000.[4]

In 2012, Industry Canada also contracted the CSLS to investigate the role of measurement issues in the Canada-US ICT investment gap (Sharpe and Rai, 2013). This work identified software investment as a key contributor to the gap. Consequently, in 2013, Industry Canada commissioned the CSLS to shed light on the reasons for this software gap (Sharpe, 2014). A key finding of that study was the concentration of the aggregate software investment intensity gap in a small number of industries. Sharpe and Rai (2013) showed similar results for total ICT investment per worker. This concentration of the ICT gap in a small number of industries suggests that the reasons for lower business sector ICT investment per worker in Canada compared to the United States are industry-specific.[5]

Hence, Industry Canada has now commissioned the CSLS to investigate why certain Canadian industries over- or under-invest in ICTs in comparison to the United States.

i. ICT Investment and Labour Productivity Linkage

a. Theoretical

In general, ICT investment is linked to economic growth and living standards through its impacts on labour productivity. Theoretically, the impact of ICT on labour productivity is said to occur through multifactor productivity growth and through growth in capital intensity, both of which contribute to overall labour productivity growth. Capital intensity is defined as the ratio of capital to labour, while multifactor productivity is a residual measure that reflects output growth that cannot be accounted for by measured input growth, such as capital or labour. When capital intensity increases, labour productivity increases. When multifactor productivity increases, labour productivity increases. Thus, low ICT investment growth may partially explain low labour productivity growth, and vice versa.[6]

---

[4] The Canada-US ICT investment per worker relative is calculated by dividing ICT investment per worker in Canada by ICT investment per worker in the United States, and subsequently multiplying the result by 100. The Canada-US ICT investment per worker gap is calculated as 100 minus the relative.

[5] In economic terms, underinvestment by the private sector can be caused either by an underestimation of the private rate of return due to imperfect information or by the presence of positive externalities.

[6] For a more detailed explanation of the ICT investment and labour productivity linkage, see Sharpe (2006:33-34). Sharpe (2006:34-35) also discusses the limitations of the ICT investment and labour productivity nexus. One major limitation is that the impact of ICT investment on labour productivity may not occur in the same time period in which the ICT investment took place due to lags. Another major limitation is that the benefits of ICT investment on

b. Empirical

This theoretical linkage of productivity performance and ICT investment has empirical support in Canada. In particular, Sharpe (2006) found that ICT investment accounted for 15.3 per cent of the 1.3 per cent average annual increase in labour productivity in Canada between 1987 and 2005. Other authors and organizations have also examined this theoretical linkage, and many have found that it appears to be empirically sound in Canada (see Dion and Fay (2008) and Sharpe (2006) for a literature review).

The theoretical linkage of labour productivity and ICT investment also appears to have empirical support in the United States (Cardona et al., 2013). Most importantly, ICTs played a central role in the revitalization of productivity growth in the United States in the 1990s (Jorgenson, 2001; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Sharpe, 2006; and Pilat and Lee, 2001).

Finally, moving outside of North America, there also exist a variety of studies showing empirical support for this linkage in other countries. For example, Cardon, Kretschmer and Strobel (2013) undertook meta-analyses of the empirical literature on the linkage between productivity and ICT. Their literature review shows the estimated contribution of ICT to labour productivity from growth accounting exercises in both the US and the European Union (EU). According to their compilation, in the EU, ICT contributed 17 per cent of labour productivity growth over the 1990-1995 period, 42 per cent over the 1995-2000 period, 45 per cent over the 2000-2005 period, and 31 per cent over the 2003-2007 period. In the US, these contributions were 36 per cent over the 1990-1995 period, 59-73 per cent over the 1995-2000 period, and 33-43 per cent over the 2000-2005 period.

Sharpe (2006) and Draca, Sadun and Van Reenan (2006) also contain brief literature reviews of the impact of ICT investment on productivity growth in other countries.

B. Structure of the Report

After the introduction, this report is divided into nine sections. Section II discusses the data sources used for Canada and the United States, and the measurement of IT investment per worker across industries within Canada and by industry across Canada and the United States.

Section III presents data on IT investment levels and growth rates by industry in Canada and the United States. This section is broken down into three subsections. The first subsection presents data on total IT investment, while the two subsequent subsections present data on computer and software investment. Section IV examines possible methodological reasons behind the large Canada-US IT investment gap. In particular, this section studies measurement errors

---

firm performance may go well beyond productivity increases and include quality improvements in products and services. A third limitation is that ICT investments may be so small in magnitude that they have a minimal effect on the capital stock, but represent such technological breakthroughs that they raise productivity significantly. A final limitation is that the net productivity gains from ICT investment may be less than expected because of offsetting factors or the law of unintended consequences (Tenner, 1996).

and industry definitions as potential explanations for the large difference in IT investment by industry across Canada and the United States. Section V examines potential explanations for the IT investment differences between Canada and the United States by industry. Some common determinants of investment are input prices, profits, industry structure and human capital. Section VI proceeds identically to the Section III, except that the data and the discussion will compare IT investment levels by industry within Canada. This section contains the same three subsections as Section III. Section VII examines Canadian industry data in a structure that is identical to Section V. Section VIII discusses the policy implications of the findings and put forward specific recommendations for private sector action and public policy to increase investment in Canada in sectors where it appears to be well behind the same industries in the United States. Section IX discusses further research areas and future data needs. Subsequently, Section X of the report concludes.

The report also consists of a number of appendices. Appendix I provides data on ICT capital stock in both Canada and the United States. Appendix II provides data on total ICT investment per worker in Canada and the United States and communications investment per worker in Canada and the United States. Appendix III reviews labour productivity growth in Canada and the United States and provides simple linkages between labour productivity growth and IT investment per worker in both countries. Appendix IV provides IT investment per worker growth in Canada. The fifth appendix contains a variety of charts and tables.

II. Data Sources and Measurement of ICT Investment Per Worker by Industry

This section briefly discusses data sources and the measurement of ICT investment per worker in Canada, in the United States, and between Canada and the United States.

A. Data Sources for Canada

In January 2015, the CSLS published an updated database on ICT investment by industry in Canada and the United States with three components: a Canadian component, a US component, and a Canada-US comparison component. These three datasets contain information on ICT investment and capital stock at the aggregate level, as well as for computers, communications and software. The figures are available in current (nominal) and chained (real) dollars. [7,8]

In the Canadian database, values extend back to 1980 for the total economy, the business sector, non-business sector and for 20 two-digit NAICS industries. In the US database, values extend back to 1987 for the business sector and to 2002 for 19 two-digit NAICS industries.[9] There is no total economy or non-business sector data for the United States since there is no estimate for public administration (i.e. the government sector). In the Canada-US database, results extend back to 1987 for the business sector and to 2002 for 19 two-digit NAICS industries. All three datasets provide information by industry and by component for total investment and capital stock, investment and capital stock per worker, ICT investment as a share of total investment, ICT investment as a proportion of GDP, and ICT capital stock as a share of total capital stock.

This online group of datasets has been used for the Canada-US ICT investment comparisons by industry. The main sources used in this database for data on ICT investment and employment by industry in Canada are from Statistics Canada. In particular, the data for employment by industry were obtained from the Labour Force Survey (CANSIM 282-0008), while the data for ICT investment and capital stock were obtained from the Stock and Consumption of Fixed Non-Residential Capital program (CANSIM 031-0003).[10] All three CSLS datasets contain data for 1987-2013. The database also contains information on GDP by industry

[7] The online database is available at http://www.csls.ca/data/ICT-CSLS-2014-Database.zip.
[8] Chained dollars in Canada have a 2007 base, while chained dollars in the United States have a 2009 base. There was no need to rebase the figures for Canada or the United States since chained dollars were only used for growth rates.
[9] ICT investment per worker in the United States only extends back to 2002 because employment figures by industry from the Current Population Survey from Bureau of Labor Statistics are only available back to 2002. The tables that were published for 2000–2001 contained data using 1990 Census-based population controls. The data for 2000–2001 were later revised to incorporate Census 2000-based population controls, but the tables were not re-issued with revised data. Thus, employment values from the Current Population Survey exist only for 2002-2014. Employment figures by industry from the Bureau of Labor Statistics can also be obtained from the Labor Productivity and Costs series back to 1987, but these figures were not used since the Current Population Survey has been used by the CSLS for its ICT analysis since 2005 and certain industry results are extremely sensitive to the choice of employment data (see Section IV, part C).
[10] This time series has been terminated by Statistics Canada and replaced by CANSIM 031-0006 to 031-0008.

from Statistics Canada (CANSIM 379-0023). Occasionally, additional data sources were required. For information on additional data sources, see the online database.

Box 1: Reclassification of ICT Investment by Statistics Canada

In the first half of 2015, the investment and capital stock time series of the Stock and Consumption of Fixed Non-Residential Capital program at Statistics Canada underwent a reclassification process back to 1980. In this report, the CSLS chose not to use the new investment and capital stock time series that resulted from this reclassification for several reasons:

1. In the new time series, there are only two components: 'software', and 'computers and electronic products', instead of three components: 'software', 'computers', and 'telecommunications'. 'Communications' has been regrouped with 'computers' into the 'computers and electronic products' category in the new time series. This means that detailed information on all three components would have been lost by updating the database for this report. In addition, 'computer and electronic products' is not entirely composed of ICT products, so its inclusion overestimates total ICT investment. In particular, Statistics Canada officials have confirmed that the new classification under the current capital stock program of 'computer and electronic products' is not exactly equivalent to the aggregation of 'computers' and 'telecommunications' in the old classification under the previous capital stock program. According to Statistics Canada officials, the main difference is the asset class 'measuring and control devices; electrical, medical, scientific and technical instruments' which was previously in 'other machinery and equipment,' but is now included in 'computers and electronic products.'

2. At the time of writing, the new time series extended only to 2013, so there were no additional years obtained by adopting the new series.

3. In the new time series, two industries have been lost relative to the old time series. Real estate and rental and leasing has been aggregated with finance and insurance, which limits the amount of detail that can be provided at the industry level, the purpose of this report. This combination is especially frustrating considering that historically, real estate and rental and leasing had higher ICT investment per worker in Canada than in the United States, while finance and insurance had lower ICT investment per worker in Canada than in the United States. By combining them together, this industry now has similar ICT investment per worker in Canada and the United States. One other industry has been completely dropped from the analysis: management of companies and enterprises, but for a variety of reasons, this is much less of a concern.

4. In the new time series, investment figures for computers and electronic products are suppressed for five of nineteen two-digit NAICS industries, which means that these industries will have even less information on ICT investment per worker in the future. In contrast, computer investment was available for all twenty two-digit NAICS industries in the old series.

5. In the new time series, Statistics Canada does not provide pre-calculated business sector estimates of investment, whereas the old time series had a pre-calculated business sector estimate. This means that business sector estimates will now need to be constructed for both Canada and the United States. The definition of the business sector will be all industries minus health care and social assistance, educational services, and public administration (See Box 2).

In order to compare the level of ICT investment by industry in Canada with the level of ICT investment by industry in the United States, purchasing power parity data were obtained for machinery and equipment from the National Gross Domestic Product by Income and by Expenditure Accounts program of Statistics Canada (CANSIM 380-0057).

It is important to note that Statistics Canada suppresses certain investment figures due to the confidentiality restraints of the *Statistics Act*. This suppression has become more widespread over time. In particular, only 6 out of 20 two-digit NAICS industries had ICT investment information available up to 2013.[11,12] The severity of the restrictions in 2013 was enormous compared to the severity of the restrictions in 2006 when 14 of the 20 two-digit NAICS industries had ICT investment information. However, the suppression of statistics appears only to affect the telecommunications component of ICT investment. Hence, when ICT investment is broken down by component and by industry in Canada, the time series extends to 2013 for both computers and software for all industries, which together accounted for 80 per cent of total ICT investment per worker in 2013.[13, 14]

B. Data Sources for the United States

The CSLS online database for ICT investment by industry also provides estimates for the United States. The online database used data from the Current Population Survey from the Bureau of Labor Statistics for employment by industry. These data were available from 2002 to 2013. Data on ICT investment by industry were obtained from the Fixed Assets Program of the US Bureau of Economic Analysis. These data were available from 1987 to 2013. The database also contains information on real and nominal GDP by industry and labour productivity by industry. These data were obtained from the US Bureau of Economic Analysis and the US Bureau of Labor Statistics respectively.

The data limitations imposed by the *Statistics Act* in Canada are only exacerbated by the limited data available for employment in the United States. In particular, since the US Bureau of Labor Statistics only provides data on employment by industry from 2002, the Canada-US ICT investment per worker analysis can only commence in 2002.

[11] Capital stock figures suffer from less suppression. Fifteen industries had information from 1987 to 2013. One industry (management of companies and enterprises) had information from 1995 to 2013. Only four industries did not have any information: utilities, construction, health care and social assistance, and accommodation and food services.

[12] These six industries are manufacturing; information and cultural industries; finance and insurance; professional, scientific and technical services; educational services; and public administration.

[13] Over the 1981-2013 period, software and computers accounted for 70 per cent of total ICT investment per worker in the business sector. Over the 2000-2013 period, software and computers accounted for 75 per cent of total ICT investment per worker in the business sector.

[14] In this report, a proxy for total ICT investment has been created which sums computer and software investment per worker. This proxy is called total IT investment. The main body of the analysis contains additional information on this proxy.

Box 2: Definition of the Business Sector

In Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital (SCFNRC) program, from which investment in information and communication technologies is obtained, the business sector is constructed using a NAICS-based definition, as all industries are included in the calculation except educational services (NAICS 61), health care and social assistance (NAICS 62), and public administration (NAICS 91).

In other Statistics Canada programs, such as the system of macroeconomic accounts and the Canadian Productivity Accounts, the business sector is calculated based on whether production at the firm level is market oriented. In particular, the business sector includes all transactors producing goods and services for sale at a price intended to cover costs of production, namely corporations, government business enterprises, unincorporated business, and independent professional practices. It also includes owners occupying their own dwelling, treated as businesses themselves, and associations of individuals, treated as businesses with respect to their capital outlays and their intermediation activities.

The impact of using the market-based definition versus the industry-based definition of the business sector on ICT investment is shown in Table 1.

The Bureau of Economic Analysis uses this market based definition, where the business sector includes all corporate and non-corporate private entities organized for profit and certain other entities that are treated as businesses in the national income and product accounts (NIPAs), including mutual financial institutions, private non-insured pension funds, cooperatives, non-profit organizations that primarily serve businesses, Federal Reserve banks, federally sponsored credit agencies, and government enterprises.

In this report, the CSLS has chosen to apply the definition from the SCFNRC program to both Canada and the United States because it would be impossible to determine what share of investment in each industry belongs in the business sector. In order to ensure that ICT investment figures from the United States are comparable, estimates for the business sector in the United States are created using the Statistics Canada definition.

Table 1: ICT Investment, Statistics Canada, 2000-2008

	Stock and Consumption of Fixed Non-Residential Capital	CPA	Difference
2000	27,763	27,666	97
2001	27,710	26,759	951
2002	26,610	24,826	1,784
2003	26,138	24,777	1,361
2004	27,970	26,767	1,203
2005	29,862	28,671	1,191
2006	31,622	30,280	1,342
2007	32,980	31,882	1,098
2008	34,280	33,111	1,169

Source: Sharpe and Rai (2013:84-86).

Note: Sharpe and Rai (2013:82-84) contains a thorough discussion of the different business sector definitions and their implications for relative ICT investment per worker estimates between Canada and the United States.
Source: Statistics Canada: http://www.statcan.gc.ca/eng/nea/gloss/gloss_b#Businesssector; Bureau of Economic Analysis: http://www.bea.gov/glossary/glossary_b.htm.

With data restrictions in Canada and limited data in the United States, this report will employ two different time periods to maximize both the length of the time series and the number of industries covered by the time series. These time periods include:

- 1987-2013: total IT, computer and software investment per worker in Canada by industry in Canadian dollars; and[15]
- 2002-2013: total IT, computer and software investment per worker in Canada and the United States by industry in US dollars.[16]

Since the availability of capital stock data is less restricted than investment data, comparisons within Canada will stretch from 1987 to 2013 for all components and all industries, while comparisons with the United States will stretch from 2002 to 2013 for all components and all industries. These comparisons are available in Appendix I.

C. Measurement of ICT Investment Per Worker by Industry

It is important to use appropriate measures when comparing ICT investment within Canada by industry and by industry across Canada and the United States. The two subsections below briefly discuss the key indicators used to examine ICT investment by industry in both a Canadian and a cross-country context.[17]

[15] In the appendices, total ICT investment per worker and communications investment per worker are examined in Canada over the 1987-2008 period due to the above mentioned restrictions. Data are available to 2009, but 2008 was chosen to avoid incorporating the negative impacts of the financial crisis into our analysis of growth rates and levels of ICT investment.

[16] In the appendices, total ICT investment per worker and communications investment per worker are examined in Canada and the United States over the 2002-2008 period due to the above mentioned restrictions. Data are available to 2009, but 2008 was chosen to avoid incorporating the negative impacts of the financial crisis into our analysis of growth rates and levels of ICT investment.

[17] It is important to point out that as software, communications equipment and computer equipment is increasingly embodied in other capital goods (e.g. navigational systems are embodied in cars), the relevance of the analysis of ICT investment per worker weakens because a larger and larger component of ICT investment is masked in other goods.

Box 3: Management of Companies and Enterprises: Analytical Challenges

In current dollars, the two-digit NAICS industry called management of companies and enterprises (i.e. headquarters) (code 55) had the highest level of total ICT investment per worker at $48,038 in 2013. However, it is important to note that the management of companies and enterprises industry presents a number of analytical challenges because data on investment and employment in management of companies and enterprises are difficult to interpret. Employment data for the industry are extremely unreliable because of small sample sizes. In addition, it is possible that there are different uses of the industry code by business survey respondents. Finally, ICT investment data are obtained through accounting procedures and business surveys, and it is quite possible that ICT investment is credited to the head office, but that the ICT investment itself is actually distributed to other establishments for use within the firm.[*] For example, suppose the head office of a firm in manufacturing purchases new software for automating the assembly line in one of their establishments. Since the software was credited to the head office, it would be counted as ICT investment in management of companies and enterprises, despite the fact that the software was actually used on the ground by the manufacturing establishment. This would overestimate the amount of ICT investment in management of companies and enterprises, while underestimating the amount of ICT investment in manufacturing.

For these reasons, this report will not include the industry of management of companies and enterprises in the analysis. In any rankings, management of companies and enterprises will also be excluded. For example, management of companies and enterprises shows the highest level of total ICT investment per worker in 2013 in Canada, followed by utilities and public administration. In this case, given the qualms surrounding data for management of companies and enterprises, this report would speak of utilities and public administration as having the highest levels of total ICT investment per worker in 2013. However, to maintain comprehensiveness, management of companies and enterprises will still be included as an industry in some of the charts and tables presented throughout this report, and it will continue to be included in the business sector totals.

[*] Bureau of Economic Analysis officials mentioned that some investment is placed in headquarters rather than in the industry the headquarters served based on their usual procedures and data sources. If they reduced investment in this industry, it would simply be redistributed to other industries, leaving the total unchanged. Hence, it is plausible that some of the investment in management of companies and enterprises in the United States should be allocated to the industry which the headquarters' serve, but it is unlikely that this measurement error can explain the massive differences in IT investment per worker by industry between Canada and the United States.

i. Comparisons within Canada

The key indicator used in this report to compare ICT investment in Canada by industry is ICT investment per worker. ICT investment per worker is calculated as ICT investment divided by the number of workers. For example, utilities investment in computers was $535 million in 2013. Further, there were 144 thousand workers. Given these data, computer investment per worker in utilities in Canada in 2013 would be about $3,715.

It is important to note that when this report compares absolute levels of ICT investment per worker, current dollars will be used to appropriately capture the value of current capital goods in the market. However, when comparing ICT investment per worker growth rates, chained dollars will be used to ensure that changes in the prices of capital goods and services

over time are not influencing the trends.[18] It is also important to note that growth rates are calculated using the compound average annual growth rate formula. An example is shown below for the time period 2002-2013:

$$\left(\left(\frac{ICT_{2013}}{ICT_{2002}}\right)^{\frac{1}{(2013-2002)}}\right)-1$$

Box 4: ICT Prices

Over the 1987-2009 period, implicit ICT prices fell by 5.3 per cent per year in the business sector. Each component of ICT saw its implicit prices fall, but computer ICT prices fell precipitously (12.8 per cent per year). Communications and software also saw their business sector prices decline, but much less rapidly at only 1.7 and 1.9 per cent per year, respectively (Table 2). It is important to note that any difference in the growth rate of prices at the aggregate level by industry reflects differences in the relative importance of the three components, because all three components tend to have similar growth rates across industries.

Table 2: Implicit Price Deflators, Canada, Compound Average Annual Growth Rates, Per Cent, 1987-2009

	Total	Computers	Communications	Software
Agriculture, fishing, forestry and hunting	-5.60	-12.85	-1.55	-2.13
Mining and oil and gas extraction	-4.87	-12.79	-1.44	-1.64
Utilities	.	-12.87	.	-1.92
Construction	.	-12.88	.	-2.85
Manufacturing	-6.30	-12.81	-1.28	-2.03
Wholesale trade	-5.80	-12.82	.	-2.02
Retail trade	-6.12	-12.89	-1.75	-2.08
Transportation and warehousing	.	-12.89	.	-1.72
Information and cultural industries	-2.52	-12.45	-1.67	-1.62
Finance and insurance	-5.35	-12.81	-1.60	-1.53
Real estate and rental and leasing	-7.14	-12.81	-1.57	-2.31
Professional, scientific and technical services	-9.42	-12.85	-1.62	-2.94
Management of companies and enterprises	n/a	n/a	.	n/a
Administrative and support, waste management and remediation services	.	-12.80	.	-2.51
Educational services	-7.22	-12.85	-1.73	-2.59
Health care and social assistance	.	-12.55	.	-2.55
Arts, entertainment and recreation	-6.77	-12.92	-1.69	-2.34
Accommodation and food services	.	-12.71	.	-3.83
Other services (except public administration)	.	-12.78	.	-2.16
Public administration	-5.65	-12.80	-1.66	-1.99
Business sector	-5.31	-12.82	-1.66	-1.91

Note: "n/a" means not available, while "." means suppressed. We use 2009 for these growth rates because implicit price deflators are only available for a limited number of industries after 2009.
Source: CSLS estimates based on the CSLS ICT database from January 2015.

[18] Chained dollars is a method that is used to adjust dollar amounts for inflation over time, which allows for a more accurate comparison of values from different time periods. Values are weighted by a basket of goods that changes yearly to more accurately reflect actual spending. Constant dollars can also be used to account for inflation, but constant dollars are weighted by a basket of goods that is constant and unchanging over time. Current dollar estimates do not account for inflation. In this report, chained dollars are used instead of current dollars for growth rates to appropriately account for the vast changes in the quality of computers, software and communications equipment over time (see Reinsdorf (2015) footnote 3 for a detailed discussion of chained and constant dollars).

Box continued from previous page…

This fall in prices means that growth rates for ICT investment per worker will be considerably higher in constant dollars than in nominal dollars (Table 3). The gap between the two will also be much larger for computers. For example, if we use current dollars, the growth rate is 2.3 per cent per year in computer investment per worker and 6.6 per cent per year in software investment per worker in the business sector. If we use chained 2007 dollars, it is 16.8 per cent per year for computers and 8.3 per cent per year for software.

Table 3: ICT Investment Per Worker, Nominal and Chained Dollars, Compound Average Annual Growth Rates, Canada, Per Cent, 1987-2013

	Computer		Software	
	Nominal	Chained	Nominal	Chained
Agriculture, fishing, forestry and hunting	11.6	27.5	7.2	9.4
Mining and oil and gas extraction	10.4	26.0	5.9	7.6
Utilities	3.2	17.9	8.9	10.6
Construction	3.2	18.0	0.2	2.9
Manufacturing	3.5	18.2	7.3	9.4
Wholesale trade	4.6	19.5	6.8	8.6
Retail trade	8.4	23.9	6.8	8.7
Transportation and warehousing	5.6	20.7	9.4	11.0
Information and cultural industries	5.9	20.5	10.3	11.8
Finance and insurance	-2.3	11.6	5.8	7.0
Real estate and rental and leasing	1.1	15.5	4.2	6.5
Professional, scientific and technical services	-0.2	14.0	3.8	6.6
Administrative and support, waste management and remediation services	-1.2	12.8	6.3	8.5
Educational services	3.0	17.7	5.8	8.3
Health care and social assistance	3.9	18.4	8.1	10.4
Arts, entertainment and recreation	4.6	19.6	6.0	8.1
Accommodation and food services	4.3	19.1	4.5	6.9
Other services (except public administration)	3.4	18.0	8.3	10.5
Public administration	0.9	15.3	7.4	9.2
Business sector	2.3	16.8	6.6	8.3

Note: the difference between nominal and chained computer investment growth rates is also prominent between 2000 and 2013. For example, business sector nominal computer investment fell 1.0 per cent per year over the 2000-2013 period, while it grew 10.6 per cent per year in chained 2007 dollars over this same period.
Source: CSLS estimates based on the CSLS ICT database from January 2015.

ii. Comparisons between Canada and the United States

The key indicator used in this report to compare ICT investment in Canada and the United States by industry is called 'relative Canada-US ICT investment per worker'. Essentially, ICT investment per worker in a given industry in Canada is converted from Canadian dollars to US dollars using purchasing power parity (PPP) estimates, which take into account the differences in the prices of goods and services between Canada and the United States. Subsequently, ICT investment per worker in Canada in US dollars in a given industry is divided by ICT investment per worker in the United States in the same industry in order to generate an estimate of relative ICT investment per worker between the two countries.

For example, supposed ICT investment per worker in construction is CAD$1,000 in Canada, while it is USD$2,000 in the United States. Further, assume that the PPP exchange rate

indicated that to purchase the same basket of ICT goods in Canada as the United States required 0.80 USD per CAD. Given these data, Canada-US ICT investment per worker would be:

$$\frac{CAD\ \$1{,}000\ per\ worker\ * 0.80\ \frac{USD}{CAD}}{USD\ \$2{,}000\ per\ worker} * 100 = 40\%$$

Box 5: Purchasing Power Parity

This report uses machinery and equipment (M&E) purchasing power parity (PPP) figures to convert ICT investment per worker in Canada in Canadian dollars into US dollars in order to make comparisons with ICT investment per worker in the United States. The optimal PPP figures would be for a basket of ICT goods, but unfortunately, Statistics Canada does not estimate PPP values for ICT. Therefore, this report uses M&E PPP figures. There are a number of issues that arise by using these figures.

First, M&E PPPs measure the price of a basket of M&E goods in Canada relative to the same basket of M&E goods in the United States. Computer equipment and communications equipment are included in this M&E basket, as are many other M&E items. In 2013, computers and telecommunications equipment represented approximately 18.2 per cent of all machinery and equipment. Software is not included, since software is classified under intellectual property products. This means that using M&E PPPs to convert ICT investment per worker in Canada in Canadian dollars into US dollars will result in a margin of error because the PPP measure used does not correspond exactly with the category of analysis.

In addition, it is possible that the inaccuracy of using the M&E PPP has increased over time because the share of software in ICT investment per worker in increasing. Despite these concerns, this report has decided to use the M&E PPP. The only other option would be to use GDP PPPs, but as Table 4 shows, the M&E PPP and the GDP PPP display different trends over time.

These different trends exist because PPPs adjust exchange rates to account for the prices of non-traded goods and services, like haircuts. Since M&E will include less of these non-traded goods and services than GDP, the M&E PPP should be more closely related to the exchange rate than the GDP PPP (correlation coefficient of 0.79 (R^2 = 0.63) versus correlation coefficient of 0.20 (R^2 = 0.04)).

Table 4: Purchasing Power Parity, Machinery and Equipment and GDP, Canadian Dollar Per US Dollar, 2002-2013, OECD and Statistics Canada

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Statistics Canada (M&E)	0.78	0.82	0.86	0.89	0.90	0.90	0.88	0.83	0.87	0.90	n/a	n/a
OECD (GDP)	0.81	0.81	0.81	0.83	0.83	0.83	0.81	0.83	0.82	0.81	0.80	0.80
Statistics Canada (GDP)	0.81	0.82	0.81	0.82	0.83	0.83	0.81	0.83	0.82	0.81	n/a	n/a
Statistics Canada (Exchange Rate)	0.64	0.71	0.77	0.83	0.88	0.93	0.94	0.88	0.97	1.01	1.00	0.97

Note: "n/a" means not available.
Source: OECD and Statistics Canada CANSIM Tables 380-0057, 176-0064, and 380-0037.

Ideally, the PPP estimates used to calculate the Canada-US ICT investment per worker relative would refer specifically to a standard basket of ICT goods. Unfortunately, such estimates do not exist. The closest alternative is the machinery and equipment (M&E) PPP calculated by Statistics Canada. This PPP is used in this report to estimate the Canada-US ICT investment per worker relative. Since computers and communications equipment can be seen as a subcategory

of M&E, using the M&E PPP provides a reasonable, albeit imperfect, alternative. The reader should bear in mind that software, a component of ICT investment, is no longer an element of M&E investment in the National Accounts,[19] and hence, divergences between the M&E PPP (which we use) and the ICT PPP (which doesn't exist) could be a potential source of measurement error.

[19] Software investment was re-categorized from M&E investment into Intellectual Property (IP) investment after revisions to the System of National Accounts (SNA) in 2008.

III. Canada-US Relative IT Investment Per Worker by Industry

This section explores trends in total IT investment per worker by industry in Canada and the United States for the period between 2002 and 2013. Since total IT investment is composed of two components, namely computers and software, this section will explore the trends in each component after reviewing data on overall IT investment per worker in Canada and the United States.

It is important to note that the comparison of total ICT investment at the industry level in Canada and the United States is restricted by the *Statistics Act* in Canada. Data are not available for a number of industries in Canada and the severity of the data restrictions in Canada has increased over time. In order to maximize the number of industries examined and the length of the time series, we have created a proxy for total ICT investment per worker which is composed solely of computer and software investment.[20] This proxy will be called information technology (IT) investment.[21] A comparison of the traditional ICT investment intensity and the IT investment intensity is available in Table 5. An analysis of the traditional total ICT investment (and communications investment) can be found in the appendices, where we limit our investigation to the period between 2002 and 2008. Software investment per worker and computer investment per worker in Canada and the United States do not face similar data restrictions, so the analysis will proceed for these two components over the entire time series, 2002-2013, and these two components are discussed in the main body of the text below.

[20] Communications accounted for only 30 per cent of business sector ICT investment between 1981 and 2013 in Canada. Moreover, this share has fallen from 44 per cent in 1981 to only 20 per cent in 2013. Finally, in 2013, of the six industries out of 20 industries in Canada with available data for communications investment, only one industry saw communications account for over 10 per cent of total ICT investment, namely information and cultural industries, where it represented 65 per cent. In 2009, of the 12 industries with available data for communications investment, only three industries saw communications account for over 10 per cent of total ICT investment, and only one industry saw it account for over 20 per cent of total ICT investment, i.e. information and cultural industries at 70 per cent.

[21] This proxy was not used in previous CSLS research reports because previous reports focused on ICT investment in the business sector, only briefly touching upon ICT investment at the industry level. There are no restrictions on ICT investment in the business sector, so this issue was never at the forefront of our analysis.

Table 5: Comparison of Relative Nominal ICT and IT Canada-US Investment Intensities by Industry, Millions of US Dollars, Per Cent, 2008

	ICT		IT		Relative Canada-US ICT Investment	Relative Canada-US IT Investment
	Canada	United States	Canada	United States		
Agriculture, fishing, forestry and hunting	306	183	267	144	155.6	185.2
Mining and oil and gas extraction	2,578	4,895	2,306	3,514	52.7	65.6
Utilities	.	5,013	7,147	3,936	.	181.6
Construction	.	306	230	241	.	95.7
Manufacturing	1,437	3,495	1,334	3,180	41.1	42.0
Wholesale trade	3,465	6,481	3,032	5,954	53.5	50.9
Retail trade	970	1,125	925	1,001	86.2	92.4
Transportation and warehousing	.	1,260	1,834	754	.	243.2
Information and cultural industries	17,162	30,924	6,134	14,084	55.5	43.6
Finance and insurance	7,933	8,701	7,373	7,740	91.2	95.3
Real estate and rental and leasing	7,912	3,249	7,514	2,288	243.6	328.4
Professional, scientific and technical services	1,518	5,914	1,332	5,477	25.7	24.3
Management of companies and enterprises	13,598	419,388	13,224	407,851	3.2	3.2
Administrative and support, waste management and remediation services	.	3,025	927	2,700	.	34.3
Educational services	1,038	598	1.012	530	173.7	191.0
Health care and social assistance	.	667	394	579	.	68.1
Arts, entertainment and recreation	1,195	518	1.076	355	230.6	303.5
Accommodation and food services	.	311	189	269	.	70.3
Other services (except public administration)	.	773	690	608	.	113.5
Business sector	2,306	3,872	1.826	3,004	59.6	60.8

Source: CSLS ICT by Industry database.

A. Total IT Investment Per Worker

This section investigates absolute levels of total IT investment per worker in Canada and in the United States in each of the 19 two-digit NAICS industries for 2002 and 2013 in current dollars. Subsequently, this section describes growth rates between 2002 and 2013. It is important to recall that total IT investment per worker is simply an aggregation of computer and software investment per worker due to data restrictions for communications investment per worker in Canada. Computer and software investment per worker in Canada and the United States will be discussed in the following sections. Communications and the traditional ICT investment per worker are discussed in the appendices.

i. Absolute Levels

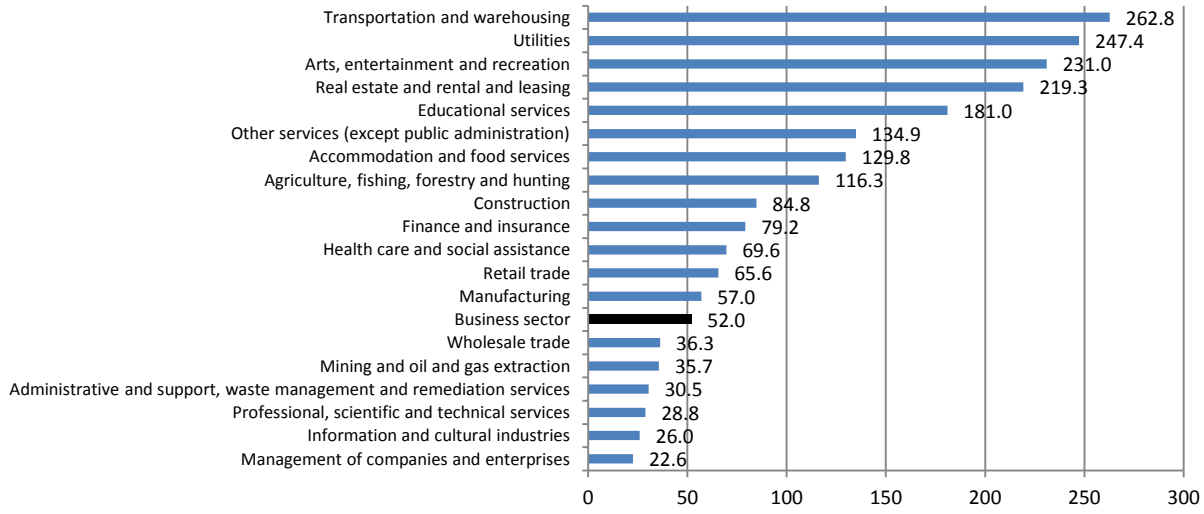
Table 6 contains data on the absolute level of total IT investment per worker in Canada and the United States in PPP-adjusted US dollars for 19 two-digit NAICS industries.

Table 6: Nominal Total IT Investment Per Worker in Canada and the United States, US Dollars, PPP-Adjusted, 2002 and 2013

	United States		Canada		Canada as a Proportion of the United States (%)	
	2002	2013	2002	2013	2002	2013
Agriculture, fishing, forestry and hunting	96	206	244	240	252.8	116.3
Mining and oil and gas extraction	1,948	3,239	590	1,155	30.3	35.7
Utilities	3,091	3,954	4,524	9,781	146.4	247.4
Construction	288	203	195	172	67.6	84.8
Manufacturing	1,963	2,847	782	1,622	39.8	57.0
Wholesale trade	4,186	9,029	2,192	3,282	52.4	36.3
Retail trade	855	1,289	486	846	56.9	65.6
Transportation and warehousing	609	861	1,021	2,262	167.7	262.8
Information and cultural industries	11,992	20,417	4,057	5,309	33.8	26.0
Finance and insurance	7,105	8,330	3,827	6,600	53.9	79.2
Real estate and rental and leasing	2,403	1,920	7,459	4,212	310.4	219.3
Professional, scientific and technical services	4,306	5,272	1,629	1,520	37.8	28.8
Management of companies and enterprises	407,357	188,907	20,124	42,754	4.9	22.6
Administrative and support, waste management and remediation services	2,380	3,189	679	973	28.5	30.5
Educational services	426	562	860	1,016	201.7	181.0
Health care and social assistance	515	565	238	394	46.3	69.6
Arts, entertainment and recreation	400	296	991	684	247.8	231.0
Accommodation and food services	109	205	149	267	136.6	129.8
Other services (except public administration)	542	494	490	667	90.4	134.9
Business sector	2,417	3,353	1,210	1,744	50.1	52.0

Source: CSLS ICT by Industry database.

Chart 1: Nominal Total IT Investment Per Worker in Canada Relative to the United States, Per Cent, 2013



Source: Table 6.

In 2013, transportation and warehousing in Canada had total IT investment per worker levels that were 262.8 per cent of total IT investment per worker levels in this same industry in the United States (Chart 1). Utilities, arts, entertainment and recreation, real estate and rental and leasing, educational services, other services (except public administration), accommodation and food services, and agriculture, fishing, forestry and hunting also had higher levels of total IT investment per worker than the same industries in the United States. In other words, seven of seventeen business sector industries, accounting for 30 per cent of employment in the business sector (Table 7), spent more on IT per worker than their American counterparts, even though on average Canadian firms spent only one half as much on a per worker basis relative to their US counterparts.

Table 7: Distribution of Business Sector IT Investment and Employment by Industry, Canada and the United States, 2002 and 2013

	United States				Canada			
	IT Investment		Employment		IT Investment		Employment	
	2002	2013	2002	2013	2002	2013	2002	2013
Agriculture, fishing, forestry and hunting	0.1	0.1	2.3	2.0	0.7	0.4	3.6	2.9
Mining and oil and gas extraction	0.4	1.0	0.5	1.0	0.6	1.6	1.4	2.3
Utilities	1.6	1.3	1.2	1.1	4.2	6.0	1.1	1.1
Construction	1.1	0.5	9.8	8.9	1.2	1.0	7.2	9.9
Manufacturing	13.4	12.1	16.8	14.2	11.7	12.5	19.3	13.0
Wholesale trade	6.9	9.4	4.0	3.5	8.0	8.6	4.6	4.6
Retail trade	5.3	5.9	15.3	15.3	6.3	7.6	15.5	15.7
Transportation and warehousing	1.4	1.5	5.8	5.9	5.3	8.4	6.4	6.5
Information and cultural industries	17.5	17.2	3.6	2.8	11.2	8.8	3.2	2.9
Finance and insurance	19.0	16.6	6.6	6.7	17.6	21.9	5.5	6.0
Real estate and rental and leasing	2.7	1.6	2.8	2.7	12.4	6.0	2.1	2.4
Professional, scientific and technical services	14.3	15.2	8.2	9.7	11.5	9.1	8.3	10.1
Management of companies and enterprises	6.8	9.8	0.0	0.2	0.6	0.5	0.0	0.0
Administrative and support, waste management and remediation services	5.2	5.9	5.4	6.2	2.9	2.9	4.9	5.3
Arts, entertainment and recreation	0.4	0.3	2.6	3.1	2.4	1.2	2.8	3.0
Accommodation and food services	0.4	0.6	8.7	9.9	1.0	1.3	8.3	8.5
Other services (except public administration)	1.4	1.0	6.5	6.8	2.3	2.3	5.8	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CSLS calculations based on the CSLS ICT by Industry database.

In 2013, there were eleven industries in Canada that invested less heavily than their counterparts in the United States. Of these industries, the worst case is information and cultural industries: for every dollar spent on total IT investment per worker in Canada in information and cultural industries, the United States spent almost four dollars. Professional, scientific and technical services saw similarly weak investment in Canada relative to the United States: for every dollar spent on total IT investment per worker in Canada, the United States spent nearly three and a half dollars.

Most of the same industries that excelled in terms of relative Canada-US IT investment intensity in Canada in 2013 had also excelled in 2002. The only exception was other services (except public administration), which had lower total IT investment per worker in Canada in 2002 than in the United States, but higher total IT investment per worker in Canada than in the United States in 2013. No other industry switched from having higher total IT investment to lower total IT investment in one country relative to the other between 2002 and 2013.

Table 8: Total Nominal IT Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to the Business Sector Gap, 2013

	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Information and cultural industries	26.55	26.93	26.74
Professional, scientific and technical services	22.52	23.60	23.06
Wholesale trade	12.44	16.44	14.44
Manufacturing	10.82	9.91	10.37
Management of companies and enterprises	15.88	2.04	8.96
Administrative and support, waste management and remediation services	8.55	7.35	7.95
Finance and insurance	7.17	6.48	6.83
Retail trade	4.21	4.32	4.27
Mining and oil and gas extraction	1.32	2.93	2.12
Construction	0.17	0.19	0.18
Agriculture, fishing, forestry and hunting	-0.04	-0.06	-0.05
Accommodation and food services	-0.38	-0.33	-0.35
Other services (except public administration)	-0.73	-0.62	-0.68
Arts, entertainment and recreation	-0.74	-0.73	-0.73
Real estate and rental and leasing	-3.90	-3.41	-3.65
Utilities	-4.11	-3.92	-4.01
Transportation and warehousing	-5.18	-5.64	-5.41
Business sector	100.00	100.00	100.00
Accounted	**94.55**	**85.49**	**90.03**
Unaccounted	**5.45**	**14.51**	**9.97**

* This is a proxy that was calculated by summing computers and software because communications equipment investment figures are not available for the majority of the industries in Canada in 2013.
Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.
Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

A simple accounting exercise shows that information and cultural industries and professional, scientific and technical services are responsible for 49.8 per cent of the total IT

investment per worker business sector gap (Table 8). Wholesale trade and manufacturing are responsible for another 24.8 per cent of the business sector total IT investment per worker gap.[22]

ii. Growth Rates

Total IT investment per worker in accommodation and food services grew extremely quickly in both Canada and the United States at 11.3 per cent per year and 13.5 per cent per year respectively (Table 9). In Canada, accommodation and food services was one of the industries that saw the fastest growth between 2002 and 2013 in total IT investment per worker; in the United States, accommodation and food services was the industry with the second fastest growth in total IT investment per worker, behind agriculture, fishing, forestry and hunting (15.1 per cent per year). In contrast, real estate and rental and leasing saw total IT investment per worker fall during this time period in Canada at a rate of -0.6 per cent per year; in the United States, there was not a single industry that saw total IT investment per worker decline between 2002 and 2013.

During this time period, there were four industries with total IT investment per worker growth rate differentials of one percentage point per year or less. Every other industry had divergent growth rates for the two countries. The largest growth rate differential that favoured the United States was in agriculture, fishing, forestry and hunting, where the United States had a total IT investment per worker growth rate that was 8.4 percentage points per year higher than Canada's between 2002 and 2013. No other industry showed a gap that was quite as large. Given this growth rate differential, it is not surprising that relative Canada-US IT investment intensity fell from 252.8 per cent in 2002 to 116.3 per cent in 2013 in agriculture, fishing, forestry and hunting.

The next largest differential favouring the United States in total ICT investment per worker was 4.6 percentage points per year in real estate and rental and leasing.

Eight industries in Canada demonstrated total IT investment per worker growth that was more than one percentage point higher than total IT investment per worker growth in the United States. The most prominent cases were transportation and warehousing and construction, which had differentials favouring Canada of 5.6 and 5.7 percentage points per year.

[22] These contributions are determined by weighting each industry's absolute IT investment per worker gap by the employment share and subsequently dividing this number by the absolute IT investment per worker gap in the business sector.

Table 9: Total Real IT Investment Per Worker in Canada and the United States, Compound Average Annual Growth Rates, 2002-2013

`	United States	Canada	Canada-US
Agriculture, fishing, forestry and hunting	15.1	6.7	-8.4
Mining and oil and gas extraction	7.1	11.3	4.2
Utilities	6.2	9.7	3.5
Construction	1.8	7.5	5.7
Manufacturing	8.2	10.7	2.5
Wholesale trade	10.3	6.3	-4.0
Retail trade	10.0	9.6	-0.4
Transportation and warehousing	5.0	10.6	5.6
Information and cultural industries	7.7	5.5	-2.2
Finance and insurance	7.0	6.4	-0.6
Real estate and rental and leasing	4.0	-0.6	-4.6
Professional, scientific and technical services	7.6	6.4	-1.2
Management of companies and enterprises	-3.7	n/a	.
Administrative and support, waste management and remediation services	7.8	8.2	0.4
Educational services	10.1	7.2	-2.9
Health care and social assistance	7.9	8.6	0.7
Arts, entertainment and recreation	4.0	3.0	-1.0
Accommodation and food services	13.5	11.3	-2.2
Other services (except public administration)	5.4	6.8	1.4
Business sector	7.3	7.0	-0.3

Note:" n/a" means not available.
Source: CSLS calculations based on the CSLS ICT database from January 2015.

B. Computer Investment Per Worker

This section investigates absolute levels of computer investment per worker in Canada and in the United States in each of the 19 two-digit NAICS industries for 2002 and 2013 in current dollars. Subsequently, this section describes growth rates between 2002 and 2013.

i. Absolute Levels

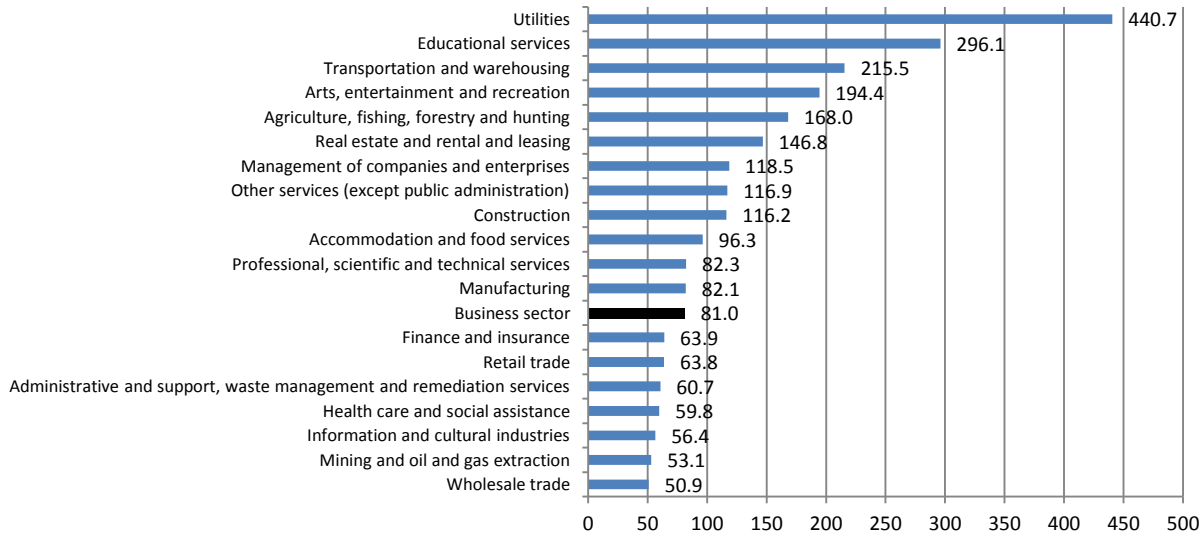
Table 10 contains data on the absolute level of computer investment per worker in Canada and the United States in purchasing power parity adjusted US dollars for 19 two-digit NAICS industries.

Table 10: Nominal Computer Investment Per Worker in Canada and the United States, US Dollars, PPP-Adjusted. 2002 and 2013

	United States		Canada		Canada as a Proportion of the United States (%)	
	2002	2013	2002	2013	2002	2013
Agriculture, fishing, forestry and hunting	50	91	140	152	279.3	168.0
Mining and oil and gas extraction	406	1,068	126	567	31.1	53.1
Utilities	614	754	1,152	3,323	187.5	440.7
Construction	157	113	155	132	98.5	116.2
Manufacturing	431	498	264	409	61.3	82.1
Wholesale trade	1,210	1,283	706	653	58.3	50.9
Retail trade	394	480	239	306	60.7	63.8
Transportation and warehousing	239	302	315	652	131.5	215.5
Information and cultural industries	2,451	3,556	1,447	2,006	59.0	56.4
Finance and insurance	2,371	1,564	1,102	999	46.5	63.9
Real estate and rental and leasing	1,590	1,080	3,510	1,586	220.7	146.8
Professional, scientific and technical services	1,391	1,049	1,213	863	87.2	82.3
Management of companies and enterprises	75,857	15,164	13,475	17,971	17.8	118.5
Administrative and support, waste management and remediation services	516	493	474	300	91.9	60.7
Educational services	119	112	567	333	475.1	296.1
Health care and social assistance	202	202	131	120	64.9	59.8
Arts, entertainment and recreation	227	175	770	340	339.3	194.4
Accommodation and food services	67	134	75	129	112.1	96.3
Other services (except public administration)	260	205	198	239	76.4	116.9
Business sector	712	663	518	537	72.7	81.0

Source: CSLS ICT by Industry database.

Chart 2: Nominal Computer Investment Per Worker in Canada Relative to the United States, Per Cent, 2013



Source: Table 10.

Table 11: Distribution of Business Sector Computer Investment and Employment by Industry, Canada and the United States, 2002 and 2013

	United States				Canada			
	Computer Investment		Employment		Computer Investment		Employment	
	02	13	02	13	02	13	02	13
Agriculture, fishing, forestry and hunting	0.2	0.3	2.3	2.0	1.0	0.8	3.6	2.9
Mining and oil and gas extraction	0.3	1.6	0.5	1.0	0.4	2.4	1.4	2.3
Utilities	1.1	1.3	1.2	1.1	2.4	6.7	1.1	1.1
Construction	2.2	1.5	9.8	8.9	2.2	2.4	7.2	9.9
Manufacturing	10.2	10.7	16.8	14.2	9.8	9.9	19.3	13.0
Wholesale trade	6.9	6.7	4.0	3.5	6.2	5.6	4.6	4.6
Retail trade	8.5	11.1	15.3	15.3	7.2	8.9	15.5	15.7
Transportation and warehousing	2.0	2.7	5.8	5.9	3.9	7.9	6.4	6.5
Information and cultural industries	12.4	15.2	3.6	2.8	8.9	10.7	3.2	2.9
Finance and insurance	21.9	15.7	6.6	6.7	11.7	11.2	5.5	6.0
Real estate and rental and leasing	6.1	4.5	2.8	2.7	14.0	7.1	2.1	2.4
Professional, scientific and technical services	16.0	15.3	8.2	9.7	19.3	16.3	8.3	10.1
Management of companies and enterprises	4.4	4.0	0.0	0.2	0.9	0.6	0.0	0.0
Administrative and support, waste management and remediation services	3.9	4.6	5.4	6.2	4.5	3.0	4.9	5.3
Arts, entertainment and recreation	0.8	0.8	2.6	3.1	4.2	1.9	2.8	3.0
Accommodation and food services	0.8	2.0	8.7	9.9	1.2	2.0	8.3	8.5
Other services (except public administration)	2.4	2.1	6.5	6.8	2.2	2.6	5.8	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CSLS calculations based on the CSLS ICT by Industry database.

In 2013, utilities in Canada had computer investment per worker levels that were 440.7 per cent of computer investment per worker levels in the United States. Educational services in Canada also had much higher levels of computer investment per worker than the same industry in the United States with a relative of 296.1 per cent. Seven other industries in Canada over-invested compared to their counterparts in the United States.

The remaining ten industries saw higher levels of computer investment per worker in the United States than in Canada in 2013. The worst case was mining and oil and gas extraction: for every dollar spent on computer investment per worker in Canada in mining and oil and gas extraction, the United States spent almost two dollars.

Over the entire time series, only the following six industries consistently showed higher computer investment per worker in Canada than in the United States: agriculture, fishing, forestry and hunting; utilities; transportation and warehousing; real estate and rental and leasing; educational services; and arts, entertainment and recreation (Appendix Chart 1-Appendix Chart 20).

Table 12: Nominal Computer Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to the Business Sector Gap, 2013

	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Information and cultural industries	34.78	35.28	35.03
Finance and insurance	29.92	27.03	28.47
Retail trade	21.12	21.69	21.40
Wholesale trade	17.41	23.01	20.21
Professional, scientific and technical services	14.26	14.94	14.60
Manufacturing	10.03	9.20	9.61
Administrative and support, waste management and remediation services	9.51	8.18	8.84
Mining and oil and gas extraction	4.05	8.99	6.52
Accommodation and food services	0.39	0.34	0.36
Agriculture, fishing, forestry and hunting	-0.99	-1.38	-1.18
Construction	-1.34	-1.50	-1.42
Other services (except public administration)	-1.84	-1.56	-1.70
Management of companies and enterprises	-3.89	-0.50	-2.20
Arts, entertainment and recreation	-4.01	-3.94	-3.98
Real estate and rental and leasing	-10.99	-9.62	-10.30
Transportation and warehousing	-16.53	-18.00	-17.26
Utilities	-23.12	-22.04	-22.58
Business sector	100.00	100.00	100.00
Accounted	**78.77**	**90.1**	**84.43**
Unaccounted	**21.23**	**9.9**	**15.57**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.
Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

A simple accounting exercise shows that information and cultural industries and finance and insurance are responsible for an incredible 63.5 per cent of the business sector computer investment per worker gap (Table 12). By including professional, scientific and technical services and manufacturing, it is possible to explain 87.7 per cent of the computer investment per worker gap, but only 32.0 per cent of employment (Table 11).[23]

[23] These contributions are determined by weighting each industry's absolute IT investment per worker gap by the employment share and subsequently dividing this number by the absolute IT investment per worker gap in the business sector.

ii. Growth Rates

Computer investment per worker in mining and oil and gas extraction grew extremely quickly in both Canada and the United States at 26.9 per cent per year and 15.6 per cent per year (Table 13). At these rates, computer investment per worker in Canada would double in approximately three years, while it would double in approximately four and a half years in the United States. In Canada, mining and oil and gas extraction was the industry that saw the fastest growth between 2002 and 2013 in computer investment per worker; in the United States, the fastest growing industry was accommodation and food services at 16.0 per cent per year.

In contrast, real estate and rental and leasing saw much slower growth in computer investment per worker in both countries at a rate of 4.2 per cent per year in the United States and 2.6 per cent per year in Canada. In the United States, only management of companies and enterprises grew more slowly (-3.4 per cent per year), and in Canada, only arts, entertainment and recreation saw slower growth (2.5 per cent per year).

Table 13: Real Computer Investment Per Worker in Canada and the United States, Compound Average Annual Growth Rates, 2002-2013

	United States	Canada	Canada-US
Agriculture, fishing, forestry and hunting	15.4	11.2	-4.2
Mining and oil and gas extraction	15.6	26.9	11.3
Utilities	12.7	21.5	8.8
Construction	5.6	8.8	3.2
Manufacturing	11.3	14.8	3.5
Wholesale trade	10.2	9.6	-0.6
Retail trade	10.7	12.9	2.2
Transportation and warehousing	11.7	17.9	6.2
Information and cultural industries	14.0	13.7	-0.3
Finance and insurance	7.8	9.3	1.5
Real estate and rental and leasing	4.2	2.6	-1.6
Professional, scientific and technical services	8.9	7.0	-1.9
Management of companies and enterprises	-3.4	13.3	16.7
Administrative and support, waste management and remediation services	9.7	5.8	-3.9
Educational services	12.9	5.1	-7.8
Health care and social assistance	10.0	9.5	-0.5
Arts, entertainment and recreation	7.1	2.5	-4.6
Accommodation and food services	16.0	15.9	-0.1
Other services (except public administration)	8.2	12.2	4.0
Business sector	9.7	10.7	1.0

Source: CSLS calculations based on the CSLS ICT database from January 2015.

During this time period (2002-2013), there were four industries with computer investment per worker growth rate differentials of one percentage point per year or less, including wholesale trade, health care and social assistance, information and cultural industries, and accommodation and food services. Every other industry had computer investment per worker growth rates that deviated from one another by more than one percentage point per year.

The largest growth rate differential was in mining and oil and gas extraction, where Canada had a computer investment per worker growth rate that was 11.3 percentage points per year higher than the United States between 2002 and 2013. No other industry showed a gap that was quite as large.

The next largest differential in favour of Canada was in utilities (8.8 percentage points per year). Seven other industries also saw higher computer investment per worker growth rates in Canada than in the United States, including construction; manufacturing; retail trade; transportation and warehousing; finance and insurance; and other services (except public administration) and management of companies and enterprises.

The remaining six industries all had computer investment per worker growth rates that were higher in the United States than in Canada. The largest differential was in educational services (7.8 percentage points), followed by arts, entertainment and recreation (4.6 percentage points). These two industries were followed by agriculture, fishing, forestry and hunting; real estate and rental and leasing; professional, scientific and technical services; and administrative and support, waste management and remediation services.

C. Software Investment Per Worker

This section investigates absolute levels of software investment per worker in Canada and the United States in each of the 19 two-digit NAICS industries for 2002 and 2013 in current dollars. Subsequently, this section describes growth rates between 2002 and 2013.

i. Absolute Levels

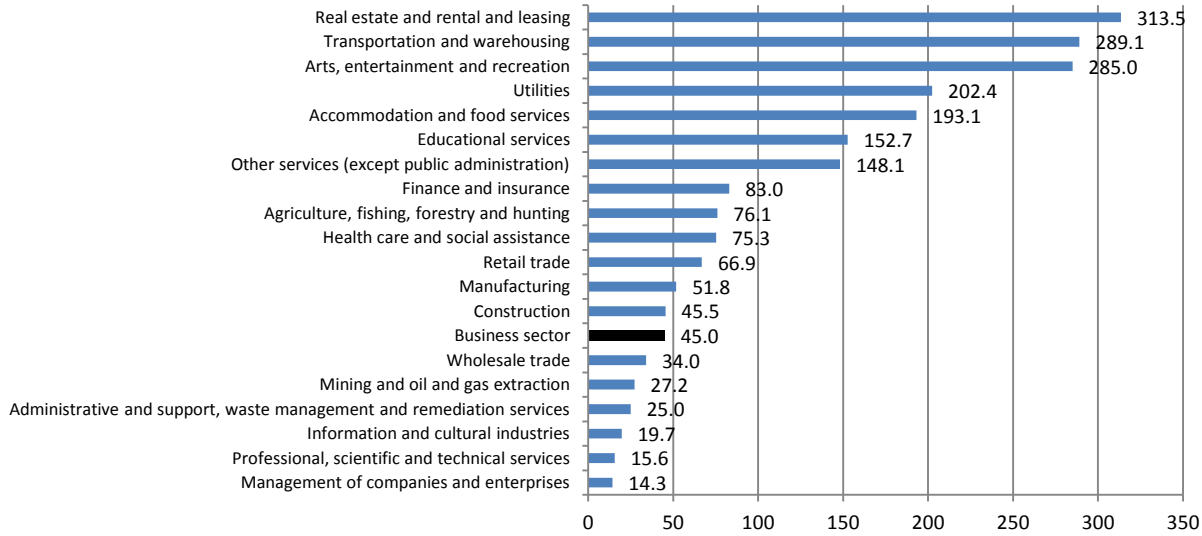
Table 14 contains data on the absolute level of software investment per worker by industry in Canada and the United States in purchasing power parity adjusted US dollars for 19 two-digit NAICS industries.

Table 14: Nominal Software Investment Per Worker in Canada and the United States, US Dollars, PPP-Adjusted, 2002 and 2013

	United States		Canada		Canada as a Proportion of the United States (%)	
	2002	2013	2002	2013	2002	2013
Agriculture, fishing, forestry and hunting	46	115	104	88	224.0	76.1
Mining and oil and gas extraction	1,542	2,172	464	590	30.1	27.2
Utilities	2,477	3,200	3,373	6,476	136.2	202.4
Construction	131	90	40	41	30.4	45.5
Manufacturing	1,532	2,350	518	1,216	33.8	51.8
Wholesale trade	2,975	7,746	1,486	2,635	49.9	34.0
Retail trade	462	809	247	541	53.5	66.9
Transportation and warehousing	369	558	706	1,615	191.2	289.1
Information and cultural industries	3,541	16,860	2,610	3,313	27.4	19.7
Finance and insurance	4,733	6,765	2,725	5,613	57.6	83.0
Real estate and rental and leasing	813	840	3,949	2,634	485.9	313.5
Professional, scientific and technical services	2,915	4,223	416	660	14.3	15.6
Management of companies and enterprises	331,500	173,743	6,650	24,864	2.0	14.3
Administrative and support, waste management and remediation services	1,864	2,696	205	675	11.0	25.0
Educational services	307	449	293	686	95.4	152.7
Health care and social assistance	313	364	107	274	34.2	75.3
Arts, entertainment and recreation	173	121	220	345	127.5	285.0
Accommodation and food services	42	72	74	138	175.5	193.1
Other services (except public administration)	282	289	282	429	103.3	148.1
Business sector	1,705	2,690	692	1,210	40.6	45.0

Source: CSLS ICT by Industry database.

Chart 3: Nominal Software Investment Per Worker in Canada Relative to the United States, Per Cent, 2013



Source: Table 14.

In 2013, real estate and rental and leasing, transportation and warehousing, and arts, entertainment and recreation had higher levels of software investment per worker in Canada than in the United States. Four other industries also had higher levels of software investment per worker in Canada than in the United States, including accommodation and food services; other services (except public administration); educational services; and utilities.

However, seven industries in Canada invested less than 50 cents for every dollar of software investment per worker in the United States, with professional, scientific and technical services as the worst case (excluding management of companies and enterprises). The remaining five industries had relatives between 50 per cent and 83 per cent, suggesting that they invested between 50 and 83 cents for every dollar of software investment per worker in the United States.

Table 15: Distribution of Business Sector Software Investment and Employment by Industry, Canada and the United States, 2002 and 2013

	United States				Canada			
	Software Investment		Employment		Software Investment		Employment	
	02	13	02	13	02	13	02	13
Agriculture, fishing, forestry and hunting	0.1	0.1	2.3	2.0	0.5	0.2	3.6	2.9
Mining and oil and gas extraction	0.4	0.8	0.5	1.0	0.9	1.5	1.4	2.3
Utilities	1.8	1.3	1.2	1.1	5.8	5.7	1.1	1.1
Construction	0.7	0.3	9.8	8.9	0.3	0.4	7.2	9.9
Manufacturing	14.7	12.4	16.8	14.2	13.4	13.7	19.3	13.0
Wholesale trade	6.9	10.0	4.0	3.5	9.6	10.0	4.6	4.6
Retail trade	4.0	4.6	15.3	15.3	5.5	6.9	15.5	15.7
Transportation and warehousing	1.2	1.2	5.8	5.9	6.5	8.7	6.4	6.5
Information and cultural industries	19.6	17.7	3.6	2.8	13.2	7.9	3.2	2.9
Finance and insurance	17.8	16.8	6.6	6.7	22.8	27.0	5.5	6.0
Real estate and rental and leasing	1.3	0.9	2.8	2.7	11.1	5.4	2.1	2.4
Professional, scientific and technical services	13.7	15.2	8.2	9.7	4.5	5.7	8.3	10.1
Management of companies and enterprises	7.8	11.3	0.0	0.2	0.4	0.4	0.0	0.0
Administrative and support, waste management and remediation services	5.8	6.2	5.4	6.2	1.4	2.9	4.9	5.3
Arts, entertainment and recreation	0.3	0.1	2.6	3.1	0.9	0.9	2.8	3.0
Accommodation and food services	0.2	0.3	8.7	9.9	0.8	1.0	8.3	8.5
Other services (except public administration)	1.0	0.7	6.5	6.8	2.4	2.1	5.8	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CSLS calculations based on the CSLS ICT by Industry database.

Table 16: Nominal Software Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2013

Software (2013)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Information and cultural industries	25.88	26.25	26.07
Professional, scientific and technical services	23.25	24.36	23.81
Wholesale trade	12.03	15.89	13.96
Manufacturing	10.88	9.97	10.43
Management of companies and enterprises	17.58	2.27	9.93
Administrative and support, waste management and remediation services	8.48	7.29	7.88
Finance and insurance	5.19	4.69	4.94
Retail trade	2.77	2.84	2.81
Mining and oil and gas extraction	1.09	2.42	1.75
Construction	0.29	0.33	0.31
Agriculture, fishing, forestry and hunting	0.04	0.05	0.04
Accommodation and food services	-0.44	-0.38	-0.41
Arts, entertainment and recreation	-0.46	-0.46	-0.46
Other services (except public administration)	-0.64	-0.55	-0.60
Utilities	-2.51	-2.39	-2.45
Real estate and rental and leasing	-3.32	-2.90	-3.11
Transportation and warehousing	-4.25	-4.63	-4.44
Business sector	100.00	100.00	100.00
Accounted	**95.86**	**85.06**	**90.46**
Unaccounted	**4.14**	**14.94**	**9.54**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.
Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Fixed Stock and Consumption of Fixed Non-Residential Capital did not consider these two industries as part of the business sector.

A simple accounting exercise shows that information and cultural industries and professional, scientific and technical services accounted for 49.9 per cent of the software investment per worker business sector gap, while manufacturing and wholesale trade accounted for 24.4 per cent of the gap (Table 16). These four industries, namely information and cultural

industries, professional, scientific and technical services, manufacturing, and wholesale trade, accounted for only 30.6 per cent of employment in 2013 in Canada (Table 15).[24]

ii. Growth Rates

Software investment per worker in agriculture, fishing, forestry and hunting grew 14.7 per cent per year between 2002 and 2013 in the United States (Table 17). In comparison, administrative and support, waste management and remediation services were the fastest growing industry in Canada at 10.7 per cent per year between 2002 and 2013. At the other end of the spectrum, real estate and rental and leasing saw software investment per worker fall 3.0 per cent per year in Canada. This was the fastest decline in software investment per worker by industry in Canada. In comparison, in the United States, construction demonstrated the sharpest declines in software investment per worker at 3.3 per cent per year.

Table 17: Real Software Investment Per Worker in Canada and the United States, Compound Average Annual Growth Rates, 2002-2013

	United States	Canada	Canada-US
Agriculture, fishing, forestry and hunting	14.7	-0.3	-15.0
Mining and oil and gas extraction	2.0	3.3	1.3
Utilities	2.6	4.9	2.3
Construction	-3.3	2.7	6.0
Manufacturing	3.7	8.9	5.2
Wholesale trade	10.6	5.2	-5.4
Retail trade	8.1	7.1	-1.0
Transportation and warehousing	2.8	7.5	4.7
Information and cultural industries	6.8	1.1	-5.7
Finance and insurance	5.4	5.6	0.2
Real estate and rental and leasing	3.6	-3.0	-6.6
Professional, scientific and technical services	3.8	5.1	1.3
Management of companies and enterprises	-4.2	.	.
Administrative and support, waste management and remediation services	5.3	10.7	5.4
Educational services	6.0	9.4	3.4
Health care and social assistance	3.6	7.9	4.3
Arts, entertainment and recreation	0.7	4.1	3.4
Accommodation and food services	7.1	6.7	-0.4
Other services (except public administration)	1.7	3.5	1.8
Business sector	5.5	4.9	-0.6

Source: CSLS calculations based on the CSLS ICT database from January 2015.

Growth rate differentials, calculated as the growth rate in the United States minus the growth rate in Canada, are more than one percentage point in 16 out of 19 two-digit NAICS industries. The largest growth rate differential was seen in agriculture, fishing, forestry and

[24] These contributions are determined by weighting each industry's absolute IT investment per worker gap by the employment share and subsequently dividing this number by the absolute IT investment per worker gap in the business sector.

hunting, where growth in software investment per worker in the United States outpaced growth in software investment per worker in Canada by 15.0 percentage points.

Growth rate differentials are below ten percentage points for every other industry. Some notable differentials are in real estate and rental and leasing (-6.6 percentage points), construction (6.0 percentage points), and information and cultural industries (-5.7 percentage points).

It is interesting to note that software investment per worker growth rates were higher in Canada than in the United States in 12 out of 19 two-digit NAICS industries, including mining and oil and gas extraction; utilities; construction; manufacturing; transportation and warehousing; finance and insurance; professional, scientific and technical services; administrative and support, waste management and remediation services; educational services; health care and social assistance; arts, entertainment and recreation; other services (except public administration). Of the six industries with higher software investment per worker in the United States, four industries showed notable growth rate differentials of more than one percentage point per year (agriculture, fishing, forestry and hunting; wholesale trade; information and cultural industries; and real estate and rental and leasing). In Canada, of the twelve industries with faster growth in software investment per worker than the United States, eleven had growth rate differentials of more than one percentage point per year. The only industry that did not was finance and insurance.

D. Summary Findings

This section will summarize the results from the section on relative Canada-US IT investment per worker. Table 18 shows the number of industries that fall above and below specific cut-offs for the Canada-US IT investment per worker relative. Table 19 lists which industries had higher IT investment per worker in Canada than the United States in 2013.

The cutoff at 100 was chosen because this cutoff determines whether investment in Canada or the United States is larger. The cutoff at 50 was chosen because this cutoff shows whether investment in Canada is one half of investment in the United States. The cutoff at 200 was chosen for the opposite reason. The other cutoffs (i.e. 75, 30, 150, and 300) were arbitrarily chosen so as to break down the distribution of industries by cutoffs into more detail.

As can be seen, there are more industries with lower IT investment per worker in Canada than in the United States in all three categories: total IT, computer, and software investment.

One of the most striking results is that there are five industries for which software investment per worker in Canada is less than 30 per cent of software investment per worker in the United States in 2013. Increasing the threshold to 50 per cent increases the number of industries to seven. In contrast, for computer investment per worker, there is not a single industry in Canada that invests less than half of its counterpart in the United States. Clearly, there is a lot of improvement to be made in software investment per worker.

Table 18: Distribution of Two-Digit NAICS Industries by Canada-US Relative ICT Investment Per Worker, Total Number of Industries, 2013

Canada-US Relative	Total*	Computer	Software
> 300	0	1	1
> 200	4	3	4
> 150	5	5	6
> 100	8	9	7
< 100	11	10	12
< 75	9	7	9
< 50	6	0	7
< 30	3	0	5
Total	19	19	19
Weighted Average Relative**	63.2	96.1	54.8
Business Sector Relative	52.0	81.0	45.0
Unweighted Average Relative***	108.4	128.2	108.2

* This is a proxy composed of software and computers only because of severe data restrictions for communications investment past 2009.
** This was calculated by adding investment in all industries, except public administration, and dividing these values by all workers in all industries, except public administration, in both Canada and the United States.
*** This was calculated by taking the average of all 19 relatives.
Source: CSLS calculations based on Table 6, Table 10, and Table 14.

Table 19: List and Number of Industries with Higher Nominal ICT Investment Per Worker in Canada Relative to the United States, 2013

	IT	Computer	Software
	Accommodation and food services		Accommodation and food services
	Agriculture, fishing, forestry, and hunting	Agriculture, fishing, forestry, and hunting	
	Arts, entertainment and recreation	Arts, entertainment and recreation	Arts, entertainment and recreation
		Construction	
	Educational services	Educational services	Educational services
		Management of companies and enterprises	
	Other services (except public administration)	Other services (except public administration)	Other services (except public administration)
	Real estate and rental and leasing	Real estate and rental and leasing	Real estate and rental and leasing
	Transportation and warehousing	Transportation and warehousing	Transportation and warehousing
	Utilities	Utilities	Utilities
Total	8	9	7

Source: CSLS calculations based on Table 6, Table 10, and Table 14.

The results from the preceding sections helped to identify the culprit industries: information and cultural industries and professional, scientific and technical services, which

were the largest contributors to the business sector Canada-US IT investment per worker gap in 2013.

In the next sections, we explore potential measurement and methodological issues, and we attempt to provide explanations for the differences in IT investment per worker in Canada and the United States in information and cultural industries and professional, scientific and technical services. Exhibit 3 shows important concluding data for these two key industries. The same data for the year 2002 is presented in Appendix II.

Exhibit 3: Summary of IT, Computer and Software Investment Per Worker in Information and Cultural Industries, Canada and the United States, 2013

	Absolute Levels, US$, 2013*					
	Canada			United States		
	IT	Computer	Software	IT	Computer	Software
Information and cultural industries	5,309	2,006	3,313	20,417	3,556	16,860
Professional, scientific and technical services	1,520	863	660	5,272	1,049	4,223
Business sector	1,744	537	1,210	3,353	663	2,690

	Relative, Per Cent, 2013		
	IT	Computer	Software
Information and cultural industries	26.0	56.4	19.7
Professional, scientific and technical services	28.8	82.3	15.6
Business sector	52.0	81.0	45.0

	Contributions to Business Sector Gap, Per Cent, 2013		
	IT	Computer	Software
Information and cultural industries	26.7	35.0	26.1
Professional, scientific and technical services	23.1	14.6	23.8
Total	49.8	49.6	49.9

	Contributions to the Business Sector Gap, 2013**		
	IT, Per Cent	Computer, Percentage Points	Software, Percentage Points
Information and cultural industries	26.7	2.7	24.0
Professional, scientific and technical services	23.1	1.3	21.9
Total	49.8	4.0	45.9

* These values will not be exactly additive due to PPP conversions.
** These values will not be exactly additive.
Source: CSLS calculations based on the CSLS ICT by Industry data, the CSLS ICT database from January 2015, Statistics Canada data and Bureau of Economic Analysis data.

IV. Measurement and Methodological Issues[25]

The previous section showed that IT investment per worker by industry in Canada relative to IT investment per worker by industry in the United States is extremely variable. According to Rai and Sharpe (2013:13), measurement errors explained only a small part of the business sector gap in ICT investment per worker in 2011. This section will attempt to explore whether or not this conclusion is equally applicable at the industry level. In other words, this section will attempt to determine whether or not measurement and methodological issues can account for the differences in IT investment per worker by industry in Canada and the United States.

The first subsection will explore whether or not there are differences in the definitions of ICT investment or differences in the definitions of industries between countries. In the case that there are similar definitions, this first subsection will also explore whether or not the application of these definitions is compatible in both countries. The second subsection will explore whether different methodologies are used to calculate certain components of ICT investment per worker in each country. The third subsection will explore the impact of using different data sources during the calculation of ICT investment per worker by industry. The fourth subsection will explore whether or not there are distinctive statistical practices implemented either by Statistics Canada, the Bureau of Economic Analysis or the Bureau of Labor Statistics. The fifth section will look at the impact of purchasing power parity estimates on relative Canada-US IT investment per worker by industry.

A. Definitions

This section explores whether or not there are significant differences in the definitions used by Statistics Canada and the Bureau of Economic Analysis for ICT investment. It also investigates whether Statistics Canada, the Bureau of Economic Analysis or the Bureau of Labor Statistics use different definitions of industries.

i. ICT Investment

According to Sharpe (2005:30-31), the "detailed list of items included in the definition of ICT investment in Canada and the United States reveals that there does not appear to be any material difference in the way ICT investment is defined between the two countries." In particular, he states that "all asset categories found in the US definitions of ICT have their counterpart in the Canadian list of assets" (Sharpe, 2005:30-31). Furthermore, the author engaged in dialogue with officials at both Statistics Canada and the Bureau of Economic Analysis and found that there did not appear to be any "apparent differences in the definition of ICT investment used by the statistical agencies" (Sharpe, 2005:30-31). Rai and Sharpe (2013:78-81) reconfirmed this result after a lengthy discussion reviewing the potential for any definitional differences. They also provided a table with a juxtaposition of the asset type descriptions that respondents are asked to report for both Canada and the United States. Table 20 summarizes and

[25] This section is based on Rai and Sharpe (2013). Page numbers are indicated for crucial information.

updates their results for the three different types of inconsistencies that could arise in ICT definitions across countries.

Table 20: Summary of the Impact of ICT Component Definition Differences between Statistics Canada and the Bureau of Economic Analysis on ICT Investment Estimates

Type of Inconsistency	Potential Impact on ICT Investment Estimates	Reasoning
Is any asset categorized as one component in one country and another component in another country?	No	No commodity is classified as a different type of ICT component in either country. Rai and Shape (2013) do note, however, that respondents are instructed to report networking equipment as computer equipment in the United States if they cannot separately account for it. This allocation issue may mean that computer investment in the United States is somewhat overestimated, while communications investment is somewhat underestimated, but it will not affect total investment.
Is there an asset that appears in the definition of a component in one country, but does not appear at all in the definition of any component in the other?	No	Rai and Sharpe (2013) found that the only potential inconsistency between the two surveys, namely the broader nature of the definition of computer investment in the United States, was not an issue through discussions with officials at the Bureau of Economic Analysis.
Are any assets vaguely defined in one country, while specific in the other?	No	In Rai and Sharpe (2013:80-81), it was not clear whether the reporting guide in Canada for 'computers and computer peripheral equipment' would be understood to include all of the items included in the definition in the US reporting guide. However, further investigation has shown that the Canadian report guide is equally, if not more, detailed than the US reporting guide. Hence, we conclude that vaguely defined asset categories are not a potential measurement issue.

Source: Rai and Sharpe (2013:80-81) and http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=247787.

ii. Industries

Both Statistics Canada and the US Census Bureau have posted the classification structure of the North American Industries Classification System (NAICS) online. Similar to the discussion of ICT investment, there are three potential differences:

1. Is any industry categorized under one sector in one country and another sector in another country?
2. Is any industry categorized under one sector in one country and not categorized at all in another country?
3. Are they any sectors at the two-digit level that are vaguely defined in one country, while they are specific in another?

Fortunately, both Statistics Canada and the US Census Bureau have answered these questions by providing superscripts for industries that are comparable across Canada and the United States. Unsurprisingly, since the NAICS codes were constructed to facilitate cross-country comparison in North America, both Statistics Canada and the US Census Bureau agree that at the two-digit NAICS level, all industries are directly comparable. At the three-digit NAICS level, comparability is still generally quite sound, but at the four-digit NAICS level and beyond, the extent of the comparability depends largely on the industry being examined. However, this report focuses solely on two-digit NAICS industries, so there cannot be any measurement issues stemming from different industry definitions.

iii. Interpretation and Use of the Definition of ICT Investment

Discussions with Statistics Canada and Bureau of Economic Analysis officials did not reveal any differences in how both organizations interpret and use their definitions of ICT investment. Hence, it is unlikely that this is a source of measurement error.

iv. Interpretation and Use of the Definitions of Industries

Discussion with Statistics Canada and Bureau of Economic Analysis officials did not reveal any differences in how both organizations interpret and use their definitions of industries. Hence, it is unlikely that this is a source of measurement error.

However, it is worth mentioning that there may be some practical difficulties in measuring the management of companies and enterprises industry. In particular, a major difficulty is respondent error. The investment reported by a unit in the management of companies and enterprises industry should only cover the expenditures required for the direct production activities of the establishment itself, such as the office space, equipment, software, etc., needed to operate the head office or the administrative and planning activities of management. Nevertheless, it may be that some respondents misinterpret the questionnaires and report expenditures for the entire group of units under their administrative control. Statistics Canada officials state that care is usually taken to remove any such double counting when editing survey responses for coherence. In particular, head office respondents may mistakenly report on the activities of the entire group of business units (or establishments) for which the head office is responsible. Such an error in reporting would provide a double count of activities since all the other constituent business units are already captured in the survey, as each has been classified to the industry of their main activity.

Statistics Canada officials pointed out that some of the differences in the amounts invested between Canada and the United States in management of companies and enterprises

(which are large) could be related to the specificities of this industry. Head office establishments may sometimes be responsible for other functions within the firm that are not of a purely head office nature. Some of these ancillary activities include hiring, training, marketing, IT and even very high cost research and development. Institutional differences, managerial practices, relative firm sizes, economies of scale, and the practicality of outsourcing, etc., may all lead to differing practices in internalizing some of these functions within the head office. Given that Canada and the United States have much different business profiles, it is likely that the majority of the differences in the amounts invested in management of companies and enterprises in the two countries stems from true differences in the nature of the activities undertaken by head offices, but it is possible that a portion of the error arises because of the practical reporting challenges mentioned above.

Nonetheless, since management of companies and enterprises has not been studied in this report due to the challenges mentioned in Box 3, this is a purely anecdotal observation.

B. Methodology for Estimation of ICT Investment Components and Employment

Sharpe (2005:30-31) states that there are methodological differences between the Canadian and American statistical agencies for the calculation of ICT investment estimates that account for a portion of the Canada-US ICT investment intensity gap. Since ICT investment by industry is calculated using the same methodologies as aggregate total economy ICT investment, it is likely that measurement and methodological differences may contribute to industry gaps.

For example, Statistics Canada uses the Survey of Capital and Repair Expenditures to gather information on capital expenditure on computers, communications equipment, and software. This survey collects data on all asset types. Before publication, the resultant figures for capital expenditure are subsequently adjusted so that they are consistent with the National Accounts, which is based on production, import and export data. The Bureau of Economic Analysis uses a similar, but slightly different, method for estimating ICT investment expenditure. According to Sharpe (2005:30-31), the Bureau of Economic Analysis "classifies investment in ICT under the investment category 'information processing (IP) equipment and software,' where IP equipment and software investment, excluding own-account software, is determined in current prices primarily by the 'commodity-flow' methodology,[26] with periodic benchmarking to the quinquennial input-output tables."[27]

Andrew Sharpe, Executive Director of the Centre for the Study of Living Standards, engaged in a discussion with officials from both Statistics Canada and the Bureau of Economic Analysis in 2005. Through this dialogue, he determined that even though there are key differences between Statistics Canada's direct demand-side survey methodology and the Bureau of Economic Analysis' indirect supply-side commodity flow methodology, the final resultant

[26] "The commodity-flow methodology is a supply-side approach, which traces commodities from their domestic production or importation to their final purchase" (Sharpe, 2005:30-31).

[27] For an extremely detailed account of the estimation methodology for private fixed investment used by the Bureau of Economic Analysis, see www.bea.gov/national/pdf/chapter6.pdf. This document contains details on the estimation of all types of private fixed investment, including computers, communications and software.

estimates of ICT investment appear to be essentially compatible, and therefore comparable. Hence, it is likely that ICT investment estimates at the industry level are also comparable. Nevertheless, Andrew Sharpe did advise that further research be undertaken to definitively determine if methodological differences in ICT investment at the aggregate level could explain the ICT investment per worker differences that exist between Canada and the United States at the aggregate level.

i. Data Collection Methodologies

Rai and Sharpe (2013:89) undertook the challenge of further research in the area of ICT investment per worker comparability between Canada and the United States. One major concern could be issues with data collection methodologies. Table 21 summarizes their results.

Table 21: Summary of the Impact of Data Collection Inconsistencies between Statistics Canada and the Bureau of Economic Analysis for ICT Investment Estimates

Type of Inconsistency	Impact on ICT Investment Estimates	Reasoning
Is the survey sample frame different in either country?	No	Surveys in both countries consist of a random sample drawn from their country's respective business registry. In both Canada and the United States, the business registry covers approximately 97 per cent of all businesses.
Are there important differences in sample size?	No	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 both the long- and short-form variants of each survey.
Are there important differences in sample stratification?	No	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. The algorithms are essentially the same.
Are there important differences in quality control and analysis methods?	No	Rai and Sharpe (2013) conducted detailed interviews with individuals from Statistics Canada and the Bureau of Economic Analysis to determine that similar efforts were being made at both agencies to ensure the reliability of survey data. Explicit measurement errors were dealt with in initial data collection phases using ratio estimators and other methods to identify reported values that were out of bounds or inconsistent with previous estimates. Follow-up calls to respondents were routine in both agencies. Both agencies reported a response rate in excess of 70 per cent.
Are there differences in how the agencies deal with non-sampled entities?	Negligible	Non-sampled entities are explicitly excluded from Statistics Canada's estimates, especially very small establishments that cannot be sampled with certainty. Statistics Canada estimates the investment values for these entities using administration data, including tax data. The Bureau of Economic Analysis similarly uses administrative data for non-employer establishments; when it is not possible to estimate establishment level data, the Bureau of Economic Analysis 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.

Source: Rai and Sharpe (2013:89-90).

In summary, it is unlikely that data collection methodologies can explain the differences in IT investment per worker between Canada and the United States, unless non-sampled entities are more common in certain industries in Canada compared to those same industries in the United States, and vice versa.[28] However, even in this case, the impact is likely to be extremely small and it is unclear in which direction it would bias IT investment estimates.

ii. Treatment of Used Equipment Purchases

There are other areas of the ICT investment estimation process that could lead to comparability challenges. For example, dealers' margins on used assets, when present, will increase investment in computers and communications equipment (since used assets tend to be tangible assets, it is unlikely that including dealers' margins has an effect on software investment). Cross-country differences in the treatment of dealers' margins thus have the potential to impact (albeit marginally) the comparability of investment in computers and communications. Depending on the amount of used equipment that is purchased at the industry level, and whether these purchases are inter- or intra-industry, this comparability constraint could be more pronounced in certain industries compared to others.

This measurement issue was first noted in Rai and Sharpe (2013), which stated that the treatment of purchases of used equipment differs between Canada and the United States. In particular, the estimates of investment at the aggregate level in the United States include dealers' margins on the sale of used assets, while the estimates for Canada do not.[29]

However, Bureau of Economic Analysis officials stated that they do not have dealers' margins on the sale of used equipment at the industry level. In addition, Statistics Canada officials mentioned that data on used assets is collected in Canada, but it is not reported very well, and therefore it is not used, and there has been no detailed analysis of the resulting information because of data quality issues. Hence, without data on dealers' margins in the United States or Canada at the industry level, it is impossible to quantify the impact of this methodological difference. However, Rai and Sharpe (2013) suggest that at the aggregate level, it is actually quite small because most ICT goods are purchased new, not used. Furthermore, Bureau of Economic Analysis officials have similarly stated that this is not likely to explain a large amount of the differences in IT investment per worker in Canada and the United States.

iii. Software Investment Measurement

As highlighted by Rai and Sharpe (2013), the most likely candidate for comparability concerns is the measurement of software investment in Canada and the United States, as software investment is the most difficult component of ICT investment to estimate. Software is composed of four asset types: pre-packaged software, custom designed software, non-capitalized

[28] Non-sampled entities are those entities who are not surveyed by Statistics Canada. One of the reasons they may not be surveyed is because they are not on the business registry. There may be other reasons why businesses are not surveyed.

[29] Bureau of Economic Analysis officials stated that dealers' margins on used assets were just under $20 billion in 2014. Since this is such a low figure relative to total investment and since dealers' margins are likely to apply only to tangible assets, Bureau of Economic Analysis officials have stated that this is not likely to explain the large differences in investment between Canada and the United States.

software, and own-account software. Pre-packaged software is of the sort that can be purchased "off-the-shelf" and is typically mass-produced and sold or licensed in standardized form. It is intended for generalized uses common to the every-day operations of businesses and governments. Custom design software by contrast is intended for specialized uses. It is typically developed for and tailored to a specific organization's needs by some third party software developed under contract. Customized software has limited applications beyond the particular 'business problem' it is designed to solve. Like custom design software, own-account software is specialized to a specific organization's needs, and distinguished only insofar as its development is undertaken 'in-house' by employees within the organization rather than being contracted out (Statistics Canada, 2007).[30] Non-capitalized software is software that is not recognized as a fixed asset.

a. Pre-Packaged Software

In both Canada and the United States, pre-packaged software is estimated indirectly because of challenges in business accounting methods. Statistics Canada uses a commodity-flow method to estimate pre-packaged software investment. Essentially, Statistics Canada determines domestic production of software, to which it adds margins on domestic sales, and imports. Subsequently, Statistics Canada subtracts exports and the value of personal expenditure by households on software. From this estimate, Statistics Canada removes intermediate spending on software, which is largely software purchased to be embedded in hardware. A more detailed discussion of this methodology is available in Rai and Sharpe (2013:91-92). The methodology used by the Bureau of Economic Analysis is essentially identical. The only significant difference that may impact industry level estimates of pre-packaged software is the inclusion of changes in inventory in benchmark years in the United States. However, changes in inventory are traditionally very small, below 0.2 per cent of the value of purchased software in benchmark years, so the magnitude of this discrepancy is extremely small. Furthermore, since the United States excludes changes in inventory in non-benchmark years, it is unlikely that inventory changes are an important determinant of the relative ICT investment level. Therefore, Rai and Sharpe (2013:94) conclude that it is unlikely that pre-packaged software is a source of comparability concerns at the aggregate level. Statistics Canada officials and Bureau of Economic Analysis officials have confirmed that this conviction can be extended to the industry level with the assumption that inventory changes at the industry level are also extremely small.

b. Custom Design Software

Custom design software is measured through a methodology that is nearly identical in both Canada and the United States. According to Rai and Sharpe (2013:94), there is only one major distinction. Statistics Canada is only able to identify aggregate intermediate purchases of software, so all intermediate purchases of software are deducted from pre-packaged software, even though some of these intermediate purchases may have been custom design software. In

[30] Making the distinction between these types of software is easier said than done. Software developed 'in-house' for own-use may have viable applications elsewhere and may be sold, leased or licensed to other organizations, blurring the distinction between own-account and custom software. Specialized software may also be integrated with more generalized software packages, blurring the boundary between custom and pre-packaged software (Statistics Canada, 2007).

contrast, the Bureau of Economic Analysis can only identify intermediate purchases of pre-packaged software. In order to approximate intermediate purchases of custom design software, the Bureau of Economic analysis assumes that intermediate purchases of custom design and pre-packaged software are equivalent.

However, Rai and Sharpe (2013:95) point out that this difference in "the treatment of intermediate purchases does not affect total software investment," it only affects the distribution of software investment between pre-package and custom design. Hence, custom design software methodologies are not a potential cause of comparability challenges at the aggregate level, and it is unlikely that they are a cause of comparability concerns at the industry level. Bureau of Economic Analysis officials have seconded this assessment.

c. Non-Capitalized Software

Non-capitalized purchases of software are not included in estimates in either country and currently do not pose any problems.[31] However, if the share of non-capitalized ICT purchases in total ICT purchases (capitalized and non-capitalized) varies between the two countries, there may be an effect on relative ICT investment. Without data, it is impossible to investigate whether this is truly a large measurement issue, although it is unlikely that it has a noticeable impact on relative ICT investment per worker. If it does have a noticeable impact, it is likely creating a negative bias for Canada, as Canada tends to have smaller firms and thereby a higher likelihood of having non-capitalized purchases.[32]

If non-capitalized purchases of software are considered investment in the future, there will be a number of potential measurement concerns, which Rai and Sharpe (2013:96) address.

d. Own-Account Software

Own-account software presents a number of potential comparability concerns. As Sharpe (2005:30-31) highlights, the "estimation of own-account software investment is difficult because firms do not make specific capital expenditures on this asset class." Instead, own-account software expenditures are generated by using the compensation of computer programmers and computer systems analysts in both Canada and the United States. Given minor methodological differences and slight dissimilarities in assumptions, Sharpe (2005) suggested that further

[31] The Bureau of Economic Analysis has a brief discussion of capitalization in their private fixed investment estimation methodology document, available at www.bea.gov/national/pdf/chapter6.pdf.

[32] Statistics Canada officials mentioned that they do make adjustments to try to account for some small items that businesses treat as operating expenses, which really should be capitalized, including small tools, single furniture, and single computers. However, the Statistics Canada officials stated that this issue is not directly linked to ICT investment. Statistics Canada officials also mentioned that it may be possible to obtain some information on non-capitalized purchased of ICT from the Canadian Supply and Use tables. The non-capitalized purchases of ICT would be treated as intermediate consumption and could be extracted from the Use table by industry. Some modeling and approximation would be needed to obtain an estimate, since the commodity dimension of the Use table may be too aggregated to identify detailed ICT items. This estimate would be based on what the 'user' feels 'should have been capitalized' as Statistics Canada does not have a method to determine this value. This estimation process is beyond the scope of this report.

research on own-account software in Canada and the United States is needed to come to a final definitive answer on comparability.

Rai and Sharpe (2013) attempted to provide a more definitive answer to the question of whether or not own-account software is comparable in Canada and the United States. Since Statistics Canada based its methodology on the one implemented by the Bureau of Economic Analysis, there are likely to be few comparability problems, but Rai and Sharpe (2013:97), nevertheless, provide an overview of the methodology and any potential differences.

Based on their analysis, there appears to be only two considerable differences between the Canadian and American estimates of own-account software: the deduction for embedded software and software in final sales and the definition of software developers. 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 (Rai and Sharpe, 2013:99). The Bureau of Economic Analysis 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. Since there are different average wages, this will result in a different share of income being excluded.

However, Rai and Sharpe (2013:99) point out that both Statistics Canada and the Bureau of Economic Analysis "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."

The second considerable methodological difference is the definition of software developers. In Canada, software developers includes (1) information system analysts and consultants, (2) database analysts and data administrators, (3) software engineers and designers, (4) computer programmers and interactive media developers, and (5) web designers and developers. In the United States, the category of software developers includes (1) computer programmers, (2) computer software engineers, applications, (3) computer software engineers, systems software, and (4) computer system analysts. Hence, the category of software developers in Canada includes web developers, while in the United States it does not. However, web developers are a small portion of employment.

Thus, Rai and Sharpe (2013) argue that this difference, and the different treatment of embedded software, are not significant and do not cause any comparability issues or account for the ICT investment gap at the aggregate level. After discussions with Statistics Canada and Bureau of Economic Analysis officials, we have determined that this belief can generally be extended to the industry level.[33]

[33] The level and distribution of own-account software by industry is calculated by using wages by occupation and industry from the Census of Population and National Household Survey (NHS) in Canada. Statistics Canada has identified a specific group of occupations that are likely to be involved with software development, 'Computer and Information System Professionals.' Statistics Canada also excludes industries that have a high proportion of their wages in this occupation group because they deem those industries to be either developing software for sale (software publishing) or embedding their software in their other products. These cases include the computer manufacturing and financial and telecommunications industries. The variable used is reported wages and they make adjustments for employee benefits, other overhead expenses, as well as time-use assumptions (i.e. time spent on

Despite the fact that the methodologies used by the Canadian and America agencies are essentially identical for own-account software, one conceptual challenge does arise. In particular, Rai and Sharpe (2013:99) argue that since investment in internally developed or own-account software is based primarily on the labour cost to employers of their software developers, even if two software developers spend the same amount of time developing the same software for internal use, there would be a higher level of investment in the United States than in Canada due to higher salaries in the United States. Rai and Sharpe (2013) estimated that this conceptual challenge accounted for 3.7 percentage points (8.8 per cent) of the Canada-US business sector ICT investment per worker gap in 2011.

Table 22 provides the breakdown of software into the three components. Given the methodologies outlined above, industries with a larger share of own-account software in total software may have smaller relative Canada-US software investment due to differences in assumptions and measurement in Canada and the United States. For example, software investment in professional, scientific and technical services accounts for 21.9 per cent of the business sector gap in software investment between Canada and the United States. Since 46.6 per cent of its software is in own-account software, it is no surprise that own-account software in this industry accounts for 8.8 per cent of the total business sector Canada-US IT investment per worker gap. Hence, measurement differences may explain part of this gap.

In contrast, software investment in information and cultural industries is responsible for 24.0 per cent of the software investment gap between Canada and the United States, even though only 22.7 per cent of its software investment is in own-account software, and measurement differences are less likely to explain as much of this industry's underinvestment in software in Canada compared to the United States. However, own-account software in information and cultural industries still accounted for 10.8 per cent of the business sector IT investment per worker gap in 2013.

These results suggest that own-account software could explain some of the ICT investment gap by industry between Canada and the United States. Furthermore, the portion of the gap explained by this feature of own-account software could vary widely by industry, depending on the relative importance of own-account software in each industry.

---

developing software versus other activities). The Census and the NHS results tend to be quite comparable despite the fact that they are in five year intervals. In the non-Census years, Statistics Canada uses the Labour Force Survey (LFS) to mimic the Census methodology. Since the LFS is a much smaller sample and they are looking for a relatively rare population, software developers not employed by a software publisher or IT heavy industry, the variance of the estimates tends to be very high. In order to overcome this, they aggregate the industry detail and use a larger occupation grouping, 'Professional Occupations in Natural and Applied Sciences.' Even this aggregation occasionally produces large growth rates that are difficult to explain, so Statistics Canada looks at the proportions of wages devoted to software developers in total wages. These proportions tend to be more stable over time, based on their analysis of the Census estimates described above, and variations are thus easier to explain. However, the estimates are always anchored to the Census-based estimates and they make virtually no adjustment to those estimates. In other words, estimates are benchmarked to the best data and methodology every five years.

Table 22: Breakdown of Software Final Demand into Components, Millions of Canadian Dollars, Canada, 2011

	Total	Total	General purpose software	Custom software design and development services	Own-account software design and development services	Total	General purpose software	Custom software design and development services	Own-account software design and development services
	Absolute Level					Share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Agriculture, fishing, forestry and hunting	52	48	11	26	15	100.0	21.2	50.0	28.8
Mining and oil and gas extraction	425	169	55	129	241	100.0	12.9	30.4	56.7
Utilities	876	925	328	267	281	100.0	37.4	30.5	32.1
Construction	187	70	15	36	136	100.0	8.0	19.3	72.7
Manufacturing	2,008	1,873	243	912	853	100.0	12.1	45.4	42.5
Wholesale trade	1,796	1,700	202	1,124	470	100.0	11.2	62.6	26.2
Retail trade	1,094	1,192	190	554	350	100.0	17.4	50.6	32.0
Transportation and warehousing	1,069	1,323	257	504	308	100.0	24.0	47.1	28.8
Information and cultural industries	1,335	1,307	345	687	303	100.0	25.8	51.5	22.7
Finance and insurance	2,929	4,455	652	1,403	874	100.0	22.3	47.9	29.8
Real estate and rental and leasing	400	976	97	228	75	100.0	24.3	57.0	18.8
Professional, scientific and technical services	1,993	887	431	634	928	100.0	21.6	31.8	46.6
Administrative and support, waste management and remediation services	931	545	118	352	461	100.0	12.7	37.8	49.5
Educational services	41	1,007	6	12	23	100.0	14.6	29.3	56.1
Health care and social assistance	237	681	55	121	61	100.0	23.2	51.1	25.7
Arts, entertainment and recreation	230	163	60	84	86	100.0	26.1	36.5	37.4
Accommodation and food services	96	189	0	61	35	100.0	0.0	63.5	36.5
Other services	238	341	93	82	63	100.0	39.1	34.5	26.5
Business sector	15,659	16,248	3,097	7,083	5,479	100.0	19.8	45.2	35.0

Note: it is important to point out that total software investment derived from the final demand categories of the input-output tables (column (1)) does not correspond with the values for software investment for every industry from the Stock and Consumption of Fixed Non-Residential Capital program (column (2)). However, for a number of industries, the estimates from both programs are quite close.
Source: CANSIM Tables 381-0023 and 031-0003 and CSLS ICT by Industry database.

C. Sensitivity of Canada-US IT Investment by Industry Relatives to Alternative Data Sources

This section will briefly discuss the different data sources that exist for ICT investment and employment by industry in both Canada and the United States and demonstrate how relative ICT investment per worker in Canada and the United States changes as a result of the use of differences sources for ICT investment and for employment for both Canada and the United States.

i. Alternative ICT Investment Data Sources

There is one source for ICT investment by industry in Canada and one source for ICT investment in the United States. In Canada, there exist estimates from the Stock and Consumption of Fixed Non-Residential Capital program at Statistics Canada. In the United States, ICT investment estimates are obtained from the US Bureau of Labor Statistics' Detailed Data for Fixed Assets and Consumer Durable Goods.

ii. Alternative Employment Data Sources

There are two sources of employment data in Canada and two sources of employment data in the United States. In Canada, employment by industry can be obtained from the Labour Force Survey or from the Canadian Productivity Accounts. In the United States, employment by industry can be obtained from the US Bureau of Labor Statistics' Labor Productivity and Cost program or the US Bureau of Labor Statistics' Current Population Survey.

iii. Impact of Differing Data Sources on the Level of Canada-US IT Investment

Given the different types of sources for employment and ICT investment in both the United States and Canada, there exist two measures of ICT investment per worker in Canada and two measures of ICT investment per worker in the United States. These four measures are briefly outlined in Table 23.

Table 23: Potential Measures of IT Investment Per Worker in Canada and the United States

Measure Number	Description
Canada	
Measure 1	*ICT Investment:* Stock and Consumption of Fixed Non-Residential Capital *Employment:* Canadian Productivity Accounts
Measure 2 (Benchmark)	*ICT Investment:* Stock and Consumption of Fixed Non-Residential Capital *Employment:* Labour Force Survey
United States	
Measure 1 (Benchmark)	*ICT Investment:* Detailed Data for Fixed Assets and Consumer Durable Goods *Employment:* Current Population Survey
Measure 2	*ICT Investment:* Detailed Data for Fixed Assets and Consumer Durable Goods *Employment:* Labor Productivity and Costs

Source: CSLS

In Table 24, the different potential measures for Canada and the United States are combined to make four different versions of relative Canada-US IT investment per worker. In column (1), Measure 1 from Canada and Measure 1 from the United States are paired together. In column (2), Measure 1 from Canada and Measure 2 from the United States are examined

together. In column (4), Measure 2 from Canada and Measure 2 from the United States are combined. Column (3) is the benchmark measure of Canada-US IT investment that has been already used throughout this report (Measure 2 in Canada and Measure 1 in the United States).

Four observations immediately jump out when examining the results in Table 24. First, using the Labor Productivity and Costs series from the US Bureau of Labor Statistics pushes up relative Canada-US IT investment per worker in agriculture, fishing, forestry and hunting, creating massive divergences between the four different measures of relative Canada-US IT investment per worker for this industry. This is because the Labor Productivity and Costs series estimates employment in the agriculture, fishing, forestry and hunting industry at 4,827,100 workers, while the Current Population Survey estimates this value at only 2,130,000 workers.[34] In contrast, for educational services and utilities using the Labor Productivity and Costs series from the US Bureau of Labor Statistics pushes down relative Canada-US IT investment per worker. Second, it appears that information and cultural industries, retail trade, and professional, scientific and technical services have very little variation in relative Canada-US IT investment per worker when altering the choice of data source. Third, only one industry, educational services, demonstrates a relative that is greater than 100 under certain combinations of data sources and less than 100 under other combinations of data sources. Fourth (and last), the overall gap for the business sector is fairly robust.

[34] The estimates of employment in the Labor Productivity and Costs series and the Current Population Survey for agriculture, fishing, forestry and hunting are drastically different because the Labor Productivity and Costs series uses the Current Employment Statistics (CES) survey to obtain data on paid employees. These data are then supplemented with data from the Current Population Survey (CPS). Hence, the Labor Productivity and Costs series will naturally be different from the CPS because it uses a different source for its data, and hence, there is the potential for different sample populations, different definitions, and different uses. One of the main challenges may be that the CPS measures employment by persons, while the CES measures employment by jobs.

Table 24: Different Measures of Relative Nominal Canada-US IT Investment Per Worker, Per Cent, 2013

	M1 & M1	M1 & M2	M2 & M1	M2 & M2
	(1)	(2)	(3)*	(4)
Agriculture, fishing, forestry and hunting	127.8	289.6	116.3	263.6
Mining and oil and gas extraction	44.8	34.8	35.7	27.7
Utilities	299.3	139.2	247.4	115.0
Construction	76.7	61.0	84.8	67.5
Manufacturing	60.6	43.2	57.0	40.6
Wholesale trade	26.4	42.7	36.3	58.8
Retail trade	64.2	63.7	65.6	65.1
Transportation and warehousing	277.8	241.2	262.8	228.2
Information and cultural industries	26.1	25.1	26.0	25.0
Finance and insurance	68.9	60.3	79.2	69.4
Real estate and rental and leasing	199.1	172.6	219.3	190.1
Professional, scientific and technical services	35.0	32.3	28.8	26.7
Administrative and support, waste management and remediation services	24.1	34.5	30.5	43.5
Educational services	179.2	50.6	181.1	51.1
Health care and social assistance	81.6	77.8	69.6	66.4
Arts, entertainment and recreation	283.1	228.2	231.0	186.2
Accommodation and food services	122.2	147.3	129.8	156.5
Other services (except public administration)	118.4	113.8	134.9	129.7
Business sector	50.2	50.6	52.0	52.4

Note: 'M1 & M1' means Measure 1 and Measure 1. * indicates that Column (3) is the benchmark for this report. Source: CSLS calculations from CANSIM Tables 031-0003, 282-0008, and 383-0031, and from the Labour Productivity and Costs series and the Current Population series from the US Bureau of Labor Statistics and from the Detailed Data for Fixed Assets and Consumer Durable Goods series from the US Bureau of Economic Analysis.

Table 25 confirms these results by presenting a number of summary statistics: the maximum relative, the minimum relative, the difference between the maximum and the minimum relative, the standard deviation, the mean, the coefficient of variation, and the difference between the mean relative and the benchmark relative. Essentially, agriculture, fishing, forestry and hunting, utilities and educational services have summary statistics that suggest that changing the data source has a large impact on relative Canada-US IT investment per worker in 2013. Information and cultural industries, professional, scientific and technical services, and retail trade have summary statistics that confirm that changing the data source has a minor impact on relative Canada-US IT investment per worker.

Table 25: Characteristics of the Different Measures of Relative Nominal Canada-US IT Investment Per Worker, 2013

	Maximum Relative (%)	Minimum Relative (%)	Difference Between Maximum and Minimum Relative (percentage points)	Standard Deviation	Average Relative (%)	Coefficient of Variation	Difference Between Average and Benchmark Relative (percentage points)
	A	B	(A-B)	C	D	E = C/D	F = (7) - D
Agriculture, fishing, forestry and hunting	289.6	116.3	173.3	90.0	199.3	0.45	-83.0
Mining and oil and gas extraction	44.8	27.7	17.1	7.0	35.7	0.20	-0.1
Utilities	299.3	115.0	184.3	87.6	200.2	0.44	47.2
Construction	84.8	61.0	23.7	10.4	72.5	0.14	12.3
Manufacturing	60.6	40.6	20.0	9.9	50.4	0.20	6.6
Wholesale trade	58.8	26.4	32.3	13.6	41.1	0.33	-4.7
Retail trade	65.6	63.7	1.9	0.9	64.7	0.01	1.0
Transportation and warehousing	277.8	228.2	49.7	22.1	252.5	0.09	10.3
Information and cultural industries	26.1	25.0	1.1	0.6	25.6	0.02	0.4
Finance and insurance	79.2	60.3	18.9	7.7	69.5	0.11	9.8
Real estate and rental and leasing	219.3	172.6	46.8	19.5	195.3	0.10	24.1
Professional, scientific and technical services	35.0	26.7	8.3	3.7	30.7	0.12	-1.9
Administrative and support, waste management and remediation services	43.5	24.1	19.4	8.1	33.2	0.24	-2.7
Educational services	181.0	50.6	130.4	74.7	115.5	0.65	65.5
Health care and social assistance	81.6	66.4	15.2	7.1	73.9	0.10	-4.2
Arts, entertainment and recreation	283.1	186.2	96.9	39.7	232.1	0.17	-1.1
Accommodation and food services	156.5	122.2	34.2	15.7	139.0	0.11	-9.1
Other services (except public administration)	134.9	113.8	21.1	9.8	124.2	0.08	10.7
Business sector	52.4	50.2	2.2	1.1	51.3	0.02	0.7

Source: CSLS calculations based on Table 24.

Now, professional, scientific and technical services and information and cultural industries are the two industries that contribute the most to the Canada-US IT investment per worker gap in 2013. Hence, it is interesting to note that using a different data source for

professional, scientific and technical services and information and cultural industries has very little impact on the overall relative in 2013, so low Canada-US IT investment per worker is not purely an aberration caused by the choice of data.

Thus, aside from agriculture, fishing, forestry and hunting, utilities and educational services, it does not appear that using different data sources has a very large impact on relative Canada-US IT investment per worker.

D. Other Distinctive Practices

Statistics Canada and Bureau of Economic Analysis officials did not identify any distinctive practices that may have an impact on the comparability of IT investment per worker data in Canada and the United States.

E. Purchasing Power Parity

In order to make the calculations of ICT investment per worker in Canada comparable to those of the United States, it is necessary to convert Canadian dollars to US dollars. Ideally, the PPP estimates used to calculate the Canada-US ICT investment per worker relative would refer specifically to a standard basket of ICT goods. Unfortunately, such estimates do not exist. The closest alternative is the machinery and equipment (M&E) PPP calculated by Statistics Canada. This PPP is used in this report to estimate the Canada-US ICT investment per worker relative.

In 2013, computers and telecommunications equipment represented approximately 18.2 per cent of all machinery and equipment. Since these two components of ICT represent only about one-fifth of total M&E, purchasing power parities for these two goods may have demonstrated different trends than other M&E goods. In other words, it is possible that the purchasing power parity conversion is causing measurement errors. We did not study this potential issue, since data is not available at this level of detail.

It is also important to point out that any purchasing power parity that is created for ICT goods and services as a whole will mask important differences between computers and software. For example, if computers are more heavily traded than software, a computer PPP would be more closely correlated to the exchange rate, while a software PPP would be less closely correlated to the exchange rate. Hence, in a perfect world, there would be different PPPs for each component of ICT to overcome differences in the tradability of the goods and services that belong to each category.

Thus, two components of ICT can be seen as a subcategory of M&E, and using the M&E PPP provides a reasonable, albeit imperfect, alternative to an ICT PPP. The reader should bear in mind, however, that software, a component of ICT investment, is not an element of M&E, and hence, divergences between the M&E PPP and the ICT PPP could be a potential source of measurement error. The extent of the measurement error will remain unknown until further research is conducted on this topic.

F. Key Points

Previous CSLS research investigated the impact of differences in definitions or measurement methodologies on the ICT investment per worker gap between Canada and the United States and found that measurement issues were responsible for around 10 per cent of the business sector gap in 2011.

This section undertook similar research concerning information and cultural industries and professional and scientific and technical services.

The findings suggest that the definitions and applications of the definitions of ICT investment and industries are not likely to explain the gap in IT investment per worker in these two industries between Canada and the United States in 2013. Furthermore, after a brief literature review and discussions with Statistics Canada and Bureau of Economic Analysis officials, we determined that data collection methodologies, the treatment of used equipment, and non-capitalized purchases are unlikely to explain the IT investment per worker gap in information and cultural industries and professional, scientific and technical services in 2013 (and subsequently the IT investment per worker gap in the business sector). Bureau of Economic Analysis officials even mentioned that there is collaboration between Statistics Canada and the Bureau of Economic Analysis on many topics related to measurement and procedures.

It was also determined that the sensitivity of IT investment per worker gaps to the use of different data sources is unlikely to explain the IT investment per worker gap in information and cultural industries and professional, scientific and technical services given their robustness when using four different measures.

However, this section did find that the methodology used to estimate own-account software investment does present a serious challenge for measurement of the IT investment per worker gap. In particular, own-account software expenditures are generated by using the compensation of computer programmers and computer systems analysts in both Canada and the United States. Since investment in own-account software is based primarily on the labour cost of their software developers, even if two software developers spend the same amount of time developing the same software for internal use, there would be a higher level of investment in the United States than in Canada due to higher salaries in the United States.

Thus, measurement issues are likely important in explaining the IT investment per worker gap in information and cultural industries and professional, scientific and technical services, and as a result, partially account for the large business sector gap between Canada and the United States. However, measurement errors do not account for the entirety of the differences in IT investment per worker. Hence, this report attempts to account for the IT investment per worker gap by investigating common drivers and determinants of IT investment.

V. Explanations for the Differences in IT Investment by Industry Between Canada and the United States

Section III showed that IT investment per worker in Canada relative to IT investment per worker in the United States by industry is variable, while Section IV showed that measurement errors cannot account for the entirety of the differences in IT investment per worker by industry between Canada and the United States.

Hence, this section will attempt to explore potential determinants, drivers, and barriers to ICT investment in Canada and the United States, focusing particularly on information and cultural industries and professional, scientific and technical services. This section is divided into three subsections which group the drivers and explanations of ICT into three themes: complementary investments, microeconomic environment, and firm environment. Each section begins with theoretical reasons for potential differences in ICT investment per worker before applying these theoretical predictions to ICT investment per worker between Canada and the United States.

However, we do not expect the absolute level of IT investment per worker in Canada to be the same as IT investment per worker in the United States because Canada has a lower GDP per capita than the United States. In particular, holding constant ICT investment as a share of GDP, a country with a higher level of labour productivity (defined as PPP-adjusted nominal GDP per worker) will have a higher level of ICT investment and hence ICT investment per worker. A stylized example is presented in Rai and Sharpe (2013:66-67). Hence, it is natural for Canada to have slightly lower ICT investment per worker than the United States.

This can be controlled for by looking at IT investment as a share of GDP. In 2013, IT investment as a proportion of GDP in the business sector was 2.40 per cent in the United States and 1.80 per cent in Canada. If Canada had an IT investment share in GDP of 2.40 per cent, IT investment per worker in US dollars would be $2,322, leading to a relative Canada-US IT investment per worker of 69.3 per cent. This means that roughly 17.2 percentage points of the 48.0 percentage point gap is the result of lower income in Canada (i.e. 35.9 per cent). Hence, in many ways, this metric is better for comparing IT performance. However, this report focuses on IT investment per worker because this metric is more commonly referred to in the media and it is easier to conceptualize.

It is important to recall that the IT investment per worker gap between Canada and the United States is largely caused by information and cultural industries and professional, scientific and technical services. If the IT investment gap closed in information and cultural industries and professional, scientific and technical services, 23.8 percentage points of the 48.0 percentage point Canada-US IT investment per worker gap would close (i.e. 49.5 per cent).

Hence, we have chosen these two industries as the focus of this section.

The information and cultural industries sector is composed of publishing industries (except Internet); motion picture and sound recording industries; broadcasting (except Internet); telecommunications; data processing, hosting, and related services; and other information

services. Professional, scientific and technical services is composed of legal services; accounting, tax preparation, bookkeeping and payroll services; architectural, engineering and related services; specialized design services; computer system design and related services; management, scientific and technical consulting services; scientific research and development services; advertising, public relations, and related services; and other professional, scientific and technical services.

These two industries were chosen based on their consistently positive contribution to the Canada-US IT investment per worker gap in the business sector over the 2002 to 2013 period (Appendix Chart 1-Appendix Chart 20).[35] In 2013 in particular, these two industries accounted for 49.5 per cent of the total IT investment per worker gap in the business sector, but only accounted for 13.0 per cent of employment in Canada. To be even more specific, the main driver behind the IT investment per worker gaps in these two industries in 2013 is software. In particular, 46.1 per cent of the business sector IT investment per worker gap in 2013 (or 22.1 percentage points) is due to small relative software investment per worker in information and cultural industries and professional, scientific and technical services. [36]

A. Complementary Investments

This section will look at explanations for variations in ICT investment per worker that are linked to the idea of complementary investments, namely

- human capital, and
- workplace reorganization.

One prominent theory suggests that "missing complementary investments" may act as "barriers to investment in ICT" (Bugamelli and Pagano, 2004:2275). In particular, in order to reap the full productivity benefits of ICT investment, firms must increase their labour force's human capital and reorganize their workplace.[37] These two preconditions entail additional costs beyond the pure cost of the ICT investment itself. For instance, if ICT investment requires changes to an organization's structure, this might entail costs that are both direct, like consultants and employee re-training, and indirect, like foregone profits "related to a temporary shutdown or slowdown of operations" (Bugamelli and Pagano, 2004:2276). This type of fixed cost can be prohibitive for many firms, preventing them from investing in ICT. In summary, Bugamelli and

[35] Data on other industries will also be presented, but the text will focus on these two industries for clarity and brevity.

[36] This figure was calculated by applying the share of software investment in IT investment per worker in both industries to the contributions of software investment per worker in both industries to the overall software investment per worker gap in the business sector. In particular, software accounted for 90 per cent of IT investment per worker in 2013 in information and cultural industries and 95 per cent of IT investment per worker in professional, scientific and technical services. Thus, the share of software in IT investment per worker multiplied by the contribution of information and cultural industries to the software investment gap in the business sector (0.9 x 26.1) = 23.5. In professional, scientific and technical services, the calculation is 0.95 x 23.8 = 22.6. By adding these two values together, software investment in information and cultural industries and professional, scientific and technical services accounted for 46.1 per cent of the total IT investment per worker gap in the business sector.

[37] The US Census Bureau has also published research that indicates that "for ICT investment to be worthwhile, firms need to invest in financial and managerial resources to changing production processes and training workers" (Martin, 2007:1). Statistics Canada has also showed that there is a "positive impact of educated workers in effecting productivity gains from ICT" (Martin, 2007:1).

Pagano (2004:2276) suggest that "both a skilled workforce and re-organization are essential for ICT accumulation."

Hence, differences in ICT investment by industry between Canada and the United States may be the result of differences in the share of skilled workers by industry and in differences in the ability of certain industries to re-organize the workplace.[38] For example, if firms in certain industries in Canada are less likely to invest in human capital or are less likely to reorganize their workplace than their counterparts in the United States, this may explain different levels of IT investment per worker in Canada and the United States.

i. Human Capital

The level of skilled workers in an industry's labour force is a complementary investment to ICT. In order to maximize the productivity impact of ICT investment, an industry must also invest in enhancing the educational attainment of its workers, assuming that educational attainment and skill level are positively correlated. If the educational attainment of an industry is low, this may act as a barrier to investment in ICT. Hence, by examining the absolute level of educational attainment in any given year and the change in educational attainment over time for any particular industry, it might be possible to assess the extent to which educational attainment in Canada is a barrier to ICT investment in certain industries.

Table 26 shows the years of educational attainment of the workforce for 19 two-digit NAICS industries in Canada and the United States. In order to calculate years of educational attainment, the expected number of years required to complete that level of educational attainment were applied to the share of individuals who had attained that level of education. This was performed for each educational attainment category, after which the results were summed together to obtain average years of educational attainment.[39] It is important to note that the average years of educational attainment may not be accurate for all individuals but instead represent an approximation of the length of time required to complete an average program at that level of educational attainment.

If human capital is a driver for IT investment per worker, we would expect to observe lower average years of educational attainment in Canada compared to the United States in information and cultural industries and professional, scientific and technical services.

According to Table 26, in the total economy, Canada has 0.45 fewer years of educational attainment than the United States, but this gap is only 0.28 years for professional, scientific and technical services and there is no gap in information and cultural industries.

---

[38] Brynjolfsson and Hitt (2000) further argue this case. They state that without organizational changes, ICT investment can be futile, leading to no change in productivity and no cost reductions. For example, if workers are able to use the new equipment in the same fashion as they used the old equipment because of the inherent flexibility of ICT technologies, there will be no increase in productivity and no cost reductions.

[39] For the estimates in this report, we used eight years for less than high school, ten years for some high school, twelve years for a high school diploma, thirteen years for some postsecondary, fourteen years for a postsecondary certificate or diploma, sixteen years for a Bachelor's degree, and eighteen years for a degree above a Bachelor's degree.

However, information and cultural industries was combined with arts, entertainment and recreation in the Labour Force Survey microdata, so it is impossible to determine to what extent this aggregation is driving these results. It is quite possible that the gap is much larger in information and cultural industries, but that in Canada, employed persons in arts, entertainment and recreation are more educated than those in the United States and this is dragging the differential toward zero.[40]

Table 26: Years of Educational Attainment, Employed Persons, 25+, Canada and the United States, United States-Canada, 2002, 2013

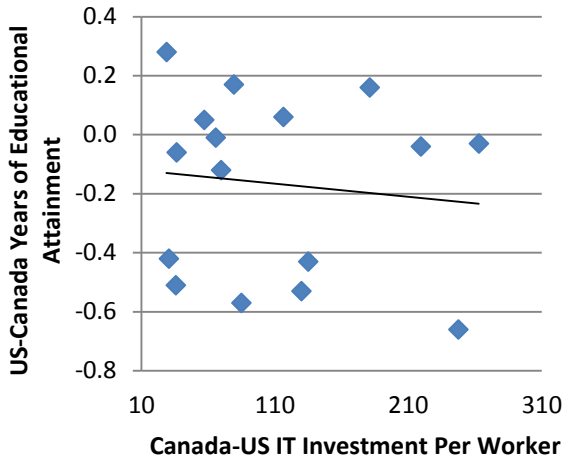
	United States		Canada		United States-Canada	
	2002	2013	2002	2013	2002	2013
Agriculture, forestry, fishing, and hunting	12.08	12.43	11.95	12.37	0.13	0.06
Mining	12.83	13.14	13.36	13.65	-0.53	-0.51
Construction	12.28	12.47	12.64	13.04	-0.36	-0.57
Manufacturing	13.00	13.43	12.89	13.38	0.11	0.05
Wholesale trade	13.36	13.61	13.21	13.67	0.15	-0.06
Retail trade	13.00	13.29	12.94	13.30	0.06	-0.01
Transportation and warehousing	12.83	13.05	12.64	13.08	0.19	-0.03
Utilities	13.49	13.79	14.05	14.45	-0.56	-0.66
Information and cultural industries and arts, entertainment and recreation	14.05	14.41	13.99	14.43	0.06	-0.02
Finance and insurance	14.37	14.85	14.18	14.68	0.19	0.17
Real estate and rental and leasing	13.57	13.96	13.37	14.00	0.20	-0.04
Professional, scientific and technical services	15.36	15.60	15.04	15.32	0.32	0.28
Administrative and support, waste management and remediation services (including management)	12.75	12.78	12.93	13.20	-0.18	-0.42
Educational services	15.43	15.79	15.40	15.63	0.03	0.16
Health care and social assistance	14.11	14.48	14.15	14.60	-0.04	-0.12
Accommodation and food services	12.31	12.59	12.56	13.12	-0.25	-0.53
Other services (except public administration)	13.03	13.27	13.23	13.70	-0.20	-0.43
Total economy	13.57	13.93	12.89	13.48	0.68	0.45

Source: CSLS calculations based on Labour Force Survey Public Use Microdata File and unpublished Current Population Survey data.

Hence, educational attainment does not appear to offer a plausible explanation for the differences in ICT investment per worker between Canada and the United States in professional, scientific and technical services and it is unclear if it can offer an explanation for information and cultural industries.

[40] With data from an unpublished Labour Force Survey time series from Statistics Canada, the CSLS calculated that years of education for individuals 15 years of age and older who are employed in information and cultural industries was 14.33 in 2013, while individuals employed in arts, entertainment and recreation had 13.62 years of education. Unfortunately, we do not have data on educational attainment by industry for individuals aged 15+ in the United States, so it is impossible to distinguish how years of education from information and cultural industries and arts, entertainment and recreation are interacting within the information and recreation aggregate.

Chart 4: Correlation of Educational Attainment and IT Investment Per Worker, Canada and the United States, 2013



Source: CSLS calculations based on Table 26 and Table 6.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level and the difference in years of educational attainment between the United States and Canada for 16 industries returns a correlation coefficient of -0.12, which confirms that educational attainment influences IT investment per worker, but the correlation is extremely weak.

Since many factors influence the level of ICT investment per worker in any given industry in any given country and since we do not have complete industry level data, deeper analysis would be required to definitively determine whether educational attainment is actually linked with ICT investment per worker.

ii. Unionization

It has also been hypothesized that workplace reorganization is another complementary investment that is required to maximize the productive potential of ICT investment. Hence, if workplace reorganization is not possible for any reason, ICT investment might be lower than expected. It is possible that unionization may reflect one potential barrier to workplace reorganization.[41] If this is the case, then higher the union coverage rate in any given industry, the less likely that industry will be able to easily reorganize the workplace, and hence, the less likely that industry will be able to invest in ICT.

[41] Unionization may or may not reflect the extent to which firms in any given industry can engage in workplace reorganization. Unions may make workplace reorganization difficult in some instances, but in other instances, unions may have no input on whether firms reorganize the workplace. It would be helpful to develop a better proxy for workplace reorganization in the future so that a deeper understanding of the impact of workplace reorganization on IT investment per worker at the industry level could be developed.

If the ability to reorganize the workplace were driving ICT investment per worker in the two industries we chose to examine, we would expect to see higher levels of unionization in Canada compared to the United States in information and cultural industries and professional, scientific and technical services. According to Table 27, union coverage in information and cultural industries and professional, scientific and technical services is 17.3 percentage points and 3.4 percentage points higher in Canada than in the United States, respectively. However, neither gap is larger than the gap in all industries (18.7 per cent), so unionization is not likely to explain total IT investment per worker gaps in professional, scientific and technical services or information and cultural industries.

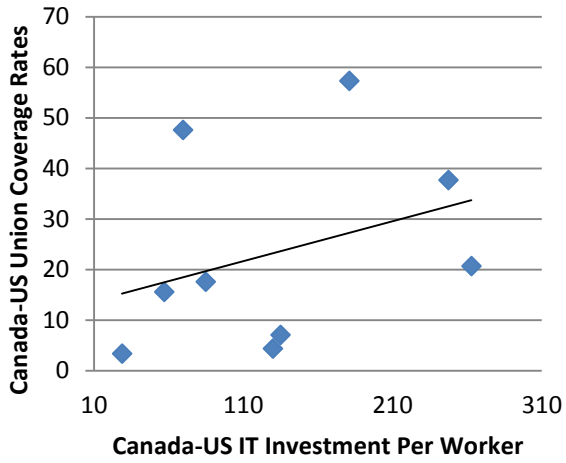
Table 27: Union Coverage Rates, Canada and the United States, Per Cent, 2003 and 2013

	Canada		United States		Canada-US	
	2003	2013	2003	2013	2003	2013
Agriculture, forestry, fishing, mining, quarrying, oil and gas	18.8	16.2	4.8	3.8	14.0	12.4
Utilities	71.5	64.8	29.8	27.1	41.7	37.7
Construction	34.2	32.5	16.7	14.9	17.5	17.6
Manufacturing	32.5	26.6	14.3	11.0	18.2	15.6
Wholesale and retail trade	14.6	13.3	6.6	5.2	8.0	8.1
Transportation and warehousing	43.5	41.5	26.8	20.8	16.7	20.7
Finance, insurance, real estate and leasing	10.0	10.8	2.8	2.6	7.2	8.2
Professional, scientific and technical services	5.4	5.4	2.0	2.0	3.4	3.4
Educational services	72.4	72.4	14.8	15.1	57.6	57.3
Health care and social assistance	55.0	55.7	8.2	8.1	46.8	47.6
Accommodation and food services	8.1	7.2	2.6	2.8	5.5	4.4
Management, administrative and waste services	14.7	16.7	4.2	4.2	10.5	12.5
Other services	11.0	10.5	3.7	3.4	7.3	7.1
Information, culture and recreation	27.1	25.2	11.7	7.9	15.4	17.3
All industries	32.2	31.1	14.3	12.4	17.9	18.7

Source: CSLS calculations based on CANSIM 282-0077 and CPS Table 42.

It must be noted that for arts, entertainment and recreation and information and cultural industries, it is impossible to determine whether or not union coverage rates were influential, since these two industries only have an aggregate measure for union coverage rates. Theoretically, it is entirely possible that the elevated union coverage rates in Canada for information, culture and recreation are concentrated in information and cultural industries and that arts, entertainment and recreation have similar union coverage rates in both countries or lower union coverage rates in Canada. However, without disaggregated data it is impossible to definitely confirm the situation.

Chart 5: Correlation of Union Coverage Rates and IT Investment Per Worker, Canada and United States, 2013



Source: CSLS calculations based on Table 6 and Table 27.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level and the difference in union coverage rates between Canada and the United States for 9 industries returns a correlation coefficient of 0.34, which refutes the hypothesis that unionization prevents IT investment per worker.

However, until additional data at a more disaggregate level of detail can be gathered, or another measure of workplace reorganization can be obtained, it will be impossible to determine whether or not the ICT investment per worker differences by industry between Canada and the United States can be partially explained by the workplace reorganization theory through union coverage rates. It is also possible that there are interaction effects between human capital and workplace reorganization, and that advances must be made in both areas in order to increase IT investment.

B. Microeconomic Environment

This section will look at explanations for variations in ICT investment per worker that are linked to the microeconomic environment, namely

- industrial structure and composition;
- foreign direct investment;
- taxation;
- competitive intensity;
- prices and unexpected costs; and
- regulation.

i. Industrial Structure and Composition

It has been shown through simulations that the two-digit NAICS industry structure accounted for only 5.7 per cent of the total ICT investment per worker gap in the business sector in 2011 (Rai and Sharpe, 2013:13).[42]

However, since ICT investment per worker in any given two-digit NAICS industry is a weighted average of the level of ICT investment per worker in every three-digit and four-digit NAICS industry classified under the parent two-digit NAICS industry, it is possible that differences in the industrial structure at the three-digit level between Canada and the United States could explain differences between ICT investment per worker by industry in Canada and the United States.[43] For example, if sub-industries that traditionally use more ICT per worker represent a smaller proportion of employment in the industry in Canada than in the United States, total ICT investment per worker will be lower in Canada relative to the United States (Sharpe, 2005).

Hence, differing industrial structures at the three-digit and four-digit NAICS level could be a driver of differing levels of ICT investment per worker by industry between Canada and the United States.

Appendix Table 5 presents the three-digit NAICS industrial structure in Canada and the United States for employment and Appendix Table 6 presents the three-digit NAICS industrial structure in Canada and the United States for GDP.

Given that information and cultural industries and professional, scientific and technical services have higher ICT investment per worker in the United States than in Canada we would expect that these industries would have a higher concentration of employment in ICT intensive sub-industries in the United States compared to Canada. However, without ICT investment per worker at a sub-industry level, it is impossible to determine which sub-industries are ICT intensive and which sub-industries are not. Nevertheless, it is still possible to present some hypotheses and investigate differences in industrial structure hypothetically. In particular, aside from the obvious minor differences that will occur between any two countries' industrial structures, there are some major differences worth noting.

For instance, in information and cultural industries, employment is concentrated much more highly in the radio and television broadcasting and cable subscription sub-industry in the United States, while it is concentrated much more highly in the telecommunication carriers sub-industry in Canada. Moreover, in professional, scientific and technical services, employment is more highly concentrated in legal services in the United States, while it is more highly

[42] These simulations attempt to provide estimates of ICT investment per worker in Canada in the business sector assuming that Canada and the United States had the same distribution of employment across industries. Recent estimates confirm the results obtained by Rai and Sharpe (2013:13). In particular, only 5.5 per cent of the gap in total business sector IT investment per worker is explained by industry structure. Surprisingly, at the component level, 21.4 per cent of the business sector gap in computer investment is explained by industry structure, while only 4.1 per cent of the industry gap is explained by industry structure for software investment.

[43] The number of workers in each sub-industry divided by the total number of workers in the parent industry serves as the "weight" for each respective sub-industry.

concentrated in architectural, engineering, and related services in Canada. If those industries with a higher share of employment in the United States invest more heavily in ICT than those industries with a higher share of employment in Canada, then the weighting process used to generated aggregate ICT investment at the two-digit NAICS level would show higher ICT investment in the United States.

Table 28: Industrial Structure, Breakdown of Information and Cultural Industries and Professional, Scientific and Technical Services Employment into Sub-Industry Shares, Per Cent, 2014

	United States	Canada	Canada-US
Information	100.00	100.00	.
Newspaper publishers, periodical, book, and directory/database publishers	15.92	16.58	0.66
Software publishers	4.37	4.41	0.04
Motion pictures and video industries	13.55	14.48	0.93
Sound recording industries	1.32	1.32	0.00
Radio and television broadcasting and cable subscription programming	18.81	11.28	-7.53
Telecommunications carriers	31.49	41.08	9.59
Data processing, hosting, and related services	2.95	1.85	-1.10
Other information services	11.59	9.03	-2.56
Professional And Business Services	100.00	100.00	**..**
Legal services	16.04	10.76	-5.28
Accounting, tax preparation, bookkeeping and payroll services	10.41	11.40	0.99
Architectural, engineering, and related services	14.20	21.36	7.16
Specialized design services	4.06	4.69	0.63
Computer systems design and related services	22.70	24.56	1.86
Management, scientific, and technical consulting services	14.74	11.53	-3.21
Scientific research and development services	5.30	3.29	-2.01
Advertising, public relations, and related services	5.64	6.14	0.50
Other professional, scientific and technical services	6.93	6.28	-0.65

Source: CSLS calculations based on an unpublished Labour Force Survey series and an unpublished Bureau of Labour Statistics series.

Hence, given that substantial differences do exist in the industries in which there is extremely low Canada-US IT investment per worker, it is entirely plausible that industrial structure can explain under-investment in Canada in IT in the two key sectors (information and cultural industries and professional, scientific and technical services). Unfortunately, without more detailed ICT investment data, it is impossible to verify whether or not this is the case. Furthermore, at such a disaggregated level, measurement issues can be exacerbated, so even if data were available, the margin of error would be larger and confidence in the final results would necessarily decrease.

Table 29: Industrial Structure, Breakdown of Information and Cultural Industries and Professional, Scientific and Technical Services GDP into Sub-Industry Shares, Per Cent, 2008

	United States	Canada	Canada-United States
Information	100.00	100.00	.
Publishing industries (except Internet)	25.62	20.60	-5.02
Motion picture and sound recording industries	11.39	6.83	-4.56
Radio and television broadcasting and telecommunications	53.22	66.39	13.17
Data processing, hosting, and related services	9.77	3.42	-6.35
Other information services	0.00	2.75	2.75
Professional And Business Services	100.00	100.00	.
Legal services	22.60	14.95	-7.65
Computer systems design and related services	16.85	21.36	4.51
Miscellaneous professional, scientific and technical services	60.55	63.69	3.14

Source: CANSIM Table 379-0031 and US Bureau of Economic Analysis GDP by Industry Tables.

ii. Foreign Direct Investment

Foreign direct investment can also explain differing levels of ICT investment per worker by industry between Canada and the United States. Essentially, "multinationals often purchase ICT assets such as computers, servers, and software in their home country for use in host countries, with the result that these investments may not be recorded as investments in the host country" (Sharpe, 2005:34).[44] However, foreign direct investment can also increase IT investment in any given industry if the company that invests in the foreign country introduces and encourages the adoption of IT by firms on the ground. Hence, foreign direct investment can both increase and decrease IT investment per worker in any given industry, and it is likely that at any given point in time, both effects are at play.

It is important to note that the problem associated with the accounting of IT purchases abroad will not exist for physical ICT assets that are shipped to the host country from the home country, as these assets would be captured as imports at the border and recorded as ICT investments. Instead, this problem presents itself for software that is shipped electronically. The problem may also present itself if physical ICT assets, such as servers, are purchased in the home country, to electronically support operations in the host country.

[44] The challenge of tracking IT investment and IT use in the host country is exceptionally difficult if firms in the host country are using services based in a cloud in the United States.

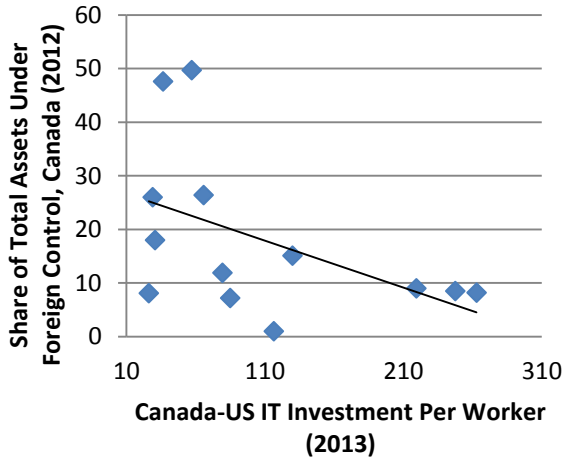
Table 30: Assets Under Foreign Control by Industry, Canada, Per Cent, 2002 and 2012

	2002	2012
Agriculture, forestry, fishing and hunting	2.0	1.0
Oil and gas extraction and support activities	49.4	36.7
Mining and quarrying (except oil and gas)	9.7	35.3
Utilities	5.4	8.5
Construction	4.2	7.2
Manufacturing	43.8	49.7
Wholesale trade	35.0	47.6
Retail trade	19.8	26.4
Transportation and warehousing	.	8.2
Information and cultural industries	4.6	8.1
Finance and insurance	16.1	11.9
Real estate and rental and leasing	11.9	9.0
Professional, scientific and technical services	14.2	26.0
Administrative and support, waste management and remediation services	24.1	18.0
Arts, entertainment and recreation	3.0	.
Accommodation and food services	15.3	15.1
Repair, maintenance and personal services	.	10.1
Total (excluding management of companies and enterprises)	20.6	18.4

Source: CANSIM 179-0004.

According to Table 30, information and cultural industries had relatively low levels of foreign ownership in 2012, while professional, scientific and technical services had much higher levels of foreign ownership in 2012. Since these two industries contribute significantly to the IT investment per worker gap in the business sector, it would be interesting to determine if perhaps additional foreign ownership in these industries would increase IT investment per worker or whether it would decrease IT investment per worker.

Chart 6: Correlation of Foreign Direct Investment and IT Investment Per Worker, Canada and United States



Source: CSLS calculations based on Table 6 and Table 30.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level and the share of total assets under foreign control in Canada for 13 industries returns a correlation coefficient of -0.48, which suggests that as foreign direct investment increases, the Canada-US IT investment per worker relative decreases. In other words, as foreign direct investment increases, IT investment in Canada decreases.

However, given the challenges of unpacking the effects of foreign ownership of IT investment, further research would be needed to confirm this finding and to confirm the findings related to professional, scientific and technical services and information and cultural industries.

iii. Taxation

Differences in taxes at the industry level between Canada and the United States could also explain differences in ICT investment per worker. Taxes can explain investment because the amount of investment any firm undertakes is determined by the "ex-ante expected return on the investment, which is in part determined by the marginal effective tax rate (METR) on investment" (Sharpe, 2005:35). If marginal effective tax rates on ICT investment by industry in Canada are higher than marginal effective tax rates on ICT investment by industry in the United States, it would not be surprising to see lower ICT investment per worker.

However, data on METRs for ICT investment by industry are not available for Canada or for the United States. Hence, further research and the construction of specific METRs for ICT investment would be required to determine if taxes on ICT investment differ between Canada and the United States by industry, and if differences do exist, whether or not these differences can explain the patterns of ICT investment per worker by industry between Canada and the United States.

It is important to note that the marginal effective tax rate of ICT investment has been estimated in previous studies at the aggregate level. In these studies, it has been found that METRs on ICT investment are about equal in the two countries (Centre for the Study of Living Standards, 2005; Conference Board of Canada, 2015; Government of Canada, 2014). Nevertheless, it is still possible that marginal effective tax rates on ICT investment differ by industry across Canada and the United States, even if the aggregate METR on ICT investment is essentially identical. Further research will be needed to confirm whether or not tax rates have impacted the level of ICT investment by industry in Canada and the United States, and thereby the relative level of Canada-US ICT investment per worker.

iv. Competitive Intensity

Competition is a key driver of productivity growth since "firms under competitive pressures are more likely to innovate and introduce new productivity-enhancing technologies such as ICT" (Sharpe, 2005:36). Moreover, a more competitive economy "puts downward pressure on ICT prices" (Sharpe, 2006:75). Hence, if competitive pressures by industry in Canada are lower than competitive pressures in the United States, it is quite possible that competitive intensity could explain differences in ICT investment per worker between Canada and the United States at the industry level.

One example of a measure of competitive intensity is the concentration ratio (Herfindalh-Hirschmann Index), which is a measure of the total output produced by a certain number of the largest firms in relation to the total output of a given industry. Concentration ratios typically suggest the extent to which the largest firms in an industry control the market.

However, concentration ratio data do not exist for the two-digit NAICS industries in Canada or the United States.

Thus, until data are created that quantifies competitive intensity at the two-digit NAICS level in Canada and the United States (either using concentration ratios or another metric), the impact of competitiveness on ICT investment per worker at the two-digit NAICS level will remain purely anecdotal.

However, there are certain proxies at the aggregate level that can be used to understand competitive intensity in Canada and the United States. One such measure is the Global Competitiveness Index (Table 31). In 2014, Canada had a higher score for competition, suggesting that Canada is a more competitive economy. However, this was not always the case. From 2006-2009, the Global Competitiveness Index suggested that the United States had a more competitive marketplace than Canada.

Table 31: Global Competitiveness Index, Canada and the United States, 2006-2014

	Canada	United States	Canada-United States
2006	5.14	5.35	-0.21
2007	5.16	5.23	-0.07
2008	5.16	5.25	-0.09
2009	5.09	5.10	-0.01
2010	5.11	4.75	0.36
2011	5.13	4.74	0.39
2012	5.17	4.83	0.34
2013	5.07	4.89	0.18
2014	5.26	5.08	0.18

Note: this score ranges from 1 to 7.
Source: Global Competitiveness Index, Pillar 6-A.

It is important to note that the level of competitiveness by industry can have very little relation to the overall competitiveness of an economy. For example, dairy products in Canada are heavily regulated and there are many tariffs on the imports of dairy products. This would impact the level of competitiveness in agriculture, fishing, forestry and hunting, while it would have no effect on other industries, like arts, entertainment and recreation.

Thus, the relative competitiveness of an industry in Canada compared to the United States could explain the differing levels of ICT investment per worker, but in order to test and confirm this hypothesis, data would need to be developed that reflects the competitiveness of the marketplace at the industry level for both Canada and the United States.

v. Input Prices and Unexpected Costs

The U.K. Department of Trade and Industry (2004) showed that another significant barrier to ICT investment is input costs, both running costs and set-up costs. If ICT investment costs differ between Canada and the United States within the same industry this may provide an explanation for differing ICT investment per worker levels. Even if there are uniform prices for ICT capital goods between Canada and the United States, the price of labour can affect the level of ICT investment. In particular, if the price of labour relative to ICT investment goods is lower in Canada than in the United States, firms in Canada would have less of an incentive to substitute ICT for labour, leading to less ICT investment (Sharpe, 2005:34).

Hence, the price of ICT capital goods and the price of labour can act as determinants of ICT investment by industry between Canada and the United States. In particular, assume that labour is uniformly productive in both Canada and the United States by industry and that the price of ICT capital goods is uniform across Canada and the United States by industry.[45] Under these assumptions, if the price of labour in a certain industry in Canada is more expensive than the price of labour in that same industry in the United States, then investment in ICT capital goods in that industry in Canada will be higher than the United States. This is because of the principle of substitution. However, the extent to which firms in any given industry will respond to labour prices in this fashion depends on the substitutability of labour and capital.

Table 32: Nominal Labour Compensation Per Hour, Exchange Rate Adjusted, Canada and the United States, US Dollars

	Canada		United States		Canada/US	
	2002	2013	2002	2013	2002	2013
Agriculture, forestry, fishing, and hunting	9.39	13.30	12.76	19.26	73.6	69.1
Mining and oil and gas extraction	31.14	48.69	34.32	51.07	90.7	95.3
Utilities	37.92	51.57	48.49	67.36	78.2	76.6
Construction	19.20	28.26	23.67	31.70	81.1	89.1
Manufacturing	21.85	29.52	28.72	38.78	76.1	76.1
Wholesale trade	20.77	29.20	31.67	43.60	65.6	67.0
Retail trade	11.94	16.76	18.99	23.90	62.9	70.1
Transportation and warehousing	18.79	25.86	27.49	34.15	68.4	75.7
Information and cultural industries	24.80	31.53	36.45	58.47	68.0	53.9
Finance, insurance, real estate and leasing	23.83	30.30	37.94	53.50	62.8	56.6
Professional, scientific and technical services*	22.99	31.24	22.77	32.80	101.0	95.2
Arts and recreation and accommodation and food services	9.88	13.59	13.97	18.53	70.7	73.3
Other services	14.03	18.74	17.74	25.28	79.1	74.1
Business sector in Canada (private industries in US)	17.86	24.78	25.89	35.28	69.0	70.2

* In the United States, this includes management of companies and enterprises, but it does not in Canada.
Source: CSLS calculations based on CANSIM 383-0021, OECD Exchange Rates, and US Bureau of Economic Analysis NIPA Table 6.2D and 6.9D.

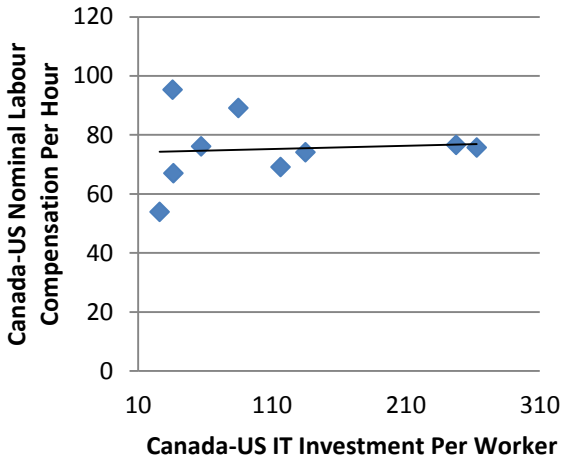
For our two industries of interest (information and cultural industries and professional, scientific and technical services), hourly compensation in Canada is lower than hourly

[45] It is important to note that a crucial assumption of this hypothesis is the uniformity of ICT prices by industry in Canada and the United States. This assumption is likely true for computers, however, it is not the case for own-account software.

compensation in the United States (Table 32). For example, hourly compensation in the United States in information and cultural industries was US$58.47 in 2013, while in Canada it was US$31.53 (exchange rate adjusted). This represents a difference of almost US$30 per hour. In professional, scientific and technical services, Canadian hourly wages are US$1.56 below those in the United States.[46] This data lend support to the labour-ICT capital substitution hypothesis. Since wages in the United States are higher than wages in Canada, firms in the United States have a greater incentive to substitute IT for labour, *ceteris paribus*. Since the total economy gap is US$10.50 per hour in 2013, this lends more support to the likelihood of this explanation for information and cultural industries.

The ICT capital goods and labour substitution hypothesis also applies if ICT prices vary between Canada and the United States. In particular, if ICT prices are higher in Canada than the United States, firms will have an incentive to continue to use labour instead of switching to ICT goods and services. Thus, if ICT prices are higher in Canada and the United States independently of the exchange rate, due to rigidities, like tariffs, which we suspect is highly likely, it is possible that ICT investment in Canada by industry is negatively impacted relative to the United States. Unfortunately, data do not exist on the price of ICT goods and services in Canada and the United States, so it is impossible to verify this hypothesis.

Chart 7: Correlation of Nominal Labour Compensation Per Hour and IT Investment Per Worker, Canada and United States, 2013



Source: CSLS calculations based on Table 6 and Table 32.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level and Canada-US nominal labour compensation per hour for 9 industries returns a correlation coefficient of 0.08, which suggests that as Canada-US nominal labour compensation

[46] Since professional, scientific and technical services includes management of companies and enterprises in the United States for NIPA Table 6.9D, but management of companies and enterprises is not included in this estimation in Canada, this difference could be purely driven by the inclusion of this industry, but it is difficult to determine without additional information.

per hour increases, the Canada-US IT investment per worker relative increases, which provides very weak support for our hypothesis.

In summary, it is plausible that ICT investment per worker is influenced by hourly compensation and ICT prices through the substitution of ICT capital for labour. It is also plausible that other costs that arise after ICT implementation are acting as barriers to ICT investment in many industries. Further research would be needed to determine if this is in fact the case. In particular, it would be important to know whether this relationship stands up to the addition of other factors that affect ICT investment per worker, like human capital and firm size.

vi. Regulation

High levels of regulation have been shown to negatively impact ICT investment per worker. Regulation impacts ICT investment in this way because high levels of regulation impede the creation of businesses, access to capital, and limit competition in the marketplace, which are all themselves linked to ICT investment per worker (Conway et al., 2006). Hence, if regulation in Canada in certain industries is stricter than regulation in those same industries in the United States, ICT investment per worker would be lower, *ceteris paribus*. Similar arguments could be made for strict labour market regulations, in which case ICT goods and services would be substituted for labour. Examining the extent of regulation policies in both Canada and the United States in a variety of industries could thus provide an explanation for the differences in ICT investment per worker by industry in these two countries.

Unfortunately, detailed data that measure the extent of regulation by industry are not available in Canada or the United States, but the OECD does provide data on regulation in the professional services (Table 33), retail distribution, and the network sector. Given our interest in the professional, scientific and technical services industry, data on professional services regulations are provided in Table 34. This index can be broken down into a number of sub-measures reflecting regulations on conduct and entry.

Table 33: Professional Services Regulation, Canada and the United States, 2003, 2008, and 2013

	Canada	United States	Canada-US
		Accounting	
2003	3.65	1.25	2.40
2008	3.83	1.25	2.58
2013	3.50	.	.
		Architect	
2003	2.69	0.73	1.96
2008	3.33	0.73	2.60
2013	3.27	0.73	2.54
		Engineer	
2003	2.96	1.21	1.75
2008	2.58	1.40	1.18
2013	2.58	.	.
		Legal	
2003	3.60	1.81	1.79
2008	3.23	1.81	1.42
2013	3.23	.	.

Note: the scores range from 0 as the least restrictive and 6 as the most restrictive.
Source: OECD.

Other measures of regulation include the Ease of Doing Business Index (Table 34). In 2014, Canada had a lower score than the United States, which suggests that it is more difficult to engage in business in Canada than the United States. According to the Ease of Doing Business Index, this has been the case since 2010. Fortunately, the difference between the indexes has been diminishing over time and the differences are not large.

Table 34: Ease of Doing Business Index, Canada and the United States, 2010-2014

	Canada	United States	US-Canada
2010	79.98	85.72	5.74
2011	80.97	85.72	4.75
2012	80.56	85.65	5.09
2013	80.98	84.94	3.96
2014	79.12	81.96	2.84

Note: Higher values indicate a higher ease of doing business.
Source: World Bank.

The Product and Labour Market Regulation indicators and the Strictness of Employment Protection indicator developed by the OECD are two other measures of regulation (Table 35). In 2013, Canada had a higher score than the United States for both indicators, which suggests that product and labour market regulation are more restrictive in Canada than the United States.

Table 35: Indicators of Product and Labour Market Regulation, Canada and the United States, 2003 and 2013

	Canada	United States	US-Canada
Product Market Regulation			
2003	1.64	1.50	-0.14
2013	1.42	1.11	-0.31
Strictness of Employment Protection (Individual and Collective Dismissals – Regular Contracts)			
2002	0.92	0.26	
2013	0.92	0.26	

Note: the scores range from 0 as the least restrictive and 6 as the most restrictive.
Source: OECD.

Since the World Bank Group's Ease of Doing Business Index and the OECD's Product and Labour Market Regulation Indicators are not available by industry, it is possible that the aggregate regulatory indexes may have very little relation to the level of regulation or the ease of doing business at the industry level.

For example, relative to the United States, it may be extremely difficult to open a new manufacturing plant in Canada, while it may be relatively easier to open a grocery store in Canada. Moreover, transportation and warehousing may have a higher rate of product market regulation in Canada compared to the United States, while retail trade has very little product market regulation in Canada compared to the United States. Without detailed industry-level data, it is impossible to determine whether or not the hypothesis that regulation negatively affects ICT investment per worker is valid for two-digit NAICS industries.

Until data are created that quantifies the extent of regulation at the two-digit NAICS levels in Canada, the impact of regulation on ICT investment per worker at the two-digit NAICS level will remain purely anecdotal. Furthermore, it is still entirely plausible that the extent of regulation in an industry in Canada compared to the United States could explain the differing levels of ICT investment per worker. In order to properly analyze and confirm this hypothesis at the industry level, data would need to be developed that reflects the extent of regulation by industry for both Canada and the United States.

C. Firm Environment

This section will look at explanations for variations in ICT investment per worker that are linked to the firm environment, namely

- managerial education;
- firm behaviour;
- profits;
- firm creation rates; and
- firm size.

i. Managerial Education

Martin (2007:1) showed that the "under education of managers and owners of SMEs is inhibiting support for ICT adoption." He argues that this is "especially important given the research evidence that more complex use of ICT along with sophisticated management practices drives the benefits of ICT on productivity" (Martin, 2007:1). Thus, the educational attainment of managers is also a potential explanation for lower levels of ICT investment per worker in Canada relative to the United States.

For example, if higher managerial educational attainment instills additional appreciation for the benefits of ICT adoption, then lower levels of ICT investment per worker by industry in Canada compared to the United States might be driven by lower educational attainment among managers.

Previous studies have investigated the average educational attainment of managers in Canada and the United States. For example, the Institute for Competitiveness and Prosperity (2009:13) found that at the aggregate level between 2005 and 2007, Canadian managers were 18.0 percentage points less likely than their American counterparts to have a Bachelor's degree or an Advanced degree in business administration.

If low levels of educational attainment among managers in Canada are concentrated in firms in information and cultural industries and professional, scientific and technical services, it is possible that managerial educational attainment is a potential explanation for the differences in ICT investment per worker between Canada and the United States.

In order to confirm the hypothesis that higher levels of managerial education encourage greater ICT investment per worker, we have analyzed data on the educational attainment of managers at the industry level for both Canada and the United States using microdata (Table 40 and Table 41). For Canada, we used the 2011 National Household Survey Public Use Microdata File. For the United States, we used the Current Population Survey March Supplement microdata file available from ceprData.org.

Table 36: Educational Attainment of Management, Per Cent, Canada, 2011

	No certificate	High school diploma	Trades, college, or GEGEP	Bachelor's degree	Master's degree	Earned doctorate
Agriculture, fishing, forestry and hunting	14.8	24.6	33.9	16.1	3.0	0.3
Mining and oil and gas extraction	5.7	20.3	30.4	25.4	11.0	1.5
Utilities	0.9	7.6	30.1	34.4	13.8	1.0
Construction	12.2	24.3	41.6	13.5	2.4	0.0
Manufacturing	6.7	20.8	30.4	23.3	7.8	0.9
Wholesale trade	6.9	25.8	27.3	24.1	6.0	0.4
Retail trade	10.7	36.0	29.7	13.5	2.8	0.2
Transportation and warehousing	9.8	31.2	29.1	16.7	5.1	0.5
Information and cultural industries	2.4	17.3	26.4	31.3	9.8	0.5
Finance and insurance and management of companies and enterprises	1.7	17.9	21.6	32.4	12.9	0.4
Real estate and rental and leasing	5.9	21.0	35.5	20.3	4.3	0.6
Professional, scientific and technical services	1.2	12.4	23.9	34.2	14.5	1.9
Administrative and support, waste management and remediation services	7.9	24.8	28.5	22.2	6.4	0.5
Educational services	0.7	7.2	12.5	30.0	30.5	3.7
Health care and social assistance	2.3	9.8	30.7	26.5	14.6	1.4
Arts, entertainment and recreation	5.9	21.7	36.1	22.0	5.8	0.3
Accommodation and food services	12.0	34.2	29.3	14.7	2.6	0.1
Other services (except public administration)	6.5	18.8	36.9	20.0	8.1	0.3
All industries	6.7	23.0	28.8	22.5	8.5	0.7

Source: CSLS estimates based on the NHS PUMF.

Table 37: Educational Attainment of Management, United States, Per Cent, 2011

	No certificate	High school diploma	Trades, college, or GEGEP	Bachelor's degree	Master's degree	Earned doctorate
Agriculture, fishing, forestry and hunting	11.3	40.8	26.3	17.6	3.2	0.5
Mining and oil and gas extraction	5.3	19.1	26.1	39.1	10.5	0.0
Utilities	4.2	7.9	25.9	42.5	17.3	0.6
Construction	5.8	32.0	29.8	25.8	6.0	1.0
Manufacturing	2.2	17.2	22.7	37.8	18.8	0.5
Wholesale trade	0.4	18.8	29.2	37.6	13.5	0.0
Retail trade	3.2	15.6	26.8	44.2	9.1	0.1
Transportation and warehousing	3.3	20.3	31.2	33.0	10.1	1.4
Information and cultural industries	0.0	14.7	31.5	39.2	13.7	0.3
Finance and insurance and management of companies and enterprises	0.7	13.9	23.5	45.6	14.2	1.2
Real estate and rental and leasing	6.1	25.6	31.5	26.1	8.5	0.2
Professional, scientific and technical services	1.1	6.4	18.8	47.2	24.0	1.2
Administrative and support, waste management and remediation services	3.4	18.5	31.1	35.0	10.5	0.8
Educational services	0.3	4.7	15.2	26.3	41.8	8.7
Health care and social assistance	2.7	12.3	25.1	34.2	20.0	3.8
Arts, entertainment and recreation	3.8	14.6	19.6	50.1	11.8	0.1
Accommodation and food services	5.4	28.3	37.9	24.2	3.3	0.4
Other services (except public administration)	2.9	24.0	22.9	35.2	12.5	2.0
All industries	3.4	19.2	26.0	34.2	14.8	1.6

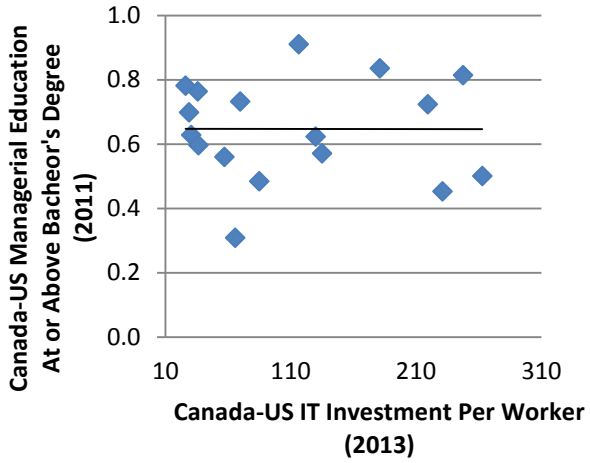
Source: CSLS estimates based on the CPS March Supplement from CEPR.

The microdata show that managers in the United States have higher levels of educational attainment. In particular, in professional, scientific and technical services, the likelihood of a manager holding a Bachelor's degree or a Master's degree is 13.0 percentage points and 9.5 percentage points less in Canada than in the United States. These gaps are higher than those that exist in the total economy (11.7 percentage points and 6.3 percentage points respectively). The differences are also elevated between Canada and the United States for managers in information and cultural industries: 7.9 percentage points for Bachelor's degrees and 3.9 percentage points for Master's degrees, although they are not larger than the total economy gaps.[47]

However, the educational attainment of managers could potentially explain some of the differences in IT investment per worker between Canada and the United States, especially in professional, scientific and technical services, which has educational attainment gaps that are larger than those of the total economy.

[47] It is possible that managers in the United States are more highly educated than managers in Canada because Canadian managers with higher educational attainment move to the United States in search of higher paying jobs. This is often referred to as the 'brain drain'. This phenomenon is likely at play, but it is unlikely that it can explain the entirety of lower educational attainment among managers in Canada.

Chart 8: Correlation of Managerial Education and IT Investment Per Worker, Canada and United States



Source: CSLS calculations based on Table 6, Table 36 and Table 37.

A simple correlation exercise of Canada-US IT investment per worker relatives at the industry level and Canada-US managerial education at or above a Bachelor's degree for 17 industries returns a correlation coefficient of -0.0, which suggests that there is an extremely weak negative correlation between the two.

Since this correlation has absolutely no controls, further research is needed before it would be possible to determine whether Canada-US IT investment per worker relatives and Canada-US managerial education at or above a Bachelor's degree are correlated or not.

ii. Risk Aversion

Risk aversion could also explain differences in ICT investment per worker between Canada and the United States. Sharpe (2005:35) aptly summarizes the belief that some observers hold concerning firm behaviour in Canada relative to the United States. For example, it is often argued that firms in Canada are more conservative and risk averse than their counterparts in the United States. It is believed that this behaviour arises from the smaller size of the Canadian market relative to the American market.

Hence, firm behaviour in Canada in response to market size could account for "a greater reluctance to be on the cutting edge of perhaps unproven technology, and hence, lower ICT spending" (Sharpe, 2005:35). In addition to conservatism and risk aversion, it has also been asserted that Canadian firms are "less aware of the latest developments, due possibly to a basic lack of interest in ICT, less aggressive marketing and sales promotion by ICT equipment vendors in Canada, or a lower level of technical understanding of ICTs and their benefits" (Sharpe, 2005:35). Furthermore, it is occasionally argued that Canadian management is more hesitant to undertake the necessary organizational changes and training investments required for effective

ICT implementation, which implies that ICT investment is likely lower in Canada than the United States.

This argument was further supported by the Deloitte executive risk behaviour index. It suggests that "Canadian small business owners choose not to be growth oriented, which may be attributable to higher risk aversion" (Deloitte, 2013:14).

Higher risk aversion in Canada may also be attributable to the fact that "57 per cent of small business owners consider their business a lifestyle choice – a source of income that importantly affords the owner work-life balance and flexibility," compared to only 43 per cent of Canadian entrepreneurs with growth-oriented attitudes (Deloitte, 2013:14). This contrast sharply with American entrepreneurs: 75 per cent [i.e. 32 percentage points more than in Canada] found the desire to build wealth to be an important or very important motivation" (Deloitte, 2013:14).

Moreover, Deloitte (2013:14) found that "Canadian firms exhibited a greater need for government incentives to induce productivity-boosting behaviour."

In contrast to Deloitte, the Institute for Competitiveness and Prosperity (2009) found that Canadian senior and middle managers do not have fundamentally different attitudes toward competition, risk taking, and innovation than their US counterparts.

Hence, it is unclear whether differing cultural attitudes or outlooks toward innovation and investment in ICT in Canada compared to the United States can explain differing levels of ICT investment per worker at either the aggregate level or the industry level. The argument of firm behaviour as a determinant of ICT investment per worker will continue to remain speculative and anecdotal until further hard evidence can be provided.

iii. Profits

Profits can also impact the level of ICT investment by industry, but the direction of impact is ambiguous. In particular, profits can lead to increased ICT investment per worker because profits indicate that there are leftover financial resources. This additional cash permits investment in ICT capital goods. However, excess profits can also decrease the incentive to invest in ICT capital goods. For example, economic rents may indicate a lower level of competition, and lower levels of competition are less likely to encourage innovative activity and ICT investment behaviour than higher levels of competition.

In order to compare profits by industry between Canada and the United States, data on profits as a share of GDP were obtained. These data are available in Table 38. Data were not available past 2010 for Canada. Given the volatility of profits on an annual basis, average profits as a share of GDP over the 2002-2010 period were calculated.

Information and cultural industries appears to have higher profits as a share of GDP in the United States than in Canada over the 2002-2010 period. Since we also found that information and cultural industries has much higher ICT investment per worker in the United

States than in Canada, this suggests that the positive relationship between profits and ICT investment per worker may be at play. Over the 2002-2010 period, the same situation seemed to prevail in professional, scientific and technical services.[48]

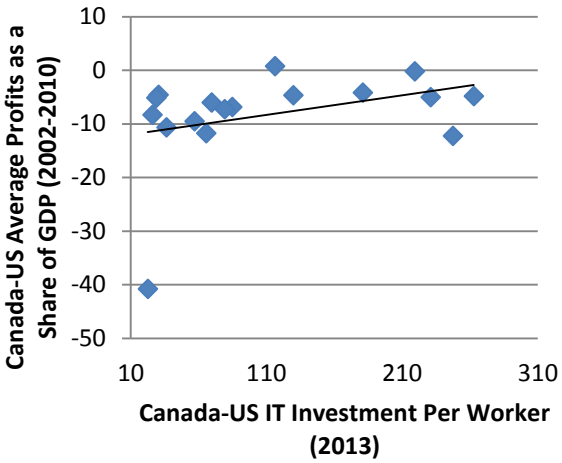
Table 38: Average Profits as a Share of GDP, United States and Canada, US-Canada, 2002-2010

	Canada (%)	United States (%)	Canada-US (percentage points)
Agriculture, fishing, forestry and hunting	3.62	2.86	0.76
Mining, except oil and gas extraction	0.41	2.96	-2.55
Oil and gas extraction and support activities	1.06	10.66	-9.6
Utilities	0.78	13.03	-12.25
Construction	1.10	7.96	-6.86
Manufacturing	4.08	13.60	-9.52
Wholesale trade	1.29	11.95	-10.66
Retail trade	1.27	13.02	-11.75
Transportation and warehousing	0.68	5.51	-4.83
Information and cultural industries	2.15	10.47	-8.32
Finance and insurance	11.47	18.74	-7.27
Real estate and rental and leasing	0.62	0.83	-0.21
Professional, scientific and technical services	0.60	5.75	-5.15
Management of companies and enterprises	22.52	63.31	-40.79
Administrative and support, waste management and remediation services	0.65	5.24	-4.59
Educational services	0.01	4.19	-4.18
Health care and social assistance	0.25	6.27	-6.02
Arts, entertainment and recreation	0.05	5.07	-5.02
Accommodation and food services	0.07	4.74	-4.67
Total economy	3.40	10.64	-7.24

Source: CSLS calculations based on CANSIM Table 187-0001 for profits, the CSLS ICT database from January 2015 for GDP, the US Bureau of Economic Analysis NIPA Table 6.17D for profits, and the GDP by Industry from the US Bureau of Economic Analysis.

[48] There is a risk of reverse causality: ICT boosts productivity, which could boost profitability.

Chart 9: Correlation of Average Share of Profits in GDP and IT Investment Per Worker, Canada and United States



Source: CSLS calculations based onTable 6 and Table 38.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level in 2013 and Canada-US average profits as a share of GDP over 2002-2010 for 17 industries returns a correlation coefficient of 0.34, which suggests that as the Canada-US IT investment per worker relative increases, Canada-US average profits as a share of GDP increase. This demonstrates that profits and IT investment may be positively correlated.

Hence, profits by industry, as measured by profits as a share of GDP by industry, may plausibly be a factor that explains the observed differences in ICT investment per worker between Canada and the United States. Further research would be needed, however, to confirm the direction of the relationship between profits and ICT investment, and whether or not this relationship is robust after the introduction of other factors explaining ICT investment per worker.

iv. Firm Creation Rates

Firm creation is also believed to be an important determinant of ICT investment since "new firms are usually more innovative and more willing to invest in riskier activities and in high-tech capital, especially in the ICT sector" (Sharpe, 2006: 76). If Canada has a lower rate of start-up and new firm activity than the United States, this may explain why ICT investment per worker is lower in Canada than in the United States. Start-ups and new firm activity can be limited due to barriers to entrepreneurship, such as administrative burdens on start-ups, regulatory and administrative opacity, barriers to competition, and the length of time over which creditors can claim assets from a bankrupt individual.

Unfortunately, neither professional, scientific and technical services nor information and cultural industries have data available on firm or establishment entry rates (Table 39). Until such data is made available, it will be impossible to test the hypothesis of the impact of firm creation

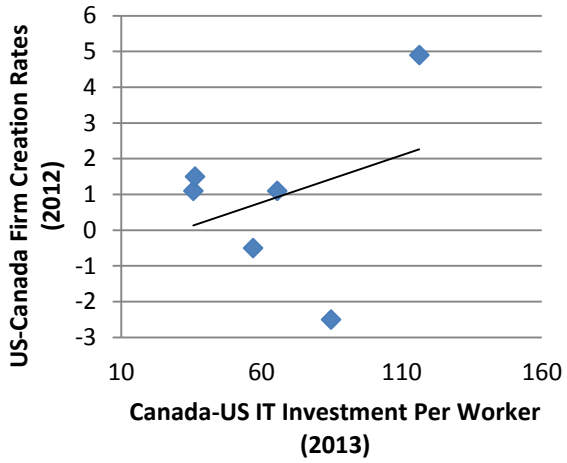
rates on relative Canada-US IT investment per worker. Further research with more detailed data by industry would help determine whether or not firm creation rates are an important explanatory variable for the differences in ICT investment per worker between Canada and the United States.

Table 39: Establishment or Firm Entry Rates, Canada and the United States, 2002 and 2012

	United States* (%)		Canada** (%)		United States-Canada (percentage points)	
	2002	2012	2002	2012	2002	2012
Agriculture, forestry, and fishing	14.9	14.8	11.0	9.9	3.9	4.9
Mining	11.2	12.6	13.1	11.5	-1.9	1.1
Construction	13.3	10.9	14.6	13.4	-1.3	-2.5
Manufacturing	8.4	6.7	8.5	7.2	-0.1	-0.5
Wholesale trade	10.7	8.3	9.5	6.8	1.2	1.5
Retail trade	12.7	10.5	10.8	9.4	1.9	1.1
Total economy (private sector in Canada)	12.8	10.2	14.0	13.1	-1.2	-2.9

Note: Statistics Canada data is based on NAICS codes while US Census Bureau data is based on SIC codes. Given the differing methods of classification used for each system, the data may not be directly comparable. There is also only six industries with data in both countries, instead of nineteen, because the different systems of classification have different industry aggregates in most cases.
* Entry rates in the United States are calculated for establishments.
** Entry rates in Canada are calculated for firms.
Source: CSLS calculations based on US Census Bureau Business Dynamics Statistics and Statistics Canada Longitudinal Employment Analysis Program (CANSIM 527-0001).

Chart 10: Correlation of Firm Creation Rates and IT Investment Per Worker, Canada and United States



Source: CSLS calculations based on Table 6 and Table 39.

A simple correlation exercise of the Canada-US IT investment per worker relatives at the industry level in 2013 and US-Canada firm creation rates for 6 industries returns a correlation coefficient of 0.33, which suggests that as the Canada-US IT investment per worker relative increases, US-Canada firm creation rates increase, which is contrary to expectations.

Since this correlation has absolutely no controls, further research is needed before it would be possible to determine whether Canada-US IT investment per worker relatives and US-Canada firm creation rates are correlated or not.

v. Firm Size

Large firms tend to invest and adopt more ICT capital than do smaller firms because they have greater financial resources, despite the fact that small- and medium-sized enterprises (SMEs) can also "achieve productivity gains from the adoption of ICT" (Martin, 2007:1). Firm size has been shown to affect ICT investment in this way because:

- large firms might be more informed of the latest technological advances;
- large firms may be better equipped to handle the level of risk associated with ICT investment because of greater resources; and,
- large firms may expect greater benefits from using ICT than smaller firms (Sharpe, 2005:33-34).

Martin (2007:1) confirms this reasoning as he shows that "while Canadian SMEs are generally well supported by providers of ICT goods and services, many have not been completely persuaded of the benefits of ICT investments." In particular, a "significant percentage of SMEs indicate that they have difficulty in seeing quantifiable benefits from their ICT investment." Moreover, many SMEs face barriers such as a "lack of specialized staff" and difficulties "integrating new investments" into existing systems (Martin, 2007:1).

Hence, if firms in Canada tend to be smaller on average than firms in the United States, it is quite possible that firm size could explain differences in ICT investment per worker between Canada and the United States by industry. One way to measure firm size by industry is to determine the share of employment in firm size categories. However, there can be many firm size categories. To simplify the analysis, a firm size index has been developed.

The firm size index was created by assigning values to the categories of employment by firm size. The category of firms with 0 to 4 employees was given a value of 1; the category of firms with 5 to 19 employees was given a value 2; the category of firms with 20 to 99 employees was given a value of 3; the category of firms with 100 to 499 employees was given a value of 4; and the category of firms with 500 or more employees was given a value of 5. The shares of employment in each of these categories were multiplied by these values and aggregated to develop the index. Hence, an industry has more small and medium sized enterprises the closer its index to one.

The hypothesis that firm size can explain differences in ICT investment per worker between Canada and the United States appears to have validity for the two industries that we have chosen to focus on (Table 40). In particular, information and cultural industries and professional, scientific and technical services have higher firm size indexes in the United States than Canada, indicating that the United States has a higher concentration of employment in larger firms than Canada. This higher concentration of employment in large enterprises hints at a higher likelihood of investing in ICT.

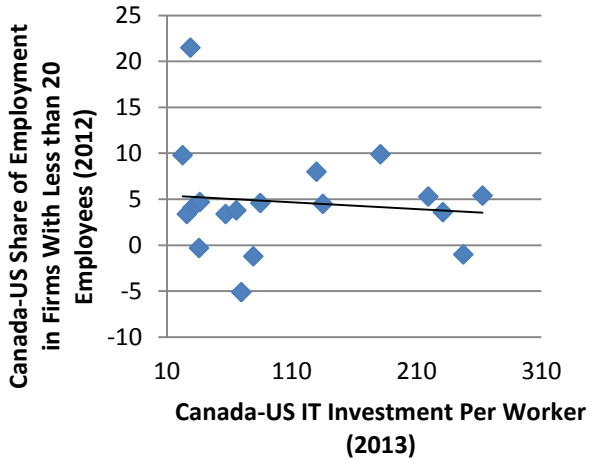
Given that both of these industries were much more concentrated in SMEs than the total economy according to the firm size index, this theory has even stronger potential for explaining the Canada-US IT investment per worker gap in 2013 in information and cultural industries and professional, scientific and technical services.

Table 40: Employment by Firm Size, Two-Digit NAICS Industries, 2002 and 2012

	Share of Employment in Firms with Less than 20 Employees, 2012		Share of Employment in Firms with More than 500 Employees, 2012		Firm Size Index (United States-Canada)	
	CA	US	CA	US	**2002**	**2012**
Forestry, logging and support*	48.1	40.9	11.3	15.2		0.28
Mining, quarrying, and oil and gas extraction	10.0	10.3	65.6	59.5	-0.03	-0.09
Utilities	2.0	3.0	90.3	82.6	-0.13	-0.13
Construction	44.0	39.4	13.7	16.7	0.33	0.15
Manufacturing	12.7	9.3	38.6	54.5	0.26	0.30
Wholesale trade	24.4	19.7	27.7	40.4	0.30	0.28
Retail trade	20.8	17.0	45.9	64.1	0.40	0.37
Transportation and warehousing	18.1	12.7	54.7	63.0	0.21	0.25
Information and cultural industries	10.7	7.3	65.1	72.5	0.19	0.18
Finance and insurance	10.2	11.4	69.1	68.1	0.07	-0.04
Real estate and renting and leasing	40.6	35.3	21.7	30.7	0.25	0.26
Management of companies and enterprises	37.4	27.6	28.1	40.5	0.40	0.41
Professional, scientific and technical services	21.9	0.4	46.4	87.3	.	1.08
Educational services	20.4	10.5	40.3	64.4	0.57	0.55
Health care and social assistance	3.5	8.6	83.7	57.1	-0.56	-0.50
Administrative and support, waste management and remediation services	18.6	14.5	52.6	54.0	0.12	0.12
Arts, entertainment and recreation	20.6	17.0	35.8	36.7	0.19	0.11
Accommodation and food services	26.9	18.9	16.3	40.1	0.59	0.53
Other services (except public administration)	51.9	47.4	10.9	14.2	0.18	0.13
Total economy	20.3	17.6	45.7	51.6	0.16	0.16

* This industry includes forestry and logging and support services in forestry for Canada, and forestry and logging and support services in agriculture and forestry in the United States. For comparability, it was assumed that support services in forestry and agriculture in the United States have the same distribution of employment by firm size.
Note: "n/a" means not available.
Source: CSLS calculations based on CANSIM 281-0042 and US Census Bureau Business Patterns and Economic Census.

Chart 11: Correlation of Firm Size and IT Investment Per Worker, Canada and United States



Source: CSLS calculations based on Table 6 and Table 40.

A simple correlation exercise of Canada-US IT investment per worker relatives at the industry level in 2013 and Canada-US shares of employment in firms with less than 20 employees in 2012 for 18 industries returns a correlation coefficient of -0.11, which suggests that as the Canada-US IT investment per worker relative increases, the Canada-US share of employment in firms with less than 20 employees falls, which is what we would expect theoretically.

Hence, it is plausible that, *ceteris paribus*, firm size could explain differences in ICT investment per worker between Canada and the United States. However, without additional research to control for a variety of other influences, it is impossible to determine whether or not this result is robust. Furthermore, there is also the risk of reverse causality.

D. Summary

Table 41 summarizes which explanations may explain part of the IT investment per worker gap in information and cultural industries and professional, scientific and technical services in 2013. The table highlights the main evidence behind the explanations if they are believed to impact the IT investment per worker gap. If the explanations are not believed to have an impact or the impact is unclear, the reasons for this assessment are also outlined.

Table 41: Summary of Explanations for the Canada-US IT Investment Per Worker Gap, Information and Cultural Industries and Professional, Scientific and Technical Services, 2013

Explanation	Evaluation	Reason
Educational Attainment	Unclear	It is unlikely that educational attainment explains IT investment per worker levels in professional, scientific and technical services. Since information and cultural industries data are combined with arts, entertainment and recreation data, it is impossible to determine to what extent educational attainment is linked to IT investment per worker levels in this industry.
Unionization	Unclear	Professional, scientific and technical services had a rate of union coverage that was 3.4 percentage points higher in Canada than in the United States. Information and cultural industries did not have data. The gap is not larger than the all industries gap of 18.7 per cent. A better proxy for workplace reorganization is needed before a final conclusion can be drawn about the impact of workplace reorganization on IT investment per worker.
Three-Digit Industrial Structure	Plausible	There are no data at the three-digit level for IT investment per worker, but employment data at the three-digit level suggest that Canada and the United States have different industrial structures, and hence different weights are applied at the three-digit level to obtain two-digit IT investment per worker. If simulations could be done using IT investment per worker at the three-digit level, a stronger conclusion might be possible.
Foreign Direct Investment	Unclear	There is no clear relationship between FDI and IT investment per worker.
Taxes	Unclear	There are no data on general capital accumulation taxation at the industry level in the United States. There are no data on IT investment taxation in either Canada or the United States.
Competitive Intensity	Unclear	There are no data on competitive intensity at the industry level in Canada or the United States.
Input Prices and Unexpected Costs	Plausible	Nominal labour compensation per hour in Canada was $31.52 compared to $58.47 in the United States in information and cultural industries in 2013. This would suggest that employers in the United States have a greater incentive to substitute IT investment for labour than employers in Canada.
Regulation	Plausible	There are no data at the industry level that discusses regulation for information and cultural industries. OECD data on regulation in professional services suggest that Canada faces stricter policies. This may prevent firms in professional, scientific and technical services from adopting IT investment per worker at the optimal level.
Managerial Education	Plausible	Managers in professional, scientific and technical services and information and cultural industries in Canada are less educated than managers in the United States: 22.5 per cent fewer managers in Canada hold a Bachelor's degree or Master's degree in professional, scientific and technical services; 11.8 per cent fewer managers in Canada hold a Bachelor's or Master's degree in information and cultural industries. This explanation is particularly valid for professional, scientific and technical services, since managers are more likely to have less education relative to the United States in this industry than in the total economy.
Risk Aversion	Unclear	There are no data on risk aversion at the industry level in either Canada or the United States.
Profits	Unclear	The relationship between profits and IT investment per worker is ambiguous.
Firm Creation Rate	Unclear	There are no data for professional, scientific and technical services or information and cultural industries on firm creation rates.
Firm Size	Plausible	Employment in information and cultural industries is more likely to be concentrated in large firms in the United States (72.5 per cent in firms over 500 people) compared to Canada (65.1 per cent). For professional, scientific and technical services, 87.3 per cent of employment in the United States is in firms with over 500 employees, compared to 46.4 per cent in Canada. Hence, firm size may explain IT investment per worker in these two industries relative to the total economy.

Source: CSLS.

E. Application of Analysis to Manufacturing, Wholesale Trade, Real Estate and Rental and Leasing, and Arts, Entertainment and Recreation

Since this report has focused on professional, scientific and technical services and information and cultural industries, Table 42 demonstrates how the analysis and data presented in this report can be used to develop a sound understanding of other industries than under- or over-invest relative to the United States. This table will examine manufacturing and wholesale trade, both of which under-invest relative to the United States. It will also examine real estate and rental and leasing and arts, entertainment and recreation, both of which over-invest relative to the United States. With this template, readers will be able to develop their own analysis of other industries using their own data or the data that are presented in this report.

Table 42: Summary of Statistics for Manufacturing, Wholesale Trade, Real Estate and Rental and Leasing, and Arts, Entertainment and Recreation

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Summary Statistics				
Relative Canada-US IT Investment Per Worker (%)	57.0	36.3	219.3	231.0
Contribution to Relative Business Sector Canada-US IT Investment Per Worker (%)	10.4	14.4	-3.65	-0.73
Share of Employment in the Business Sector (%)	13.0	4.6	2.4	3.0
Share of IT Investment in the Business Sector (%)	12.5	8.6	6.0	1.2

Source: CSLS

Table 43: Measurement Errors for Manufacturing, Wholesale Trade, Real Estate and Rental and Leasing, and Arts, Entertainment and Recreation

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Measurement Errors				
Measurement Errors Due to Data Source Choices	**Unlikely:** the lowest relative was 40.6 per cent, while the highest relative was 60.6 per cent. The coefficient of variation is low (0.20).	**Plausible:** the lowest relative was 26.4 per cent, while the highest relative was 58.8 per cent. The coefficient of variation is moderate (0.33).	**Unlikely:** the lowest relative was 172.6 per cent, while the highest relative was 219.3 per cent. The coefficient of variation is quite low (0.10).	**Unlikely:** the lowest relative was 186.2 per cent, while the highest relative was 283.1 per cent. The coefficient of variation is low (0.17).
Measurement Errors Due to Own-Account Software Investment	**Plausible:** if there is a large gap between Canada and the United States in own-account software in manufacturing, then the large share of own-account software in overall software (42.5 per cent) implies that there is the potential for large measurement errors.	**Unlikely:** if there is a large gap between Canada and the United States in own-account software in wholesale trade, then the small share of own-account software in overall software (26.2 per cent) implies that there is less potential for large measurement errors.	**Unlikely:** if there is a large gap between Canada and the United States in own-account software in real estate and rental and leasing, then the small share of own-account software in overall software (18.8 per cent) implies that there is less potential for large measurement errors.	**Plausible:** if there is a large gap between Canada and the United States in own-account software in arts, entertainment and recreation, then the large share of own-account software in overall software (37.4 per cent) implies that there is the potential for large measurement errors.

Source: CSLS

Table 44: ICT Investment Factors for Manufacturing, Wholesale Trade, Real Estate and Rental and Leasing, and Arts, Entertainment and Recreation

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Drivers of IT Investment				
Human Capital	**Unlikely:** employed persons in Canada in manufacturing have only 0.05 years less educational attainment than persons employed in manufacturing in the United States.	**Unlikely:** employed persons in Canada in wholesale trade have 0.06 years more educational attainment than persons employed in wholesale trade in the United States. This is contrary to expectations.	**Unlikely:** employed persons in real estate and rental and leasing have 0.04 years more educational attainment in Canada than in the United States. This is not a significant difference.	**Unclear:** this industry is combined with information and cultural industries, so it is impossible to draw conclusions.
Unionization	**Unlikely:** union coverage rates in Canada are 15.6 per cent higher in manufacturing than in the United States.	**Unclear:** this industry is combined with retail trade, so it is impossible to draw conclusions.	**Unclear:** this industry is combined with finance and insurance, so it is impossible to draw conclusions.	**Unclear:** there are no data for this industry.

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Industrial Structure	**Plausible:** the United States has a higher share of manufacturing employment in computers and electronic products compared to Canada (8.3 per cent versus 4.2 per cent), while Canada has a higher share in wood products manufacturing (6.7 per cent versus 2.6 per cent). Without data on IT investment at this level in Canada and without consistent three-digit NAICS industries in both countries, it is currently impossible to fully confirm this hypothesis.	**Plausible:** Canada has a higher share of wholesale trade in machinery, equipment, and supplies merchant wholesalers than the United States (30.6 per cent versus 11.0 per cent), while the United States has a greater share in household appliances and electrical and electronic goods merchant wholesales (6.0 per cent versus 0.7 per cent). Without data on IT investment at this level in Canada and without consistent three-digit NAICS industries in both countries, it is currently impossible to fully confirm this hypothesis.	**Plausible:** Canada has a higher share in commercial, industrial, and other intangible assets rental and leasing than the United States (6.9 per cent versus 2.9 per cent). Without data on IT investment at this level in Canada and without consistent three-digit NAICS industries in both countries, it is currently impossible to fully confirm this hypothesis.	**Plausible:** Canada has a higher share in independent artists, performing arts, spectator sports, and related industries than the United States (31.3 per cent versus 26.9 per cent). Without data on IT investment at this level in Canada and without consistent three-digit NAICS industries in both countries, it is currently impossible to fully confirm this hypothesis.
Foreign Direct Investment	**Plausible:** If foreign control implies that ICT investment is catalogued in the home country and not the host country, then foreign direct investment could be reducing ICT investment levels in Canada relative to the United States, since 49.7 per cent of total assets are under foreign control in Canada in manufacturing. However, foreign direct investment can affect ICT investment in two directions, so this analysis is limited by the uncertainty of its impact.	**Plausible:** If foreign control implies that ICT investment is catalogued in the home country and not the host country, then foreign direct investment could be reducing ICT investment levels in Canada relative to the United States, since 47.6 per cent of total assets are under foreign control in Canada. However, foreign direct investment can affect ICT investment in two directions, so this analysis is limited by this uncertainty.	**Unlikely:** foreign control of total assets in real estate and rental and leasing is only 9.0 per cent, much lower than the total economy level at 18.4 per cent. However, foreign direct investment can affect ICT investment in two directions, so this analysis is limited by the uncertainty of its impact.	**Unclear:** there are no data for this industry in 2013.

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Taxation	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.
Competitive Intensity	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.
Input Prices and Unexpected Costs	**Unlikely:** nominal labour compensation per hour worked in Canada is 76.1 per cent of nominal labour compensation per hour worked in the United States.	**Plausible:** nominal labour compensation per hour worked in Canada is 67.0 per cent of nominal labour compensation per hour worked in the United States. This compares to 70.2 per cent in the business sector.	**Unclear:** this industry is combined with finance and insurance services, so it is impossible to develop any conclusions.	**Unclear:** this industry is combined with accommodation and food services, so it is impossible to develop any conclusions.
Regulation	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.
Managerial Education	**Plausible:** 32.0 of managers in Canada have a university degree, compared to 57.1 in the United States (a difference of 25.1 per cent).	**Unlikely:** 30.5 of managers in Canada have a university degree, compared to 51.1 in the United States (a difference of 20.6 per cent). This compares to a differential of 18.9 per cent in all industries.	**Unlikely:** 25.2 of managers in Canada have a university degree, compared to 34.8 in the United States (a difference of 9.6 per cent). This compares to a differential of 18.9 per cent in all industries. We would expect managers to be more educated in Canada.	**Unlikely:** 28.1 of managers in Canada have a university degree, compared to 62.0 in the United States (a difference of 33.9 per cent). This compares to a differential of 18.9 per cent in all industries. We would expect managers to be more educated in Canada.
Risk Aversion	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.
Firm Size	**Plausible:** 38.6 per cent of workers in Canada are employed in firms with over 500 people compared to 54.5 per cent in the United States. In the total economy, these figures are 45.7 per cent and 51.6 per cent respectively.	**Plausible:** 27.7 per cent of workers in Canada are employed in firms with over 500 people compared to 40.4 per cent in the United States. In the total economy, these figures are 45.7 per cent and 51.6 per cent respectively.	**Unlikely:** 21.7 per cent of workers in Canada are employed in firms with over 500 people compared to 30.7 per cent in the United States. We would expect the reverse if this were a factor.	**Unlikely:** 35.8 per cent of workers in Canada are employed in firms with over 500 people compared to 36.7 per cent in the United States. We would expect the reverse if this were a factor.

	Manufacturing	Wholesale Trade	Real Estate and Rental and Leasing	Arts, Entertainment and Recreation
Profits	**Unclear:** average profits in Canada are 4.1 per cent of GDP compared to 13.6 per cent in the United States. If profits are positively linked with IT investment, this could provide an explanation.	**Unclear:** average profits in Canada are 1.3 per cent of GDP compared to 12.0 per cent in the United States. If profits are positively linked with IT investment, this could provide an explanation.	**Unclear:** average profits in Canada were 0.2 percentage points less than those in the United States over the 2002-2010 period. This compares to 7.2 percentage points in the total economy. It is also possible to look at the absolute levels of average profits over the 2002-2010 period without comparison to the total economy. In this case, average profits in manufacturing in Canada are 0.6 per cent of GDP compared to 0.8 per cent in the United States.	**Unclear:** average profits in Canada were 5.0 percentage points less than those in the United States over the 2002-2010 period. This compares to 7.2 percentage points in the total economy. It is also possible to look at the absolute levels of average profits over the 2002-2010 period without comparison to the total economy. In this case, average profits in Canada are 0.1 per cent of GDP compared to 5.1 per cent in the United States.
Firm Creation Rates	**Unlikely:** entry rates in Canada are 0.5 percentage points higher than those in the United States.	**Plausible:** entry rates in Canada are 1.5 percentage points less than those in the United States. This compares to entry rates that are 2.9 percentage points higher in the total economy. This suggests that there are less new firms in wholesale trade in Canada relative to the United States than there is in the total economy.	**Unclear:** industry data are not available.	**Unclear:** industry data are not available.

Source: CSLS

Table 42, Table 43 and Table 44 focus the reader onto a number of conclusions concerning these four industries. These conclusions will subsequently be discussed.

i. Manufacturing

Canada-US IT investment per worker in manufacturing is 57.0 per cent and this industry contributes 10.4 per cent to the overall Canada-US IT investment per worker gap in the business sector. Table 45 shows that 9.6 percentage points of this 10.4 per cent are driven by software investment.

The large contribution of manufacturing to the Canada-US IT investment per worker gap likely arises from its large share of employment and IT investment because manufacturing actually has a larger relative (57.0 per cent) than the business sector (52.0 per cent).

Since manufacturing had such a large relative compared to the total economy, it is difficult to fully understand the implications of the drivers because they cannot be compared to the total economy; there is no benchmark.

However, if we excuse this issue, it is likely that some of the gap stems from measurement errors related to own-account software. If measurement errors are not responsible for the gap, than the following factors may explain part of the gap:

- industrial structure at the three-digit level;
- foreign direct investment;
- managerial education; and
- firm size.

Further research is needed before any of these factors can be confirmed as contributing to the Canada-US IT investment per worker gap in manufacturing.

ii. Wholesale Trade

Canada-US IT investment per worker in wholesale trade is 36.3 per cent and this industry contributes 14.4 per cent to the overall Canada-US IT investment per worker gap in the business sector. Table 45 shows that 12.4 percentage points of this 14.4 per cent are driven by software investment.

Using different data sources did show that the relative in wholesale trade is moderately sensitive. Hence, it is quite possible that measurement errors could be contributing to the large gap in this industry, although the extent of these contributions is unknown. If we disregard measurement errors, then the following factors may explain part of the gap:

- industrial structure at the three-digit level;
- foreign direct investment;
- nominal labour compensation;
- firm creation rates; and
- firm size.

Further research is needed before any of these factors can be confirmed as contributing to the Canada-US IT investment per worker gap in wholesale trade.

Table 45: Summary of IT, Computer and Software Investment Per Worker in Manufacturing and Wholesale Trade

	Absolute Levels, US$, 2013					
	Canada			United States		
	IT	Computer	Software	IT	Computer	Software
Manufacturing	1,622	409	1,216	2,847	498	2,350
Wholesale trade	3,283	653	2,635	9,029	1,283	7,746
Business sector	1,744	537	1,210	3,353	663	2,690

	Relative, Per Cent, 2013		
	IT	Computer	Software
Manufacturing	57.0	82.1	51.8
Wholesale trade	36.3	50.9	34.0
Business sector	52.0	81.0	45.0

	Contributions to Business Sector Gap, Per Cent, 2013		
	IT	Computer	Software
Manufacturing	10.4	9.6	10.4
Wholesale trade	14.4	20.2	14.0
Total	49.8	49.6	49.9

	Contributions to the Business Sector Gap, 2013*		
	IT, Per Cent	Computer, Percentage Points	Software, Percentage Points
Manufacturing	10.4	0.7	9.6
Wholesale trade	14.4	2.2	12.4
Total	49.8	4.0	45.9

* These values will not be exactly additive.
Source: CSLS calculations based on the CSLS ICT by Industry database, the CSLS ICT database from January 2015, Statistics Canada data and US BEA data.

iii. Real Estate and Rental and Leasing

Canada-US IT investment per worker in real estate and rental and leasing is 219.3 per cent. Using different data sources did not seem to demonstrate any sensitivity and own-account software does not seem to be very important. Hence, measurement errors are unlikely to account for over-investment in IT in this industry in Canada.

Furthermore, of all of the factors that we examined, the only plausible culprit that we encountered was the three-digit industrial structure. Every other factor examined either did not have data available for this industry or the data available showed results that did not support the hypothesis.

Further research is needed before any of these factors can be definitively removed from consideration and further research is needed before the three-digit industrial structure can be confirmed as contributing to the Canada-US IT investment per worker gap in real estate and rental and leasing.

iv. Arts, Entertainment and Recreation

Canada-US IT investment per worker in arts, entertainment and recreation is 231.0 per cent. Using different data sources did not seem to demonstrate any sensitivity. However, own-account software is an important component of overall software investment, so it is possible that measurement errors could explain part of the over-investment in Canada in IT. This situation is highly unlikely though, since this would imply that software developers are paid more highly in Canada than in the United States, which counters the current state of published literature.

Even if measurement errors cannot explain over-investment in Canada in this industry, our research shows that the three-digit industrial structure may help explain part of this gap.

Unfortunately, every other factor examined either did not have data available for this industry or the data available showed results that did not support the hypothesis.

Hence, further research is needed before any of these factors can be definitively removed from consideration and further research is needed before the three-digit industrial structure can be confirmed as contributing to the Canada-US IT investment per worker gap in real estate and rental and leasing.

v. Conclusion

This section should help the reader understand how they could implement the same steps and processes to determine potential factors in other industries that have data in this report. The rest of the report will continue to focus on professional, scientific and technical services and information and cultural industries given that these industries are so crucial to explaining the Canada-US IT investment per worker gap in the business sector (except Section VI and VII, which cover only industries within Canada).

VI. IT Investment Per Worker by Industry in Canada

This section explores trends in total IT investment per worker by industry in Canada between 1987 and 2013. Both levels and growth rates will be examined.

It is important to point out that the Statistics Act in Canada restricts the availability of data on communications investment at the industry level: data are not available for a number of industries, and the severity of the data restrictions has increased over time.[49]

In order to maximize the number of industries examined and the length of the time series, we have created a proxy of total ICT investment per worker which is composed solely of computer and software investment. This proxy will be called information technology (IT) investment. Data tables on the traditional total ICT investment and communications investment can be found in Appendix II, where we limit our investigation to the period between 2002 and 2008. Software investment per worker and computer investment per worker do not face similar data restrictions, so the analysis will proceed for these two components over the entire time series: 1987-2013.

A. Total IT Investment Per Worker

This section investigates absolute levels of total IT investment per worker in Canada in each of the 20 two-digit NAICS industries for 1987, 2000 and 2013 in current dollars. Subsequently, the section discusses growth rates between 2000 and 2013 for chained 2007 dollar IT investment per worker.[50]

i. Absolute Levels

The industry with the highest total IT investment per worker in current dollars in 2013 was utilities with $10,990 per worker (Table 46 and Chart 12).[51] Finance and insurance, with $7,416 per worker was the industry with the next highest level of total IT investment per worker

[49] Data on ICT investment are not available for 8 of the 20 two-digit NAICS industries for all years over the 1987 to 2009 period, including utilities; construction; transportation and warehousing; management of companies and enterprises; administrative and support, waste management and remediation services; health care and social assistance; accommodation and food services; and other services (except public administration). Between 2000 and 2013, these eight industries accounted for 50 per cent of employment on average. In 2000, these eight industries accounted for 47 per cent of employment. By 2013, they accounted for 53 per cent of employment. Furthermore, the *Statistics Act* in Canada has become increasingly strict in the last ten years, resulting in less data coverage for fewer industries. For example, in 2006, estimates for total ICT investment for 6 out of 20 two-digit NAICS industries were suppressed due to confidentiality constraints; by 2013, this number had increased to 14. Hence, in order to maximize the number of industries analyzed in this report, the time series for total ICT investment per worker stops at 2009 with 8 out of 20 two-digit NAICS industries suppressed and 12 out of 20 two-digit NAICS industries available. In the Appendix, we carry out an analysis of ICT investment per worker for total and communications investment up to 2008 to avoid the negative impacts of the financial crisis on investment figures.

[50] For simplicity, when calculating the IT investment per worker proxy, computer investment in chained dollars and software investment in chained dollars, were simply summed together. However, chained dollars are not exactly additive, so this implies that these results are approximate.

[51] We are ignoring management of companies and enterprises because of the measurement and definitional issues surrounding analysis of this industry.

in 2013. In comparison, at the low end of the spectrum, construction and agriculture, fishing, forestry and hunting invested a meagre $194 and $269 per worker, respectively.

Table 46: Nominal Total IT Investment Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, and 2013

	1987	2000	2013
Agriculture, fishing, forestry and hunting	26	113	269
Mining and oil and gas extraction	197	707	1,298
Utilities	2,449	8,229	10,990
Construction	108	279	194
Manufacturing	403	1,047	1,822
Wholesale trade	763	2,915	3,688
Retail trade	151	676	950
Transportation and warehousing	351	1,727	2,542
Information and cultural industries	801	5,065	5,965
Finance and insurance	3,504	5,777	7,416
Real estate and rental and leasing	2,328	5,543	4,733
Professional, scientific and technical services	1,303	3,109	1,708
Management of companies and enterprises	.	32,600	48,038
Administrative and support, waste management and remediation services	612	981	1,093
Educational services	353	962	1,142
Health care and social assistance	90	307	442
Arts, entertainment and recreation	203	1,179	769
Accommodation and food services	97	140	300
Other services (except public administration)	173	655	749
Public administration	1,228	4,037	5,070
Business sector	592	1,660	1,960

Source: CSLS ICT by Industry database.

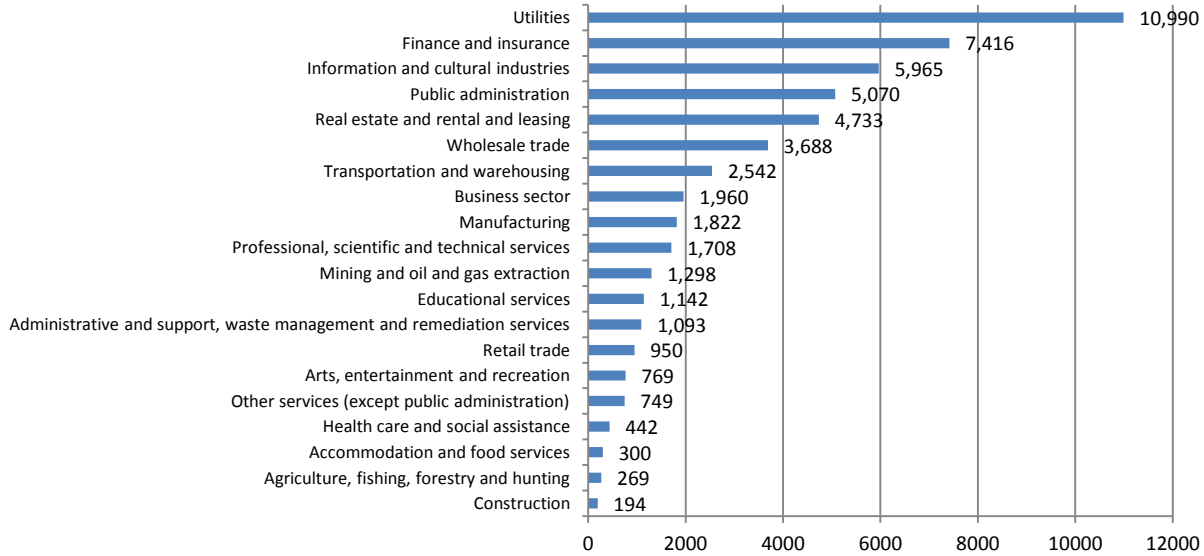
The industry with the largest share of total IT investment in 2013 was finance and insurance (21.9 per cent), which accounted for only a mere 6.0 per cent of employment in 2013 (Table 47).

Table 47: Distribution of Industry Shares in Total Nominal Business Sector IT Investment and Employment by Industry, Per Cent, 1987, 2000 and 2013

	IT Investment (Current Dollar)			Employment (Workers)		
	1987	2000	2013	1987	2000	2013
Agriculture, fishing, forestry and hunting	0.2	0.3	0.4	5.9	4.2	2.9
Mining and oil and gas extraction	0.6	0.5	1.6	1.9	1.4	2.3
Utilities	5.2	5.2	6.0	1.2	1.0	1.1
Construction	1.3	1.2	1.0	7.5	7.0	9.9
Manufacturing	13.6	11.7	12.5	21.2	19.5	13.0
Wholesale trade	4.8	8.1	8.6	4.3	4.7	4.6
Retail trade	3.5	6.1	7.6	16.2	15.3	15.7
Transportation and warehousing	3.8	6.9	8.4	6.6	6.7	6.5
Information and cultural industries	4.9	10.5	8.8	3.5	3.3	2.9
Finance and insurance	34.0	18.7	21.9	5.6	5.3	6.0
Real estate and rental and leasing	9.1	7.2	6.0	2.4	2.2	2.4
Professional, scientific and technical services	11.9	15.9	9.1	5.1	8.1	10.0
Management of companies and enterprises	n/a	0.6	0.5	0.0	0.0	0.0
Administrative and support, waste management and remediation services	3.1	2.8	2.9	2.8	4.6	5.3
Arts, entertainment and recreation	0.6	1.8	1.2	1.8	2.5	3.0
Accommodation and food services	1.1	0.6	1.3	7.4	8.2	8.5
Other services (except public administration)	2.0	2.3	2.3	6.6	5.9	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0

Note: "n/a" means not available.
Source: CSLS ICT by Industry database.

Chart 12: Nominal Total IT Investment Per Worker, Canada, 2013

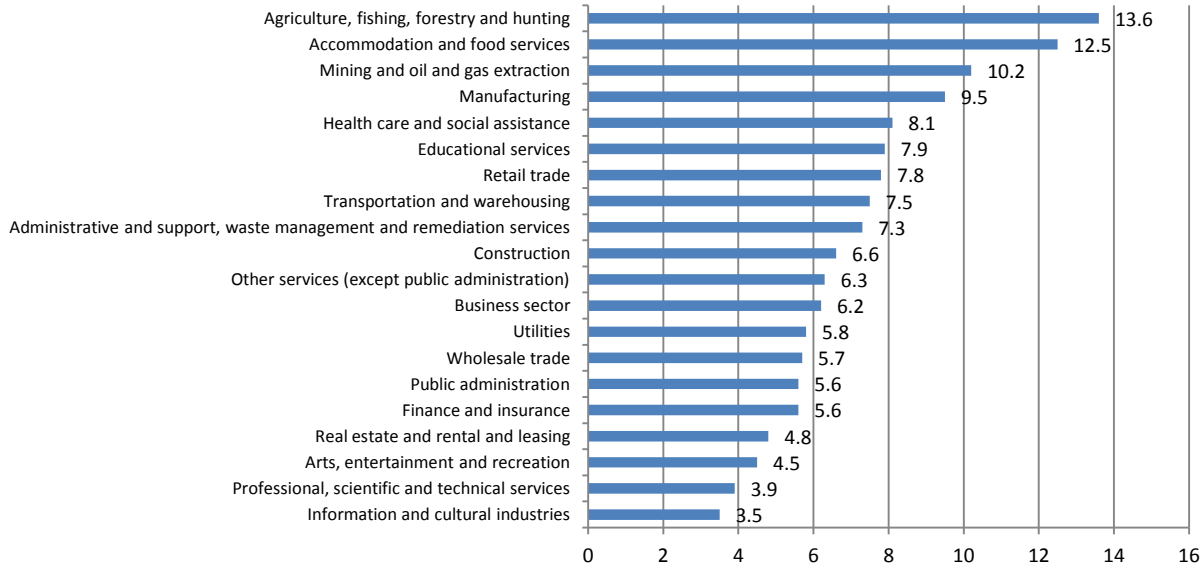


Source: Table 46.

ii. Growth Rates

The fastest growing industry in terms of total IT investment per worker between 2000 and 2013 was agriculture, fishing, forestry and hunting (13.6 per cent per year) (Chart 13). The next fastest growing industry was accommodation and food services at 12.5 per cent per year. On the other end of the spectrum, the industry that saw the slowest growth in total IT investment per worker over this period was information and cultural industries (3.5 per cent per year), followed by professional, scientific and technical services (3.9 per cent per year).

Chart 13: Real Total IT Investment Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT by Industry database from January 2015.

B. Computer Investment Per Worker

This section examines computer investment per worker in Canada in all of the 20 two-digit NAICS industries. It first investigates absolute levels of computer investment per worker in Canada for 1987, 2000, and 2013 in current dollars. Subsequently, it discusses growth rates between 2000 and 2013.

i. Absolute Levels

In 2013, utilities recorded the highest level of computer investment per worker ($3,727 per worker) (Table 48 and Chart 14). Utilities was followed by information and cultural industries ($2,250 per worker) and real estate and rental and leasing ($1,779 per worker).

At the bottom of the ranking, health care and social assistance had the lowest level of computer investment per worker in 2013 ($135 per worker), which is surprising given the need for computers for medical records. Accommodation and food services was the industry with the second lowest level of computer investment per worker ($144 per worker).

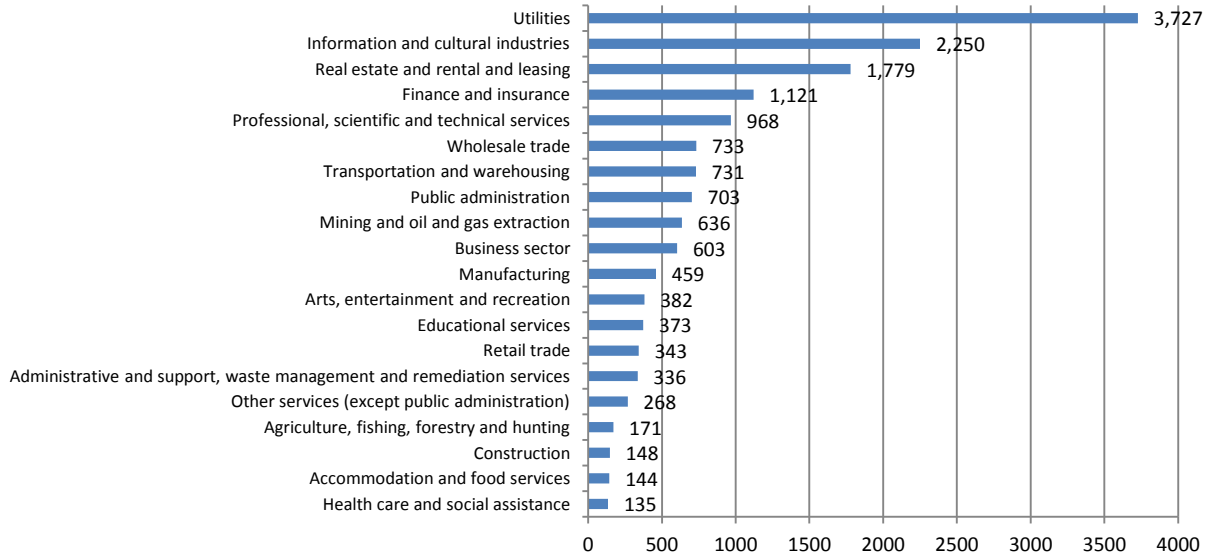
Table 48: Nominal Computer Investment Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, and 2013

	1987	2000	2013
Agriculture, fishing, forestry and hunting	10	28	171
Mining and oil and gas extraction	49	129	636
Utilities	1,652	2,654	3,727
Construction	64	210	148
Manufacturing	187	452	459
Wholesale trade	227	1,088	733
Retail trade	42	300	343
Transportation and warehousing	176	709	731
Information and cultural industries	508	163	2,250
Finance and insurance	2,039	2,751	1,121
Real estate and rental and leasing	1,326	3,125	1,779
Professional, scientific and technical services	1,023	2,594	968
Management of companies and enterprises	n/a	11,567	20,154
Administrative and support, waste management and remediation services	459	743	336
Educational services	174	583	373
Health care and social assistance	50	184	135
Arts, entertainment and recreation	117	958	382
Accommodation and food services	48	59	144
Other services (except public administration)	113	305	268
Public administration	550	1,855	703
Business sector	334	791	603

Note:" n/a" means not available.
Source: CSLS ICT by Industry database.

Professional, scientific and technical services had the largest share of computer IT investment per worker in 2013 (16.3 per cent) (Table 49). This was 6.3 percentage points higher than its share of total business sector employment (10.0 per cent).

Chart 14: Nominal Computer Investment Per Worker, Canada, 2013



Source: Table 48.

Table 49: Distribution of Industry Shares in Business Sector Nominal Computer Investment and Employment by Industry, Per Cent, 1987 and 2013

	Computer Investment (Current Dollar)			Employment (Workers)		
	1987	2000	2013	1987	2000	2013
Agriculture, fishing, forestry and hunting	0.2	0.2	0.8	5.9	4.2	2.9
Mining and oil and gas extraction	0.3	0.2	2.4	1.9	1.4	2.3
Utilities	5.9	3.4	6.7	1.2	1.0	1.1
Construction	1.5	1.9	2.4	7.5	7.0	9.9
Manufacturing	11.8	11.1	9.9	21.2	19.5	13.0
Wholesale trade	2.9	6.5	5.6	4.3	4.7	4.6
Retail trade	2.0	5.8	8.9	16.2	15.3	15.7
Transportation and warehousing	3.4	6.0	7.9	6.6	6.7	6.5
Information and cultural industries	5.2	0.7	10.7	3.5	3.3	2.9
Finance and insurance	33.9	18.4	11.2	5.6	5.3	6.0
Real estate and rental and leasing	9.4	8.6	7.1	2.4	2.2	2.4
Professional, scientific and technical services	15.5	26.7	16.3	5.1	8.1	10.0
Management of companies and enterprises	n/a	0.4	0.6	0.0	0.0	0.0
Administrative and support, waste management and remediation services	3.8	4.3	3.0	2.8	4.6	5.3
Arts, entertainment and recreation	0.7	3.0	1.9	1.8	2.5	3.0
Accommodation and food services	1.1	0.6	2.0	7.4	8.2	8.5
Other services (except public administration)	2.2	2.3	2.6	6.6	5.9	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0

Note:" n/a" means not available.
Source: CSLS ICT by Industry database.

ii. Growth Rates

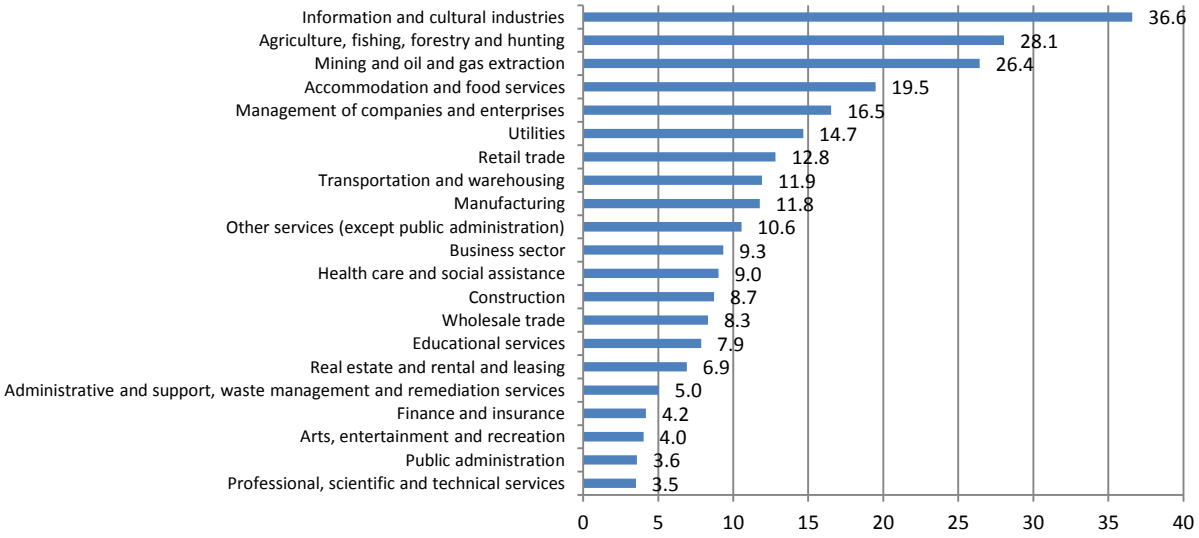
Over the 2000-2013 period, implicit price deflators in the business sector for computer investment fell 10.4 per cent per year and nominal computer investment per worker fell 1.0 per cent per year. However, by using chained 2007 dollar investment per worker to control for inflation, it can be shown that real computer investment grew 9.3 per cent per year over the 2000-2013 period.

Over the 2000-2013 period every industry showed growth in chained 2007 dollar computer investment per worker (Chart 15). The industry that saw the smallest rise in computer investment per worker between 2000 and 2013 was professional, scientific and technical services at 3.5 per cent per year. Computer investment per worker in public administration also performed poorly during this time frame at 3.6 per cent per year.

At the top end, information and cultural industries saw a massive increase in computer investment per worker between 2000 and 2013, registering 36.6 per cent per year, 8.5 percentage points faster than second placed agricultural, fishing, forestry and hunting (28.1 per cent per year between 2000 and 2013).

The industry with the third fastest growth in computer investment per worker is mining and oil and gas extraction (26.4 per cent per year). This is over ten percentage points lower than the growth rate exhibited by information and cultural industries, but it still implies a doubling of computer investment per worker in less than three years.

Chart 15: Real Computer Investment Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

C. Software Investment Per Worker

This section examines software investment per worker in Canada in all of the 20 two-digit NAICS industries. It first investigates absolute levels of software investment per worker in Canada for 1987, 2000, and 2013 in current dollars. Subsequently, it discusses growth rates between 2000 and 2013.

i. Absolute Levels

In 2013, utilities and finance and insurance had the highest levels of software investment per worker ($7,263 per worker and $6,295 per worker respectively), followed by public administration (Table 50 and Chart 16). At the lower end of the distribution, construction had the smallest amount of software investment per worker, followed by agriculture, fishing, forestry and hunting, and accommodation and food services.

Table 50: Nominal Software Investment Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, and 2013

	1987	2000	2013
Agriculture, fishing, forestry and hunting	16	84	99
Mining and oil and gas extraction	148	578	662
Utilities	796	5,575	7,263
Construction	44	69	46
Manufacturing	216	595	1,364
Wholesale trade	536	1,827	2,955
Retail trade	109	376	607
Transportation and warehousing	175	1,017	1,811
Information and cultural industries	293	4,901	3,716
Finance and insurance	1,465	3,026	6,295
Real estate and rental and leasing	1,002	2,417	2,954
Professional, scientific and technical services	280	514	740
Management of companies and enterprises	n/a	21,033	27,885
Administrative and support, waste management and remediation services	153	239	757
Educational services	179	379	769
Health care and social assistance	41	123	307
Arts, entertainment and recreation	86	221	387
Accommodation and food services	49	81	155
Other services (except public administration)	60	351	481
Public administration	678	2,182	4,367
Business sector	258	868	1,357

Note:" n/a" means not available.
Source: CSLS ICT by Industry database.

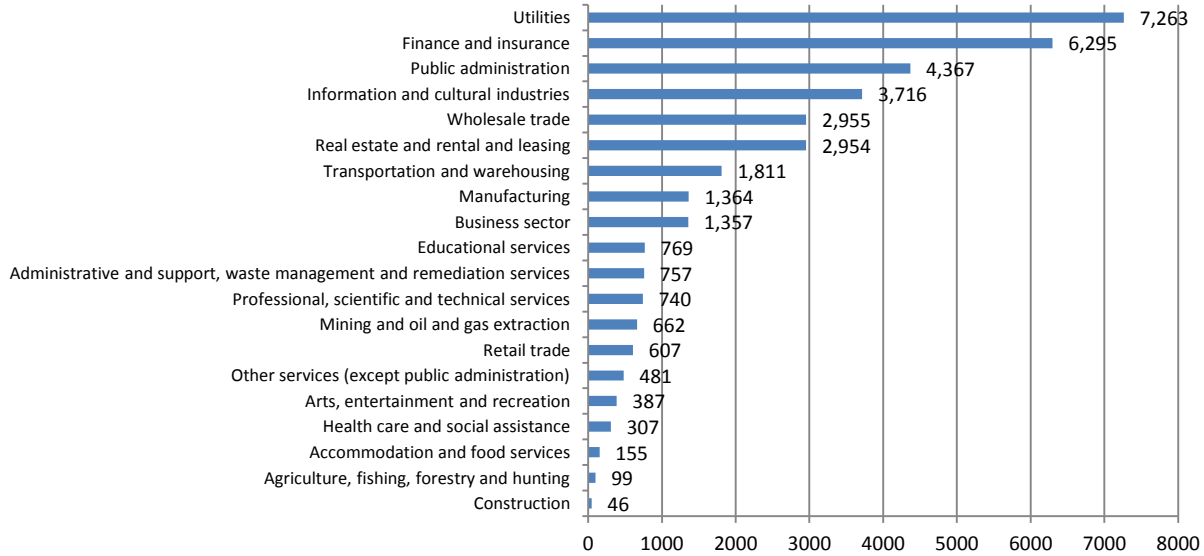
The industry with the largest share of software investment in 2013 was finance and insurance with 27.0 per cent of the business sector total (Table 51). This compares to a meagre 6.0 per cent of total business sector employment.

Table 51: Distribution of Business Sector Nominal Software Investment and Employment by Industry, Per Cent, 1987, 2000 and 2013

	Software Investment (Current Dollar)			Employment (Workers)		
	1987	2000	2013	1987	2000	2013
Agriculture, fishing, forestry and hunting	0.3	0.4	0.2	5.9	4.2	2.9
Mining and oil and gas extraction	1.2	0.8	1.2	1.9	1.4	2.3
Utilities	3.6	7.1	5.7	1.2	1.0	1.1
Construction	1.0	0.4	0.4	7.5	7.0	9.9
Manufacturing	17.3	12.3	13.7	21.2	19.5	13.0
Wholesale trade	8.8	9.7	10.0	4.3	4.7	4.6
Retail trade	6.6	6.4	6.9	16.2	15.3	15.7
Transportation and warehousing	4.7	7.9	8.7	6.6	6.7	6.5
Information and cultural industries	4.2	21.2	7.9	3.5	3.3	2.9
Finance and insurance	34.2	19.0	27.0	5.6	5.3	6.0
Real estate and rental and leasing	8.5	5.8	5.4	2.4	2.2	2.4
Professional, scientific and technical services	4.4	4.4	5.7	5.1	8.1	10.0
Management of companies and enterprises	n/a	0.7	0.4	0.0	0.0	0.0
Administrative and support, waste management and remediation services	1.4	1.3	2.9	2.8	4.6	5.3
Arts, entertainment and recreation	0.6	0.6	0.9	1.8	2.5	3.0
Accommodation and food services	1.2	0.7	1.0	7.4	8.2	8.5
Other services (except public administration)	1.4	2.4	2.1	6.6	5.9	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0

Note:" n/a" means not available.
Source: CSLS ICT by Industry database.

Chart 16: Nominal Software Investment Per Worker, Canada, Current Dollars, 2013



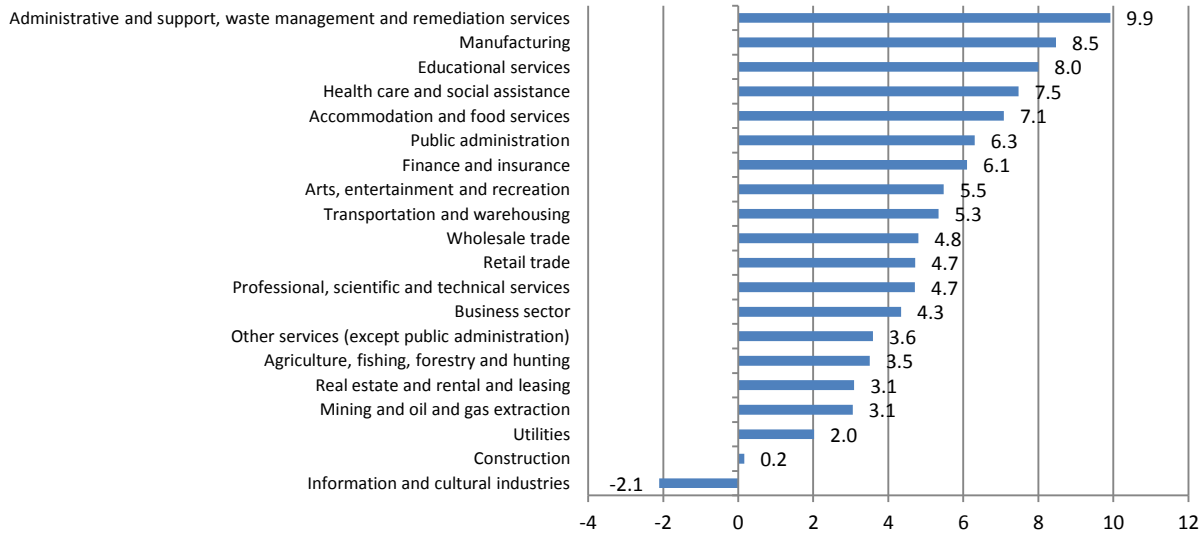
Source: Table 50.

ii. Growth Rates

Over the 2000-2013 period, 19 out of 20 two-digit NAICS industries saw growth in software investment per worker (Chart 17).

The fastest growing industry was administrative and support, waste management and remediation services at 9.9 per cent per year, followed by manufacturing (8.5 per cent per year), and educational services (8.0 per cent per year). At the bottom of the distribution of software investment per worker growth was information and cultural industries with negative growth (2.1 per cent per year). Construction was also at the bottom of the distribution with weak positive growth (0.2 per cent per year).

Chart 17: Real Software Investment Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

VII. Explanations for Industry Differences in IT Investment Per Worker Across Canada

This appendix applies the drivers and barriers of IT investment discussed in Section V to IT investment per worker by industry within Canada. This appendix is divided into three subsections which group the drivers and explanations of ICT investment into three themes: complementary investments, microeconomic environment, and firm environment.

A. Complementary Investments

i. Human Capital

The level of skilled workers in an industry's labour force is a complementary investment to ICT. In order to maximize the productivity impact of ICT investment, an industry must also invest in enhancing the skill sets of its workers. If educational attainment is a proxy for the skill level of workers in an industry's labour force and the educational attainment of an industry is low, this may act as a barrier to investment in ICT. Hence, by examining the absolute level of educational attainment in any given year and the change in educational attainment over time for any particular industry, it might be possible to assess the extent to which educational attainment in Canada is a barrier to ICT investment in certain industries.

Table 52 shows the years of educational attainment of those employed for 19 two-digit NAICS industries in Canada in 2002 and 2013. In order to calculate years of educational attainment, the average number of years required to complete a given level of educational attainment were applied to the share of individuals who had attained that level of education. This was performed for each educational attainment category, after which the results were summed together to obtained average years of educational attainment.[52]

In 2013, educational services (15.5 years), professional, scientific and technical services (15.2 years), and finance and insurance (14.6 years) had the highest average years of educational attainment, while agriculture, fishing, forestry and hunting (12.3 years), accommodation and food services (12.7 years), and construction (14.4 years) had the lowest average years of educational attainment.

This would imply that educational services, professional, scientific and technical services, and finance and insurance should have high levels of IT investment per worker, while agriculture, fishing, forestry and hunting, accommodation and food services, and construction have low levels of IT investment.

However, in 2013, only finance and insurance had high levels of IT investment per worker, while agriculture, fishing, forestry and hunting, accommodation and food services, and

[52] For the estimates in this report, we used eight years for less than high school, ten years for some high school, twelve years for a high school diploma, thirteen years for some postsecondary, fourteen years for a postsecondary certificate or diploma, sixteen years for a Bachelor's degree, and eighteen years for a degree above a Bachelor's degree.

construction all had low levels of IT investment per worker. Hence, it would seem that low levels of educational attainment are linked to low levels of IT investment per worker, but that the correlation becomes weaker at higher levels of educational attainment. This may arise because educational attainment is only a proxy for ICT skills and the accuracy of the proxy decreases as educational attainment increases.

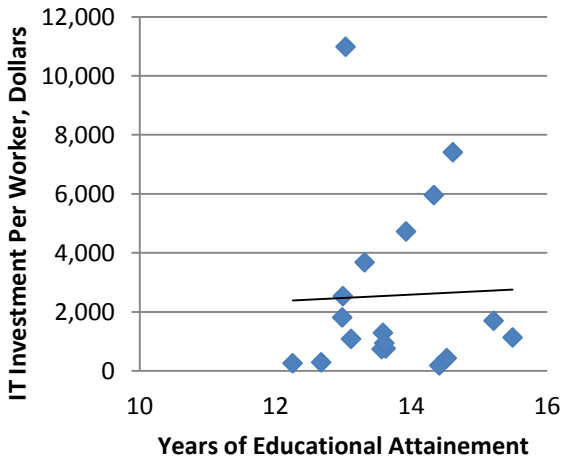
Table 52: Average Years and Growth Rate of Educational Attainment, Employed Persons, Canada, 2000 and 2013

	2000	2013	2000-2013
Agriculture, fishing, forestry and hunting	11.75	12.25	4.26
Mining	12.97	13.58	4.70
Construction	13.83	14.41	4.19
Manufacturing	12.46	12.98	4.17
Wholesale trade	12.76	13.31	4.31
Retail trade	13.09	13.60	3.90
Transportation and warehousing	12.58	12.99	3.26
Utilities	12.51	13.03	4.16
Information and cultural industries	13.87	14.33	3.32
Finance and insurance	14.02	14.61	4.21
Real estate and rental and leasing	13.23	13.92	5.22
Professional, scientific and technical services	14.84	15.21	2.49
Administrative and support, waste management and remediation services	12.71	13.11	3.15
Educational services	15.24	15.49	1.64
Health care and social assistance	14.04	14.52	3.42
Arts, entertainment and recreation	13.05	13.62	4.37
Accommodation and food services	12.11	12.67	4.62
Other services (except public administration)	12.95	13.56	4.71
Total	13.26	13.83	4.30

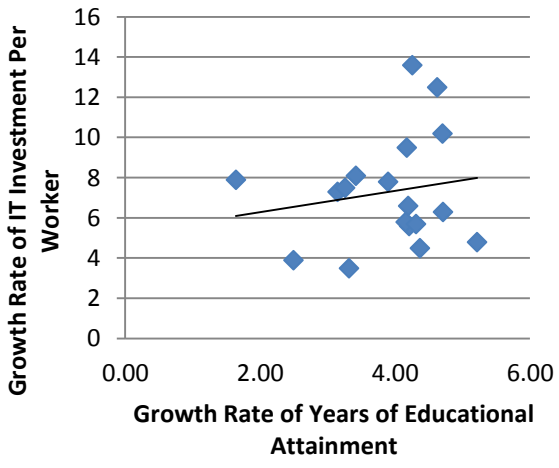
Source: CSLS calculations based on unpublished LFS series.

Chart 18: Correlation of Years of Educational Attainment and IT Investment Per Worker, Canada

Panel A: Absolute Level, 2013



Panel B: Growth Rate, 2000-2013



Source: CSLS calculations based on Table 46 and Table 52.

Real estate and rental and leasing and other services (except public administration) had the fastest growth rates of average years of educational attainment between 2000 and 2013. The lowest growth rates were in educational services and professional, scientific and technical services. Hence, based on the theory above, it would be expected that real estate and rental and leasing and other services (except public administration) would have fast growth rates of ICT investment, while educational services and professional, scientific and technical services would have lower growth rates of ICT investment.

However, the IT investment data only corroborate these predictions for professional, scientific and technical services, which had the second slowest growth in IT investment per worker between 2000 and 2013 (3.9 per cent per year).

Even though a simple correlation of IT investment per worker in Canada and years of educational attainment returns an extremely weak (albeit positive) correlation coefficient of 0.03 (R^2=0.00), average years of educational attainment could still be a plausible driver behind relative IT investment per worker by industry in Canada in the 2000s, especially for industries with lower levels of educational attainment. The correlation has too few controls and too few observations for any strong conclusions to be drawn.

In terms of growth rates, a simple correlation returns a mildly positive coefficient of 0.17 (R^2=0.03). However, it is unlikely that the industry growth rates of the average years of educational attainment are a plausible driver behind the relative growth rates of ICT investment per worker that were seen in Canada in the 2000s in the industries we have examined.

Nevertheless, it is important to note that there are many other drivers and determinants of ICT investment per worker that could influence both the absolute level and the growth rate of ICT investment per worker either in the same direction or in the opposite direction of human capital.[53] These other determinants, drivers and barriers may be counteracting the impact of human capital on ICT investment thereby explaining why, at first glance, the human capital and ICT investment per worker linkage is less strong or not present at all in certain industries in Canada. Further research is needed to definitively confirm whether or not the share of skilled workers in an industry's workforce is an important determinant of the level and growth rate of ICT investment per worker by industry in Canada.

ii. Unionization

It has also been theorized that workplace reorganization is another complementary investment that is required to maximize the productive potential of ICT investment. Hence, if workplace reorganization is not possible for any reason, ICT investment might be lower than expected. It can be argued that unionization may reflect one potential barrier to workplace reorganization. Hence, the higher the union coverage rate in any given industry, the less likely that industry will be able to easily reorganize the workplace, and hence, the less likely that industry will be able to invest in ICT.

[53] For example, the occupational distribution of an industry will heavily determine the educational attainment of an industry. Hence, the occupational distribution of an industry may be the true culprit behind differing levels of IT investment per worker.

In 2013, the industry in Canada with the highest union coverage rate was educational services (72.4 per cent), followed by utilities (64.8 per cent), and health care and social assistance (55.7 per cent) (Table 53). The industries with the lowest levels of union coverage were professional, scientific and technical services (5.4 per cent) and accommodation and food services (7.2 per cent).

This distribution of union coverage rates by industry in Canada in 2013 implies that educational services, utilities, and health care and social assistance should have relatively low levels of IT investment per worker if the workplace reorganization hypothesis is valid, while professional, scientific, and technical services and accommodation and food services should have relatively high levels of IT investment per worker.

According to the available IT investment per worker data, utilities had high levels of IT investment per worker (contrary to predictions), while health care and social assistance had relatively low levels of IT investment per worker (confirming predictions). Professional, scientific and technical services and educational services had average relative levels of IT investment per worker (contrary to predictions), while accommodation and food services had relatively low levels of IT investment per worker (contrary to predictions).

A simple correlation of the absolute level of IT investment per worker with the absolute level of union coverage rates by industry returns a positive coefficient of 0.36 (R^2=0.13), contrary to expectations.

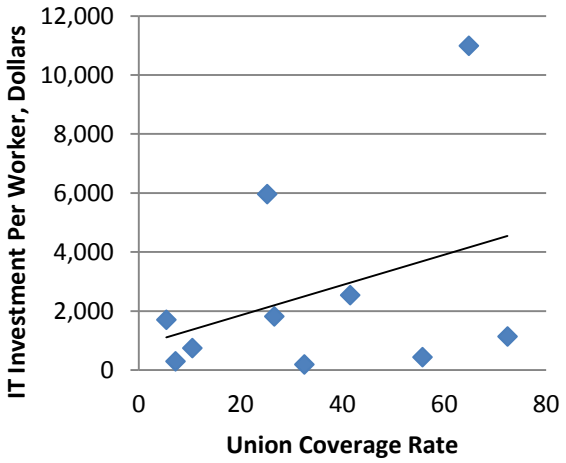
Table 53: Union Coverage Rate by Industry, Per Cent, Canada, 2003 and 2013

	2003	2013	2000-2013
Agriculture, forestry, fishing, mining, quarrying, oil and gas	18.8	16.2	-2.6
Utilities	71.5	64.8	-6.7
Construction	34.2	32.5	-1.7
Manufacturing	32.5	26.6	-5.9
Wholesale and retail trade	14.6	13.3	-1.3
Transportation and warehousing	43.5	41.5	-2.0
Finance, insurance, real estate and leasing	10.0	10.8	0.8
Professional, scientific and technical services	5.4	5.4	0.0
Educational services	72.4	72.4	0.0
Health care and social assistance	55.0	55.7	0.7
Accommodation and food services	8.1	7.2	-0.9
Management, administrative and waste services	14.7	16.7	2.0
Other services	11.0	10.5	-0.5
Information, culture and recreation	27.1	25.2	-1.9
Total	32.2	31.1	-1.1

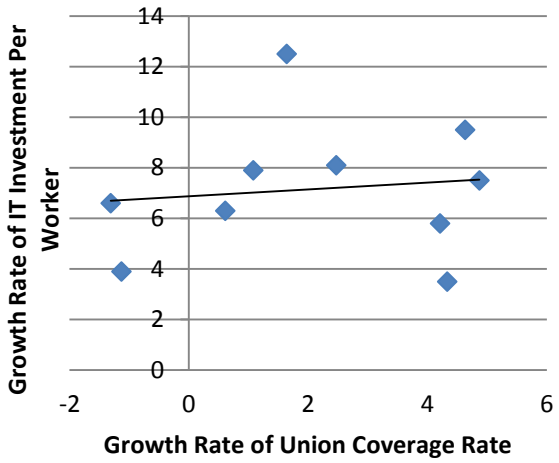
Source: CSLS calculations based on CANSIM 282-0007.

Chart 19: Correlation of Union Coverage Rates and IT Investment Per Worker, Canada

Panel A: Absolute Level, 2013



Panel B: Growth Rate, 2003-2013



Source: CSLS calculations based on Table 46 and Table 53.

Union coverage rates fell the most between 2003 and 2013 in manufacturing (18.2 per cent), agriculture, forestry, fishing, mining, quarrying, oil and gas, (13.8 per cent), and accommodation and food services (11.1 per cent). Finance, insurance, real estate and leasing, and health care and social assistance saw their union coverage rates increase the most over the 2003-2013 period (8.0 per cent and 1.3 per cent respectively).

Hence, according to the theory of workplace reorganization, we would expect that manufacturing, agriculture, forestry, fishing, mining, quarrying, oil and gas, and accommodation and food services would find it easier to reorganize the workplace over this period, making investment in IT more likely, while finance, insurance, real estate and leasing, and health care and social assistance would find it more difficult to reorganize the workplace and thereby they would be less likely to invest in IT.

The data for health care and social assistance do not corroborate this prediction at all, since health care and social assistance saw relatively strong growth in total IT investment per worker. There were no data for total IT investment per worker for finance, insurance, real estate and leasing or agriculture, forestry, fishing, mining, quarrying, oil and gas, as these are not two-digit NAICS industries but instead aggregates of two-digit NAICS industries.

Manufacturing showed mild support for the hypothesis that an increasing ability to reorganize the workplace should increase ICT investment. In particular, total IT investment per worker increased relatively quickly for manufacturing (4.6 per cent per year between 2003 and 2013). IT investment per worker grew at 1.6 per cent per year in accommodation and food services, which also shows weak support for the hypothesis.

To further test the hypothesis, we performed a simple correlation exercise which did not show the anticipated relationship, returning instead a weak positive correlation coefficient of 0.12 (R^2=0.01).

Hence, it seems like the validity of the workplace reorganization hypothesis is tenuous regarding the absolute level of IT investment per worker, but the argument in terms of growth rates is more strongly supported by the data.

Nonetheless, it is important to note that there are many other drivers and determinants of ICT investment per worker that could influence both the absolute level and the growth rate of ICT investment per worker either in the same direction or in the opposite direction of union coverage rates (or other variables that measure the potential for workplace reorganization).

These other determinants, drivers and barriers may be counteracting the impact of the potential for workplace reorganization on IT investment, thereby explaining why, at first glance, the workplace reorganization and IT investment per worker linkage is less strong or not present at all in certain industries in Canada.

Moreover, workplace reorganization may need to be combined with other complementary investments, like human capital, without which IT investment would be futile. Hence, further research is needed to definitively confirm whether or not workplace reorganization is an important determinant of the level and growth rate of IT investment per worker by industry in Canada.

B. Microeconomic Environment

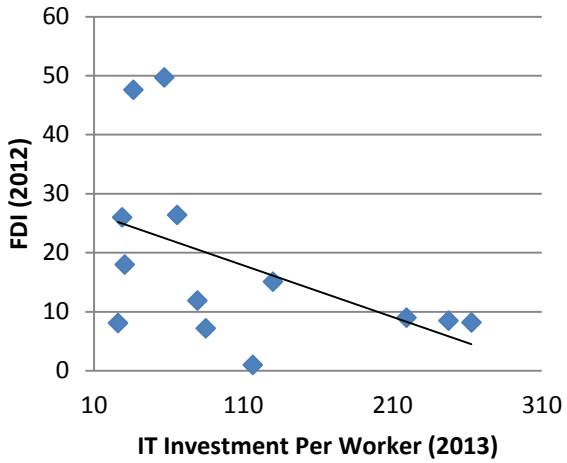
i. Foreign Direct Investment

As highlighted above, high levels of foreign direct investment can bias ICT investment per worker downward, but high levels of foreign direct investment could also push ICT investment per worker upward. This depends on whether the foreign firms introduce additional ICT investment within Canada, or whether they invest in ICT in their home countries, allowing host country access through the cloud or through online downloads.

Hence, if foreign direct investment by industry is higher in one industry compared to another, then *ceteris paribus*, it is quite possible that foreign direct investment could explain differing levels of ICT investment per worker by industry. However, untangling the counteracting effects is currently impossible empirically.

Undertaking further research may help illuminate the relationship between foreign direct investment and ICT investment per worker in Canada at the industry level.

Chart 20: Correlation of Share of Assets Under Foreign Control and IT Investment Per Worker, Canada



Source: CSLS calculations based on Table 46 and Table 54.

A simple correlation exercise of the IT investment per worker at the industry level and foreign direct investment in Canada for 13 industries returns a correlation coefficient of -0.17, which suggests that as foreign direct investment increases, IT investment per worker decreases. This implies that foreign direct investment may be bad for IT investment per worker. However, without controls, this simple correlation cannot provide any definitive answers.

Table 54: Assets Under Foreign Control, Canada, Two-Digit NAICS Industries, Per Cent, 2002 and 2012

	2002	2012
Agriculture, forestry, fishing and hunting	2.0	1.0
Oil and gas extraction and support activities	49.4	36.7
Mining and quarrying (except oil and gas)	9.7	35.3
Utilities	5.4	8.5
Construction	4.2	7.2
Manufacturing	43.8	49.7
Wholesale trade	35.0	47.6
Retail trade	19.8	26.4
Transportation and warehousing	.	8.2
Information and cultural industries	4.6	8.1
Finance and insurance	16.1	11.9
Real estate and rental and leasing	11.9	9.0
Professional, scientific and technical services	14.2	26.0
Administrative and support, waste management and remediation services	24.1	18.0
Arts, entertainment and recreation	3.0	.
Accommodation and food services	15.3	15.1
Repair, maintenance and personal services	.	10.1
Total (excluding management of companies and enterprises)	20.6	18.4

Source: CANSIM 179-0004.

ii. Taxation

It is arguable that taxes can explain investment because the amount of investment any firm undertakes is determined by the prior expected rate of return on the investment, and the prior expected rate of return on an investment is in part determined by the marginal effective tax rate (METR) on investment.

Hence, if there are different marginal effective tax rates on ICT investment for different industries in Canada, it is plausible that taxes could partially explain the differences in ICT investment per worker across industries within Canada. Table 55 contains data on METRs by industry in Canada for 2005, 2012 and 2014.

Table 55: Marginal Effective Tax Rate on Capital Investment in Canada, Per Cent, 2005, 2012, and 2014

	2005	2012	2014
Forestry	21.4	-0.4	3.2
Manufacturing	35.5		
Utility		18.0	19.3
Construction	42.3	22.5	24.8
Manufacturing		6.0	8.2
Wholesale Trade	40.9	21.5	23.1
Retail Trade	40.1	21.8	23.5
Transportation	33.4	17.6	19.8
Communication	46.1	20.8	23.9
Other Services		23.6	25.4
Total	38.9	16.8	19.0

Source: Mintz and Chen (2015), Mintz and Chen (2012) and Mintz et al. (2005).

Wholesale trade, construction, and retail trade had above average METRs in 2012 and 2014, while manufacturing and forestry had below average METRs. This would lead us to expect that wholesale trade, construction, and retail trade would have lower levels of IT investment per worker, while manufacturing and forestry would have higher IT investment per worker in 2012 and 2014.

According to the available IT investment per worker data from 2013, construction had low levels of IT investment per worker compared to other industries, which supports the hypothesis, but wholesale trade had relatively high levels of IT investment per worker and retail trade had average levels of IT investment per worker. Hence, the relationship between METRs and IT investment per worker is unclear. Additional research would be needed to clarify whether or not industry-specific taxation on ICT investment in Canada is affecting ICT investment per worker levels, given that this conclusion is based on a simple correlation exercise and does not control for differences in other variables.

iii. Competitive Intensity

A competitive marketplace can foster increasing levels of ICT investment per worker. Hence, if certain industries in Canada are more competitive than other industries in Canada, these industries will also likely see higher rates of ICT investment per worker. However, data

that measure competitive intensity are not available at the industry level in Canada. Until data are created that quantify competitive intensity at the two-digit NAICS levels in Canada, the impact of competitiveness on ICT investment per worker at the two-digit NAICS level will remain purely anecdotal.

iv. Input Prices and Unexpected Costs

It can be argued that differences in the price of labour relative to the price of ICT capital goods can be a determinant of ICT investment per worker. In particular, consider industry A and industry B. Assuming that labour is uniformly productive, if the price of labour in industry A is more expensive than the price of labour in industry B, while the price of ICT capital goods is uniform across all industries, then industry A will have a much stronger incentive to invest more in ICT capital goods compared to industry B because of the principle of substitution.

Hence, since the price of ICT capital goods in the Canadian economy can be assumed to be fairly uniform across industries, differences in the price of labour by industry can potentially explain variations in the level of ICT investment per worker by industry. However, predictions based on this hypothesis depend highly on the extent to which labour and capital are substitutable in certain industries.

Table 56: Nominal Labour Compensation Per Hour, Canadian Dollars, Two-Digit NAICS Industries, Canada, 2000 and 2013

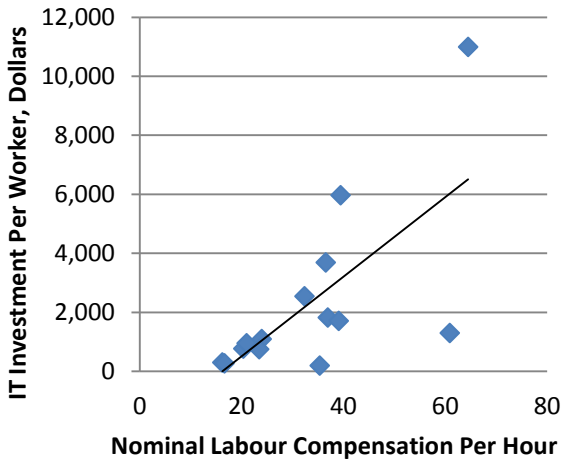
	2000	2013	2000-2013 (%)
Agriculture, forestry, fishing and hunting	11.82	16.62	40.61
Mining and oil and gas extraction	34.54	60.86	76.20
Utilities	44.49	64.46	44.89
Construction	22.65	35.32	55.94
Manufacturing	25.43	36.90	45.10
Wholesale trade	24.60	36.50	48.37
Retail trade	14.63	20.96	43.27
Transportation and warehousing	22.16	32.33	45.89
Information and cultural industries	28.35	39.42	39.05
Finance, insurance, real estate and renting and leasing	27.29	37.87	38.77
Professional, scientific and technical services	25.75	39.05	51.65
Administrative and support, waste management and remediation services	15.91	23.93	50.41
Arts, entertainment and recreation	14.44	20.31	40.65
Accommodation and food services	10.96	16.19	47.72
Other private services	15.70	23.43	49.24
Total economy	22.04	30.97	40.50

Source: CSLS calculations based on CANSIM 383-0021.

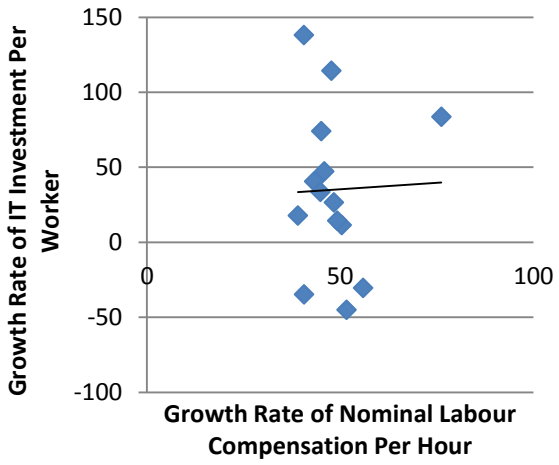
In 2013, utilities had the highest labour compensation per hour ($64.46 per hour), followed by mining and oil and gas extraction ($60.86 per hour), and information and cultural industries ($39.42 per hour) (Table 91). If the theory of labour and ICT capital substitution applies, we would expect these industries to have higher ICT investment per worker than the other industries in Canada.

Chart 21: Correlation of Nominal Labour Compensation Per Hour and IT Investment Per Worker, Canada

Panel A: Absolute Level, 2013



Panel B: Growth Rate, 2000-2013



Source: CSLS calculations based on Table 46 and Table 56.

The industries with the lowest labour compensation per hour were accommodation and food services ($16.19 per hour), agriculture, forestry, fishing and hunting ($16.62 per hour), and arts, entertainment and recreation ($20.31 per hour). These industries should have comparatively lower ICT investment per worker because of lower labour costs according to the substitution hypothesis.

The predictions of the ICT capital-labour substitution theory appear to describe the case for accommodation and food services extremely well: IT investment per worker is much lower than in many other industries. The expected outcome for agriculture, fishing, forestry and hunting is also confirmed by IT investment per worker data. The prediction of relatively higher ICT investment per worker in utilities and information and cultural industries is also corroborated by the available data for total IT investment per worker in 2013.

Furthermore, a simple correlation exercise returns the predicted results: a positive correlation coefficient of 0.68 (R^2=0.47).

In addition to expectations concerning the absolute level of ICT investment, the ICT capital-labour substitution theory also has implications for growth rates of ICT investment per worker: industries with extremely high labour compensation growth rates should see ICT investment per worker increase more rapidly than industries with lower labour compensation growth rates.

Since mining and oil and gas extraction, construction, and professional, scientific and technical services all saw rapid growth in their labour compensation per hour over the 2000-2013 period (76.2 per cent, 55.9 per cent and 51.7 per cent respectively), they should also have seen rapid growth in ICT investment per worker. Furthermore, finance, insurance, real estate and rental and leasing, information and cultural industries, and agriculture, fishing, forestry and

hunting should see weaker growth in ICT investment per worker because they demonstrated weaker growth in labour compensation per hour between 2000 and 2013 (38.8 per cent, 39.1 per cent and 40.6 per cent).

It appears that the predictions for two of the industries are borne out by the data: mining and oil and gas extraction saw strong growth over the 2000-2013 period (85.6 per cent), while information and cultural industries saw weaker growth (17.8 per cent). The predictions for the other four industries are not borne out by the data: agriculture, fishing, forestry and hunting had the fastest IT investment per worker growth (138.1 per cent) and construction and professional, scientific and technical services had extremely weak growth in IT investment per worker (-30.5 per cent and -45.1 per cent).

Hence, it appears that the ICT capital-labour substitution hypothesis may be a determinant of IT investment per worker levels, but labour compensation per hour is probably not a determinant of the growth rates of ICT investment per worker by industry.

As was the case for the other determinants, it is important to note that many other facotrs could influence both the absolute level and the growth rate of ICT investment per worker either in the same direction or in the opposite direction of labour compensation per hour. These other factors may be counteracting the impact of relative prices on ICT investment, thereby explaining why, at first glance, the ICT investment and labour compensation nexus is less strong or not present at all in certain industries in Canada. Moreover, these estimates assume that labour productivity is uniform across all industries, which is certainly a strong assumption. If labour compensation per hour were adjusted by labour productivity measures, the ICT capital-labour substitution hypothesis would probably see a stronger confirmation from the data.

Although this discussion has focused on labour costs, it is also important to note that ICT investment imposes unexpected non-labour costs on businesses. For example, according to a Financial Post article by Hollie Shaw (2015) “one of the thorniest issues for retailers is figuring out how to deal with e-commerce returns, with 95 per cent of those surveyed in a recent HRC study saying that their biggest issue in transforming the supply chain is mitigating the costs of returns, which can run as high as 30 per cent of online orders.” These retailers, however, feel pressure to create an online presence nonetheless because of the threat of Amazon.com Incorporated and other online retail giants. Other cited cost impediments in online retail trade were the difficulty of ensuring the fulfilment of an online order from the closest location. Hence, it is not surprising that 55 per cent of retailers reported having “separate fulfilment facilities for stores and online deliveries,” which creates additional capital costs.

Hence, further research is needed to definitively confirm whether or not the relative price of ICT capital goods and unexpected costs from ICT investment are important determinants of the level and growth rate of ICT investment per worker by industry in Canada.

v. Regulation

Regulation can impede ICT investment per worker through many channels. Hence, if certain industries in Canada have higher levels of regulation than other industries in Canada, these industries will also likely see lower rates of ICT investment per worker. However, detailed data that measure the extent of regulation by industry are not available in Canada. The OECD does provide data on regulation in the professional services, retail distribution, and the network sector, but these data are limited and do not cover the full economy, thereby limiting the extent of cross-industry comparisons within Canada.

Thus, until data are created that quantify the extent of regulation at the two-digit NAICS levels in Canada, the impact of regulation on ICT investment per worker at the two-digit NAICS level will remain purely anecdotal.

C. Firm Environment

i. Managerial Education

In order to confirm the hypothesis that higher levels of managerial education encourage greater ICT investment per worker, we developed estimates of the educational attainment of managers in Canada based on the 2011 National Household Survey Public Use Microdata File (Table 57).

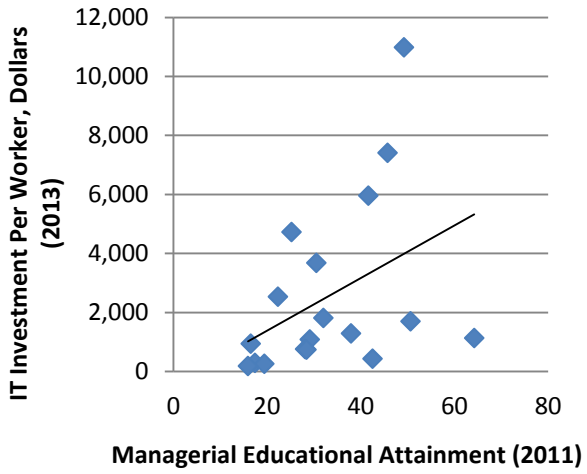
Table 57: Educational Attainment of Management, Canada, Per Cent, 2011

	No certificate	High school diploma	Trades, college, or GEGEP	Bachelor's degree	Master's degree	Earned doctorate
Agriculture, fishing, forestry and hunting	14.8	24.6	33.9	16.1	3.0	0.3
Mining and oil and gas extraction	5.7	20.3	30.4	25.4	11.0	1.5
Utilities	0.9	7.6	30.1	34.4	13.8	1.0
Construction	12.2	24.3	41.6	13.5	2.4	0.0
Manufacturing	6.7	20.8	30.4	23.3	7.8	0.9
Wholesale trade	6.9	25.8	27.3	24.1	6.0	0.4
Retail trade	10.7	36.0	29.7	13.5	2.8	0.2
Transportation and warehousing	9.8	31.2	29.1	16.7	5.1	0.5
Information and cultural industries	2.4	17.3	26.4	31.3	9.8	0.5
Finance and insurance and management of companies and enterprises	1.7	17.9	21.6	32.4	12.9	0.4
Real estate and rental and leasing	5.9	21.0	35.5	20.3	4.3	0.6
Professional, scientific and technical services	1.2	12.4	23.9	34.2	14.5	1.9
Administrative and support, waste management and remediation services	7.9	24.8	28.5	22.2	6.4	0.5
Educational services	0.7	7.2	12.5	30.0	30.5	3.7
Health care and social assistance	2.3	9.8	30.7	26.5	14.6	1.4
Arts, entertainment and recreation	5.9	21.7	36.1	22.0	5.8	0.3
Accommodation and food services	12.0	34.2	29.3	14.7	2.6	0.1
Other services (except public administration)	6.5	18.8	36.9	20.0	8.1	0.3
All industries	6.7	23.0	28.8	22.5	8.5	0.7

Source: CSLS estimates based on the NHS PUMF.

According to Table 57, educational services had the highest share of managers with a university education (defined as a Bachelor's degree, Master's degree or Doctorate degree) at 64.2 per cent. This industry was followed by professional, scientific and technical services (50.6 per cent) and utilities (49.2 per cent). At the lower end, only 15.9 per cent of construction workers had a university education, followed by retail trade (16.5 per cent) and accommodation and food services (17.4 per cent).

Chart 22: Correlation of Managerial Educational Attainment and IT Investment Per Worker, Canada



Note: Managerial educational attainment is the sum of the share of managers with a Bachelor's, Master's or Doctorate degree.
Source: CSLS calculations based on Table 46 and Table 57.

If the hypothesis that managerial education is correct, educational services, professional, scientific and technical services, and utilities should have higher levels of IT investment per worker, while construction, retail trade and accommodation and food services should have lower levels of educational attainment.

Many of these predictions are borne out by the data. Construction and accommodation and food services have two of the lowest levels of IT investment per worker in 2013, while utilities has one of the highest levels of IT investment per worker. A simple correlation exercise for 18 industries with IT investment per worker in 2013 and managerial education at or above the Bachelor's level in 2011 shows the expected relationship: a positive correlation coefficient of 0.41 (R^2=0.17). However, without controls, this cannot be considered a definitive conclusion.

ii. Risk Aversion

Risk aversion could explain differences in ICT investment per worker by industry within Canada. For example, if the distribution of risk aversion is the same across all industries, then risk aversion will have no impact. However, if firms in certain industries are on average more risk averse than firms in other industries, then IT investment per worker may be affected.

However, without underlying data on the risk aversion or conservatism of management in Canadian industries, it is impossible to test this theory. Nevertheless, with further research, it would be possible to determine whether different industries in Canada display different behaviour at the aggregate level, and whether this differential behaviour has impacts on ICT investment per worker.

For example, if management in finance and insurance is less risk averse than management in professional, scientific and technical services in Canada, then it is quite possible that risk aversion could be a potential explanation for the vast differences in ICT investment per worker in these two industries. Unfortunately, this theory is not testable as it stands. Hence, it is unclear whether this variable has any relevance for explaining differences in ICT investment patterns by industry in Canada.

iii. Profits

Theoretically, profits can affect ICT investment per worker in both directions. In particular, excess profits can encourage additional ICT investment per worker because there are supplementary financial resources that can be allocated to ICT investment per worker without undue budgetary stress. However, excess profits may also indicate less competition. When firms are protected against competition, they have less incentive to innovate and increase productivity, and thereby, less incentive to invest in ICT. The overall impact of profits is therefore ambiguous.

Given that different industries have different market sizes, profits are measured as a share of GDP in this section of the report. Over the 2002-2010 period, the industry with the highest average share of profits in GDP was finance and insurance (11.47 per cent) (Table 58). Oil and gas extraction and support activities and agriculture, fishing, forestry and hunting had the next highest average shares of profits in GDP with 10.94 per cent and 3.42 per cent respectively.

The industry with the lowest average profits as a share of GDP was educational services with 0.02 per cent. Arts, entertainment and recreation had the next lowest average with 0.04 per cent, followed by accommodation and food services (0.12 per cent).

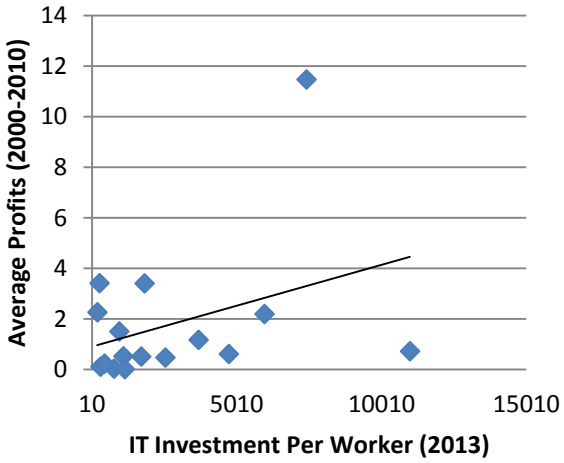
Table 58: Average Profits as a Share of GDP by Industry, Canada, Per Cent, 2000- 2010

Agriculture, fishing, forestry and hunting	3.42
Mining, except oil and gas	2.58
Oil and gas extraction and support activities	10.94
Utilities	0.73
Construction	2.27
Manufacturing	3.41
Wholesale trade	1.18
Retail trade	1.51
Transportation and warehousing	0.48
Information and cultural industries	2.20
Real estate and rental and leasing	0.62
Professional, scientific and technical services	0.52
Management of companies and enterprises	22.52
Administrative and support, waste management and remediation	0.53
Educational services	0.02
Health care and social assistance	0.24
Arts, entertainment and recreation	0.04
Accommodation and food services	0.12
Finance and insurance	11.47
Total economy	3.31

Source: CSLS calculations based on CANSIM 187-0001.

Unfortunately, since profits ambiguously impact IT investment per worker, further research is needed to clarify the relationship between profits and ICT investment per worker before any analysis of the available data can be performed at the industry level in Canada.

Chart 23: Correlation of Profits and IT Investment Per Worker, Canada



Source: CSLS calculations based on Table 46 and Table 58.

A simple correlation exercise of IT investment per worker at the industry level and the average share of profits in GDP in Canada for 16 industries returns a correlation coefficient of 0.35, which suggests that as the share of profits in GDP increases, IT investment per worker increases. This implies that increasing profits as a share of GDP may be good for IT investment per worker. However, without controls, this simple correlation cannot provide any definitive answers.

iv. Firm Creation Rates

Consistently high levels of firm creation rates are believed to be an important determinant of ICT investment since firms that are entering the market are typically more innovative and risk-loving, especially concerning ICT. Hence, if certain industries in Canada have higher firm entry rates, then these industries would also likely have higher ICT investment per worker, *ceteris paribus*.

In 2013, transportation and warehousing had the highest entry rate, followed by professional, scientific and technical services, and construction (Table 59). According to the prediction above, these three industries should have relatively higher levels of ICT investment per worker in 2013. On the other end of the distribution, wholesale trade, manufacturing, and other services (except public administration) had the lowest entry rates. These three industries should therefore have relatively low levels of ICT investment per worker.

Interestingly, the hypothesis is not largely borne out by the data. Professional, scientific and technical services did have relatively higher computer investment per worker in 2013, but only average software investment per worker. Moreover, none of the other predictions appear to be confirmed by the IT investment figures.

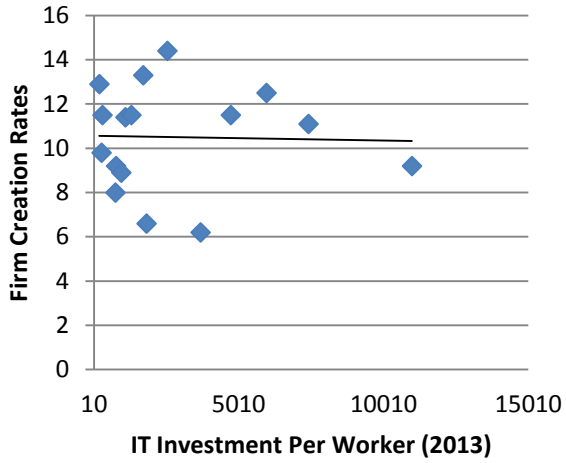
Thus, it appears that firm creation rates are not capable of explaining differences in ICT investment per worker across industries within Canada. These results, however, cannot be deemed conclusive. There could be many other factors that are causing the equivocal relationship between firm creation rates and ICT investment per worker. Further research would need to be undertaken on a larger array of data with controls for other potential influences to fully determine the extent to which firm creation rates affect IT investment per worker at the industry level in Canada.

Table 59: Entry Rates by Industry, Number of Entrants Relative to Number of Active Employer Businesses in the Private Sector, Canada, Per Cent, 2002 and 2013

	2002	2013	2002-2013
Agriculture, fishing, forestry and hunting	11.0	9.8	-1.2
Mining and oil and gas extraction	13.1	11.5	-1.6
Utilities	9.3	9.2	-0.1
Construction	14.6	12.9	-1.7
Manufacturing	8.5	6.6	-1.9
Wholesale trade	9.5	6.2	-3.3
Retail trade	10.8	8.9	-1.9
Transportation and warehousing	14.4	14.4	0.0
Information and cultural industries	14.3	12.5	-1.8
Finance and insurance	12.0	11.1	-0.9
Real estate and rental and leasing	13.6	11.5	-2.1
Professional, scientific and technical services	15.8	13.3	-2.5
Management of companies and enterprises	14.1	10.0	-4.1
Administrative and support, waste management and remediation services	15.2	11.4	-3.8
Arts, entertainment and recreation	12.5	9.2	-3.3
Accommodation and food services	14.9	11.5	-3.4
Other services (except public administration)	13.6	8.0	-5.6
Private sector	14.0	12.7	-1.3

Note: the denominator used in the calculation of entry rates is the average number of active businesses in the previous and current years.
Source: CANSIM 527-0001.

Chart 24: Correlation of Firm Creation Rates and IT Investment Per Worker, Canada, 2013



Source: CSLS calculations based on Table 46 and Table 59.

A simple correlation exercise of IT investment per worker at the industry level and firm creation rates for 16 industries returns a correlation coefficient of -0.03, which suggests that as the rate of firm creation increases, IT investment per worker decreases. However, without controls, this simple correlation cannot provide any definitive answers.

v. Firm Size

It has been shown that small- and medium- sized enterprises (SMEs) invest less in ICT than larger firms (Jarrett, Carey and Luu, 2015). Hence, if certain industries in Canada have a higher share of SMEs than other industries, it can be expected that all else constant, these industries would invest less in ICT. One way to measure firm size by industry is to determine the share of employment in firm size categories. However, there can be many firm size categories. To simplify the analysis, a firm size index has been developed.

The firm size index was created by assigning values to the categories of employment by firm size. The category of firms with 0 to 4 employees was given a value of 1; the category of firms with 5 to 19 employees was given a value 2; the category of firms with 20 to 99 employees was given a value of 3; the category of firms with 100 to 499 employees was given a value of 4; and the category of firms with 500 or more employees was given a value of 5. The shares of employment in each of these categories were multiplied by these values and aggregated to develop the index. Hence, an industry has more SMEs the closer its index to one.

Table 60: Employment Shares and Index of Employment by Firm Size, Canada, Two-Digit NAICS Industries, 2002 and 2012

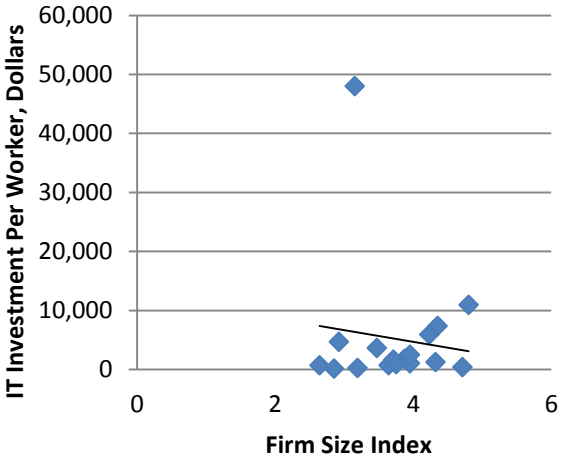
	Index of Firm Size		Share of Employment (2013)	
	2002	2013	20 employees or less	500 employees or more
Forestry, logging and support	n/a	2.67	47.8	11.2
Mining, quarrying, and oil and gas extraction	4.11	4.32	9.7	65.9
Utilities	4.81	4.80	2.1	88.8
Construction	2.63	2.85	42.7	14.8
Manufacturing	3.97	3.87	12.7	38.4
Wholesale trade	3.33	3.47	23.8	27.7
Retail trade	3.58	3.75	20.5	45.0
Transportation and warehousing	3.89	3.95	18.1	54.0
Information and cultural industries	4.30	4.23	11.3	61.8
Finance and insurance	4.26	4.35	10.1	69.1
Real estate and renting and leasing	3.03	2.92	42.5	20.1
Management of companies and enterprises		3.15	37.2	27.9
Professional, scientific and technical services	3.05	3.71	22.1	43.5
Educational services	4.71	3.75	20.0	40.8
Health care and social assistance	3.91	4.71	3.5	83.8
Administrative and support, waste management and remediation services	3.66	3.95	18.6	52.2
Arts, entertainment and recreation	3.48	3.64	20.0	35.6
Accommodation and food services	3.12	3.19	26.5	16.2
Other services (except public administration)	2.60	2.64	51.4	10.6
Total economy	3.75	3.79	20.3	45.2

Note: "n/a" means not available.
Source: CSLS calculations based on CANSIM 281-0042.

In 2013, utilities had the highest firm size index (4.80), followed by health care and social assistance (4.71). At the bottom end of the distribution were other services (except public administration) and forestry, logging and support (2.64 and 2.67 respectively). This suggests utilities should have higher ICT investment per worker, as should health care and social assistance, while other services (except public administration) and forestry, logging and support should have lower levels of ICT investment per worker.

It appears that IT investment per worker data confirm the predictions for utilities and forestry, logging and support, but other services (except public administration) and health care and social assistance do not have the predicted levels of ICT investment per worker. A simple correlation exercise of the firm size index in 2013 and IT investment per worker in 2013 for 18 industries with the presents results contrary to predictions: a negative correlation coefficient of -0.11 (R^2=0.01). However, if we exclude management of companies and enterprises from the correlation, the correlation coefficient is 0.46 (R^2=0.21), which suggests that the hypothesis may be correct.

Chart 25: Correlation of Firm Size and IT Investment Per Worker, Canada, 2013



Source: CSLS calculations based on Table 46 and Table 60.

Hence, it appears that the firm size hypothesis is not validated by the data for absolute levels of IT investment per worker. However, to appropriately and definitively confirm this explanation for differences in ICT investment per worker by industry in Canada, it would be necessary to control for other factors that influence ICT investment per worker.

D. Conclusion

The above discussion highlighted potential explanations for the differing levels of ICT investment per worker across industries within Canada.

It is important to point out that the occupational mix of an industry is likely the largest determinant of the levels of ICT investment per worker. Each particular industry needs a certain number of workers in each type of occupation, and each type of occupation only requires a certain amount of ICT investment per worker. For example, the construction industry requires a lot of trades workers, and trades workers do not need a lot of ICT investment to perform their duties. In contrast, workers in information and cultural industries are likely white collar workers, who will require greater levels of ICT investment to perform their duties.

Even though differences in ICT investment per worker across industries in Canada are likely due to the occupational mix of each particular industry, this section undertook the task of looking at different explanations for the levels of IT investment per worker seen in 2013 in 20 two-digit NAICS industries. Table 61 provides a summary of the results.

The essential conclusion of this section is that educational attainment (a proxy for ICT skills), unionization (a proxy for workplace reorganization), input prices (as defined by nominal labour compensation per hour), managerial education, and firm size all offer potential explanations for the observed differences in IT investment per worker by industry within Canada.

Further research would be needed to determine the importance of each of these factors. In addition, it would be worthwhile to attempt to find data to confirm whether or not other explanations, such as competitive intensity, regulation and risk aversion, can offer any insight into differences in IT investment per worker at the industry level.

Table 61: Summary of Explanations for Differing Levels of IT Investment Per Worker By Industry in Canada

Explanation	Evaluation	Reason
Educational Attainment	Plausible	*Absolute levels:* industries with low levels of educational attainment seemed to have low levels of IT investment per worker. Industries with high levels of educational attainment did not necessarily have high levels of IT investment per worker. The hypothesis thus seems stronger at lower levels of educational attainment. *Growth rates:* it is unlikely that growth rates of educational attainment can explain differing growth rates of ICT investment per worker.
Unionization	Plausible	*Absolute levels*: health care and social assistance confirmed the hypothesis that high levels of unionization lead to low levels of IT investment per worker, but utilities, professional, scientific and technical services, and accommodation and food services did not corroborate the hypothesis. A simple correlation exercise returned a correlation coefficient of 0.36 with an R-squared of 0.13.
Foreign Direct Investment	Unclear	The relationship between foreign direct investment and ICT investment per worker is ambiguous.
Taxes	Unlikely	*Absolute levels:* construction confirmed the hypothesis as it had high levels of taxation and low levels of IT investment per worker, but wholesale trade and retail trade presented cases against the hypothesis.
Competitive Intensity	Unclear	There are no data on competitive intensity at the industry level in Canada.
Input Prices and Unexpected Costs	Plausible	*Absolute levels:* accommodation and food services, utilities and information and cultural industries all corroborate the hypothesis. A simple correlation exercise returned a correlation coefficient of 0.68 with an R-squared of 0.47. *Growth rates:* it does not appear that growth rates of labour compensation can explain growth rates of IT investment per worker.
Regulation	Unclear	There are no data on regulation at the industry level in Canada.
Managerial Education	Plausible	*Absolute levels:* construction, accommodation and food services, and utilities all offered confirmation of the hypothesis. A simple correlation exercise returned a correlation coefficient of 0.41 with an R-squared of 0.17.
Risk Aversion	Unclear	There are no data on risk aversion at the industry level in Canada.
Profits	Unclear	There is no clear relationship between profits and ICT investment per worker.
Firm Creation Rate	Unlikely	*Absolute levels:* The hypothesis that higher rates of firm creation will lead to higher levels of ICT investment per worker was not borne out in the data.
Firm Size	Plausible	*Absolute levels:* Utilities and forestry, logging and support offered confirmation that larger firms have higher levels of ICT investment per worker, while smaller firms have lower levels of ICT investment per worker, but health care and social assistance offered evidence to the contrary.

Source: CSLS.

VIII. Policy Implications

Since about one half of the business sector Canada-US IT investment per worker gap is concentrated in information and cultural industries and professional, scientific and technical services, with a further quarter concentrated in wholesale trade and manufacturing, it would make the most sense to implement policies that aim to specifically influence the level and growth rate of IT investment in these industries. However, encouraging investment at the industry level is a much more complex task and it is often harder to make industry-specific policies politically feasible. Fortunately, general policies that help encourage investment in IT at the aggregate level will likely have an impact on IT investment in information and cultural industries and professional, scientific and technical services. Hence, this section will discuss several general policies that may increase IT investment in these industries.

In particular, it was shown that lower levels of managerial education in Canada relative to the United States could explain part of the IT investment per worker gap. Hence, policies that help boost educational attainment and IT skills in Canada should be encouraged, including the:

- modification of the tax treatment of employee training: the complementarity of ICT and technical knowledge requires policy makers to act to ensure a steady supply of qualified workers is available to fill technical jobs. The best way to achieve this is for firms themselves to train employees according to job specifications, but there are very few incentives for firms to behave this way because employees are not definitively attached to an employer; they may quit after being trained and the firm will subsequently lose its investment in human capital. Hence, it would be possible to modify the tax treatment of employee training, so that it resembles what is done for physical capital or R&D; that is, give allowances for depreciating human capital.

- creation and promotion of programs for ICT skills: to address the issue of under-investment in workplace training, it would be possible to provide incentives for workers to obtain more qualifications by creating a more thorough certification system. It is believed that if workers have a way to certify their skill level, which would be recognized by employers, they would be more willing to invest their own resources in learning new ICT skills.

- modification of higher education systems: two types of programs might help alleviate problems of ICT literacy in the workplace: (1) short cycle programs, developed based on the needs of the labour market and corporate sector input, could provide applied courses that advance the ICT literacy of graduates from higher education systems, and (2) school-to-work programs, like apprenticeships and co-op programs, could be more generalized, and perhaps mandatory.

- more flexible college training: increasing the availability of part-time studies may increase adult enrolment, and thereby ICT literacy levels.

Martin (2007:1) supports the case for "ongoing investments in post secondary education and creative solutions to the training needs of current managers and owners" as this will likely

help address the issues surrounding the "under education of managers and owners in SMEs" and thereby increase the "benefits of ICT on productivity." In particular, "continued development of programs by colleges, universities and others to deliver training and education that enhances managers' and owners' skills to assess the costs and benefits of ICT in their businesses; and longer term, a general increase in the educational attainment of Canadians, will be a positive development for the management of SMEs" (Martin, 2007:1).

Finally, it was shown that there were a greater proportion of small- and medium-sized firms in professional, scientific and technical services and information and cultural industries in Canada than the United States. This may also partially explain the gap in IT investment per worker between Canada and the United States in these industries. Hence, the adoption of IT investment in small- and medium-sized enterprises should be encouraged by implementing policies that (Martin, 2007:1):

- establish the appropriate communication networks or support organizations: these types of communication networks and support organizations will ensure a broad dispersion of information concerning ICT investment and help increase ICT investment in SMEs. In particular, the appropriate communication networks and support organizations would help SMEs determine the ICT investment needed to increase the efficiency and productivity of their business, while providing support for those SMEs who need troubleshooting assistance or advice on how to effectively use their investments.

- create "greater competitive pressure among suppliers through smarter regulation" of ICT industries: a greater competitive pressure would "enhance the capability of ICT suppliers to meet the needs of Canadian customers, including SMEs."

- encourage greater competitive intensity among SMEs: a greater competitive intensity among SMEs will encourage the adoption of ICT.

- support a "greater effort and more customized solutions to educating SMEs on the costs and benefits of ICT": "the nature of SMEs means that technology suppliers will [need to] play [a] significant role in increasing ICT adoption. In particular, "capitalizing on the potential of greater adoption of ICT by SMEs will require suppliers to create more jobs in selling and project management, [but] suppliers will also need to develop more economical ways to reach SME potential customers and to develop more standardized implementation processes, which may entail greater use of Internet enabled selling and more packaged solutions".

- create special tax credits aimed at assisting SME adoption of IT: SMEs tend not to "have the complexity of business operations for maximum benefits from ICT solutions [and]…they lack the financial resources to implement such solutions". Nevertheless, Martin (2007:1) argues that "non-financial barriers are more critical and that tax reform needs to focus instead on reducing overall rates on business investment."

Many of the above policy recommendations were supported and seconded by other authors and organizations, including Digital Canada 150 (2010) and the Standing Committee on

Industry, Science and Technology (2011). One of the most important recommendations from the latter is increasing the quality of information available regarding ICT adoption and use by Canadian SMEs and the information on the business impact of such adoption and use.

Thus, in general, we should promote policies that increase ICT investment including broad framework policies, such as low and stable inflation, sound fiscal policy, policies that ensure markets are competitive, and openness to international trade and foreign investment. Other policies that directly affect investment, such as low interest rates and low business taxes, should equally be supported. In addition, government programs that provide information to firms to facilitate the adoption of advanced technologies and business practices should be encouraged (Sharpe, 2006).

However, industry-specific policies could also be important in increasing IT investment per worker in information and cultural industries and professional, scientific and technical services. For example, since it was shown that regulation in professional, scientific and technical services is much higher in Canada than in the United States, an inquiry into regulation in Canada in accounting, architectural, legal and engineering services might help highlight which regulations are important for safety and quality control and which regulations simply deter competitive intensity, increase barriers to entry, and limit access to capital, subsequently reducing IT investment levels.

As this report (and research by many other authors and organizations) has shown, increasing ICT investment per worker in Canada will increase productivity performance in Canada which will subsequently increase Canadian living standards.

IX. Further Research Areas and Data Needs

This section highlights potential areas of future research, including:

- A comparison with the United States has shown that Canada is greatly underinvesting in IT in two specific industries: information and cultural industries and professional, scientific and technical services. However, relative to other OECD countries, this may not be the case. Hence, it may be worthwhile to undertake OECD-level comparisons of industries to determine the actual extent to which Canada is underinvesting in ICT by industry.

- Given that industry structure was deemed unimportant at the two-digit level, it would be interesting to determine if industry structure is important at the three-digit level. The United States BEA provides investment in ICT at the three-digit level for selected industries (although the number of three-digit industries is severely reduced from the actual total due to arbitrary groupings of three-digit industries for confidentiality reasons). By combining this information with employment at the three-digit level in Canada, it would be possible to determine ICT investment in the United States at the two-digit level under a Canadian employment structure, thereby demonstrating how much of the ICT investment per worker gap is due to industry structure.

- It was assumed throughout this report that the correlation between ICT investment and innovation is strong. Nevertheless, it is quite possible that small investments in ICT may result in extremely innovative activity. For example, the purchase of low-cost software, like Microsoft Excel, could completely change the dynamic of many small firms, and result in increased innovative activity and productivity. The likelihood of an apparent lack of a relationship between ICT investment and innovation is especially an issue because of decreasing ICT prices. Hence, further research into the correlation between ICT investment and innovative activity is required.

- This report assumes that it is optimal to close the Canada-US IT investment per worker gap in the business sector. However, we should consider the possibility that IT investment by industry in Canada may already currently be at its optimal level and that aiming for US-comparable IT investment levels may be overshooting Canadian IT requirements. More specifically, each country has its own specific business environment and Canada's current level of IT investment per worker at the industry level may actually reflect optimal levels under the current circumstances, or alternatively, the United States could be overinvesting in IT at the industry level. Hence, examining whether or not IT investment in Canada is currently at an optimal level will help determine if policies should be implemented to boost IT investment in Canada or not.

- It would be informative to attempt to develop a model for IT investment based on the explanations discussed in this report. A simple linear multiple regression was attempted during the development of this report, but a number of obstacles related to data limitations at the industry level prevented a complete analysis. A study that focuses solely on developing a methodology for estimating IT investment per worker in Canada and the

United States based on the factors discussed in this report might help highlight what are the most important explanations for the Canada-US IT investment per worker gap. This study could consider accessing firm-level data from Statistics Canada to perform its analysis.

- This report highlights that software investment in information and cultural industries and professional, scientific and technical services is the main driver behind the Canada-US IT investment per worker gap in the business sector. Hence, it would be highly informative to survey businesses or interview key informants in these two industries to develop a more detailed understanding of barriers to software investment.

- It was shown in this report that own-account software comparisons between Canada and the United States present a number of methodological challenges. Given the importance of own-account software in information and cultural industries and professional, scientific and technical services to the IT investment per worker gap in the business sector, it should be a priority to develop a deeper understanding of this component of software.

- Software, communications equipment and computer equipment are increasingly embodied in other capital goods (e.g. navigational systems are embodied in cars). Hence, the relevance of the analysis of ICT investment per worker weakens because a larger component of ICT investment is masked in other goods. This issue should be investigated in more detail to determine to what extent embodied ICT is affecting ICT investment.

- It has been shown that in 2013, computers and telecommunications equipment represented approximately 18.2 per cent of all machinery and equipment. Since these two components of ICT represent only about one-fifth of total M&E and purchasing power parities for these two goods may differ compared to that of other M&E goods, it is possible that the purchasing power parity proxy of M&E is causing measurement errors. Furthermore, since software is not included in M&E, these differences could be exacerbated. This issue should be examined in more detail in the future.

- In 2013, IT investment as a proportion of GDP in the business sector was 2.40 per cent in the United States and 1.80 per cent in Canada. If Canada had an IT investment share in GDP of 2.40 per cent, IT investment per worker in US dollars would be $2,322 (up from $1,744), leading to a relative Canada-US IT investment per worker of 69.3 per cent (up from 52.0 per cent). This means that roughly 17.2 percentage points of the 48.0 percentage point gap is the result of lower income in Canada (i.e. 35.9 per cent). Hence, in many ways, this metric is better for comparing IT performance and future ICT research should likely give greater attention to ICT intensity as measured by the ICT share of GDP.

- This paper has taken an approach that focuses mostly on the demand side for ICT investment. In future research, it would be informative to investigate ICT supply in Canada. It has been suggested that ICT supply in Canada could be lower due to language requirements and other barriers to importation.

- Cloud computing is another area where future research is needed. In particular, tracking IT investment and IT use in the host country is exceptionally difficult if firms in the host country are using services based in a cloud in the United States. As Robert Atkinson (2014) has noted, cloud computing could have profound effects on ICT investment levels.[54] In particular, cloud computing and related services imply that companies will invest less in IT and instead opt to use IT services. At this point, the impact of this shift on IT investment is unclear, depending entirely upon the location of the host for the IT services. If IT services hosts are not located in the country where the service is being provided, IT investment levels will fall at the aggregate level and at the industry level. If IT services hosts are mainly in the country where the services are being used, then IT investment at the aggregate level may remain unchanged or increase, while the distribution of IT investment at the industry level could undergo massive shifts. Whatever the outcome for IT investment at the aggregate and industry level, however, the shift from IT investment to cloud computing and related services implies an increasing need to change the focus of analysis from IT investment to the adoption and use of IT, including purchases of services related to cloud computing. By focusing on ICT use instead of ICT investment, we would also be controlling for any possible issues that might arise from companies and businesses that lease their ICT goods and services.

As was highlighted a number of times throughout the report, there are a number of potential explanations for the Canada-US IT investment per worker gap that could not be analyzed due to a dearth of data. Below we have highlighted data needs that would need to be met in both Canada and the United States using similar methodologies in order to better understand the drivers and determinants of IT investment per worker at the industry level:

- risk aversion measures by industry;
- IT investment at the three-digit NAICS level;
- concentration ratios by industry;
- purchasing power parity values for computer investment and software investment;
- marginal effective tax rates by industry for IT investment;
- establishment entry rates in Canada by industry or firm entry rates in the United States by industry;
- labour force IT skill levels by industry;
- IT set-up costs and IT running costs by industry; and
- proxies for the readiness of firms within an industry to adapt and effectively use IT.

[54] The *Economist* (2015) has recently highlighted the significant changes that have been occurring in the IT industry in recent years.

X. Conclusion

The level of information technology (IT) investment per worker in the Canadian business sector in 2013 was 52.0 per cent of that in the US business sector, which implies a gap of 48.0 percentage points. When broken down by industry, 11 of 19 industries had less IT investment per worker than their US counterparts in 2013, leaving only 8 of 19 industries with higher levels of IT investment per worker.

Of the 11 industries with less IT investment per worker in Canada than in the United States, professional, scientific and technical services and information and cultural industries had the largest gaps. In particular, Canada invested $5,309 in IT per worker in 2013 in information and cultural industries, while the United States invested $20,417 in IT per worker.

The professional, scientific and technical services industry also showed large gaps with $1,520 in IT investment per worker in Canada in 2013 compared to $5,272 in the United States. These figures lead to very small relative Canada-US IT investment per worker levels: 26.0 per cent in information and cultural industries and 28.8 per cent in professional, scientific and technical services. No other two-digit NAICS industries had a relative level of Canada-US IT investment per worker below 30.0 per cent.

If these two industries hypothetically had the same levels of IT investment per worker as their US counterparts in 2013, the IT investment per worker gap in the business sector would close by 23.8 percentage points, or 49.5 per cent.

Given the large contributions from professional, scientific and technical services and information and cultural industries, this report has attempted to develop explanations for the IT investment per worker gap in these two industries.

It is important to point out, however, that differences in income per capita can explain a significant part of the business sector gap in IT investment per worker between Canada and the United States. By roughly controlling for income with IT investment as a share of GDP, we find that IT investment as a share of GDP explains 17.2 percentage points, or 35.9 per cent, of the business sector gap in IT investment per worker in 2013.

This report undertakes research concerning information and cultural industries and professional and scientific and technical services. The measurement section concludes by suggesting that differences in definitions and methodologies are unlikely to explain the computer investment per worker gap, but that they may be important in explaining differences in software investment per worker, especially own-account software investment per worker. Given that own-account software represents nearly one-half of software investment in professional, scientific and technical services and nearly one-quarter of software investment in information and cultural industries, own-account software in these two industries is responsible for 19.6 per cent of the total IT investment per worker gap in the business sector in 2013.

Table 62: Contributions to the Canada-US Business Sector IT Investment Gap by Income Differentials, Industry, and IT Component, Per Cent and Percentage Points, 2013

	Percentage Points	Per Cent
Canada-US IT Investment Per Worker Business Sector Gap	48.0	100.0
Impact of Income Controls on Canada-US Business Sector IT Investment Per Worker Gap	17.2	35.9
Industry Contributions to the Canada-US Business Sector IT Investment Per Worker Gap		
Information and cultural industries and professional, scientific and technical services	23.9	49.8
Wholesale trade and manufacturing	11.9	24.8
Other positive contributors*	14.5	30.2
Other negative contributors**	-20.1	-41.9
Software and Computer Contributions to the Canada-US Business Sector IT Investment Per Worker Gap		
Software	44.2	92.1
Computers	3.8	7.9
Software and Computer Contributions at the Industry Level to the Canada-US Business Sector IT Investment Per Worker Gap		
Information and cultural industries	12.8	26.7
Software	11.5	24.0
General purpose software	1.9	4.0
Custom design software and development services	4.4	9.2
Own-account software design and development services	5.2	10.8
Computers	1.3	2.7
Professional, scientific and technical services	11.1	23.1
Software	10.5	21.9
General purpose software	2.0	4.2
Custom design software and development services	4.3	9.0
Own-account software design and development services	4.2	8.8
Computers	0.6	1.3

* Other positive contributors includes management of companies and enterprises; administrative and support, waste management and remediation services; mining and oil and gas extraction; finance and insurance; construction; and retail trade. These are industries with relative Canada-US IT investment per worker levels that are below 100.0 per cent.

** Other negative contributors includes agriculture, fishing, forestry and hunting; accommodation and food services; other services (except public administration); arts, entertainment and recreation; real estate and rental and leasing; utilities; and transportation and warehousing. These are industries with relative Canada-US IT investment per worker levels that are above 100.0 per cent.

Source: CSLS calculations based on CSLS ICT by Industry database, CSLS ICT database from January 2015, US BEA data and Statistics Canada data.

However, it is unlikely that measurement issues account for the entirety of the business sector gap in IT between Canada and the United States. Hence, this report suggests that the three-digit industrial structure, input prices (especially nominal labour compensation per hour), regulation, managerial education, and firm size all offer other plausible explanations for the large IT investment per worker gap in information and cultural industries and professional, scientific and technical services.

- Input prices: nominal labour compensation per hour in Canada was US$31.52 compared to US$58.47 in the United States in information and cultural industries in 2013. This would suggest that employers in the United States have a greater incentive to substitute IT investment for labour than employers in Canada.

- Regulation: OECD data on regulation in professional services suggest that Canada faces stricter policies. This may prevent firms in professional, scientific and technical services from adopting IT investment per worker at the optimal level.

- Managerial education: in professional, scientific and technical services, 48.7 per cent of managers have attained a Bachelor's or Master's degree in Canada relative to 71.2 per cent in the United States. In information and cultural industries, 41.1 per cent of managers in Canada have attained this level of education compared to 52.9 per cent in the United States. This compares to the total economy, where 31.0 per cent of managers in Canada have a Bachelor's or Master's degree compared to 49.0 per cent in the United States.

- Firm size: employment in information and cultural industries is more likely to be concentrated in large firms in the United States (72.5 per cent in firms over 500 people) compared to Canada (65.1 per cent). For professional, scientific and technical services, 87.3 per cent of employment in the United States is in firms with over 500 employees, compared to 46.4 per cent in Canada.

Additional data will need to be developed and further research will need to be undertaken in order to confirm these findings and verify the likelihood of the other explanations that were put forward, such as foreign direct investment, taxes, risk aversion, profits, and firm creation rates. It will also be important to develop better proxies for barriers to workplace reorganization (or the willingness to reorganize the workplace).

In summary, this report finds that information and cultural industries and professional, scientific and technical services accounted for approximately 49.8 per cent of the business sector IT investment per worker gap in 2013, when they only accounted for 13.0 per cent and 17.9 per cent of employment and IT investment in the business sector respectively. Moreover, it was found that software investment in information and cultural industries and professional, scientific and technical services is responsible for 46.1 per cent of the total IT investment per worker gap between Canada and the United States in 2013.

Measurement issues likely account for a significant share of the software investment gap in professional, scientific and technical services, and subsequently, account for a large share of the total IT investment per worker gap. Other explanations, such as human capital, regulation, firm size, managerial education, and labour compensation likely play a smaller role in this industry. In contrast, measurement issues likely account for much less of the information and cultural industries software gap between Canada and the United States. Hence, explanations such as human capital, managerial education, labour compensation and firm size, are more likely to play a larger role in this industry.

This report outlines a number of general policy recommendations that could be implemented to address the explanations for Canada's lower IT investment per worker, including policies to increase IT-related human capital and educational attainment, as well as policies related to increasing IT adoption and use among small- and medium-sized enterprises, which are more prominent in Canada than the United States. This report also suggests industry-specific policies related to regulation in professional, scientific and technical services.

XI. References

Atkinson, Robert D. (2014). "How IT, Including the Cloud and IOT, Can Drive Canadian Economic Growth," Information Technology and Innovation Fund, October 30.

Brynjolfsson, Erik and Lorin Hitt. (2000). "Beyond Computation: Information Technology, Organizational Transformation and Business Performance," *Journal of Economic Perspectives, 14*(4), 23-48.

Bugamelli, Matteo and Patrizio Pagano. (2004). "Barriers to investment in ICT," *Applied Economics, 36*, 2275-2286.

Capeluck, Evan. (2012). *Overview of Developments in ICT Investment in Canada, 2011*. CSLS Research Note 2012-02.

Capeluck, Evan. (2013a). *Canada-US ICT Investment in 2011: The Gap Narrows*. CSLS Research Note 2013-01.

Capeluck, Evan. (2013b). *Overview of Developments in ICT Investment in Canada, 2012*. CSLS Research Note 2012-02.

Cardona, M. T. Kretschmer, and T. Strobel. (2013). "ICT and productivity: conclusions from the empirical literature," *Information Economics and Policy, 25*(3), 109-125.

Centre for the Study of Living Standards. (2008). *The Canada-US ICT Investment Gap in 2007: Narrowing but Progress Still Needed*. CSLS Research Note 2008-01.

Centre for the Study of Living Standards. (2005). *What Explains the Canada-US ICT Investment Intensity Gap?* December 12.

Conference Board of Canada. (2015). *ICT Investment*. http://www.conferenceboard.ca/hcp/details/innovation/ict.aspx

Conway, Paul, Donato de Roas, Guiseppe Nicoletti and Faye Steiner (2006). "Regulation, Competition and Productivity Convergence," OECD Economics Department Working Papers No. 509.

Corrado, Carol. (2015). "The Internet and Productivity: An Interpretation of Recent Trends in US Productivity and ICT Prices," presented at the session on North American Productivity and Competitiveness at the 57th NABE Annual Meeting, October 12-14, 2015, Washington, D.C.

Deloitte. (2013). "The future of productivity: Clear choices for a competitive Canada," The Future of Manufacturing, General Presentation, February 13.

Digital Canada 150. (2010). "Improving Canada's Digital Advantage: Strategies for Sustainable Prosperity," Consultation Paper on a Digital Economy Strategy for Canada. Government of Canada.

Dion, Richard and Robert Fay. (2008). *Understanding Productivity: A Review of Recent Technical Research*. Bank of Canada Discussion Paper 2008-3.

Draca, Mirko, Raffaella Sadun, and John Van Reenan. (2006). "Productivity and ICT: A Review of the Evidence," CEP Discussion paper No. 749, Centre for Economic Performance, LSE.

The Economist. (2015). "Mergers (1): Partly cloudy," The *Economist*, October 17th, 2015.

Garg, Abhinav. (2011). *Cloud Computing for the Financial Services Industry*. Sapient Global Markets Report.

Godsiff, P.J., C.E.A. Mulligan, and Zeynep Gurguc. (2014). *ICT and the Future of Financial Services*. Ericsson Report.

Government of Canada. (2014). *Catalyzing Canada's Digital Economy – Report by the Expert Panel on Digital Technologies and Innovation*. https://www.ic.gc.ca/eic/site/028.nsf/eng/00504.html

Institute for Competitiveness and Prosperity. (2009). *Management Matters*. Working Paper 12.

Jarrett, Peter, David Carey and Corinne Luu. (2015). OECD Structural Mission to Canada, 19-23 October 2013, in Preparation for the 2016 Economic Survey of Canada. OECD.

Jorgenson, Dale. (2001). "Information Technology and the US Economy," *American Economic Review, 91*91), 1-32.

Joregenson, Dale and K. J. Stiroh. (2000). "Raising the Speed Limit: US Economic Growth in the Information Age," *Brookings Papers on Economic Activity,* 125-211.

Martin, Roger L. (2007). "Enhancing the Productivity of Small and Medium Enterprises through Greater Adoption of Information and Communication Technology," Information and Communications Technology Council Reports, March.

Manyika, James, Sree Ramaswamy, Somesh Khanna, Hugo Sarrazin, Gary Pinkus, Guru Sethupathy and Andrew Yaffe (2015). "Digital America: A Tale of the Haves and Have Nots," McKinsey Global Institute report.

Mintz, Jack, Duanjie Chen, Yvan Guillemette and Finn Poschmann. (2005). "The 2005 Tax Competitiveness Report: Unleashing the Canadian Tiger," *C.D. Howe Institute Commentary, No. 216*.

Mintz, Jack and Duanjie Chen. (2012). "2012 Annual Global Tax Competitiveness Ranking – A Canadian Good News Story," *University of Calgary School of Public Policy Research Papers,* 5(28).

Mintz, Jack and Duanjie Chen. (2015). "The 2014 Global Tax Competitiveness Report: A Proposed Business Tax Reform Agenda," *University of Calgary School of Public Policy Research Papers,* 8(4).

Mulligan, C.E.A., Zeynep Gurguc, and Sohrab Mosiri. (2014). *ICT and the Future of Media*. Ericsson Report.

OECD. (2015). "Investment in ICT." *OECD Factbook 2013: Economic, Environmental and Social Statistics*.

Oliner, S. and D. Sichel. (2000). "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives, 14*(4), 3-22.

Ottawa Citizen. (2015). "Technology can aid commercial real estate sector: Report," *Ottawa Citizen,* C10, Wednesday, September 30, 2015.

Pellegrini, Christina. (2015). "Canadian firms lagging on mobile use," *Financial Post,* June 2.

Pilat, D. and E. C. Lee. (2001). "Productivity Growth in ICT-Producing Industries – A Source of Growth Differentials in the OECD?" DSTI/EAS/IND/SWP(2000)3/REV1, OECD STI Working Paper.

Resindorf, Marshall. (2015). "Measuring Industry Contributions to Labour Productivity Change: A New Formula in a Chained Fisher Index Framework," *International Productivity Monitor, 28*(Spring), 3-26.

Sharpe, Andrew. (2014). What *Explains the Canada-US Software Investment Intensity Gap?* CSLS Research Report 2014-04.

Sharpe, Andrew and Vikram, Rai. (2013). *Can the Canada-US ICT Investment Gap Be Explained by Measurement Issues?* CSLS Research Report 2013-03.

Sharpe, Andrew and Brendon Andrews. (2012). *The Canada-US ICT Investment Gap in 2010: The Widening Continues*. CSLS Research Note 2012-01.

Sharpe, Andrew and Dylan Moeller. (2011). *Overview of Developments in ICT Investment in Canada, 2010: Rebounding from the Recession*. CSLS Research Note 2011-02.

Sharpe, Andrew. (2010). *The Canada-US ICT Investment Gap in 2008: Gains in Communications Equipment and Losses in Computers*. CSLS Research Note 2010-01.

Sharpe, Andrew and Ricardo De Avillez. (2010). *Canada-US ICT Investment in 2009: The ICT Investment Per Worker Gap Widens*. CSLS Research Report 2010-08.

Sharpe, Andrew and Jean-Francois Arsenault. (2008). *The Canada-US ICT Investment Gap: An Update*. CSLS Research Report 2008-01.

Sharpe, Andrew. (2006). *The Relationship Between ICT Investment and Productivity in the Canadian Economy: A Review of the Evidence*. CSLS Research Report 2006-05.

Sharpe, Andrew. (2005). *The Diffusion and Adoption of Advanced Technologies in Canada: An Overview of the Issues*. CSLS Research Report 2005-05.

Sharpe, Andrew. (2005). "What Explains the Canada-US ICT Investment Gap?" *International Productivity Monitor, 11*(Fall), 21-38.

Shaw, Hollie. (2015). "Retailers absorb huge costs to compete online," *Financial Post*, Thursday, September 17, 2015, FP6.

Standing Committee on Industry, Science and Technology. (2011). "E-Commerce in Canada: Pursing the Promise," Parliament of Canada Publications.

Statistics Canada. (2007). Capitalization of Software in the National Accounts. http://www.statcan.gc.ca/pub/13-605-x/2003001/concept/2001software-2001logiciel/index-eng.htm

Tenner, Edward. (1996). *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. New York: Alfred A. Knopf.

Thomas, Jasmin. (2015). *An Analysis of the Canada-US ICT Investment Gap: An Update to 2013*. CSLS Research Report 2015-01.

U.K. Department of Trade and Industry. (2004). *Business in the Information Age: The International Benchmarking Study 2004*

Appendix I: ICT Capital Stock

Since investment drives capital stock, this appendix excludes a discussion of capital stock data. In addition, since investment and capital stock are affected by the same drivers and determinants, this section also excludes a discussion of the causes of the different levels of ICT capital stock by industry and by component. Instead, this section will provide ICT capital stock data by industry and by component in a series of charts and tables for the reader's delight. The charts and tables will appear in the same sequence as the charts and tables for IT investment in the main body of the report. The only discussion of drivers and determinants that occurs in this appendix concerns depreciation rates, since depreciation rates are the only factor that affects capital stock, but not investment.

A. ICT Capital Stock Per Worker by Industry in Canada

i. Total ICT Capital Stock Per Worker

a. Absolute Levels

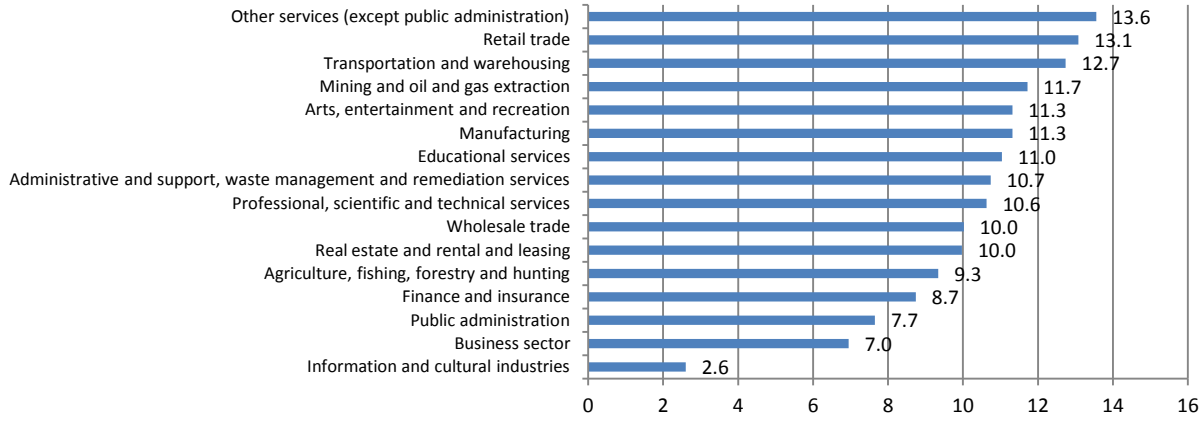
Table 63: Total Nominal ICT Capital Stock Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008, 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	208	545	718	716
Mining and oil and gas extraction	608	2,273	4,794	3,755
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	801	2,211	3,417	3,799
Wholesale trade	1,465	6,744	7,858	8,996
Retail trade	309	1,395	2,032	2,332
Transportation and warehousing	1,020	4,086	5,128	6,671
Information and cultural industries	43,798	62,193	54,172	50,101
Finance and insurance	5,820	13,050	18,780	19,372
Real estate and rental and leasing	4,489	11,157	18,457	12,266
Professional, scientific and technical services	2,262	4,810	3,572	3,662
Management of companies and enterprises	.	64,900	29,877	103,000
Administrative and support, waste management and remediation services	1,222	1,655	2,133	2,881
Educational services	761	1,786	2,194	2,653
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	550	2,774	2,275	2,309
Accommodation and food services	.	.	.	.
Other services (except public administration)	316	1,437	1,665	1,854
Public administration	4,744	11,951	12,164	14,215
Business sector	2,612	5,241	5,780	5,860

Note: "." means that this was suppressed.
Source: CSLS ICT by Industry database.

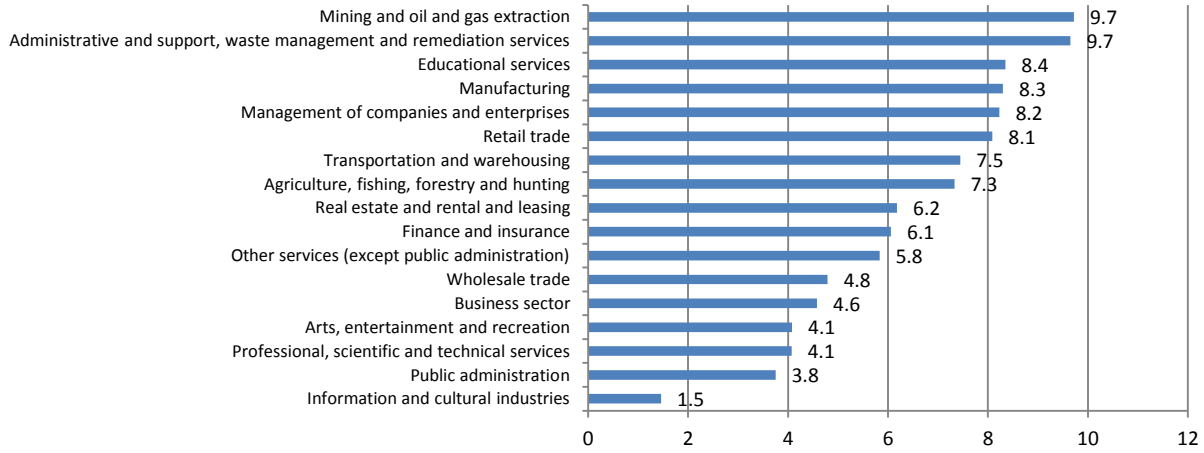
b. Growth Rates

Chart 26: Total Real ICT Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 1987-2013



Source: CSLS database from January 2015.

Chart 27: Total Real ICT Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

ii. Computer Capital Stock Per Worker

a. Absolute Levels

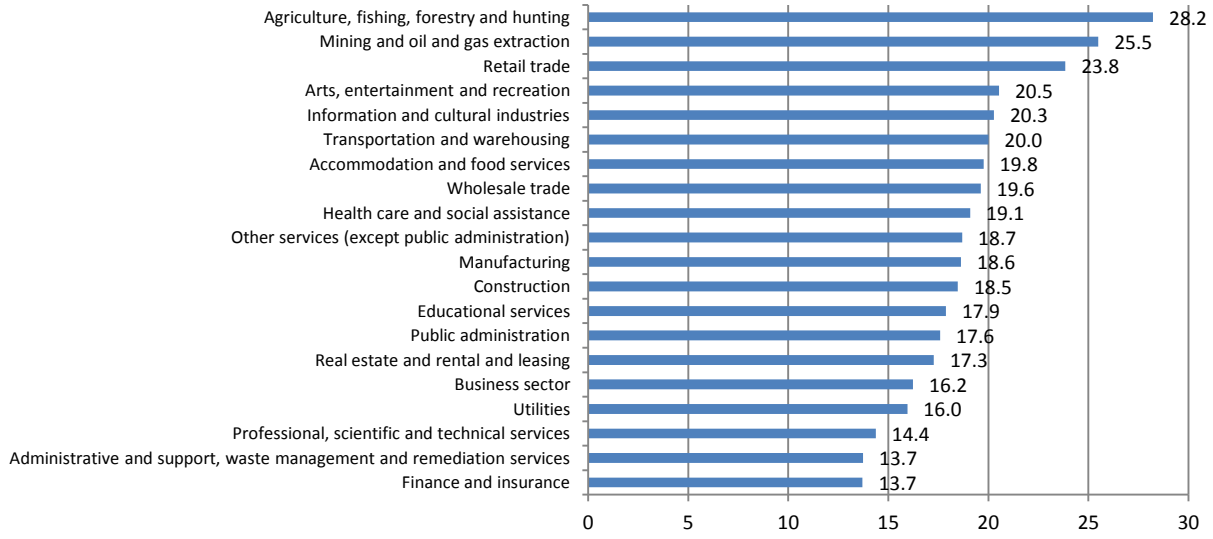
Table 64: Nominal Computer Capital Stock Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008, 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	18	99	263	331
Mining and oil and gas extraction	115	203	2,581	1,363
Utilities	4,334	5,792	3,930	6,360
Construction	113	294	323	290
Manufacturing	315	742	909	844
Wholesale trade	413	1,585	1,416	1,361
Retail trade	78	361	647	631
Transportation and warehousing	362	1,409	1,380	1,288
Information and cultural industries	1,032	1,326	3,899	4,103
Finance and insurance	2,478	3,836	5,076	2,213
Real estate and rental and leasing	2,024	3,908	9,261	4,044
Professional, scientific and technical services	1,620	3,163	1,392	1,665
Management of companies and enterprises	n/a	23,467	8,342	36,538
Administrative and support, waste management and remediation services	721	911	848	649
Educational services	305	706	697	690
Health care and social assistance	87	305	322	267
Arts, entertainment and recreation	189	1,312	1,020	759
Accommodation and food services	79	79	174	276
Other services (except public administration)	183	514	385	501
Public administration	923	2,633	1,777	1,310
Business sector	530	1,163	1,402	1,126

Note: “n/a” means not available.
Source: CSLS ICT by Industry database.

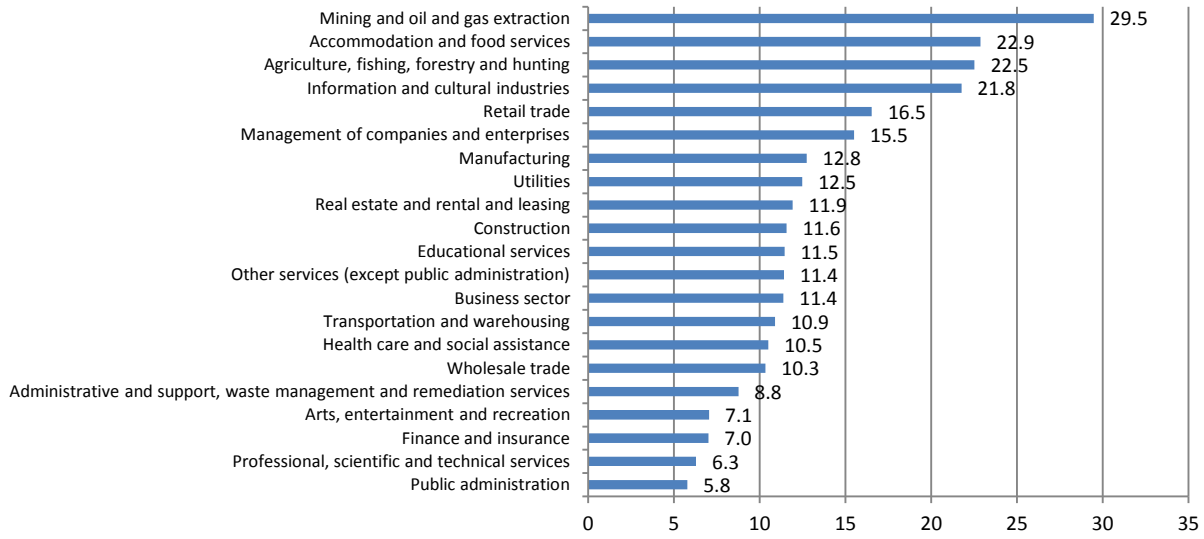
b. Growth Rates

Chart 28: Real Computer Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 1987-2013



Source: CSLS ICT database from January 2015.

Chart 29: Real Computer Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

iii. Communications Investment Per Worker

a. Absolute Levels

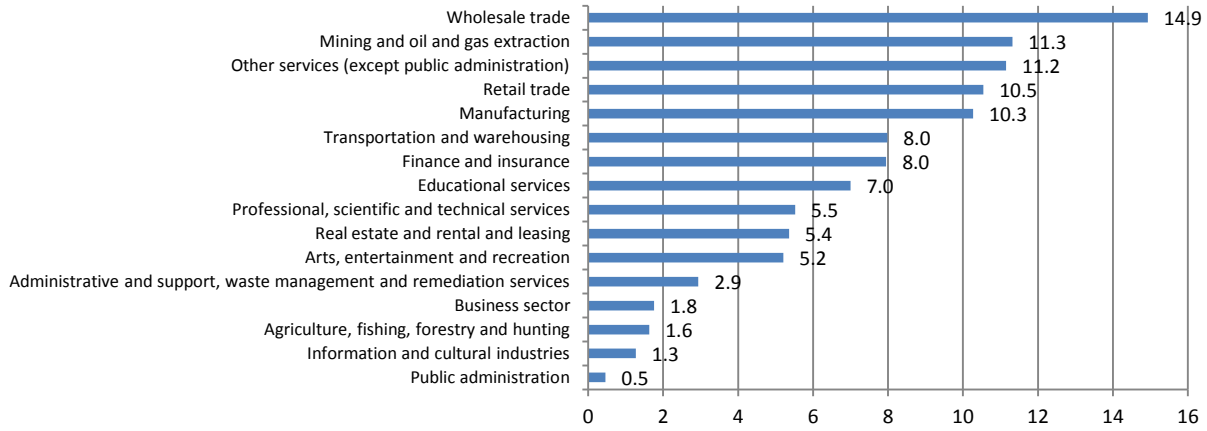
Table 65: Nominal Communications Capital Stock Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008, 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	154	210	161	149
Mining and oil and gas extraction	99	594	680	1,001
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	37	62	326	299
Wholesale trade	19	386	720	444
Retail trade	49	80	311	248
Transportation and warehousing	255	513	684	1,197
Information and cultural industries	42,207	53,606	38,721	36,257
Finance and insurance	355	822	1,691	1,623
Real estate and rental and leasing	575	1,483	1,476	1,396
Professional, scientific and technical services	172	364	621	433
Management of companies and enterprises	n/a	4,567	1,219	2,192
Administrative and support, waste management and remediation services	238	171	290	330
Educational services	64	170	106	229
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	200	862	304	459
Accommodation and food services	.	.	.	.
Other services (except public administration)	23	218	103	227
Public administration	2,371	4,038	1,484	1,670
Business sector	1,180	1,430	1,506	1,484

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

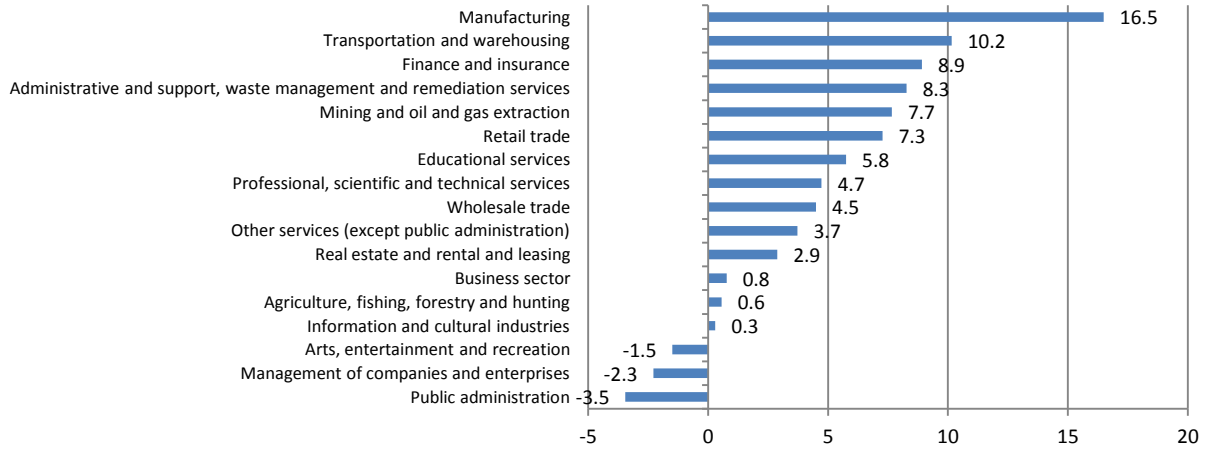
b. Growth Rates

Chart 30: Real Communications Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 1987-2013



Source: CSLS ICT database from January 2015.

Chart 31: Real Communications Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

iv. Software Capital Stock Per Worker

a. Absolute Levels

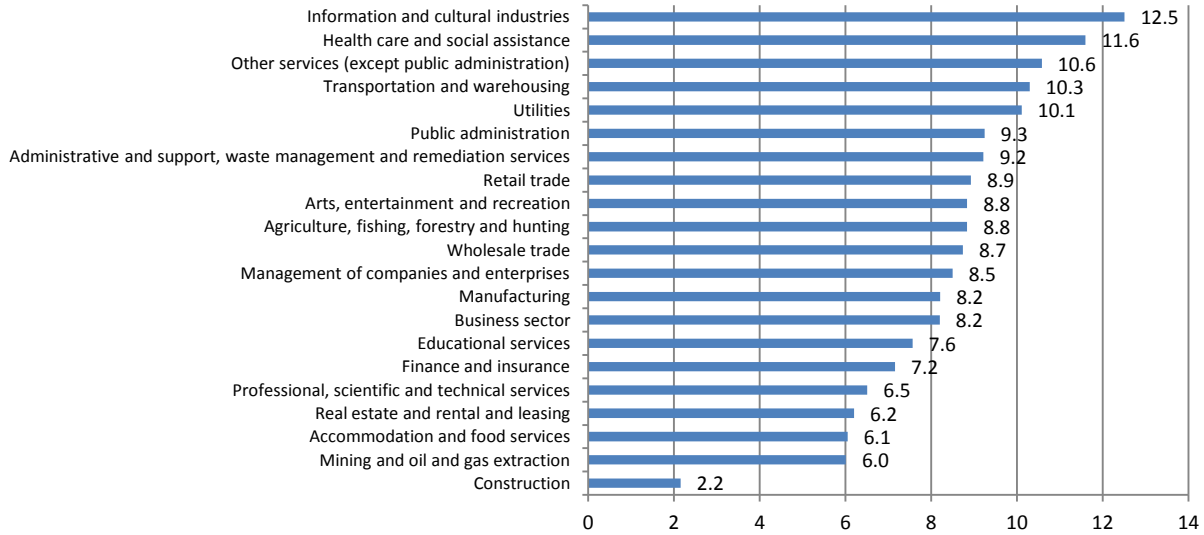
Table 66: Nominal Software Capital Stock Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008, 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	36	236	294	236
Mining and oil and gas extraction	394	1,476	1,533	1,390
Utilities	1,820	9,829	14,260	17,962
Construction	77	175	100	90
Manufacturing	449	1,407	2,182	2,656
Wholesale trade	1,033	4,774	5,722	7,191
Retail trade	210	927	1,265	1,528
Transportation and warehousing	403	2,164	3,064	4,187
Information and cultural industries	559	7,261	11,552	9,741
Finance and insurance	2,987	8,393	12,013	15,537
Real estate and rental and leasing	1,889	5,765	7,720	6,825
Professional, scientific and technical services	469	1,283	1,559	1,563
Management of companies and enterprises	n/a	36,867	20,315	64,269
Administrative and support, waste management and remediation services	262	572	995	1,902
Educational services	391	911	1,391	1,734
Health care and social assistance	71	241	680	826
Arts, entertainment and recreation	162	600	952	1,090
Accommodation and food services	94	192	232	317
Other services (except public administration)	110	706	1,177	1,126
Public administration	1,449	5,280	8,903	11,235
Business sector	516	1,954	2,771	3,205

Note: “n/a” means not available.
Source: CSLS ICT by Industry database.

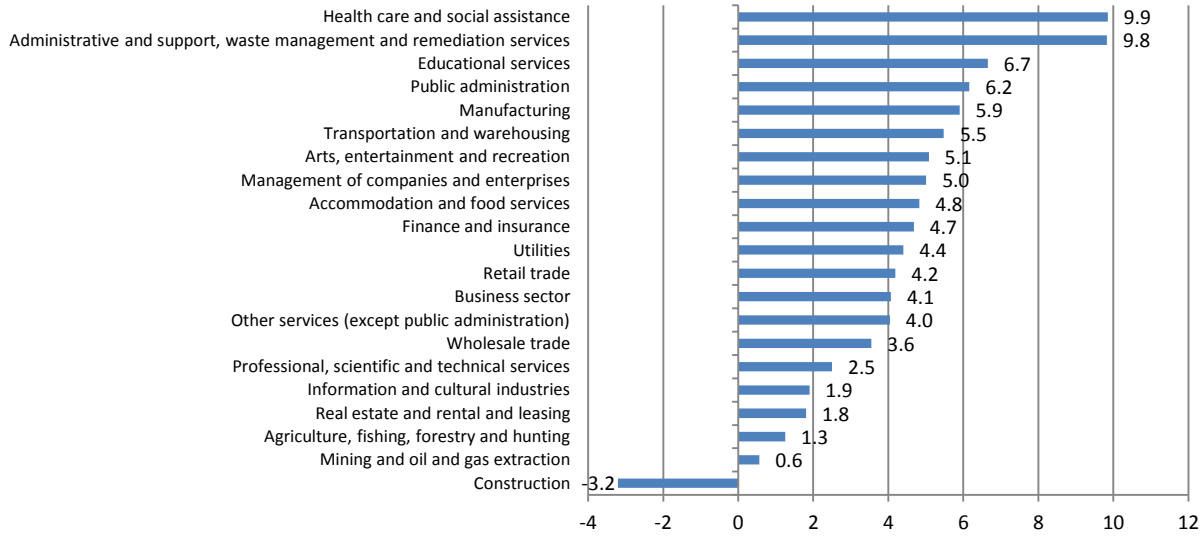
b. Growth Rates

Chart 32: Real Software Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 1987-2013



Source: CSLS ICT database from January 2015.

Chart 33: Real Software Capital Stock Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2013



Source: CSLS ICT database from January 2015.

B. Canada-US Relative ICT Capital Stock Per Worker by Industry

i. Total ICT Capital Stock Per Worker

a. Absolute Levels

Table 67: Total Nominal ICT Capital Stock Per Worker in Canada and the United States, US Dollars, PPP-Adjusted, 2002, 2008, 2013

	United States			Canada		
	2002	2008	2013	2002	2008	2013
Agriculture, fishing, forestry and hunting	489	561	702	527	632	639
Mining and oil and gas extraction	9,440	10,581	11,409	1,613	4,218	3,348
Utilities	11,500	12,149	14,347	.	.	.
Construction	1,198	1,047	917	.	.	.
Manufacturing	6,033	7,553	8,169	1,769	3,007	3,387
Wholesale trade	11,511	16,048	23,090	5,392	6,915	8,022
Retail trade	2,270	2,916	3,416	1,091	1,788	2,079
Transportation and warehousing	10,568	6,497	6,041	3,009	4,513	5,949
Information and cultural industries	98,252	122,166	169,206	55,595	47,672	44,673
Finance and insurance	17,456	21,160	23,503	9,135	16,526	17,274
Real estate and rental and leasing	11,780	10,410	9,659	12,715	16,242	10,937
Professional, scientific and technical services	10,855	13,956	14,185	3,862	3,143	3,265
Management of companies and enterprises	820,500	815,388	444,896	42,023	26,292	91,842
Administrative and support, waste management and remediation services	6,043	8,354	9,391	7,271	1,877	2,569
Educational services	884	1,365	1,701	1,691	1,930	2,366
Health care and social assistance	1,429	1,598	1,666	.	.	.
Arts, entertainment and recreation	1,504	1,680	1,551	1,772	2,002	2,059
Accommodation and food services	478	737	664	.	.	.
Other services (except public administration)	1,737	2,171	1,994	1,133	1,465	1,653
Business sector	9,531	11,060	12,817	4,260	5,086	5,226

Source: CSLS ICT by Industry database.

Table 68: Total Nominal ICT Capital Stock Per Worker in Canada Relative to the United States, Per Cent or Percentage Points, 2002, 2008, 2013, and 2002-2013

	2002	2008	2013	2002-2013
Agriculture, fishing, forestry and hunting	107.7	112.7	91	-16.7
Mining and oil and gas extraction	17.1	39.9	29.3	12.3
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	29.3	39.8	41.5	12.1
Wholesale trade	46.8	43.1	34.7	-12.1
Retail trade	48.1	61.3	60.9	12.8
Transportation and warehousing	28.5	69.5	98.5	70
Information and cultural industries	56.6	39	26.4	-30.2
Finance and insurance	52.3	78.1	73.5	21.2
Real estate and rental and leasing	107.9	156	113.2	5.3
Professional, scientific and technical services	35.6	22.5	23	-12.6
Management of companies and enterprises	5.1	3.2	20.6	15.5
Administrative and support, waste management and remediation services	21	22.5	27.4	6.3
Educational services	191.3	141.5	139.1	-52.3
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	117.8	119.2	132.8	14.9
Accommodation and food services	.	.	.	.
Other services (except public administration)	65.2	67.5	82.9	17.7
Business sector	44.7	46	40.8	-3.9

Note: "." means suppressed.
Source: CSLS ICT by Industry database.

b. Growth Rates

Table 69: Real Total ICT Capital Stock, Employment, and Capital Stock Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, Per Cent, 2002-2013

	United States			Canada		
	Capital Stock	Employment	Capital Stock Per Worker	Capital Stock	Employment	Capital Stock Per Worker
Agriculture, fishing, forestry and hunting	6.39	-0.74	7.18	5.32	-0.99	6.37
Mining and oil and gas extraction	12.18	7.08	4.77	18.53	5.28	12.59
Utilities	4.11	-0.63	4.77	.	0.88	.
Construction	-0.01	-0.67	0.67	.	3.99	.
Manufacturing	3.02	-1.33	4.41	6.36	-2.50	9.09
Wholesale trade	7.23	-1.16	8.49	6.48	1.10	5.32
Retail trade	7.16	0.20	6.95	10.26	1.14	9.01
Transportation and warehousing	-1.29	0.38	-1.67	10.25	1.18	8.97
Information and cultural industries	5.92	-1.99	8.07	0.75	0.07	0.68
Finance and insurance	5.96	0.31	5.63	9.52	1.87	7.81
Real estate and rental and leasing	2.87	0.16	2.70	5.56	2.42	3.06
Professional, scientific and technical services	6.04	1.69	4.28	6.42	2.93	3.39
Management of companies and enterprises	8.54	14.32	-5.06	7.55	-3.84	11.84
Administrative and support, waste management and remediation services	7.17	1.42	5.67	12.58	1.84	10.55
Educational services	9.02	0.93	8.02	9.59	2.30	7.12
Health care and social assistance	6.42	1.90	4.43	.	2.76	.
Arts, entertainment and recreation	5.78	1.78	3.93	7.70	1.67	5.93
Accommodation and food services	8.21	1.38	6.74	.	1.25	.
Other services (except public administration)	5.05	0.61	4.41	7.21	0.98	6.17
Business sector	5.50	0.20	5.28	5.87	1.04	4.78

Note: "." means suppressed.
Source: CSLS ICT database from January 2015.

.

ii. Computer Capital Stock Per Worker

a. Absolute Levels

Table 70: Nominal Computer Capital Stock Per Worker, Canada and the United States, US Dollars, PPP-Adjusted, 2002, 2008, 2013

	United States			Canada		
	2002	2008	2013	2002	2008	2013
Agriculture, fishing, forestry and hunting	109	137	200	141	231	295
Mining and oil and gas extraction	1,207	2,129	2,333	223	2,271	1,215
Utilities	1,320	1,451	1,765	3,386	3,458	5,671
Construction	283	317	271	257	285	259
Manufacturing	916	1,166	1,214	497	800	752
Wholesale trade	2,734	2,237	2,994	1,345	1,246	1,213
Retail trade	737	925	1,096	381	569	562
Transportation and warehousing	674	614	703	776	1,215	1,148
Information and cultural industries	5,354	6,084	8,516	1,737	3,431	3,658
Finance and insurance	5,118	3,781	3,931	2,071	4,467	1,973
Real estate and rental and leasing	5,595	3,011	2,662	4,910	8,149	3,606
Professional, scientific and technical services	2,550	2,691	2,591	2,101	1,225	1,485
Management of companies and enterprises	118,929	71,597	34,683	19,929	7,341	32,580
Administrative and support, waste management and remediation services	941	1,078	1,169	731	746	578
Educational services	193	230	269	862	614	615
Health care and social assistance	367	461	481	223	283	238
Arts, entertainment and recreation	423	467	425	959	898	677
Accommodation and food services	127	341	308	87	153	246
Other services (except public administration)	459	568	504	380	339	447
Business sector	1,515	1,465	1,595	873	1,234	1,004

Source: CSLS ICT by Industry database.

Table 71: Nominal Computer Capital Stock Per Worker in Canada Relative to the United States, Per Cent or Percentage Points, 2002, 2008, 2013, and 2002-2013

	2002	2008	2013	2002-2013
Agriculture, fishing, forestry and hunting	130.3	169.0	147.2	17.0
Mining and oil and gas extraction	18.5	106.7	52.1	33.6
Utilities	256.6	238.4	321.3	64.7
Construction	91.1	89.9	95.5	4.4
Manufacturing	54.3	68.6	62.0	7.7
Wholesale trade	49.2	55.7	40.5	-8.7
Retail trade	51.8	61.5	51.3	-0.5
Transportation and warehousing	115.1	197.9	163.4	48.3
Information and cultural industries	32.4	56.4	43.0	10.5
Finance and insurance	40.5	118.1	50.2	9.7
Real estate and rental and leasing	87.8	270.6	135.4	47.7
Professional, scientific and technical services	82.4	45.5	57.3	-25.1
Management of companies and enterprises	16.8	10.3	93.9	77.2
Administrative and support, waste management and remediation services	77.7	69.2	49.5	-28.2
Educational services	447.8	266.5	228.6	-219.2
Health care and social assistance	60.8	61.4	49.4	-11.4
Arts, entertainment and recreation	227.0	192.3	159.3	-67.8
Accommodation and food services	68.4	44.8	79.8	11.4
Other services (except public administration)	82.7	59.7	88.7	6.0
Business sector	57.6	85.5	62.9	5.3

Source: CSLS ICT by Industry database.

b. Growth Rates

Table 72: Real Computer Capital Stock, Employment, and Capital Stock Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, 2002-2013

	United States			Canada		
	Capital Stock	Employment	Capital Stock Per Worker	Capital Stock	Employment	Capital Stock Per Worker
Agriculture, fishing, forestry and hunting	10.81	-0.74	11.64	16.84	-0.99	18.02
Mining and oil and gas extraction	21.19	7.08	13.18	35.97	5.28	29.15
Utilities	9.98	-0.63	10.68	16.67	0.88	15.65
Construction	3.32	-0.67	4.02	14.82	3.99	10.41
Manufacturing	7.31	-1.33	8.76	11.70	-2.50	14.56
Wholesale trade	7.23	-1.16	8.49	10.49	1.10	9.28
Retail trade	9.14	0.20	8.92	15.61	1.14	14.30
Transportation and warehousing	8.21	0.38	7.79	15.71	1.18	14.36
Information and cultural industries	8.55	-1.99	10.75	18.13	0.07	18.05
Finance and insurance	6.34	0.31	6.01	11.87	1.87	9.83
Real estate and rental and leasing	1.27	0.16	1.11	9.84	2.42	7.24
Professional, scientific and technical services	9.06	1.69	7.24	10.05	2.93	6.92
Management of companies and enterprises	8.60	14.32	-5.00	11.01	-3.84	15.45
Administrative and support, waste management and remediation services	9.42	1.42	7.89	9.98	1.84	7.98
Educational services	11.88	0.93	10.86	9.47	2.30	7.01
Health care and social assistance	10.17	1.90	8.11	14.05	2.76	10.98
Arts, entertainment and recreation	7.11	1.78	5.24	8.70	1.67	6.92
Accommodation and food services	14.79	1.38	13023	22.80	1.25	21.29
Other services (except public administration)	7.05	0.61	6.40	13.05	0.98	11.95
Business sector	7.55	0.20	7.33	12.91	1.04	11.74

Source: CSLS ICT database from January 2015.

iii. Communications Investment Per Worker

a. Absolute Levels

Table 73: Nominal Communications Capital Stock Per Worker, Canada and the United States, PPP-Adjusted, US Dollars, 2002, 2008 and 2013

	United States			Canada		
	2002	2008	2013	2002	2008	2013
Agriculture, fishing, forestry and hunting	278	307	335	163	142	133
Mining and oil and gas extraction	3,319	4,967	5,733	288	598	893
Utilities	4,890	5,602	6,574	.	.	.
Construction	613	525	483	.	.	.
Manufacturing	1,255	1,671	1,855	69	287	267
Wholesale trade	3,707	3,444	4,222	282	633	396
Retail trade	847	899	950	64	106	155
Transportation and warehousing	8,603	5,012	4,365	466	602	1,067
Information and cultural industries	74,620	90,714	123,339	47,112	34,075	32,329
Finance and insurance	4,161	5,817	6,331	580	1,488	1,447
Real estate and rental and leasing	4,989	5,790	5,474	974	1,299	1,245
Professional, scientific and technical services	1,903	2,378	2,362	758	546	386
Management of companies and enterprises	108,976	69,731	28,246	1,697	1,073	1,955
Administrative and support, waste management and remediation services	1,916	2,206	2,265	102	255	294
Educational services	177	312	399	99	93	204
Health care and social assistance	540	535	533	.	.	.
Arts, entertainment and recreation	827	983	934	370	267	410
Accommodation and food services	272	273	247	.	.	.
Other services (except public administration)	735	978	935	119	90	202
Business sector	4,636	4,976	5,592	1,770	1,414	1,363

Source: CSLS ICT by Industry database.

Table 74: Nominal Communications Capital Stock Per Worker in Canada Relative to the United States, Per Cent and Percentage Points, 2002, 2008, 2013 and 2002-2013

	2002	2008	2013	2002-2013
Agriculture, fishing, forestry and hunting	58.6	46.2	39.7	-18.9
Mining and oil and gas extraction	8.7	12.0	15.6	6.9
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	5.5	17.2	14.4	8.9
Wholesale trade	7.6	18.4	9.4	1.8
Retail trade	7.6	11.8	16.3	13.1
Transportation and warehousing	5.4	12.0	24.4	9.0
Information and cultural industries	63.1	37.6	26.2	-36.9
Finance and insurance	13.9	25.6	22.9	8.9
Real estate and rental and leasing	19.5	22.4	22.7	3.2
Professional, scientific and technical services	39.8	23.0	16.4	-23.5
Management of companies and enterprises	1.6	1.5	6.9	5.4
Administrative and support, waste management and remediation services	5.3	11.6	13.0	7.7
Educational services	56.0	29.8	51.1	-4.9
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	44.7	27.2	43.9	-0.9
Accommodation and food services	.	.	.	.
Other services (except public administration)	16.2	9.2	21.7	21.7
Business sector	38.2	28.4	24.4	-13.8

Source: CSLS ICT by Industry database.

b. Growth Rates

Table 75: Real Communications Capital Stock, Employment, and Capital Stock Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, 2002-2013

	United States			Canada		
	Capital Stock	Employment	Capital Stock Per Worker	Capital Stock	Employment	Capital Stock Per Worker
Agriculture, fishing, forestry and hunting	4.56	-0.74	5.33	-0.15	-0.99	0.85
Mining and oil and gas extraction	16.53	7.08	8.83	20.42	5.28	14.38
Utilities	5.70	-0.63	6.38	.	0.88	.
Construction	0.65	-0.67	1.33	.	3.99	.
Manufacturing	5.87	-1.33	7.29	13.49	-2.50	16.40
Wholesale trade	3.57	-1.16	4.78	7.45	1.10	6.27
Retail trade	4.84	0.20	4.63	12.86	1.14	11.58
Transportation and warehousing	-2.27	0.38	-2.64	12.36	1.18	11.05
Information and cultural industries	6.24	-1.99	8.39	-0.40	0.07	-0.47
Finance and insurance	7.92	0.31	7.58	13.98	1.87	11.89
Real estate and rental and leasing	4.60	0.16	4.43	7.83	2.42	5.28
Professional, scientific and technical services	7.39	1.69	5.61	-0.23	2.93	-3.07
Management of companies and enterprises	4.70	14.32	-8.41	0.30	-3.84	4.31
Administrative and support, waste management and remediation services	6.64	1.42	5.14	15.51	1.84	13.42
Educational services	12.53	0.93	11.50	12.58	2.30	10.04
Health care and social assistance	5.39	1.90	3.43	.	2.76	.
Arts, entertainment and recreation	6.57	1.78	4.70	5.80	1.67	4.07
Accommodation and food services	4.05	1.38	2.64	.	1.25	.
Other services (except public administration)	6.49	0.61	5.84	9.22	0.98	8.15
Business sector	5.55	0.20	5.33	1.63	1.04	0.58

Note: "." means suppressed.
Source: CSLS ICT by Industry database from January 2015.

iv. Software Capital Stock Per Worker

a. Absolute Levels

Table 76: Nominal Software Capital Stock Per Worker in Canada and the United States, PPP-Adjusted, US Dollars, 2002, 2008, and 2013

	United States			Canada		
	2002	2008	2013	2002	2008	2013
Agriculture, fishing, forestry and hunting	103	117	167	223	259	211
Mining and oil and gas extraction	4,914	3,485	3,343	1,102	1,349	1,240
Utilities	5,291	5,096	6,008	7,325	12,549	16,017
Construction	302	206	163	118	88	80
Manufacturing	3,862	4,716	5,100	1,203	1,920	2,368
Wholesale trade	5,070	10,366	15,874	3,765	5,036	6,412
Retail trade	686	1,091	1,370	646	1,113	1,362
Transportation and warehousing	1,291	871	973	1,766	2,696	3,733
Information and cultural industries	18,278	25,368	37,351	6,746	10,166	8,686
Finance and insurance	8,177	11,562	13,241	6,484	10,572	13,852
Real estate and rental and leasing	1,196	1,609	1,523	6,831	6,794	6,086
Professional, scientific and technical services	6,402	8,887	9,232	1,003	1,372	1,394
Management of companies and enterprises	592,595	674,060	381,967	20,397	17,877	57,307
Administrative and support, waste management and remediation services	3,186	5,070	5,956	438	875	1,696
Educational services	514	823	1,033	730	1,224	1,546
Health care and social assistance	523	602	652	238	598	736
Arts, entertainment and recreation	254	230	192	443	837	972
Accommodation and food services	79	122	109	163	204	283
Other services (except public administration)	542	625	556	634	1,036	1,004
Business sector	3,380	4,619	5,629	1,617	2,439	2,858

Source: CSLS ICT by Industry database.

Table 77: Nominal Software Capital Stock Per Worker in Canada Relative to the United States, Per Cent and Percentage Points, 2002, 2008, 2013, and 2002-2013

	2002	2008	2013	2002-2013
Agriculture, fishing, forestry and hunting	216.4	221.7	126.4	-90.0
Mining and oil and gas extraction	22.4	38.7	37.1	14.7
Utilities	138.5	246.3	266.6	128.1
Construction	39.0	42.7	48.9	9.9
Manufacturing	31.1	40.7	46.4	15.3
Wholesale trade	74.2	48.6	40.4	-33.9
Retail trade	94.1	102.0	99.4	5.3
Transportation and warehousing	136.8	309.6	383.7	246.9
Information and cultural industries	36.9	40.1	23.3	-13.7
Finance and insurance	79.3	91.4	104.6	25.3
Real estate and rental and leasing	571.2	422.3	399.7	-171.5
Professional, scientific and technical services	15.7	15.4	15.1	-0.6
Management of companies and enterprises	3.4	2.7	15.0	11.6
Administrative and support, waste management and remediation services	13.7	17.3	28.5	14.7
Educational services	141.9	148.8	149.7	7.8
Health care and social assistance	45.5	99.4	112.9	67.4
Arts, entertainment and recreation	174.1	363.8	505.8	331.7
Accommodation and food services	207.5	167.1	258.7	51.2
Other services (except public administration)	116.9	167.5	180.7	63.7
Business sector	47.8	52.8	50.8	2.9

Source: CSLS ICT by Industry database.

b. Growth Rates

Table 78: Real Software Capital Stock, Employment and Capital Stock Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, 2002-2013

	United States			Canada		
	Capital Stock	Employment	Capital Stock Per Worker	Capital Stock	Employment	Capital Stock Per Worker
Agriculture, fishing, forestry and hunting	5.15	-0.74	5.93	-1.14	-0.99	-0.15
Mining and oil and gas extraction	4.33	7.08	-2.57	6.70	5.28	1.35
Utilities	0.95	-0.63	1.59	6.78	0.88	5.84
Construction	-5.67	-0.67	-5.03	1.56	3.99	-2.34
Manufacturing	0.97	-1.33	2.33	3.64	-2.50	6.29
Wholesale trade	9.14	-1.16	10.42	5.36	1.10	4.21
Retail trade	7.55	0.20	7.34	7.36	1.14	6.15
Transportation and warehousing	-1.75	0.38	-2.13	7.52	1.18	6.27
Information and cultural industries	4.20	-1.99	6.31	0.89	0.07	0.81
Finance and insurance	5.00	0.31	4.68	7.71	1.87	5.74
Real estate and rental and leasing	2.95	0.16	2.79	0.91	2.42	-1.48
Professional, scientific and technical services	4.61	1.69	2.87	6.08	2.93	3.06
Management of companies and enterprises	8.94	14.32	-4.71	5.32	-3.84	9.52
Administrative and support, waste management and remediation services	6.93	1.42	5.44	14.13	1.84	12.06
Educational services	6.90	0.93	5.92	10.17	2.30	7.69
Health care and social assistance	4.62	1.90	2.67	12.53	2.76	9.51
Arts, entertainment and recreation	0.43	1.78	-1.33	8.48	1.67	6.70
Accommodation and food services	5.98	1.38	4.54	6.38	1.25	5.07
Other services (except public administration)	1.13	0.61	0.52	4.55	0.98	3.53
Business sector	4.72	0.20	4.51	5.50	1.04	4.41

Source: CSLS ICT database from January 2015.

C. Depreciation Rates

Aside from depreciation rates, every determinant or driver of ICT investment per worker is equally a determinant or driver of ICT capital stock per worker. Hence, for a discussion of the other drivers and determinants of ICT capital stock, refer to Section V.

In this section, we discuss the impact of depreciation rates on capital stock differences between Canada and the United States. In particular, Rai and Shape (2013) noted that Canada's lower performance for capital stock is in part explained by lower ICT investment in Canada, but also by higher rates of depreciation used by Statistics Canada to estimate capital stock (Table 79).[55] Essentially, higher depreciation rates in Canada imply that for the same level of investment in Canada and the United States, capital stock will be lower in Canada.

Table 79: Depreciation Rates, Bureau of Economic Analysis and Canada

	Implicit Bureau of Economic Analysis Depreciation Rate	Statistics Canada Depreciation Rate	Difference
	A	B	C = A-B
Communication equipment	0.14	0.22	-0.08
Computers, hardware, and word processors	0.5	0.47	0.03
Software	0.49	0.55	-0.06
Total	0.38	0.41	-0.03

Note: Statistics Canada updated depreciation rates in January 2015. See http://www.statcan.gc.ca/pub/15-206-x/2015039/t/tbl04-eng.htm.
Source: Statistics Canada, 2007, *Depreciation Rates for the Productivity Accounts; and Bureau of Economic Analysis, 2003, Fixed Assets and Consumer Durable Goods in the United States, 1925-97.*

In part of their analysis, Tang, Rao, and Li (2010) investigated the impact of using BEA depreciation rates and Statistics Canada depreciation rates on Canadian ICT capital stock estimates. Their analysis indicates that business sector Canada-US ICT capital intensity is 38.7 per cent with Statistics Canada depreciation rates for Canada and BEA depreciation rates for the United States. However, using Statistics Canada depreciation rates for both countries changes business sector Canada-US ICT capital intensity to 47.9 per cent, and using BEA depreciation rates for both countries changes business sector Canada-US ICT capital intensity to 47.7 per cent.

These results imply that methodological differences in capital stock estimation accounts for 14.7 to 15.0 per cent (or 9.0 to 9.2 percentage points) of the Canada-US ICT capital stock business sector gap of 61.3 per cent.

Hence, before investigating the impact of the determinants and drivers of ICT capital stock discussed in the body of this report, it is important to control for measurement or methodological issues, especially this particular disparity.

[55] See Tang, Rao and Li (2010) for more details on depreciation rates by country.

Appendix II: Total ICT Investment and Communications Investment Analysis

A. Total ICT Investment

i. Total ICT Investment Per Worker in Canada[56]

a. Absolute Levels

Table 80: Nominal Total ICT Investment Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008 and 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	62	205	348	.
Mining and oil and gas extraction	224	1,160	2,930	.
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	411	1,082	1,633	1,922
Wholesale trade	763	3,185	3,938	.
Retail trade	154	722	1,102	.
Transportation and warehousing	394	2,052	.	.
Information and cultural industries	9,458	22,846	19,502	17,015
Finance and insurance	3,658	6,075	9,015	8,006
Real estate and rental and leasing	2,483	5,683	8,991	.
Professional, scientific and technical services	1,342	3,328	1,724	1,856
Management of companies and enterprises	n/a	35,767	15,452	.
Administrative and support, waste management and remediation services	.	.	.	.
Educational services	367	1,073	1,180	1,231
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	272	1,252	1,358	.
Accommodation and food services	.	.	.	.
Other services (except public administration)	.	.	.	.
Public administration	1,898	5,058	5,349	5,591
Business sector	920	2,415	2,620	2,454

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

[56] Data are not available for 8 of the 20 two-digit NAICS industries for any year over the 1987 to 2009 period, including utilities; construction; transportation and warehousing; management of companies and enterprises; administrative and support, waste management and remediation services; health care and social assistance; accommodation and food services; and other services (except public administration). Between 2000 and 2013, these eight industries accounted for 50 per cent of employment on average. In 2000, these eight industries accounted for 47 per cent of employment. By 2013, they accounted for 53 per cent of employment.

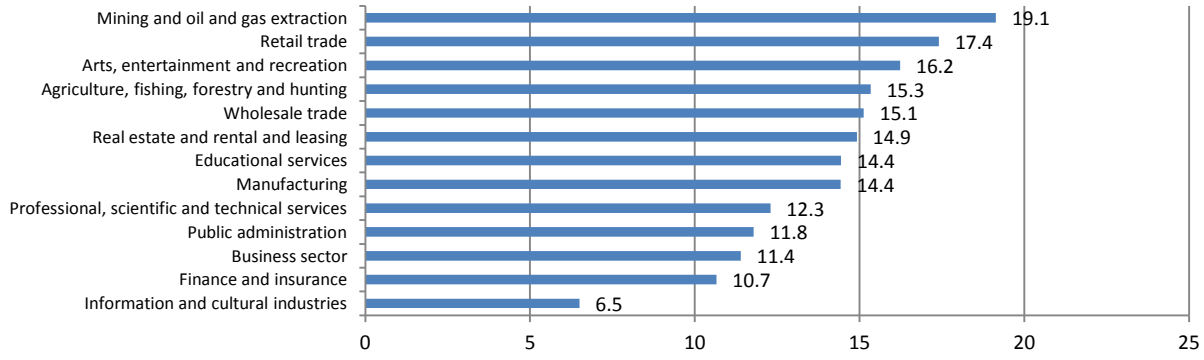
Table 81: Distribution of Business Sector Total Nominal ICT Investment and Employment by Industry, Per Cent, 1987, 2000, and 2013

	Total ICT Investment (Current Dollars)			Employment (Workers)		
	1987	2000	2013	1987	2000	2013
Agriculture, fishing, forestry and hunting	0.4	0.3	.	5.9	4.2	2.9
Mining and oil and gas extraction	0.4	0.6	.	1.9	1.4	2.3
Utilities	.	.	.	1.2	1.0	1.1
Construction	.	.	.	7.5	7.0	9.9
Manufacturing	8.4	8.1	10.4	21.2	19.5	13.0
Wholesale trade	2.9	6.0	.	4.3	4.7	4.6
Retail trade	2.2	4.4	.	16.2	15.3	15.7
Transportation and warehousing	2.7	5.6	.	6.6	6.7	6.5
Information and cultural industries	39.4	33.1	20.3	3.5	3.3	2.9
Finance and insurance	21.5	13.2	18.8	5.6	5.3	6.0
Real estate and rental and leasing	5.9	5.0	.	2.4	2.2	2.4
Professional, scientific and technical services	7.4	11.4	7.8	5.1	8.1	10.0
Management of companies and enterprises	n/a	0.4	.	0.0	0.0	0.0
Administrative and support, waste management and remediation services	.	.	.	2.8	4.6	5.3
Arts, entertainment and recreation	0.5	1.3	0.9	1.8	2.5	3.0
Accommodation and food services	.	.	.	7.4	8.2	8.5
Other services (except public administration)	.	.	.	6.6	5.9	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0

Note: "n/a" means not available, while "." means suppressed.
Source: CSLS ICT by Industry database.

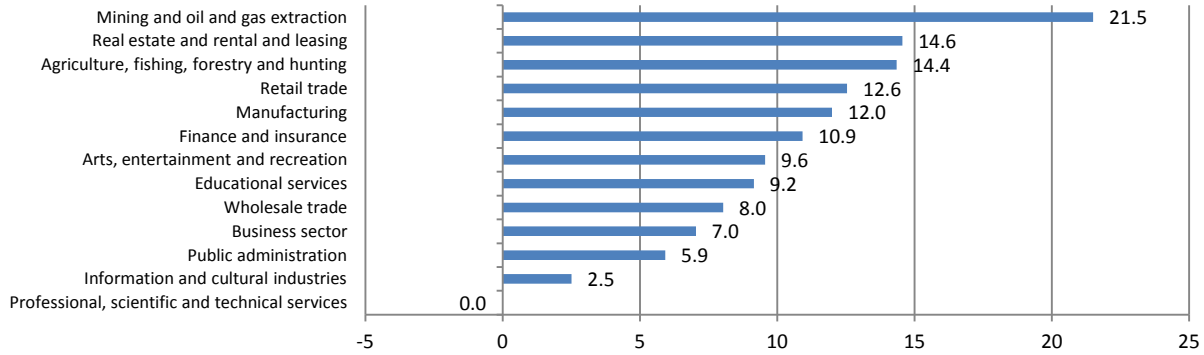
b. Growth Rates

Chart 34: Real Total ICT Investment Per Worker, Canada, Compound Average Annual Growth, 1987-2008



Source: CSLS ICT database from January 2015.

Chart 35: Real Total ICT Investment Per Worker, Canada, Compound Average Annual Growth, 2000-2008



Source: CSLS ICT database from January 2015.

ii. Canada-US Total ICT Investment Per Worker

a. Absolute Levels

Table 82: Nominal Total ICT Investment Per Worker in Canada and the United States, Millions of US Dollars, PPP-Adjusted, 2002, 2008 and 2013

	United States			Canada			Canada as a Proportion of the United States	
	2002	2008	2013	2002	2008	2013	2002	2008
Agriculture, fishing, forestry and hunting	157	183	262	285	306	.	182.1	155.6
Mining and oil and gas extraction	2,685	4,895	4,496	629	2,578	.	23.4	52.7
Utilities	3,958	5,013	5,018	.	.	.	.	.
Construction	403	306	259	.	.	.	.	.
Manufacturing	2,255	3,495	3,131	803	1,437	1,714	35.6	41.1
Wholesale trade	4,488	6,481	9,781	2,235	3,465	.	49.8	53.5
Retail trade	1,020	1,125	1,443	504	970	.	49.4	86.2
Transportation and warehousing	1,166	1,260	1,429	1,165	.	.	99.9	.
Information and cultural industries	24,056	30,924	41,440	18,061	17,162	15,172	75.1	55.5
Finance and insurance	8,304	8,701	9,283	4,040	7,933	7,139	48.7	91.2
Real estate and rental and leasing	3,758	3,249	2,898	7,636	7,912	.	203.2	243.6
Professional, scientific and technical services	4,772	5,914	5,668	2,169	1,518	1,655	45.5	25.7
Management of companies and enterprises	434,690	419,388	193,716	20,241	13,598	.	4.7	3.2
Administrative and support, waste management and remediation services	2,804	3,025	3,549	.	.	.	.	.
Educational services	489	598	630	884	1,038	1,098	180.6	173.7
Health care and social assistance	615	667	649	.	.	.	.	.
Arts, entertainment and recreation	642	518	436	1,016	1,195	.	158.3	230.6
Accommodation and food services	164	311	244	.	.	.	.	.
Other services (except public administration)	760	773	627	.	.	.	.	.
Business sector	3,212	3,872	4,279	1,746	2,306	2,188	54.4	59.6

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

Table 83: Distribution of Business Sector Total ICT Investment and Employment by Industry, Canada and the United States, Per Cent, 2002 and 2013

	United States				Canada			
	Total ICT Investment		Employment		Total ICT Investment		Employment	
	02	13	02	13	02	13	02	13
Agriculture, fishing, forestry and hunting	0.1	0.1	2.3	2.0	0.6	.	3.6	2.9
Mining and oil and gas extraction	0.4	1.1	0.5	1.0	0.5	.	1.4	2.3
Utilities	1.5	1.3	1.2	1.1	.	.	1.1	1.1
Construction	1.2	0.5	9.8	8.9	.	.	7.2	9.9
Manufacturing	11.8	10.4	16.8	14.2	8.1	10.4	19.3	13.0
Wholesale trade	5.7	8.0	4.0	3.5	5.5	.	4.6	4.6
Retail trade	4.9	5.2	15.3	15.3	4.4	.	15.5	15.7
Transportation and warehousing	2.1	2.0	5.8	5.9	4.1	.	6.4	6.5
Information and cultural industries	27.0	27.4	3.6	2.8	34.7	20.3	3.2	2.9
Finance and insurance	17.0	14.5	6.6	6.7	12.6	18.8	5.5	6.0
Real estate and rental and leasing	3.2	1.9	2.8	2.7	8.6	.	2.1	2.4
Professional, scientific and technical services	12.2	12.8	8.2	9.7	10.4	7.8	8.3	10.1
Management of companies and enterprises	5.6	7.9	0.0	0.2	0.4	.	0.0	0.0
Administrative and support, waste management and remediation services	4.7	5.1	5.4	6.2	.	.	4.9	5.3
Arts, entertainment and recreation	0.5	0.3	2.6	3.1	1.7	0.9	2.8	3.0
Accommodation and food services	0.4	0.6	8.7	9.9	.	.	8.3	8.5
Other services (except public administration)	1.5	1.0	6.5	6.8	.	.	5.8	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CSLS calculations based on the CSLS ICT by Industry database.

Table 84: Nominal Total ICT Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2008

Total (2008)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Information and cultural industries	28.54	26.53	27.54
Professional, scientific and technical services	24.52	25.51	25.01
Manufacturing	19.50	19.72	19.61
Management of companies and enterprises	16.20	13.87	15.03
Wholesale trade	7.28	9.30	8.29
Finance and insurance	3.33	2.91	3.12
Mining and oil and gas extraction	1.13	3.04	2.09
Retail trade	1.53	1.55	1.54
Agriculture, fishing, forestry and hunting	-0.16	-0.24	-0.20
Arts, entertainment and recreation	-1.20	-1.20	-1.20
Real estate and rental and leasing	-8.19	-6.76	-7.48
Business sector	100.00	100.00	100.00
Accounted	**92.46**	**94.24**	**93.35**
Unaccounted	**7.54**	**5.76**	**6.65**

Source: CSLS calculations based on CSLS ICT by Industry database and CSLS ICT database from January 2015.
Note: Utilities, construction, accommodation and food services, and other services (except public administration) since data were not available for 2008. Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

b. Growth Rates

Table 85: Real Total ICT Investment Per Worker in Canada and the United States, Compound Average Annual Growth Rates, 2002-2008

	United States	Canada	Canada-US
Agriculture, fishing, forestry and hunting	14.93	7.78	-7.15
Mining and oil and gas extraction	10.14	36.65	26.51
Utilities	5.11	.	.
Construction	4.16	.	.
Manufacturing	8.12	15.67	7.55
Wholesale trade	10.74	11.40	0.66
Retail trade	11.00	17.12	6.12
Transportation and warehousing	3.98	.	.
Information and cultural industries	8.15	3.43	-4.72
Finance and insurance	8.13	16.30	8.17
Real estate and rental and leasing	6.85	7.52	0.67
Professional, scientific and technical services	8.59	0.68	-7.91
Management of companies and enterprises	1.48	.	.
Administrative and support, waste management and remediation services	8.33	.	.
Educational services	10.63	8.87	-1.76
Health care and social assistance	8.25	.	.
Arts, entertainment and recreation	8.31	9.63	1.32
Accommodation and food services	20.48	.	.
Other services (except public administration)	9.59	.	.
Business sector	8.03	9.84	1.81

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS calculations based on the CSLS ICT database from January 2015.

B. Communications Investment

i. Communications Investment Per Worker in Canada

a. Absolute Levels

Table 86: Nominal Communications Investment Per Worker by Industry in Canada, Canadian Dollars, 1987, 2000, 2008 and 2013

	1987	2000	2008	2013
Agriculture, fishing, forestry and hunting	36	92	44	.
Mining and oil and gas extraction	27	453	309	.
Utilities	.	.	.	.
Construction	.	.	.	.
Manufacturing	7	35	117	100
Wholesale trade	0	270	492	.
Retail trade	2	46	51	.
Transportation and warehousing	43	326	.	.
Information and cultural industries	8,658	17,782	12,531	11,050
Finance and insurance	154	298	637	591
Real estate and rental and leasing	155	140	453	.
Professional, scientific and technical services	39	220	211	148
Management of companies and enterprises	.	3,167	425	.
Administrative and support, waste management and remediation services	.	.	.	.
Educational services	14	111	30	89
Health care and social assistance	.	.	.	.
Arts, entertainment and recreation	69	73	135	.
Accommodation and food services	.	.	.	.
Other services (except public administration)	.	.	.	.
Public administration	670	1,021	467	521
Business sector	327	755	546	494

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

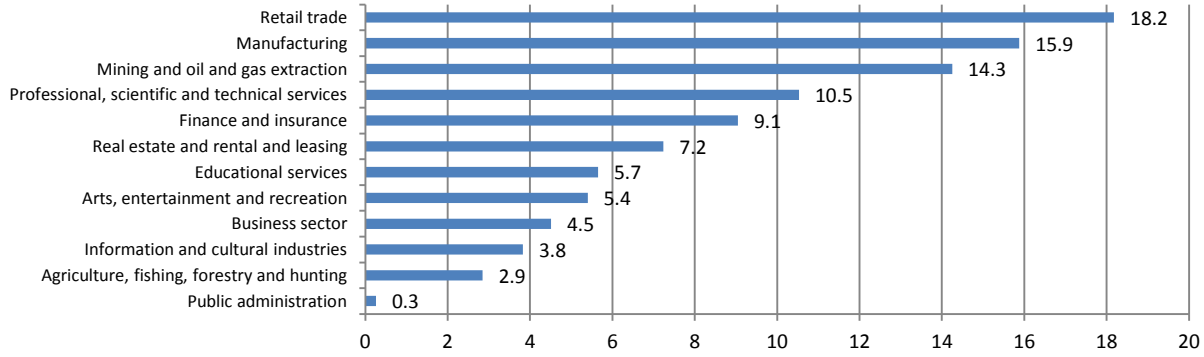
Table 87: Distribution of Nominal Business Sector Communications Investment and Employment by Industry, Per Cent, 1987, 2000, and 2013

	Total ICT Investment (Current Dollar)			Employment (Workers)		
	1987	2000	2013	1987	2000	2013
Agriculture, fishing, forestry and hunting	0.7	0.5	.	5.9	4.2	2.9
Mining and oil and gas extraction	0.2	0.8	.	1.9	1.4	2.3
Utilities	.	.	.	1.2	1.0	1.1
Construction	.	.	.	7.5	7.0	9.9
Manufacturing	0.5	0.9	2.6	21.2	19.5	13.0
Wholesale trade	0.0	1.7	.	4.3	4.7	4.6
Retail trade	0.1	0.9	.	16.2	15.3	15.7
Transportation and warehousing	0.9	2.9	.	6.6	6.7	6.5
Information and cultural industries	91.4	78.6	64.1	3.5	3.3	2.9
Finance and insurance	2.6	2.1	7.2	5.6	5.3	6.0
Real estate and rental and leasing	1.1	0.4	.	2.4	2.2	2.4
Professional, scientific and technical services	0.6	2.4	3.0	5.1	8.1	10.0
Management of companies and enterprises	n/a	0.1	.	0.0	0.0	0.0
Administrative and support, waste management and remediation services	.	.	.	2.8	4.6	5.3
Arts, entertainment and recreation	0.4	0.2	0.0	1.8	2.5	3.0
Accommodation and food services	.	.	.	7.4	8.2	8.5
Other services (except public administration)	.	.	.	6.6	5.9	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

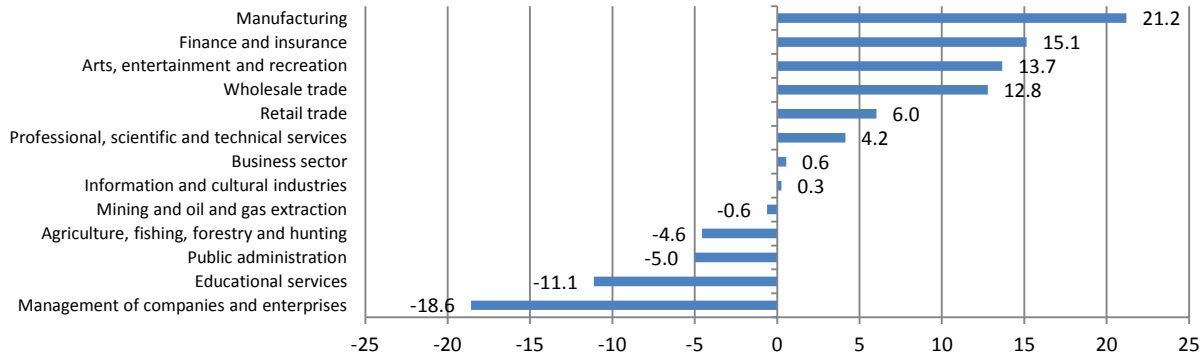
b. Growth Rates

Chart 36: Real Communications Investment Per Worker, Canada, Compound Average Annual Growth, Per Cent, 1987-2008



Note: Wholesale trade grew from $0 (chained 2007 dollars) in 1987 to $494 in 2008. Unfortunately, it is impossible to calculate a growth rate when the base year value is zero.
Source: CSLS ICT by Industry database from January 2015.

Chart 37: Real Communications Investment Per Worker, Canada, Compound Average Annual Growth, Per Cent, 2000-2008



Source: CSLS ICT by Industry database from January 2015.

ii. Canada-US Communications Investment Per Worker

a. Absolute Levels

Table 88: Nominal Communications Investment Per Worker in Canada and the United States, US Dollars, PPP-Adjusted, 2002, 2008, and 2013

	United States			Canada			Canada as a Proportion of the United States	
	2002	2008	2013	2002	2008	2013	2002	2008
Agriculture, fishing, forestry and hunting	60	39	56	41	39	.	68.6	100.0
Mining and oil and gas extraction	737	1,381	1,256	39	272	.	5.3	19.7
Utilities	867	1,077	1,064	.	.	.	.	.
Construction	115	66	55	.	.	.	.	.
Manufacturing	292	315	284	21	103	89	7.3	32.6
Wholesale trade	302	527	752	43	433	.	14.4	82.1
Retail trade	165	124	155	17	45	.	10.6	36.4
Transportation and warehousing	558	505	569	144	.	.	25.9	.
Information and cultural industries	12,064	16,840	21,023	14,004	11,028	9,853	116.1	65.5
Finance and insurance	1,199	961	954	213	560	527	17.7	58.3
Real estate and rental and leasing	1,355	960	978	177	399	.	13.0	41.5
Professional, scientific and technical services	466	437	396	540	186	132	115.9	42.5
Management of companies and enterprises	27,333	11,537	4,809	117	374	.	0.4	3.2
Administrative and support, waste management and remediation services	424	324	360	.	.	.	.	.
Educational services	63	68	68	24	26	79	38.5	38.6
Health care and social assistance	100	88	84	.	.	.	.	.
Arts, entertainment and recreation	242	164	140	26	119	.	10.6	72.6
Accommodation and food services	55	42	39	.	.	.	.	.
Other services (except public administration)	218	165	133	.	.	.	.	.
Business sector	795	868	926	536	480	441	67.4	55.3

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT by Industry database.

Table 89: Distribution of Business Sector Communications Investment and Employment by Industry, Canada and the United States, 2002 and 2013

	United States				Canada			
	Total ICT Investment		Employment		Total ICT Investment		Employment	
	02	13	02	13	02	13	02	13
Agriculture, fishing, forestry and hunting	0.2	0.1	2.3	2.0	0.3	.	3.6	2.9
Mining and oil and gas extraction	0.5	1.4	0.5	1.0	0.1	.	1.4	2.3
Utilities	1.4	1.3	1.2	1.1	.	.	1.1	1.1
Construction	1.4	0.5	9.8	8.9	.	.	7.2	9.9
Manufacturing	6.2	4.4	16.8	14.2	0.8	2.6	19.3	13.0
Wholesale trade	1.5	2.8	4.0	3.5	0.4	.	4.6	4.6
Retail trade	3.2	2.6	15.3	15.3	0.5	.	15.5	15.7
Transportation and warehousing	4.1	3.7	5.8	5.9	1.7	.	6.4	6.5
Information and cultural industries	54.7	64.2	3.6	2.8	83.3	64.1	3.2	2.9
Finance and insurance	9.9	6.9	6.6	6.7	2.2	7.2	5.5	6.0
Real estate and rental and leasing	4.7	2.9	2.8	2.7	0.7	.	2.1	2.4
Professional, scientific and technical services	4.8	4.1	8.2	9.7	8.3	3.0	8.3	10.1
Management of companies and enterprises	1.4	0.9	0.0	0.2	0.0	.	0.0	0.0
Administrative and support, waste management and remediation services	2.9	2.4	5.4	6.2	.	.	4.9	5.3
Arts, entertainment and recreation	0.8	0.5	2.6	3.1	0.1	.	2.8	3.0
Accommodation and food services	0.6	0.4	8.7	9.9	.	.	8.3	8.5
Other services (except public administration)	1.8	1.0	6.5	6.8	.	.	5.8	5.8
Business sector	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CSLS calculations based on the CSLS ICT by Industry database.

Table 90: Nominal Communications Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2008

Communications (2008)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Information and cultural industries	45.70	42.49	44.09
Manufacturing	7.62	7.70	7.66
Finance and insurance	6.59	5.76	6.18
Professional, scientific and technical services	5.31	5.52	5.42
Real estate and rental and leasing	4.79	3.95	4.37
Mining and oil and gas extraction	2.05	5.52	3.79
Retail trade	2.95	3.00	2.98
Management of companies and enterprises	1.69	1.45	1.57
Wholesale trade	0.86	1.10	0.98
Arts, entertainment and recreation	0.30	0.30	0.30
Agriculture, fishing, forestry and hunting	0.00	0.00	0.00
Business sector	100.00	100.00	100.00
Accounted	**77.86**	**76.80**	**77.33**
Unaccounted	**22.14**	**23.20**	**22.67**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Utilities, construction, accommodation and food services, and other services (except public administration) since data were not available for 2008. Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

b. Growth Rates

Table 91: Real Communications Investment Per Worker in Canada and the United States, Compound Average Annual Growth Rates, Per Cent, 2002-2008

	United States	Canada	Canada-US
Agriculture, fishing, forestry and hunting	7.47	3.25	-4.22
Mining and oil and gas extraction	12.65	45.08	32.43
Utilities	7.01	.	.
Construction	1.95	.	.
Manufacturing	10.58	36.13	25.55
Wholesale trade	3.34	53.81	50.47
Retail trade	5.66	22.70	17.04
Transportation and warehousing	0.62	.	.
Information and cultural industries	8.32	0.68	-7.64
Finance and insurance	11.16	23.04	11.88
Real estate and rental and leasing	7.51	19.86	12.35
Professional, scientific and technical services	9.80	-12.20	-22.00
Management of companies and enterprises	-2.89	25.25	28.14
Administrative and support, waste management and remediation services	7.42	.	.
Educational services	14.97	6.26	-8.71
Health care and social assistance	4.86	.	.
Arts, entertainment and recreation	7.72	35.56	27.84
Accommodation and food services	5.08	.	.
Other services (except public administration)	9.72	.	.
Business sector	7.15	2.88	-4.27

Source: CSLS calculations based on the CSLS ICT by Industry database from January 2015.

Appendix III: Labour Productivity

Since ICT investment per worker growth is one determinant of labour productivity growth, data are presented below on the growth rates of labour productivity by industry. In the context of Canada, data are presented on labour productivity growth by industry between 1987 and 2013. This period is also broken down into equal sub-periods: 1987-2000 and 2000-2013. For the comparison of labour productivity growth by industry between Canada and the United States, data are presented for the 2002-2013 period. The trends in labour productivity data presented here will be linked to IT investment trends.

It is important to note that different sources were used for the labour productivity estimates in Canada for Section A and Section B. Section A uses official Statistics Canada estimates of output per hour, while Section B uses CSLS estimates of output per worker. This will result in slight differences in the growth rates of labour productivity in Canada between the two sections.

A. Industry Comparison within Canada

Labour productivity growth in agriculture, fishing, forestry and hunting was 3.9 per cent per year between 1987 and 2013 (Table 92). No other industry in Canada demonstrated labour productivity growth of this magnitude during this time period. Wholesale trade and manufacturing showed the next highest labour productivity growth rates at 2.6 per cent per year and 2.2 per cent per year, respectively. At the other end of the spectrum over this same time frame, labour productivity levels declined 0.8 per cent per year in arts, entertainment and recreation. Two other industries also showed negative labour productivity performance: mining and oil and gas extraction (-0.4 per cent per year), and utilities (-0.4 per cent per year).

In the more recent period (2000-2013), agriculture, fishing, forestry and hunting (4.2 per cent per year) and wholesale trade (2.7 per cent per year) saw the strongest growth. Retail trade replaced manufacturing as the third fastest growing industry for labour productivity (1.9 per cent per year). Negative labour productivity performance was restricted to three industries: arts, entertainment and recreation (-0.3 per cent per year), utilities (-1.0 per cent per year), and mining and oil and gas extraction (-2.7 per cent per year).

Given the results discussed above, we would expect relatively higher ICT investment per worker growth in agricultural, fishing, forestry and hunting than other industries between 1987 and 2013 and between 2000 and 2013, *ceteris paribus*.[57] We would also expect to see relatively higher ICT investment growth in wholesale trade and manufacturing between 1987 and 2013 and relative higher ICT investment growth in wholesale trade and retail trade in 2000 to 2013. In contrast, we would expect to see relatively lower ICT investment per worker growth in arts, entertainment and recreation; mining and oil and gas extraction; and utilities in both time periods, *ceteris paribus*.

[57] Merriam-Webster defines ceteris paribus as "if all other relevant things, factors, or elements remain unaltered." http://www.merriam-webster.com/dictionary/ceteris%20paribus

Table 92: Labour Productivity Growth by Industry, Compound Average Annual Growth, Per Cent, Canada, 1987-2000, 2000-2013, and 1987-2013

	Growth		
	1987-2013	1987-2000	2000-2013
Business sector	1.30	1.69	0.92
Agriculture, fishing, forestry and hunting	3.92	3.60	4.24
Mining and oil and gas extraction	-0.43	1.85	-2.66
Utilities	-0.42	0.11	-0.95
Construction	0.13	0.03	0.24
Manufacturing	2.17	3.31	1.04
Wholesale trade	2.62	2.54	2.69
Retail trade	2.05	2.26	1.85
Transportation and warehousing	1.27	1.70	0.84
Information and cultural industries	1.84	1.86	1.82
Finance, insurance, real estate and rental and leasing	1.37	1.48	1.25
Professional, scientific and technical services	0.80	0.55	1.05
Administrative and support, waste management and remediation services	0.31	0.25	0.37
Arts, entertainment and recreation	-0.84	-1.35	-0.32
Accommodation and food services	0.36	0.21	0.51
Other services (except public administration)	0.40	0.38	0.78

Note: the business sector covers the whole economy, less public administration, non-profit institutions and the rental value of owner-occupied dwellings.
Source: CANSIM Table 383-0021.

B. Industry Comparison between Canada and the United States

Labour productivity growth in the United States outperformed labour productivity in Canada in fourteen out of eighteen industries between 2002 and 2013 (Table 93). The four industries in which Canada's labour productivity growth outpaced labour productivity growth in the United States were construction; retail trade; accommodation and food services; and other services (except public administration).

Given these results, we would expect stronger growth in ICT investment per worker in Canada compared to the United States in these four industries, *ceteris paribus*. Of these four industries, the differential in labour productivity growth between Canada and the United States was the largest in other services (except public administration) (2.7 per cent), while it was the smallest in accommodation and food services (0.3 per cent). Hence, we would also expect that the differential in ICT investment per worker growth between Canada and the United States would be much larger in other services (except public administration) compared to accommodation and food services, *ceteris paribus*. However, given that a number of different factors besides ICT investment growth drive labour productivity growth, it is entirely possible that these predictions may not hold true in the data.

Table 93: Labour Productivity Growth, Output Per Worker, Compound Average Annual Growth, Canada and the United States, Per Cent, 2002-2013

	2002-2013	
	United States	Canada
Business sector	1.60	0.82*
Agriculture, fishing, forestry and hunting	4.59	4.35
Mining and oil and gas extraction	-3.44	-3.86
Utilities	1.74	0.95
Construction	-1.41	-0.29
Manufacturing	3.37	1.46
Wholesale trade	2.74	1.84
Retail trade	0.51	1.68
Transportation and warehousing	2.03	0.62
Information and cultural industries	6.24	2.08
Finance and insurance	1.03	0.80
Real estate and rental and leasing	2.01	0.53
Professional, scientific and technical services	0.63	-0.34
Administrative and support, waste management and remediation services	1.43	0.16
Educational services	1.22	0.10
Health care and social assistance	0.65	-0.62
Arts, entertainment and recreation	0.11	-1.21
Accommodation and food services	-0.37	-0.11
Other services (except public administration)	-1.80	0.93

Note: the business sector covers all industries less public administration, educational services, and health care and social assistance.
* Official statistics from CANSIM 383-0021 show business sector labour productivity growth at 0.80 per cent per year between 2002 and 2013.
Source: CSLS calculations based on the CSLS ICT database from January 2015.

C. IT Investment Per Worker and Labour Productivity Linkage in Canada

It was suggested above that three industries, *ceteris paribus*, should demonstrate relatively stronger growth rates in ICT investment per worker between 1987 and 2013: agriculture, fishing, forestry and hunting; wholesale trade; and manufacturing, while the shorter time period (2000-2013), agriculture, fishing, forestry and hunting; wholesale trade; and retail trade should demonstrate relatively stronger ICT investment per worker growth rates. It was also concluded that arts, entertainment and recreation, mining and oil and gas extraction, and utilities should demonstrate relatively weaker ICT investment per worker growth rates for both time periods.

Unfortunately, total ICT investment per worker and communications investment per worker for all industries are not available between 1987 and 2013. Hence, the linkage between labour productivity and ICT investment per worker will only be discussed for total IT, software, and computer investment.

The theoretical prediction that ICT investment per worker growth should be higher in agriculture, fishing, forestry and hunting (because agriculture, fishing, forestry and hunting had high productivity growth) appears to be upheld by the longer time series data: computer investment per worker grew 27.5 per cent between 1987 and 2013, while software investment grew 9.4 per cent in this same time frame. In contrast, the prediction that higher ICT investment per worker growth contributed to stronger labour productivity growth in 2000-2013 in wholesale trade is less plausible since computer investment per worker and software investment per worker saw average or less than average growth rates during this period.

To further attempt to confirm this theoretical linkage in Canada, a simple correlation exercise with no controls shows that software investment per worker growth between 1987 and 2013 is mildly correlated with labour productivity growth between 1987 and 2013 with a coefficient of 0.29 (R^2=0.09). Over the 1987-2000 period, software investment per worker growth is mildly correlated with labour productivity growth with a correlation coefficient of 0.24 (R^2=0.06), while software investment per worker growth is not correlated with labour productivity growth between 2000 and 2013 with a coefficient of -0.01 (R^2=0.00) (Chart 40).

The same correlation exercise for computer investment per worker growth and labour productivity growth produces a positive correlation between 1987 and 2013 with a coefficient of 0.40 (R^2=0.16), no correlation between 1987 and 2000 with a correlation coefficient of -0.05 (R^2=0.00), and a mild positive correlation between 2000 and 2013 with a coefficient of 0.14 (R^2=0.02) (Chart 39).[58]

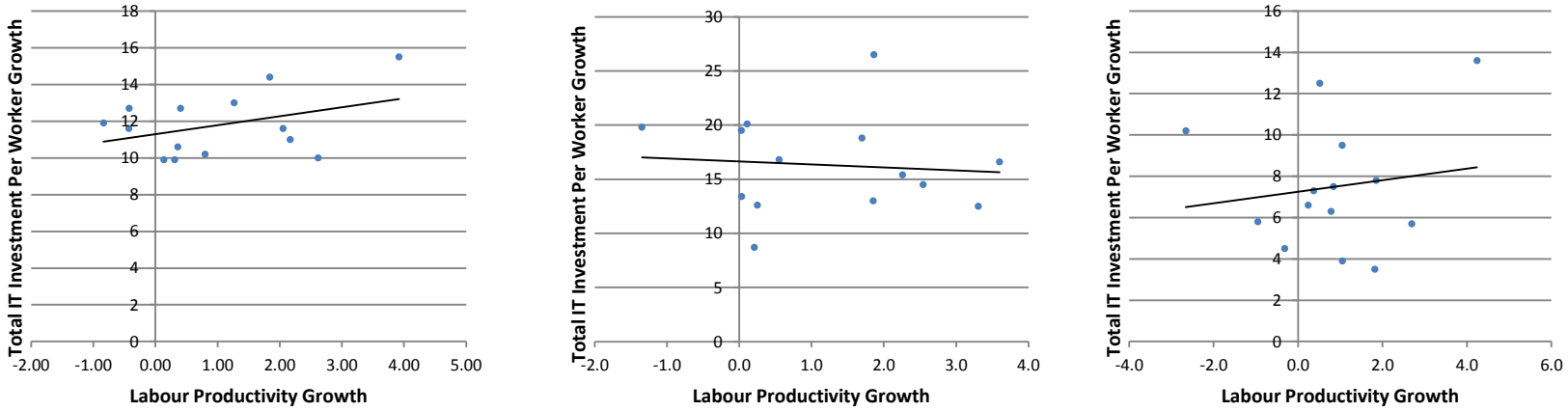
When these exercises are performed for total IT investment per worker, we get the following results: total IT investment per worker and labour productivity over the 1987-2013 period have a correlation coefficient of 0.38 (R^2=0.15); total IT investment per worker and labour productivity over the 1987-2000 period have a correlation coefficient of -0.09 (R^2=0.01); and total IT investment per worker and labour productivity over the 2000-2013 period have a correlation coefficient of 0.15 (R^2=0.02) (Chart 38).

Hence, it appears that the linkage between labour productivity growth and software investment per worker is tenuous in the twenty-first century, but computer and total IT investment per worker and labour productivity show a stronger relationship during this time frame. However, it must be kept in mind that these correlations do not include any controls, so it is entirely possible that once controls are added, the linkage will be much stronger and positive in both periods for total IT investment and for each component. Moreover, it is entirely possible that total ICT investment per worker (including communications) is more positively correlated with labour productivity growth than IT investment per worker or any of its two components because of interactions between computers, communications, and software investment.

[58] This correlation was performed with no controls for only fourteen industries between 1987 and 2013: accommodation and food services; administrative and support, waste management and remediation services; agriculture, fishing, forestry, and hunting; arts, entertainment and recreation; construction; information and cultural industries; manufacturing; mining and oil and gas extraction; other services (except public administration), professional, scientific and technical services; retail trade; transportation and warehousing; utilities; and wholesale trade.

Chart 38: Total IT Investment Per Worker and Labour Productivity Growth

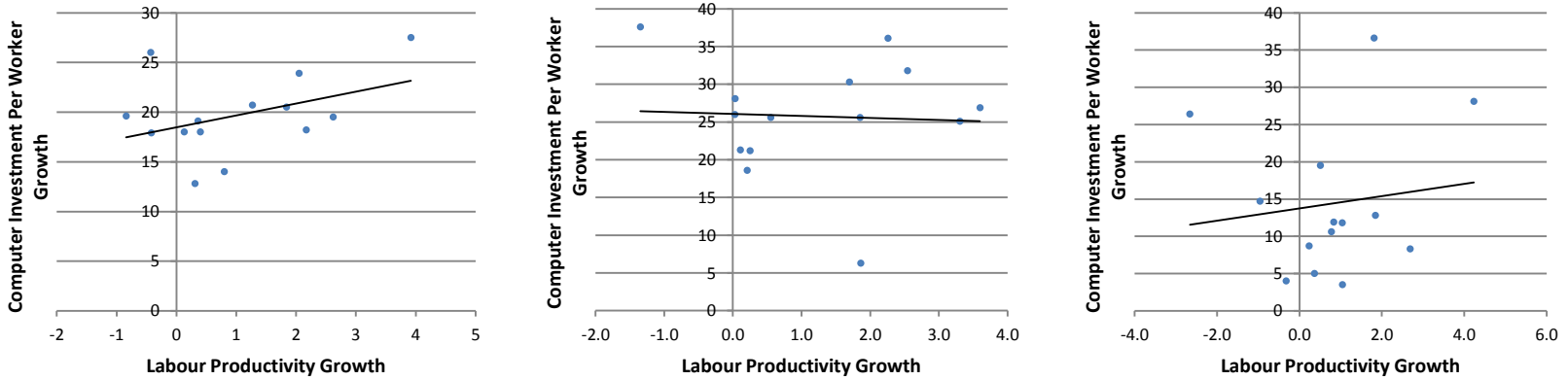
Panel A: 1987-2013 **Panel B: 1987-2000** **Panel C: 2000-2013**



Source: CSLS calculations based on Chart 13 and Table 92.

Chart 39: Computer Investment Per Worker and Labour Productivity Growth

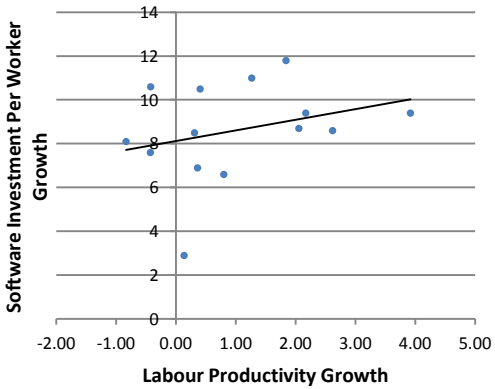
Panel A: 1987-2013 **Panel B: 1987-2000** **Panel C: 2000-2013**



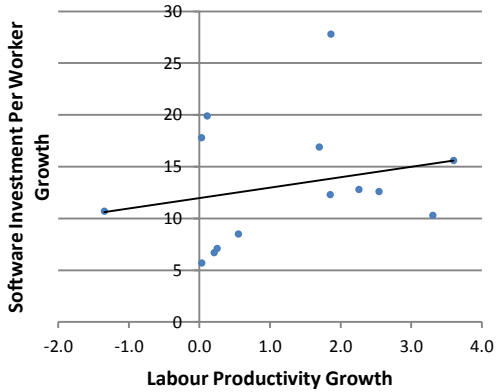
Source: CSLS calculations based on Table 92 and Chart 15.

Chart 40: Software Investment Per Worker and Labour Productivity Growth

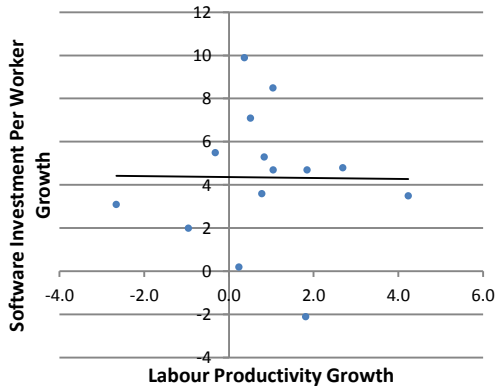
Panel A: 1987-2013



Panel B: 1987-2000



Panel C: 2000-2013



Source: CSLS calculations based on Table 92 and Chart 17.

D. Canada-US ICT Investment Per Worker and Labour Productivity Linkage

It was argued previously that four industries should demonstrate relatively stronger growth rates in ICT investment per worker between 2002 and 2013 in Canada compared to the United States: construction; retail trade; accommodation and food services; and other services (except public administration). Assuming that labour productivity growth is driven by ICT investment per worker, it was also concluded that the largest difference in ICT investment per worker should be seen in other services (except public administration), while the smallest difference in ICT investment per worker growth rates should be seen in accommodation and food services.

Unfortunately, total ICT investment per worker and communications investment per worker are not available for all industries between 2002 and 2013. Hence, the linkage between labour productivity and ICT investment per worker will only be discussed for total IT, software and computer investment per worker.

From the perspective of computer investment per worker, the theoretical linkage appears to hold for three of the four industries. These three industries had higher computer investment per worker growth than their US counterpart, namely retail trade (2.2 percentage points higher), construction (3.2 percentage points higher), and other services (except public administration) (4.0 percentage points higher). Furthermore, as predicted, other services (except public administration) had the highest computer investment per worker growth differential, while accommodation and food services had the lowest.

Switching to the software investment per worker perspective, the predictions derived from the theoretical linkage are upheld for two of the four industries. These two industries had higher software investment per worker than their US counterparts, namely other services (except public administration) (1.8 percentage points) and construction (6.0 percentage points).

The only industry for which the theoretical linkage is not upheld for both components is accommodation and food services which saw software investment per worker grow 0.4 percentage points faster in the United States than in Canada and computer investment per worker grow 0.1 percentage points faster in the United States than in Canada. The prediction also did not hold for retail trade when examining software investment per worker.

A simple correlation exercise with no controls is undertaken to further confirm the implications of this theoretical linkage for labour productivity and ICT investment growth in Canada and the United States. The correlation of the difference between computer investment per worker growth in Canada and the United States between 2002 and 2013 and the difference between labour productivity growth in Canada and the United States between 2002 and 2013 returns a coefficient of 0.23 (R^2=0.05), which suggests that the difference between computer investment per worker growth in Canada and the United States is weakly positively correlated with the difference between labour productivity growth in Canada and the United States (Chart 41).

The correlation of the difference between software investment per worker growth in Canada and the United States between 2002 and 2013 and the difference between labour productivity growth in Canada and the United States between 2002 and 2013 returns a coefficient of 0.11 (R^2=0.01), which suggests that the difference between software investment per worker growth in Canada and the United States is also weakly positively correlated with the difference between labour productivity growth in Canada and the United States.

Separate correlations were performed on labour productivity growth and investment per worker growth for both computers and software in both countries (Chart 42 and Chart 43). It is interesting to note that the correlations are positive for the United States: 0.19 (R^2=0.04) for the correlation between labour productivity growth and computer investment per worker growth and 0.58 (R^2=0.34) for the correlation between labour productivity growth and software investment per worker growth. Comparatively, the correlation is weakly negative in Canada: computer investment per worker growth was weakly negatively correlated with labour productivity growth between 2002 and 2013 with a coefficient of -0.18 (R^2=0.03), and software investment per worker growth and labour productivity growth were also weakly negatively correlated with a coefficient of -0.18 (R^2=0.03).[59]

These exercises were also performed for total IT investment per worker differentials. We obtained the following results: the total IT investment per worker gap between Canada and the United States is mildly positively correlated with labour productivity growth gap between Canada and the United States with a correlation coefficient of 0.17 (R^2=0.03); total IT investment per worker in Canada is mildly negatively correlated with labour productivity growth with a coefficient of -0.16 (R^2=0.02); and total IT investment per worker in the United States is positively correlated with labour productivity growth with a coefficient of 0.34 (R^2=0.11).

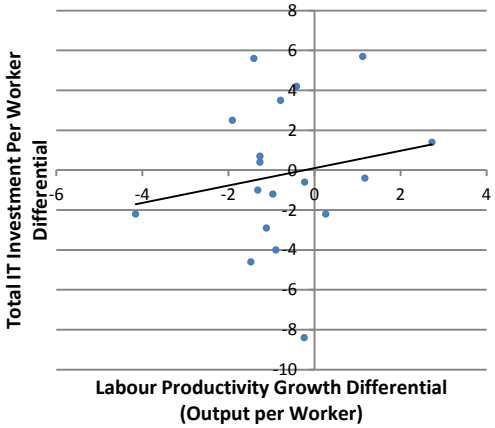
Hence, it appears that the linkage between labour productivity growth and ICT investment per worker is not present in the twenty-first century in Canada, but that it is present and extremely strong for software investment in the United States. Moreover, it appears that differences between the two countries in labour productivity growth and computer and software investment per worker growth are correlated, although the correlation is stronger for computers.

Despite these promising preliminary findings, it must be kept in mind that these correlations do not include any controls, so it is entirely possible that once controls are added, the coefficients will change drastically. Moreover, as previously mentioned, it is entirely possible that the differences in total ICT investment per worker by country are more positively correlated with the differences in labour productivity growth by country than any of the individual components of ICT investment per worker because of interactions between the different components.

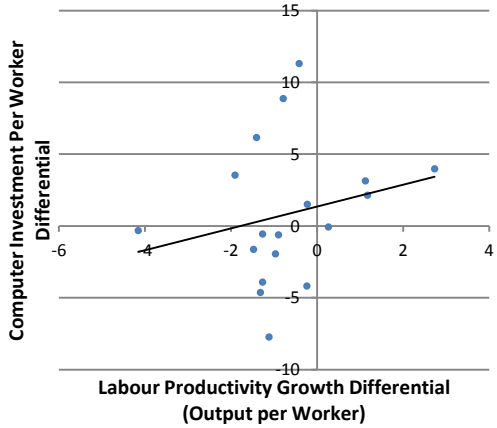
[59] These correlation were performed with no controls for sixteen industries between 2002 and 2013: accommodation and food services; administrative and support, waste management and remediation services; agriculture, fishing, forestry, and hunting; arts, entertainment and recreation; construction; educational services; health care and social assistance; information and cultural industries; manufacturing; mining and oil and gas extraction; other services (except public administration), professional, scientific and technical services; retail trade; transportation and warehousing; utilities; and wholesale trade.

Chart 41: IT Investment Per Worker Growth and Labour Productivity Growth Differentials, Canada-US, 2002-2013

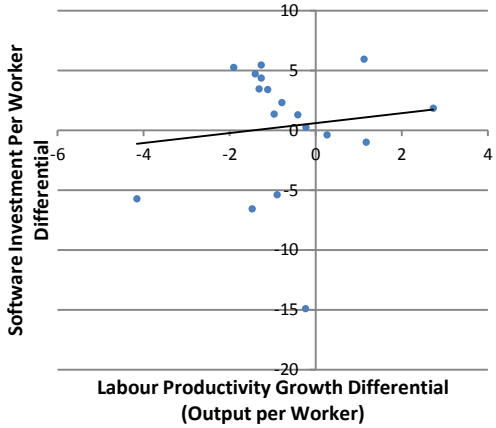
Panel A: Total IT Investment Per Worker



Panel B: Computer Investment Per Worker



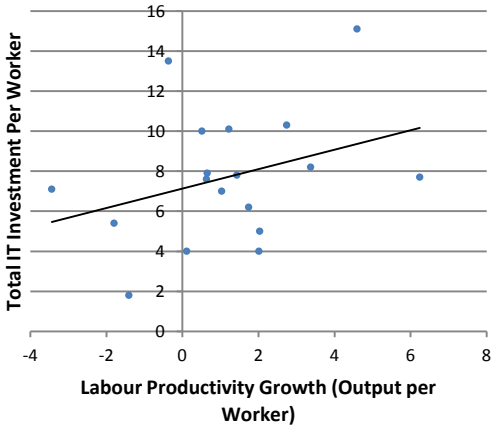
Panel C: Software Investment Per Worker



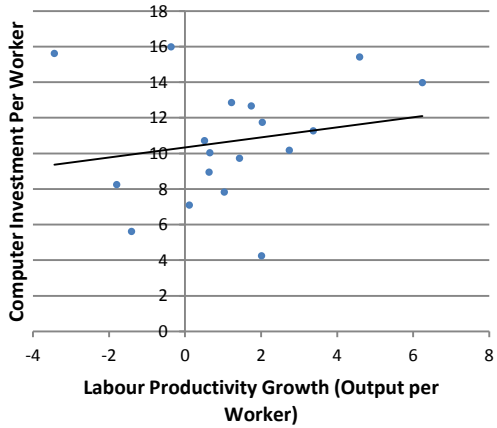
Source: CSLS calculations based on Table 9, Table 13, Table 17, and Table 93.

Chart 42: IT Investment Per Worker and Labour Productivity Growth, United States, 2002-2013

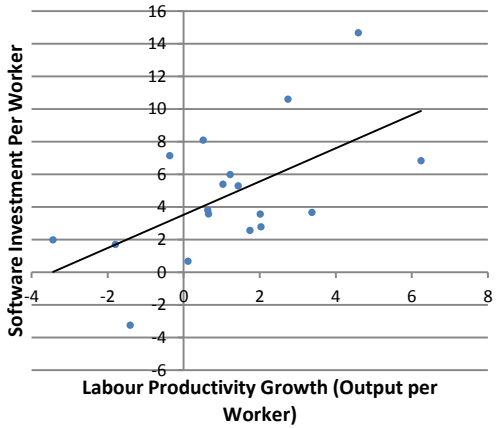
Panel A: Total IT Investment Per Worker



Panel B: Computer Investment Per Worker



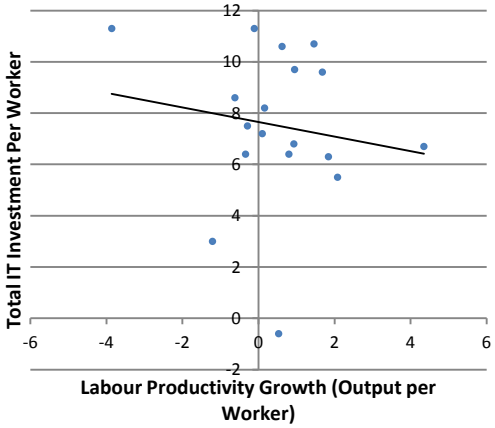
Panel C: Software Investment Per Worker



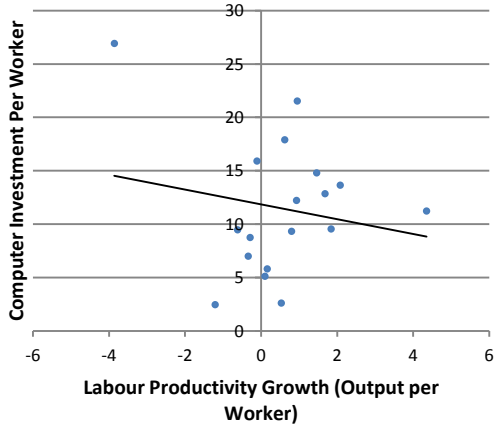
Source: CSLS calculations based on Table 9, Table 13, Table 17, and Table 93.

Chart 43: IT Investment Per Worker and Labour Productivity Growth, Canada, 2002-2013

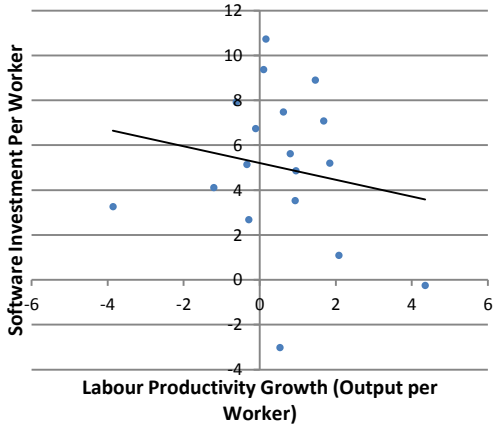
Panel A: Total IT Investment Per Worker



Panel B: Computer Investment Per Worker



Panel C: Software Investment Per Worker



Source: CSLS calculations based on Table 9, Table 13, Table 17, and Table 93.

Appendix IV: ICT Investment Per Worker Growth Rates in Canada

A. Total IT Investment Per Worker

Table 94: Real Total IT Investment Per Worker, Compound Average Annual Growth, Canada, Per Cent, 1987-2013

	1987-2013	1987-2000	2000-2013
Agriculture, fishing, forestry and hunting	15.5	16.6	13.6
Mining and oil and gas extraction	11.6	13.0	10.2
Utilities	12.7	20.1	5.8
Construction	9.9	13.4	6.6
Manufacturing	11.0	12.5	9.5
Wholesale trade	10.0	14.5	5.7
Retail trade	11.6	15.4	7.8
Transportation and warehousing	13.0	18.8	7.5
Information and cultural industries	14.4	26.5	3.5
Finance and insurance	7.8	10.0	5.6
Real estate and rental and leasing	9.0	13.3	4.8
Professional, scientific and technical services	10.2	16.8	3.9
Administrative and support, waste management and remediation services	9.9	12.6	7.3
Educational services	10.5	13.0	7.9
Health care and social assistance	12.4	16.8	8.1
Arts, entertainment and recreation	11.9	19.8	4.5
Accommodation and food services	10.6	8.7	12.5
Other services (except public administration)	12.7	19.5	6.3
Public administration	10.0	14.6	5.6
Business sector	10.4	14.7	6.2

Source: CSLS ICT database from January 2015.

B. Total ICT Investment Per Worker

Table 95: Real Total ICT Investment Per Worker, Compound Average Annual Growth, Canada, Per Cent, 1987-2013

	1987-2008	1987-2000	2000-2008
Agriculture, fishing, forestry and hunting	15.3	16.0	14.4
Mining and oil and gas extraction	19.1	17.7	21.5
Utilities	.	.	.
Construction	.	.	.
Manufacturing	14.4	16.0	12.0
Wholesale trade	15.1	19.7	8.0
Retail trade	17.4	20.5	12.6
Transportation and warehousing	n/a	22.7	.
Information and cultural industries	6.5	9.0	2.5
Finance and insurance	10.7	10.5	10.9
Real estate and rental and leasing	14.9	15.1	15.5
Professional, scientific and technical services	12.3	20.6	0.0
Management of companies and enterprises	.	.	.
Administrative and support, waste management and remediation services	.	.	.
Educational services	14.4	17.8	9.2
Health care and social assistance	.	.	.
Arts, entertainment and recreation	16.2	20.5	9.6
Accommodation and food services	.	.	.
Other services (except public administration)	.	.	.
Public administration	11.8	15.6	5.9
Business sector	11.4	14.2	7.0

Source: CSLS ICT by Industry database from January 2015.

C. Computer Investment Per Worker

Table 96: Real Computer Investment Per Worker Growth, Compound Average Annual Growth, Canada, Per Cent, 1987-2013

	1987-2013	1987-2000	2000-2013
Agriculture, fishing, forestry and hunting	27.5	26.9	28.1
Mining and oil and gas extraction	26.0	25.6	26.4
Utilities	17.9	21.3	14.7
Construction	18.0	28.1	8.7
Manufacturing	18.2	25.1	11.8
Wholesale trade	19.5	31.8	8.3
Retail trade	23.9	36.1	12.8
Transportation and warehousing	20.7	30.3	11.9
Information and cultural industries	20.5	6.3	36.6
Finance and insurance	11.6	19.6	4.2
Real estate and rental and leasing	15.5	24.8	6.9
Professional, scientific and technical services	14.0	25.6	3.5
Management of companies and enterprises	n/a	n/a	16.5
Administrative and support, waste management and remediation services	12.8	21.2	5.0
Educational services	17.7	28.4	7.9
Health care and social assistance	18.4	28.6	9.0
Arts, entertainment and recreation	19.6	37.6	4.0
Accommodation and food services	19.1	18.6	19.5
Other services (except public administration)	18.0	26.0	10.6
Public administration	15.3	28.3	3.6
Business sector	16.8	24.8	9.3

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT database from January 2015.

D. Communications Investment Per Worker

Table 97: Real Communications Investment Per Worker Growth, Compound Average Annual Growth, Canada, Per Cent, 1987-2013

	1987-2008	1987-2000	2000-2008
Agriculture, fishing, forestry and hunting	2.8	7.7	-4.6
Mining and oil and gas extraction	14.2	24.5	-0.6
Utilities	.	.	.
Construction	.	.	.
Manufacturing	15.9	12.7	21.2
Wholesale trade	n/a	n/a	12.8
Retail trade	18.2	26.3	6.0
Transportation and warehousing	n/a	17.0	.
Information and cultural industries	3.8	6.1	0.3
Finance and insurance	9.1	5.5	15.1
Real estate and rental and leasing	7.2	-0.6	21.3
Professional, scientific and technical services	10.5	14.6	4.1
Management of companies and enterprises	.	.	-18.6
Administrative and support, waste management and remediation services	n/a	n/a	
Educational services	5.7	17.5	-11.1
Health care and social assistance	.	.	.
Arts, entertainment and recreation	5.4	0.9	13.1
Accommodation and food services	.	.	.
Other services (except public administration)	.	.	.
Public administration	0.3	3.7	-5.0
Business sector	4.5	7.0	0.6

Note: “n/a” means not available, while “.” means suppressed.
Source: CSLS ICT database from January 2015.

E. Software Investment Per Worker

Table 98: Real Software Investment Per Worker Growth, Compound Average Annual Growth, Canada, Per Cent, 1987-2013

	1987-2013	1987-2000	2000-2013
Agriculture, fishing, forestry and hunting	9.4	15.6	3.5
Mining and oil and gas extraction	7.6	12.3	3.1
Utilities	10.6	19.9	2.0
Construction	2.9	5.7	0.2
Manufacturing	9.4	10.3	8.5
Wholesale trade	8.6	12.6	4.8
Retail trade	8.7	12.8	4.7
Transportation and warehousing	11.0	16.9	5.3
Information and cultural industries	11.8	27.8	-2.1
Finance and insurance	7.0	7.9	6.1
Real estate and rental and leasing	6.5	10.0	3.1
Professional, scientific and technical services	6.6	8.5	4.7
Administrative and support, waste management and remediation services	8.5	7.1	9.9
Educational services	8.3	8.5	8.0
Health care and social assistance	10.4	13.3	7.5
Arts, entertainment and recreation	8.1	10.7	5.5
Accommodation and food services	6.9	6.7	7.1
Other services (except public administration)	10.5	17.8	3.6
Public administration	9.2	12.2	6.3
Business sector	8.3	12.5	4.3

Source: CSLS ICT database from January 2015.

Appendix Tables and Charts

A. General

Appendix Table 1: Summary of IT, Computer and Software Investment Per Worker in Information and Cultural Industries and Professional, Scientific and Technical Services, Canada and the United States, 2002

	Absolute Levels, US$					
	Canada			United States		
	IT	Computer	Software	IT	Computer	Software
Information and cultural industries	4,057	1,447	2,610	11,992	2,451	3,541
Professional, scientific and technical services	1,629	1,213	416	4,306	1,391	2,915
Business sector	1,210	518	692	2,417	712	1,705

	Relative, Per Cent		
	IT	Computer	Software
Information and cultural industries	33.8	59.0	27.4
Professional, scientific and technical services	37.8	87.2	14.3
Business sector	50.1	72.7	40.6

	Contributions to Business Sector Gap, Per Cent		
	IT	Computer	Software
Information and cultural industries	22.3	17.6	23.2
Professional, scientific and technical services	18.3	7.6	20.3
Total	40.6	25.2	43.5

	Contributions to the Business Sector Gap*		
	IT, Per Cent	Computer, Percentage Points	Software, Percentage Points
Information and cultural industries	22.3	2.2	20.3
Professional, scientific and technical services	18.3	0.5	19.0
Total	40.6	2.7	39.3

* These values will not be exactly additive.
Source: CSLS

Appendix Table 2: IT Investment, Total Investment, Employment and GDP, Canada and the United States, Domestic Currency, 2011

	United States				Canada			
	IT Investment (millions)	Total Investment (millions)	GDP (millions)	Employment (thousands)	IT Investment (millions)	Total Investment (millions)	GDP (millions)	Employment (thousands)
Agriculture, fishing, forestry and hunting	387	50.359	197,693	2,254	129	5.372	29,616	372
Mining and oil and gas extraction	3,009	158,508	409,324	817	417	78,469	139,800	271
Utilities	4,354	104,752	279,974	1,243	1,491	25,644	39,630	140
Construction	1,617	27,731	546,080	9,039	339	6,173	119,792	1,262
Manufacturing	43,765	398,118	1,922,874	14,336	2,708	22,455	176,232	1,760
Wholesale trade	28,550	74,094	909,357	3,798	2,210	6,740	86,966	633
Retail trade	18,336	72,624	894,584	15,927	1,963	8,192	85,025	2,037
Transportation and warehousing	4,782	79,066	447,836	5,957	1,937	17,501	68,638	843
Information and cultural industries	62,606	225,167	741,325	3,150	2,263	11,851	53,245	391
Finance and insurance	52,618	128,107	1,011,637	6,613	5,331	11,098	107,421	758
Real estate and rental and leasing	4,210	84,225	2,000,103	2,773	1,726	10,974	201,401	325
Professional, scientific and technical services	46,062	100,993	1,079,073	9,461	2,260	6,706	93,418	1,309
Management of companies and enterprises	30,555	38,890	282,866	195	151	392	11,232	3
Administrative and support, waste management and remediation services	19,166	39,138	462,773	6,163	822	2,453	45,357	674
Educational services	7,252	32,490	174,019	12,965	1,560	17,959	89,183	1,219
Health care and social assistance	10,309	116,650	1,109,095	18,902	1,054	10,024	117,830	2,092
Arts, entertainment and recreation	887	21,543	150,260	2,922	353	1,783	12,822	393
Accommodation and food services	1,762	26,072	412,530	9,775	407	3,601	33,726	1,093
Other services (except public administration)	3,351	27,521	337,473	6,724	590	2,650	34,118	759
Business sector	326,017	1,656,908	13,368,876	101,149	25,093	222,055	1,338,439	13,024

Source: CSLS estimates based on CSLS ICT database from January 2015.

Appendix Table 3: IT Investment as a Share of Total Investment and GDP, Total Investment as a Share of GDP, and IT Investment Per Worker, Canada and the United States, 2011

	United States				Canada			
	Total Investment as a Share of GDP (%)	IT Investment as a Share of Total Investment (%)	IT Investment as a Share of GDP (%)	IT Investment Per Worker ($US)	Total Investment as a Share of GDP (%)	IT Investment as a Share of Total Investment (%)	IT Investment as a Share of GDP (%)	IT Investment Per Worker ($US)
Agriculture, fishing, forestry and hunting	25.5	0.77	0.20	172	18.1	2.41	0.35	313
Mining and oil and gas extraction	38.7	1.90	0.74	3,683	56.1	0.53	0.28	1,380
Utilities	37.4	4.16	1.56	3,503	64.7	5.81	3.98	9,595
Construction	5.1	5.83	0.30	179	5.2	5.49	0.21	242
Manufacturing	20.7	10.99	2.28	3,053	12.7	12.06	1.79	1,385
Wholesale trade	8.1	38.53	3.14	7,517	7.7	32.80	2.60	3,144
Retail trade	8.1	25.25	2.05	1,151	9.6	23.96	2.34	867
Transportation and warehousing	17.7	6.05	1.07	803	25.5	11.07	3.20	2,068
Information and cultural industries	30.4	27.80	8.45	19,875	22.3	19.09	4.28	5,205
Finance and insurance	12.7	41.07	5.20	7,957	10.3	48.04	5.54	6,330
Real estate and rental and leasing	4.2	5.00	0.21	1,518	5.4	15.73	0.75	4,775
Professional, scientific and technical services	9.4	45.61	4.27	4,869	7.2	33.71	2.46	1,554
Management of companies and enterprises	13.7	78.57	10.80	156,692	3.5	38.43	1.11	45,180
Administrative and support, waste management and remediation services	8.5	48.97	4.14	3,110	5.4	33.28	1.71	1,090
Educational services	18.7	22.32	4.17	559	20.1	8.69	1.65	1,152
Health care and social assistance	10.5	8.84	0.93	545	8.5	10.51	0.82	453
Arts, entertainment and recreation	14.3	4.12	0.59	304	13.9	19.82	2.40	810
Accommodation and food services	6.3	6.76	0.43	180	10.7	11.30	1.01	335
Other services (except public administration)	8.2	12.18	0.99	498	7.8	22.27	1.69	700
Business sector	12.4	19.68	2.44	3,223	16.6	11.30	1.95	1,734

Source: CSLS estimates based on Appendix Table 2.

Appendix Table 4: IT Investment Per Worker and IT Investment as a Share of Total Investment and GDP, Canada as a Proportion of the United States, 2011

	Total Investment as a Share of Total GDP	IT Investment as a Share of Total Investment	IT Investment as a Share of GDP	IT Investment Per Worker
	(1)	(2)	(3)	(4)
Agriculture, fishing, forestry and hunting	71.2	313.2	177.1	182.4
Mining and oil and gas extraction	144.9	27.9	38.0	37.5
Utilities	172.9	139.8	255.9	273.9
Construction	101.5	94.2	72.3	135.2
Manufacturing	61.5	109.7	78.8	45.4
Wholesale trade	95.1	85.1	82.8	41.8
Retail trade	118.7	94.9	114.1	75.3
Transportation and warehousing	144.4	183.1	299.3	257.6
Information and cultural industries	73.3	68.7	50.7	26.2
Finance and insurance	81.6	117.0	106.6	79.6
Real estate and rental and leasing	129.4	314.7	356.5	314.5
Professional, scientific and technical services	76.7	73.9	57.7	31.9
Management of companies and enterprises	25.4	48.9	10.3	28.8
Administrative and support, waste management and remediation services	64.0	68.0	41.4	35.1
Educational services	107.9	38.9	39.6	205.9
Health care and social assistance	80.9	118.9	87.9	83.1
Arts, entertainment and recreation	97.0	481.4	407.1	266.7
Accommodation and food services	168.9	167.3	235.3	185.9
Other services (except public administration)	95.3	182.9	170.1	140.5
Business sector	133.9	57.4	80.0	53.8

Source: CSLS estimates based on Appendix Table 3.

Appendix Table 5: Industrial Structure, Breakdown of Two-Digit NAICS Industry Employment into Sub-Industry Shares, 2008 and 2014

	United States		Canada	
	2014	**2008**	**2014**	**2008**
Agriculture, forestry, fishing, and hunting	100.00	100.00	100.00	100.00
Crop production	49.49	44.00	35.98	31.70
Animal production and aquaculture	34.87	39.85	38.38	42.50
Forestry and logging	6.53	6.69	7.97	8.26
Fishing, hunting, and trapping	1.79	2.44	4.29	5.38
Support activities for agriculture and forestry	7.33	7.01	8.86	8.16
Farming not elsewhere classified	--	--	4.48	4.00
Mining	100.00	100.00	100.00	100.00
Oil and gas extraction	9.56	9.28	34.70	32.66
Coal mining	7.72	12.21	2.70	4.70
Metal ore mining	4.60	4.40	12.62	13.39
Non-metallic mineral mining and quarrying	7.17	12.33	8.39	8.92
Not specified type of mining	0.92	0.85	1.40	1.32
Support activities for mining	70.04	60.81	40.23	39.05
Manufacturing	100.00	100.00	100.00	100.00
Non-metallic mineral products manufacturing	2.80	3.28	2.84	2.99
Primary metals and fabricated metal products manufacturing	10.76	11.31	12.74	13.06
Machinery manufacturing	8.55	8.22	7.63	5.71
Computers and electronic products manufacturing	8.27	9.22	4.21	5.58
Electrical equipment and appliances manufacturing	2.83	3.09	2.13	2.42
Transportation equipment manufacturing	15.28	14.67	14.28	13.60
Wood products manufacturing	2.58	3.02	6.67	6.53
Furniture and related product manufacturing	2.76	3.66	4.32	5.24
Miscellaneous manufacturing	9.34	8.12	5.35	4.30
Food manufacturing	11.43	9.90	14.90	13.13
Beverage manufacturing	1.75	1.45	1.82	1.85
Tobacco manufacturing	0.21	0.17	0.13	0.09
Textiles, apparel and leather manufacturing	3.84	4.40	3.07	3.86
Paper manufacturing and printing	6.18	6.83	7.83	9.74
Petroleum and coal products manufacturing	1.40	1.06	0.89	0.96
Chemicals manufacturing	8.83	8.13	6.01	5.58
Plastics and rubber products manufacturing	3.17	3.46	5.18	5.35
Wholesale trade	100.00	100.00	100.00	100.00
Motor vehicle and motor vehicle parts and supplies merchant wholesalers	4.56	5.33	6.93	8.44
Furniture and home furnishing merchant wholesalers	1.26	2.22	1.24	1.07
Lumber and other construction materials merchant wholesalers	4.45	5.68	6.03	6.35
Professional and commercial equipment and supplies merchant wholesalers	9.34	8.66		
Metals and minerals, except petroleum merchant wholesalers	1.37	1.63	1.94	2.35
Household appliances and electrical and electronic goods merchant wholesalers	6.04	5.53	0.71	0.83
Hardware, plumbing and heating equipment, and supplies merchant wholesalers	3.84	4.24	8.34	6.13
Personal goods wholesale distribution			2.49	2.95
Machinery, equipment, and supplies merchant wholesalers	10.96	10.46	30.63	29.43
Paper and paper products, disposable plastics products and recyclable material merchant wholesalers	4.78	5.03	5.46	6.96
Drug, sundries, and chemical and allied products merchant wholesalers	6.67	6.29	6.93	6.42
Apparel, piece goods and notions merchant wholesalers	3.32	3.16	3.04	3.57
Grocery and related product merchant wholesalers	22.54	20.46		
Food and beverage and tobacco wholesaler distribution			13.47	12.78
Farm product raw material merchant wholesalers	1.70	1.68	1.25	1.66
Petroleum and petroleum products merchant wholesalers	3.57	3.55	1.54	1.53
Alcoholic beverages merchant wholesalers	3.60	3.68		
Farm suppliers merchant wholesalers	1.07	0.91	2.70	2.09
Miscellaneous goods merchant wholesalers	7.58	7.92	7.12	5.84
Wholesale electronic markets and agents and brokers	1.92	1.83	0.00	1.55
Not specified wholesale trade	1.43	1.73		

	United States		Canada	
	2014	2008	2014	2008
Retail trade	100.00	100.00	100.00	100.00
Automobile dealers	7.72	8.17	7.43	7.54
Other motor vehicle dealers	0.75	1.06	1.09	1.10
Automotive parts, accessories, and tire stores	3.15	3.07	1.95	2.11
Furniture and home furnishings stores	3.44	3.96	3.41	4.06
Household appliance and electronics stores	3.82	4.32	3.73	3.84
Building material and supplies, hardware and lawn and garden equipment and supplies dealers	8.59	8.84	7.70	7.05
Grocery stores	17.27	15.99	20.67	21.52
Specialty food stores	1.67	1.54	2.58	2.36
Beer, wine, and liquor stores	0.86	0.87	1.97	1.69
Pharmacies and drug stores, and health and personal care stores	7.59	7.13	9.18	7.91
Gasoline stations	3.17	3.07	3.26	3.52
Clothing stores	6.29	5.84	8.31	8.06
Shoe stores	1.07	0.83	1.02	1.09
Jewelry, luggage and leather goods stores	1.19	1.49	1.42	1.19
Sporting goods, hobby and toy stores, sewing, needlework, piece goods, musical instruments, books	4.30	4.94	4.12	4.33
Department stores and discount stores	12.83	13.90	6.78	8.03
Miscellaneous general merchandise stores	3.30	2.97	5.79	6.07
Retail florists	0.77	0.88	0.46	0.55
Office supplies and stationery stores, gift novelty, and souvenir shops	1.75	2.13	1.59	2.03
Used merchandise stores	1.46	1.18	1.21	0.96
Miscellaneous retail stores	2.77	2.49	3.73	2.78
Electronic shopping, auctions and mail-order houses	2.00	1.30	0.66	0.44
Vending machine operators	0.31	0.38	0.18	0.22
Fuel dealers	0.45	0.69		
Other direct selling establishments	1.10	1.39	1.75	1.54
Not specified retail trade	2.36	1.59		
Transportation and warehousing	100.00	100.00	100.00	100.00
Air	8.28	8.75	6.63	7.20
Rail	4.06	4.37	4.07	4.48
Water	1.03	1.17	1.61	1.26
Truck	30.39	30.67	32.77	33.93
Bus service and urban transit and ground transportation	12.80	13.06	18.99	16.57
Pipeline	0.83	0.54	1.15	0.56
Scenic and sightseeing transportation	0.69	0.52	0.35	0.38
Services incidental to transportation	12.48	11.28	13.09	12.51
Postal service	10.62	12.78	6.99	9.56
Couriers and messengers	11.53	10.92	8.07	8.25
Warehousing and storage	7.31	5.92	6.27	5.30
Utilities	100.00	100.00	100.00	100.00
Electric power generation, transmission, and distribution	51.91	50.78	75.53	76.54
Natural gas distribution	10.38	10.29	11.25	12.72
Electric and gas, and other combinations	37.62	38.94	13.29	10.74
Information	100.00	100.00	100.00	100.00
Newspaper publishers, periodical, book, and directory/database publishers	15.92	20.40	16.58	17.74
Software publishers	4.37	2.27	4.41	3.62
Motion pictures and video industries	13.55	11.40	14.48	14.40
Sound recording industries	1.32	1.18	1.32	1.26
Radio and television broadcasting and cable subscription programming	18.81	16.60	11.28	11.09
Telecommunications carriers	31.49	34.62	41.08	40.67
Data processing, hosting, and related services	2.95	2.50	1.85	2.49
Other information services	11.59	11.06	9.03	8.73
Finance and insurance	100.00	100.00	100.00	100.00
Banking and related activities	46.46	46.33	51.24	52.85
Securities, commodities, funds, trusts, and other financial investments	15.64	18.67	17.51	15.02
Insurance carriers and related activities	38.34	35.00	31.10	32.08

	United States		Canada	
	2014	**2008**	**2014**	**2008**
Real estate and rental and leasing	100.00	100.00	100.00	100.00
Real estate	87.44	83.93	82.51	74.81
Automotive equipment rental and leasing	5.69	6.21	6.02	6.50
Video tape and disk rental	4.01	5.56	4.47	10.52
Commercial, industrial, and other intangible assets rental and leasing	2.85	4.31	6.94	7.87
Professional and business services	100.00	100.00	100.00	100.00
Legal services	16.04	17.54	10.76	11.06
Accounting, tax preparation, bookkeeping and payroll services	10.41	10.70	11.40	12.20
Architectural, engineering, and related services	14.20	17.25	21.36	21.06
Specialized design services	4.06	4.12	4.69	4.99
Computer systems design and related services	22.70	20.78	24.56	23.50
Management, scientific, and technical consulting services	14.74	11.88	11.53	11.47
Scientific research and development services	5.30	5.80	3.29	3.33
Advertising, public relations, and related services	5.64	5.55	6.14	6.12
Other professional, scientific and technical services	6.93	6.39	6.28	6.26
Administrative support and waste management and remediation services	100.00	100.00	100.00	100.00
Employment services	15.19	16.10	11.24	12.88
Business support services	12.25	13.11	13.48	18.36
Travel arrangements and reservation services	4.39	4.45	6.35	6.71
Investigation and security services	11.73	13.32	16.25	13.35
Services to buildings and dwellings	22.79	22.09	41.59	37.56
Landscaping services, other administrative and other support services	25.28	23.81	5.02	5.75
Waste management and remediation services	8.39	7.15	5.90	5.33
Educational services	100.00	100.00	100.00	100.00
Elementary and secondary schools	66.44	68.62	59.91	62.49
Colleges, universities, and professional schools, including junior	26.93	25.52	28.72	28.39
Business, technical, and trade schools and training	0.71	0.76	1.19	1.19
Other schools and instruction, and educational support services	5.92	5.10	10.19	7.93
Health care and social assistance	100.00	100.00	100.00	100.00
Hospitals	33.64	34.23	35.38	35.00
Offices of physicians	8.38	8.57	6.45	7.81
Offices of dentists	4.52	4.25	4.68	5.21
Officers of other health practitioners	2.97	2.44	6.10	4.55
Outpatient care centers	7.91	6.07	1.86	2.26
Home health care services	6.72	4.83	1.95	1.89
Other health care services	6.76	9.03	2.77	2.50
Nursing and residential care facilities	13.47	13.45	17.04	17.51
Individual and family services	7.28	7.04	11.26	10.98
Community food and housing, and emergency services	0.55	0.61	0.52	0.37
Vocational rehabilitation services	0.67	0.93	1.07	1.88
Child day care services	7.13	8.57	10.93	10.05
Arts, entertainment, and recreation	100.00	100.00	100.00	100.00
Independent artists, performing arts, spectator sports, and related industries	**26.90**	**27.25**	**31.33**	33.99
Museums, art galleries, historical sites, and similar institutions	**11.00**	**12.75**	**6.54**	8.75
Bowling centers, other amusement, gambling, and recreation industries	62.10	59.96	62.14	57.26
Accommodation and food services	100.00	100.00	100.00	100.00
Traveler accommodation	13.64	14.53	15.50	16.36
Recreational vehicle parks and camps, and room and boarding houses	0.87	1.02	1.40	1.84
Restaurants and other food services	82.97	82.00	80.00	77.69
Drinking places, alcoholic beverages	2.51	2.45	3.10	3.98
Other services	100.00	100.00	100.00	100.00
Repair and maintenance	28.79	29.78	36.28	36.32
Personal and laundry services	33.03	31.98	30.54	30.61
Membership associations and organizations	26.74	26.75	24.40	23.49
Private households	11.44	11.49	8.78	9.57

Source: CSLS calculations based on an LFS special order and a US BEA special request.

Appendix Table 6: Industrial Structure, Breakdown of Two-Digit NAICS Industry GDP into Sub-Industry Shares, 2008

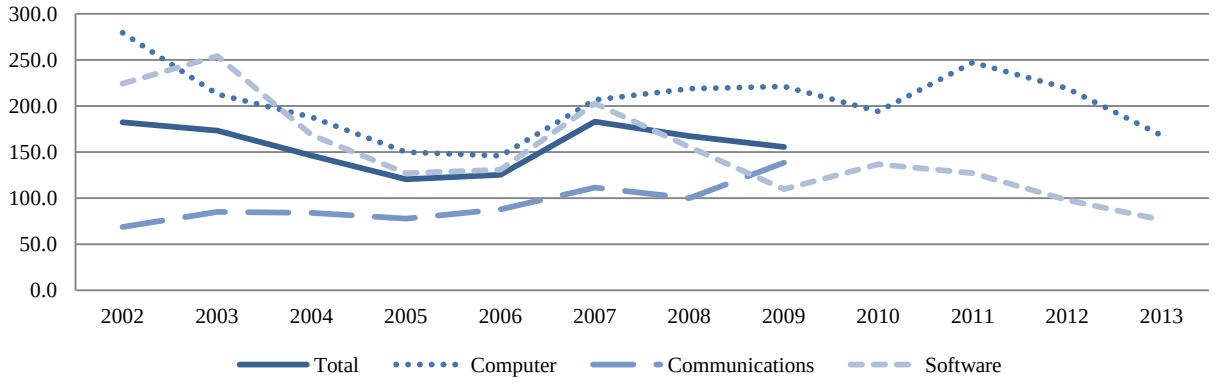
	Canada	United States
Agriculture, forestry, fishing, and hunting	100.00	100.00
Farms	71.67	81.76
Forestry, fishing and related activities	20.16	18.24
Support activities for agriculture and forestry	8.17	0.00
Mining	100.00	100.00
Oil and gas extraction	70.73	69.87
Mining, except oil and gas	22.48	15.69
Support activities for mining	9.55	14.44
Manufacturing	100.00	100.00
Non-metallic mineral products manufacturing	3.52	2.41
Primary metals and fabricated metal products manufacturing	15.97	11.04
Machinery manufacturing	7.71	12.11
Computers and electronic products manufacturing	4.33	12.90
Electrical equipment and appliances manufacturing	2.21	3.04
Transportation equipment manufacturing	14.33	11.20
Wood products manufacturing	4.87	1.40
Furniture and related product manufacturing	2.92	1.54
Miscellaneous manufacturing	2.19	4.13
Food and beverage and tobacco manufacturing	15.39	11.09
Textiles, apparel and leather manufacturing	2.03	10.50
Paper manufacturing and printing	4.87	5.29
Petroleum and coal products manufacturing	3.96	8.64
Chemicals manufacturing	7.32	15.44
Plastics and rubber products manufacturing	5.00	3.11
Retail trade	100.00	100.00
Motor vehicle and parts dealers	16.69	17.54
Food and beverage stores	19.52	15.11
General merchandise stores	11.95	148.65
Other retail stores	51.84	52.49
Transportation and warehousing	100.00	100.00
Air	8.23	15.16
Rail	9.41	8.89
Water	2.70	3.99
Truck	26.24	28.38
Urban transit systems	12.14	6.37
Pipeline	8.71	3.76
Other transportation and support activities	28.86	22.68
Warehousing and storage	3.71	10.78
Information	100.00	100.00
Publishing industries (except Internet)	20.60	25.62
Motion picture and sound recording industries	6.83	11.39
Radio and television broadcasting and telecommunications	66.39	53.22
Data processing, hosting, and related services	3.42	9.77
Other information services	2.75	0.00
Finance and insurance	100.00	100.00
Banking and related activities	57.90	46.01
Securities, commodities, funds, trusts, and other financial investments	10.16	16.55
Insurance carriers and related activities	25.14	37.44
Real estate and rental and leasing	100.00	100.00
Real estate	93.72	90.60
Rental and leasing services and lessors of intangible assets	6.28	9.40
Professional and business services	100.00	100.00
Legal services	14.95	22.60
Computer systems design and related services	21.36	16.85
Miscellaneous professional, scientific and technical services	63.69	60.55

	Canada	United States
Administrative support and waste management and remediation services	100.00	100.00
Administrative and support services	89.80	91.72
Waste management and remediation services	10.20	8.28
Health care and social assistance	100.00	100.00
Ambulatory health care services	38.91	47.77
Hospitals	36.86	32.12
Nursing and residential care facilities	13.98	11.47
Social assistance	10.25	8.64
Health care	89.75	0.00
Arts, entertainment, and recreation	100.00	100.00
Performing arts, spectator sports, museums, and related activities	62.73	55.79
Amusements, gambling, and recreation industries	37.27	44.21
Accommodation and food services	100.00	100.00
Accommodation services	32.99	31.08
Food services and drinking places	67.01	68.92

Source: CSLS calculations based on CANSIM 379-0031 and US BEA GDP by Industry tables.

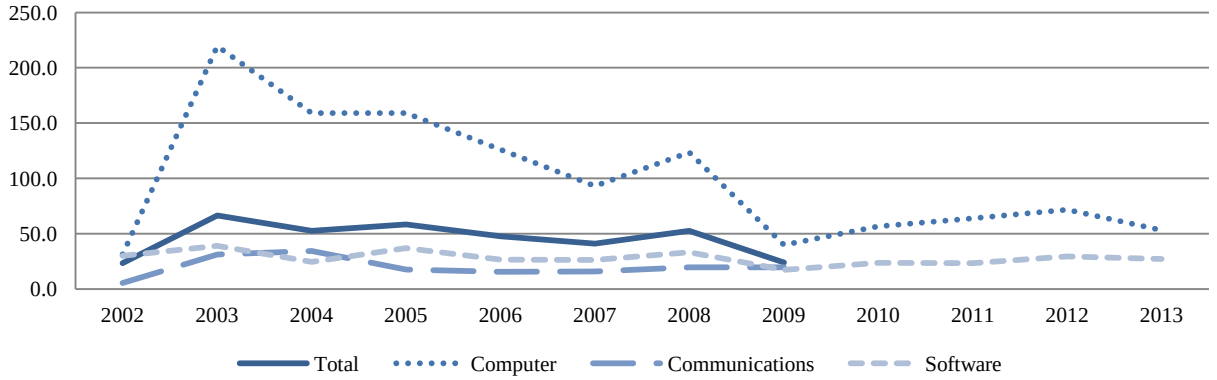
B. ICT Investment Per Worker in Canada Relative to the United States, Per Cent, 2002-2013

Appendix Chart 1: Agriculture, Fishing, Forestry and Hunting



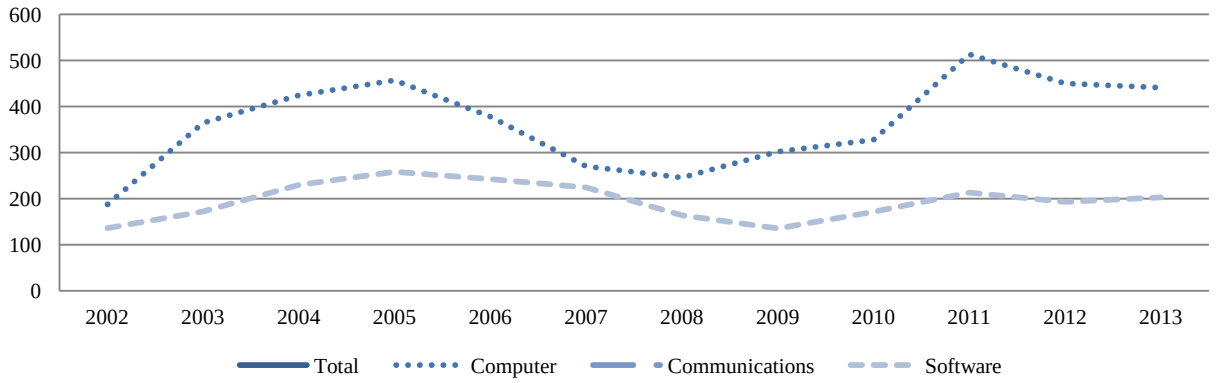
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 2: Mining and Oil and Gas Extraction



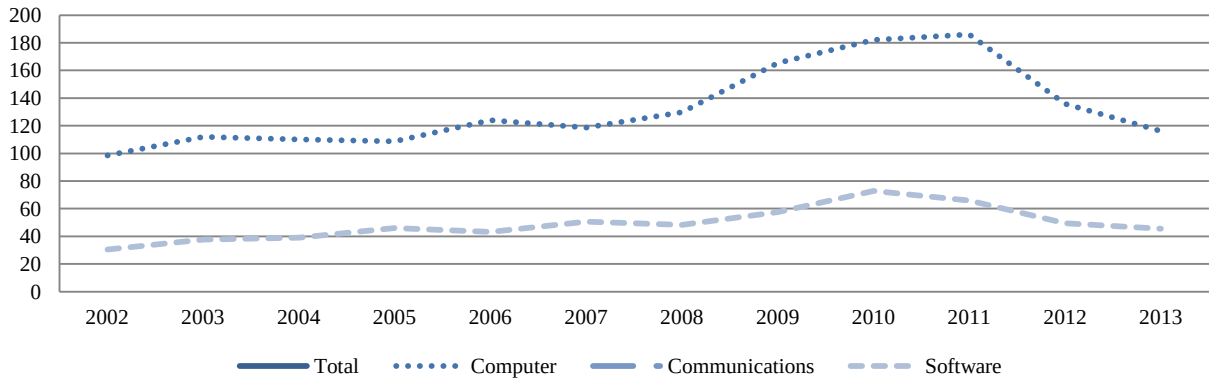
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 3: Utilities



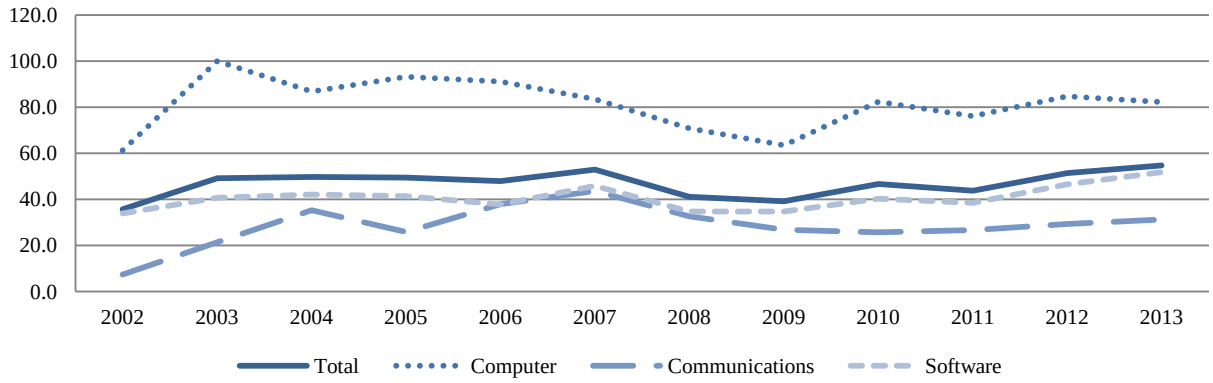
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 4: Construction



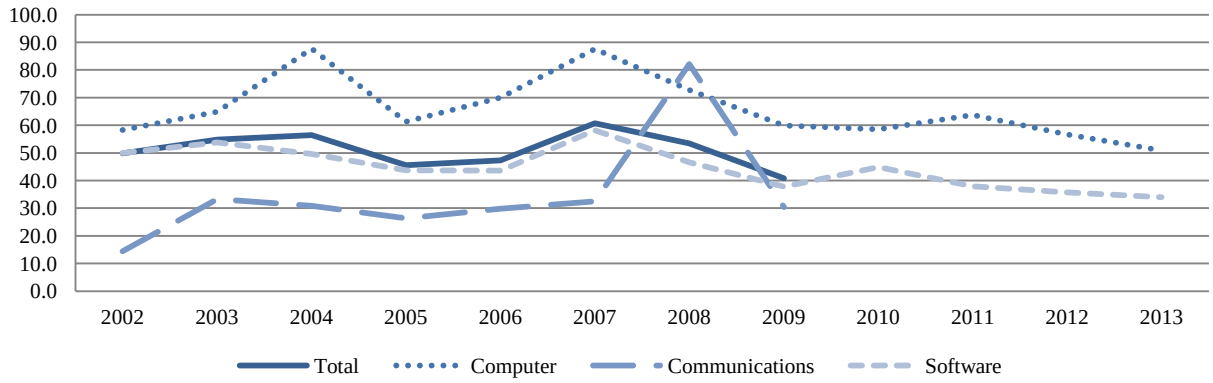
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 5: Manufacturing



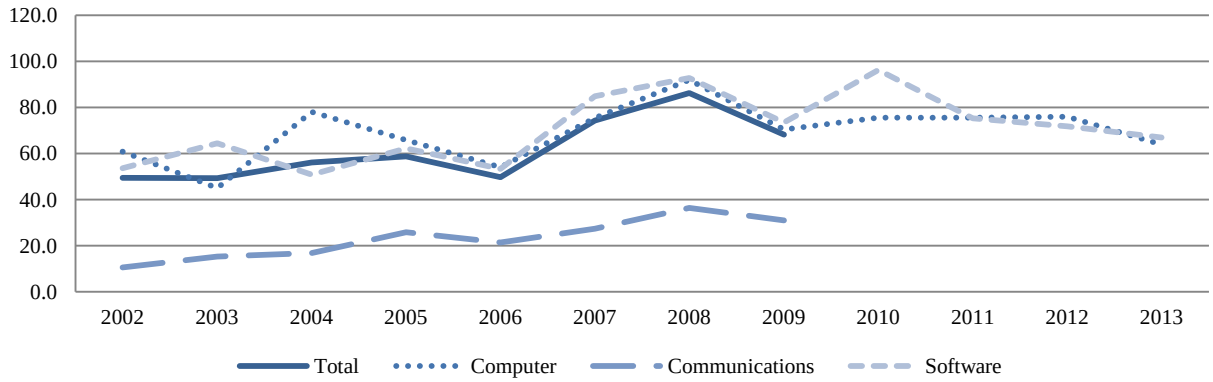
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 6: Wholesale Trade



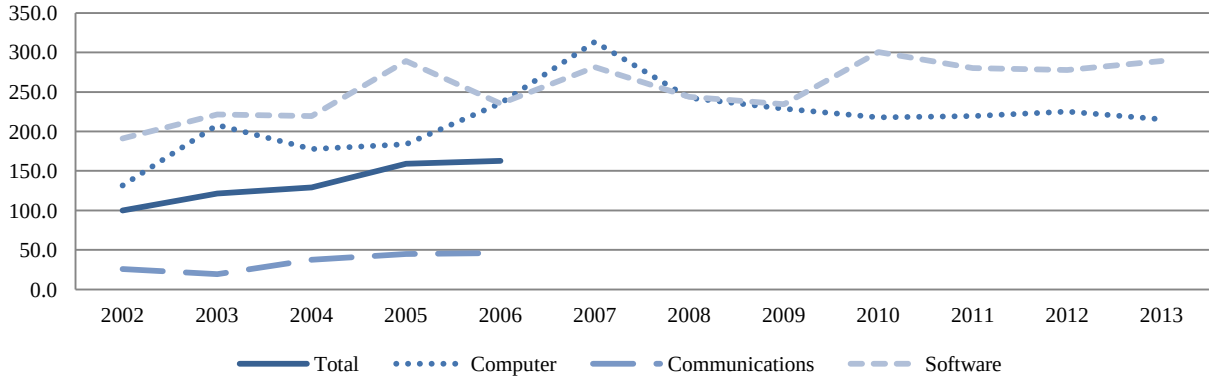
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 7: Retail Trade



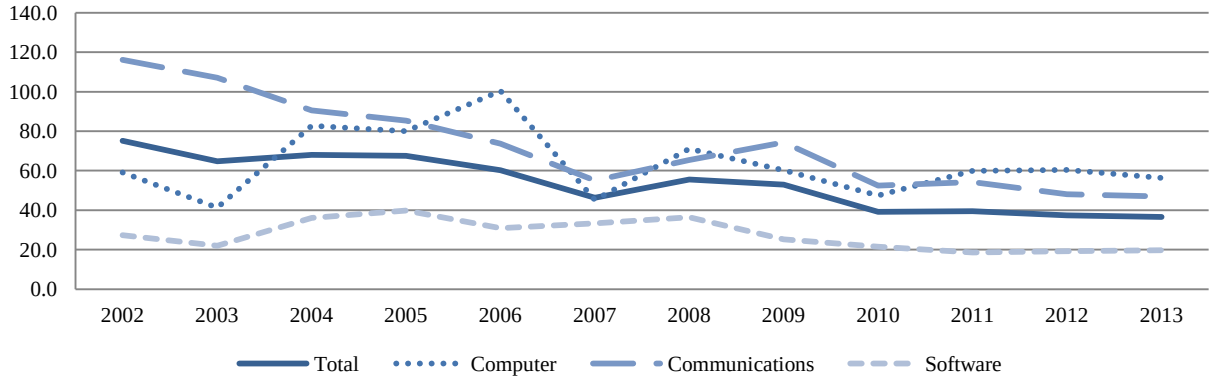
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 8: Transportation and Warehousing



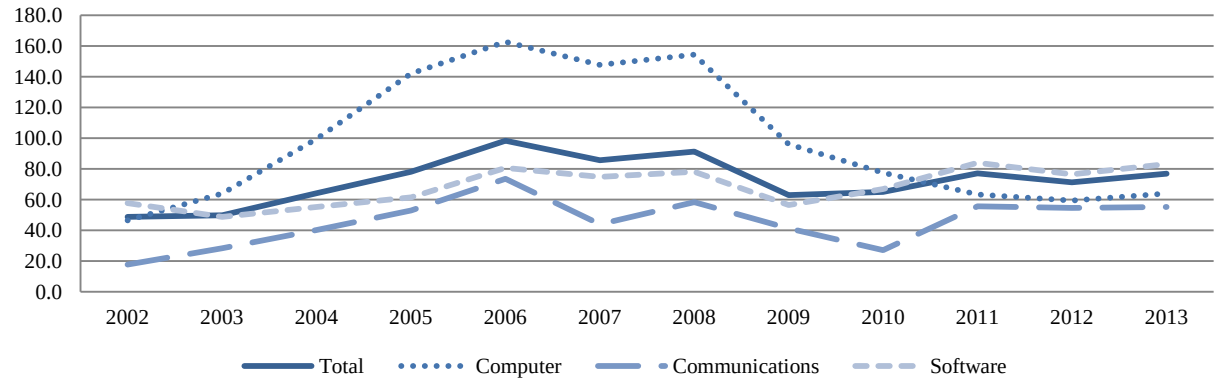
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 9: Information and Cultural Industries



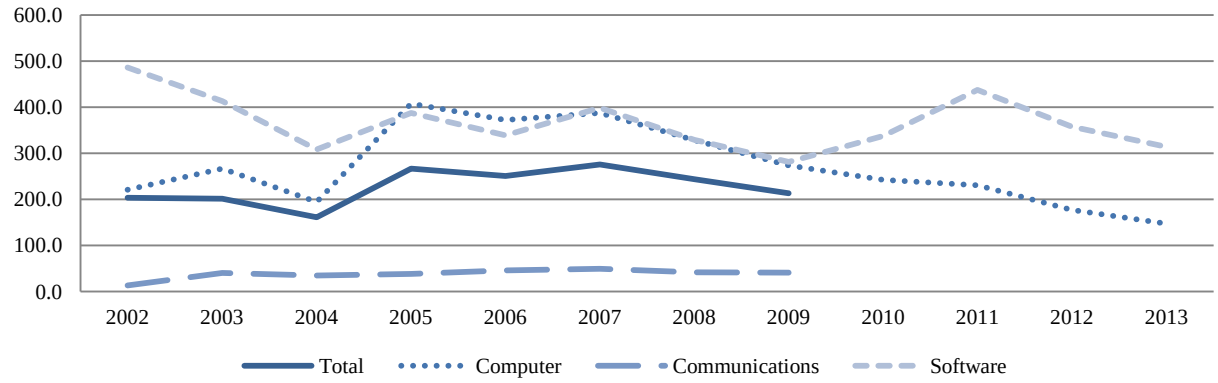
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 10: Finance and Insurance



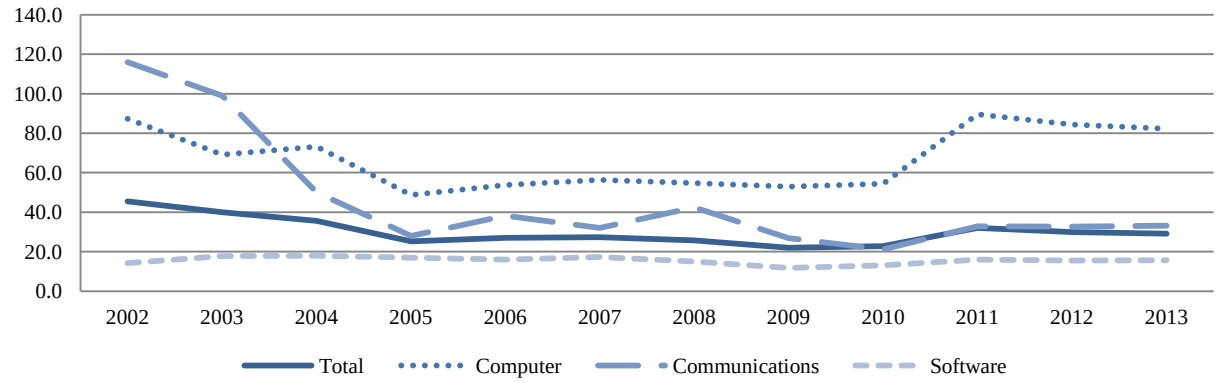
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 11: Real Estate and Rental and Leasing



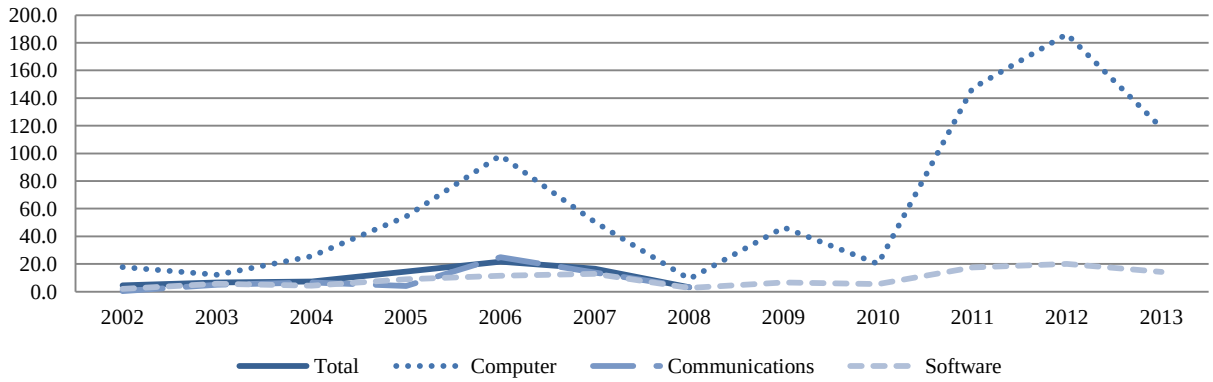
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 12: Professional, Scientific and Technical Services



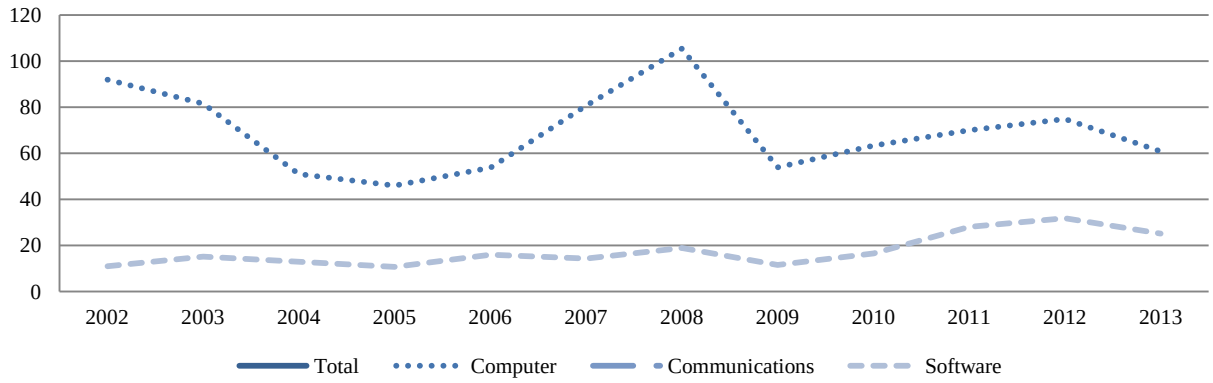
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 13: Management of Companies and Enterprises



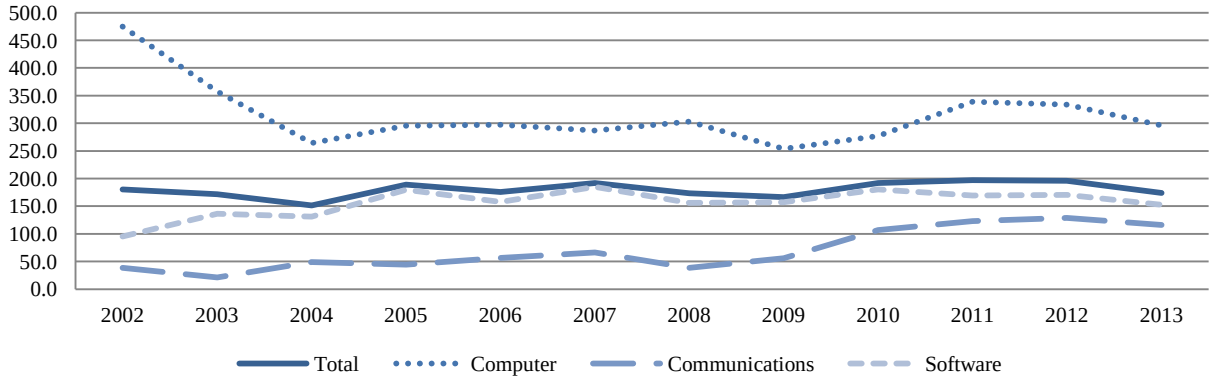
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 14: Administrative and Support, Waste Management and Remediation Services



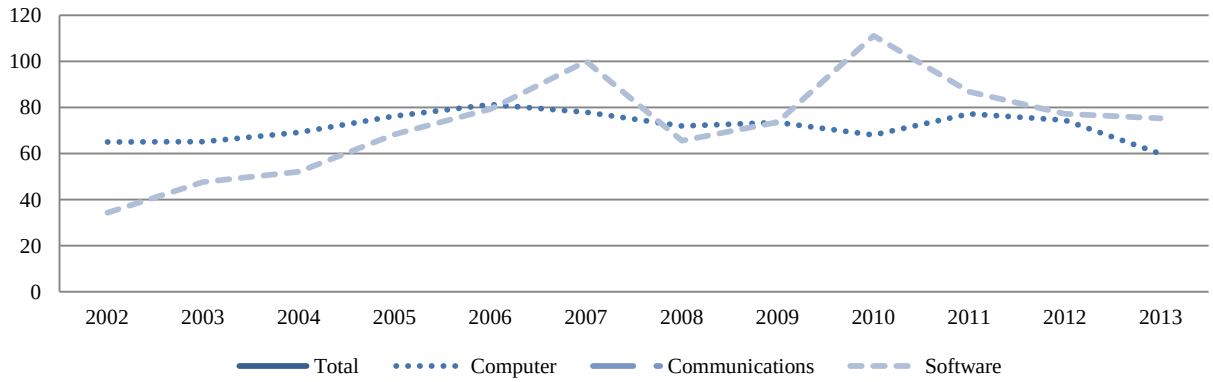
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 15: Educational Services



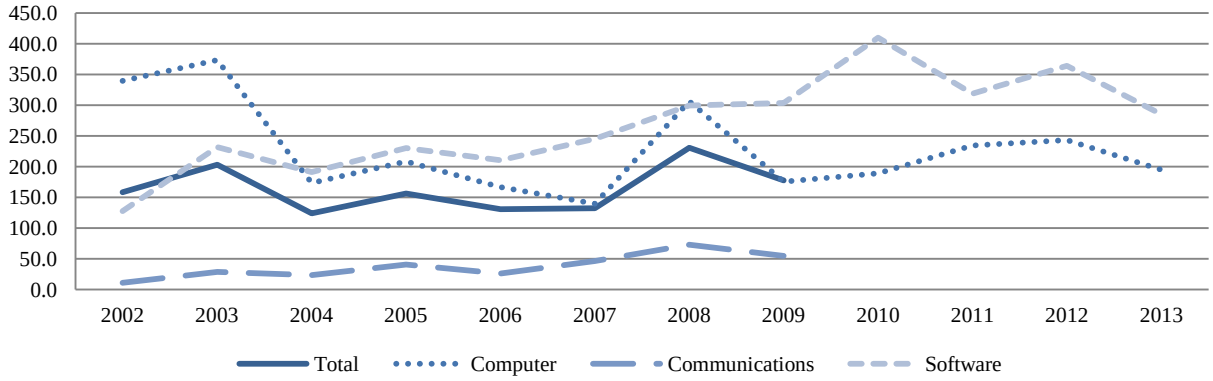
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 16: Health Care and Social Assistance



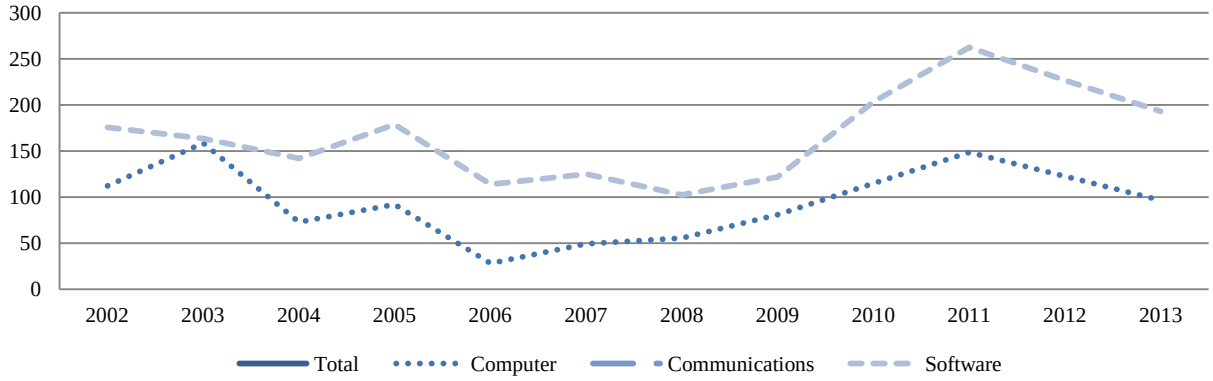
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 17: Arts, Entertainment and Recreation



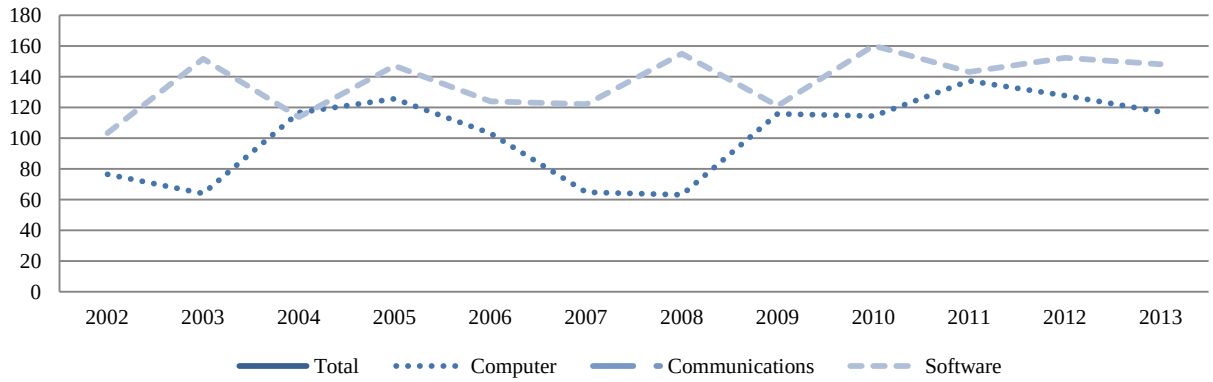
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 18: Accommodation and Food Services



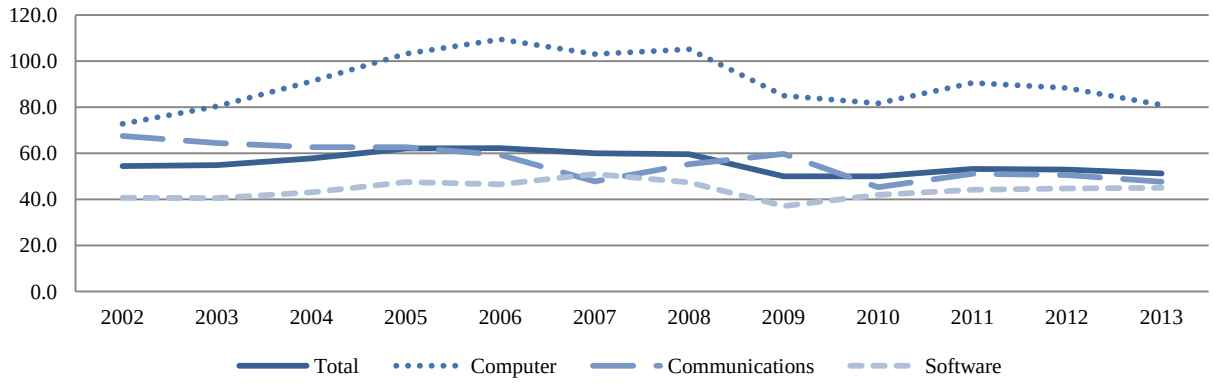
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 19: Other Services (Except Public Administration)



Source: CSLS calculations from CSLS ICT by Industry database.

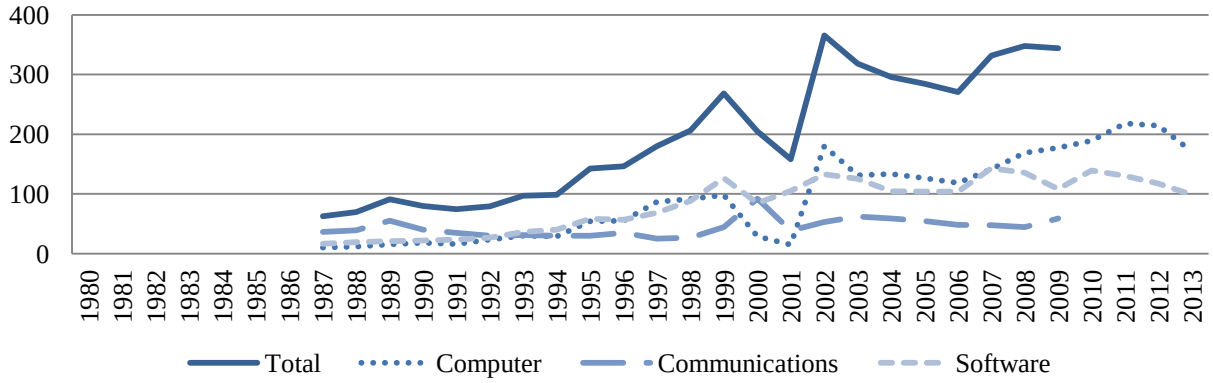
Appendix Chart 20: Business Sector



Source: CSLS calculations from CSLS ICT by Industry database.

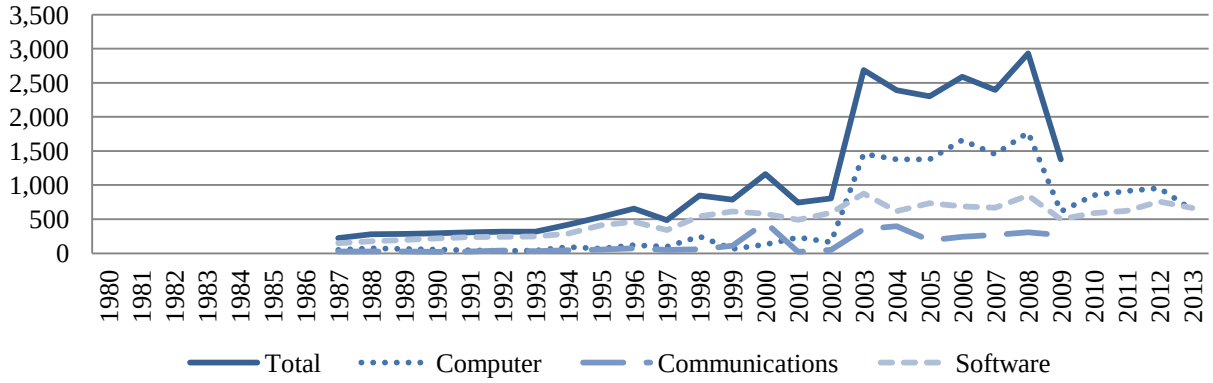
C. ICT Investment Per Worker in Canada, Dollars, 1980-2013

Appendix Chart 21: Agriculture, Fishing, Forestry and Hunting



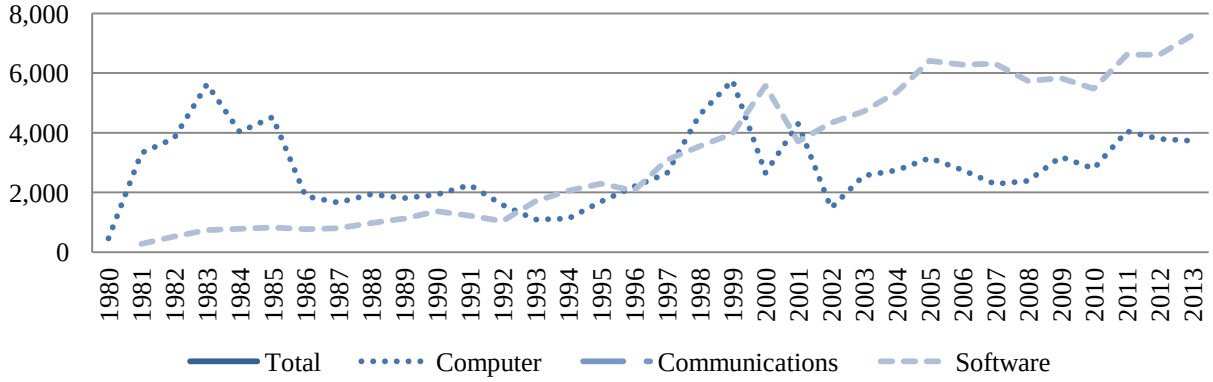
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 22: Mining and Oil and Gas Extraction



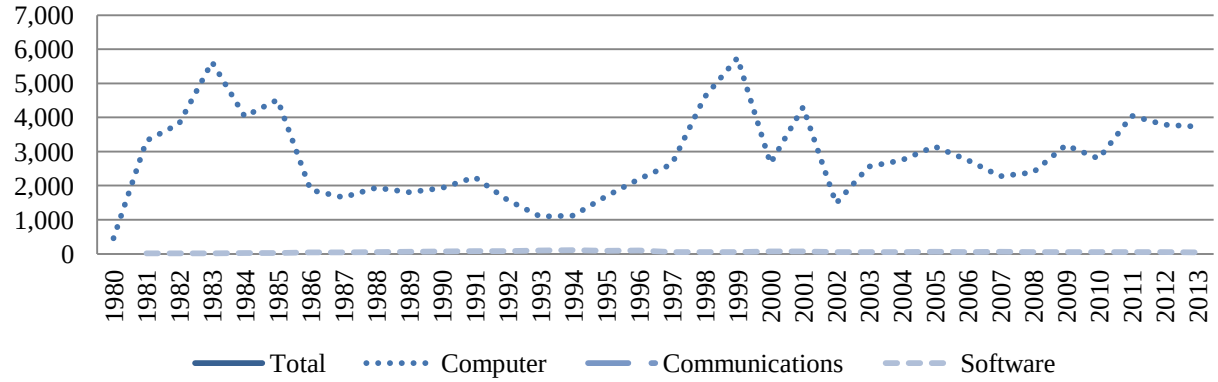
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 23: Utilities



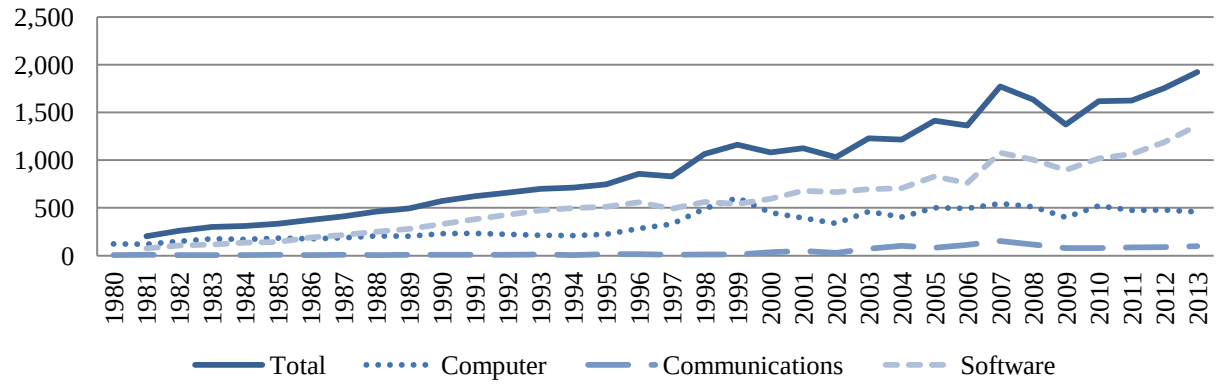
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 24: Construction



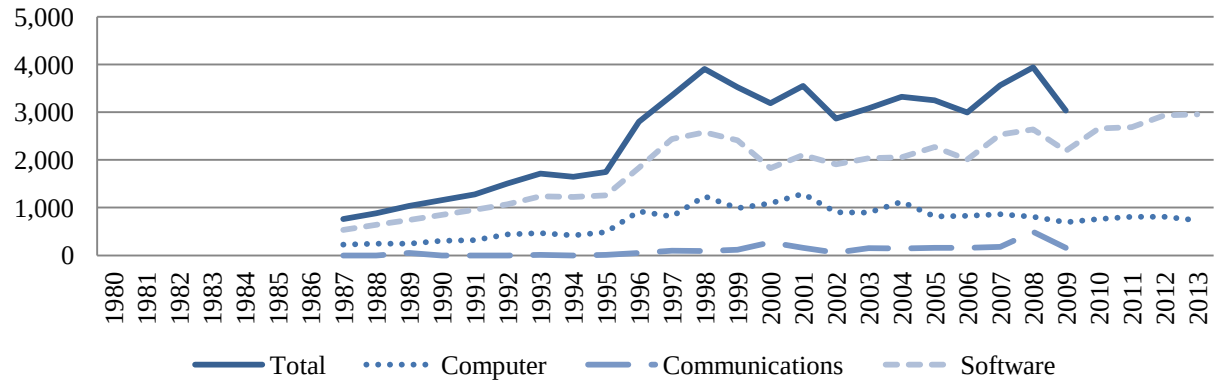
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 25: Manufacturing



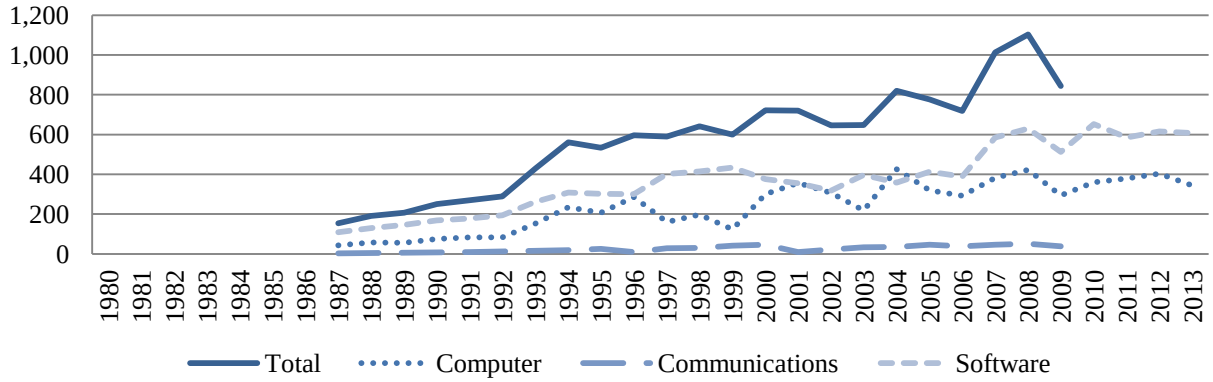
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 26: Wholesale Trade



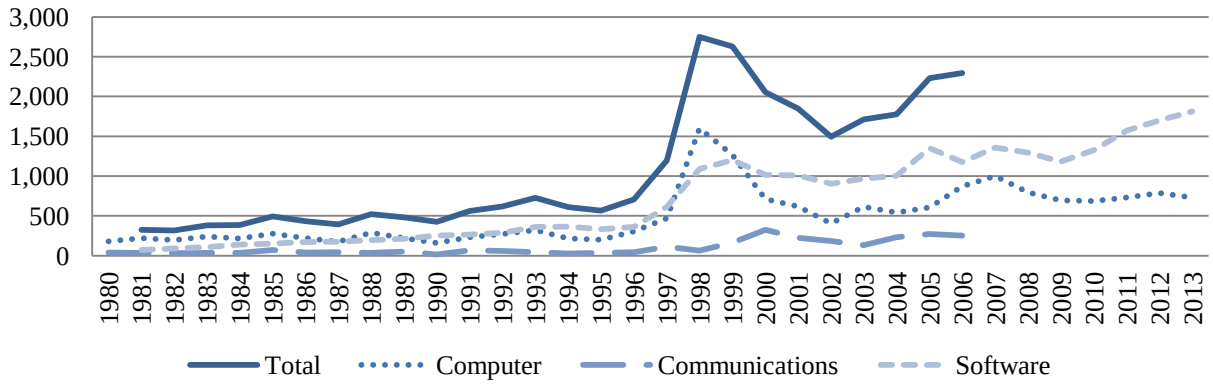
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 27: Retail Trade



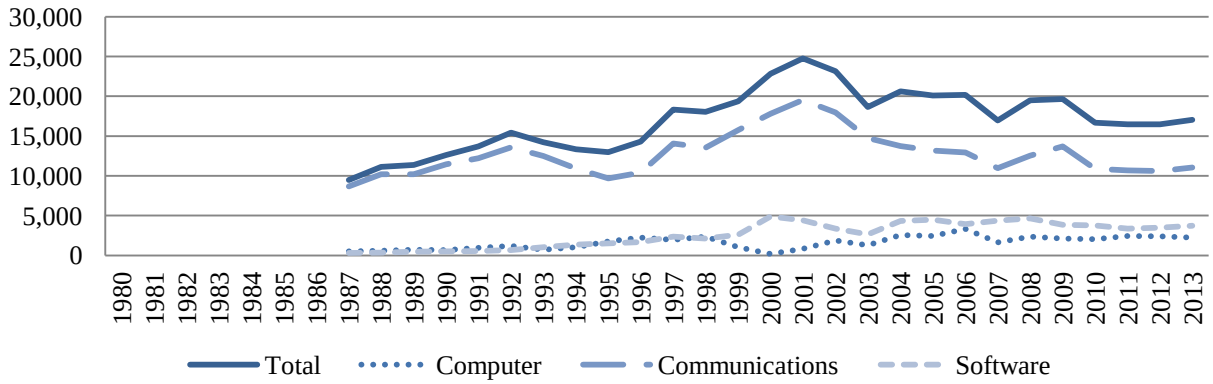
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 28: Transportation and Warehousing



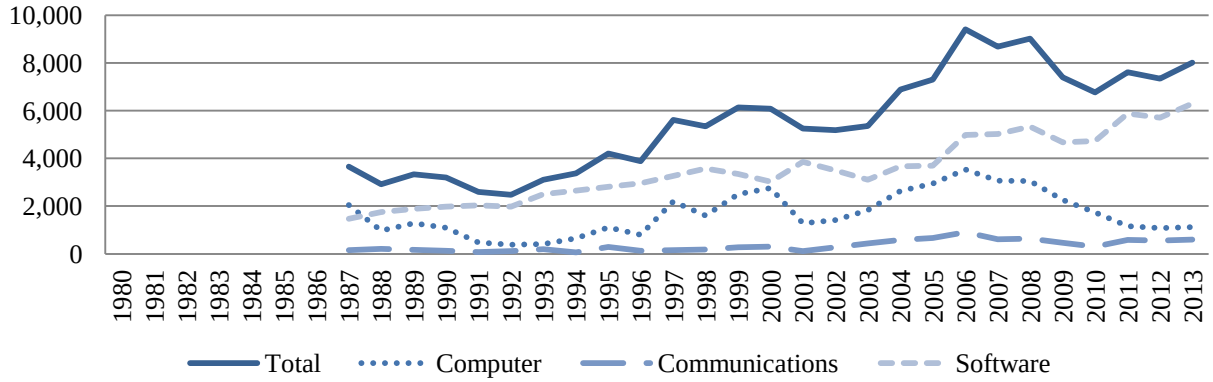
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 29: Information and Cultural Industries



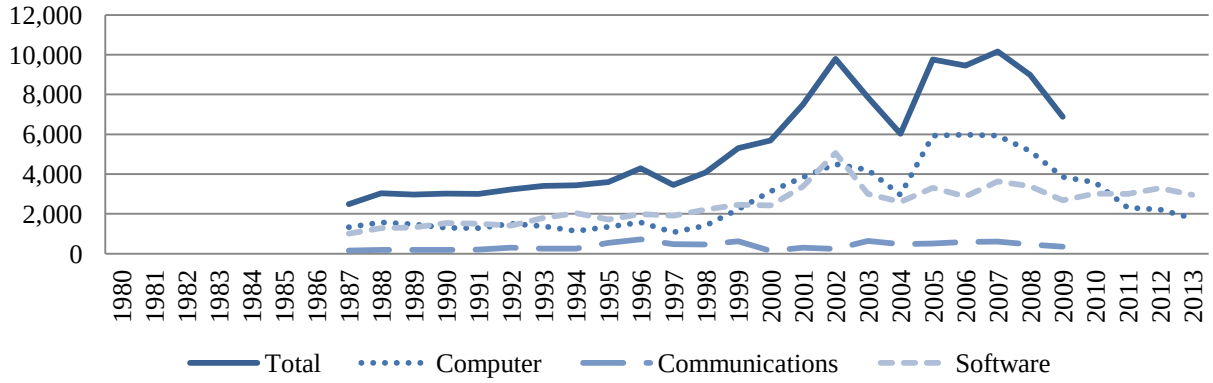
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 30: Finance and Insurance



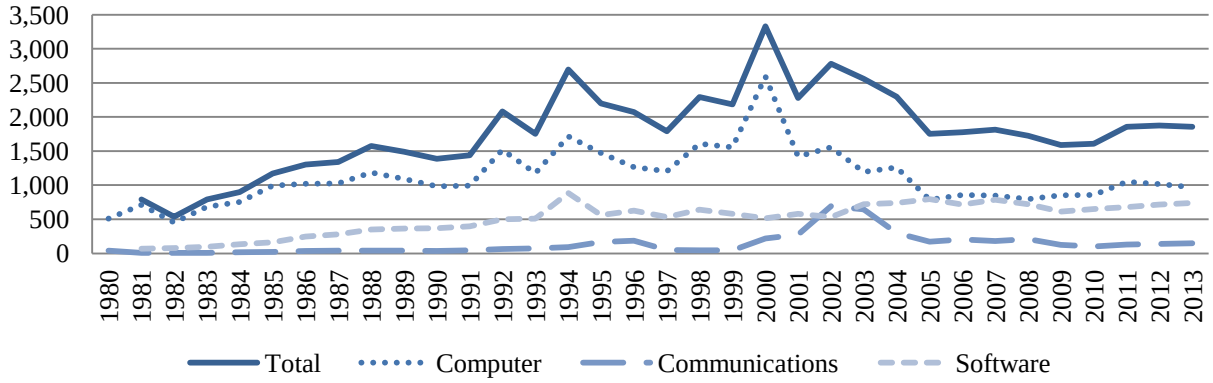
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 31: Real Estate and Rental and Leasing



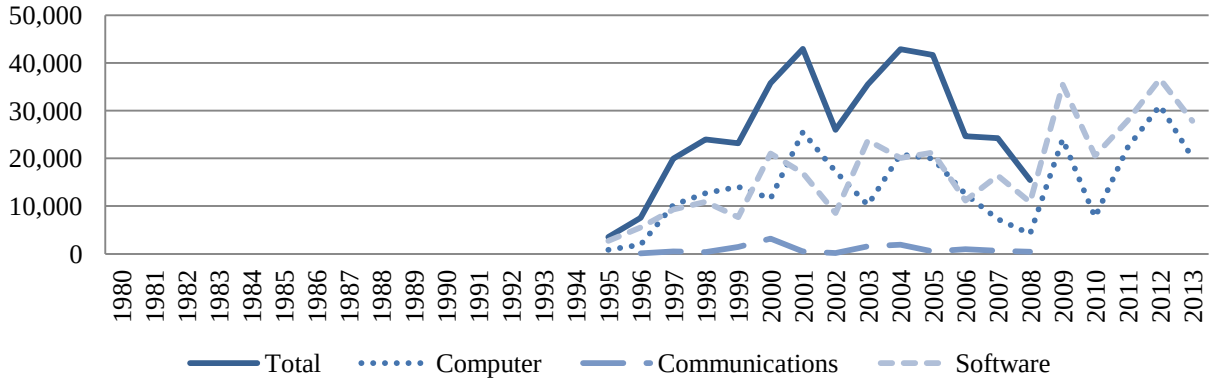
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 32: Professional, Scientific and Technical Services



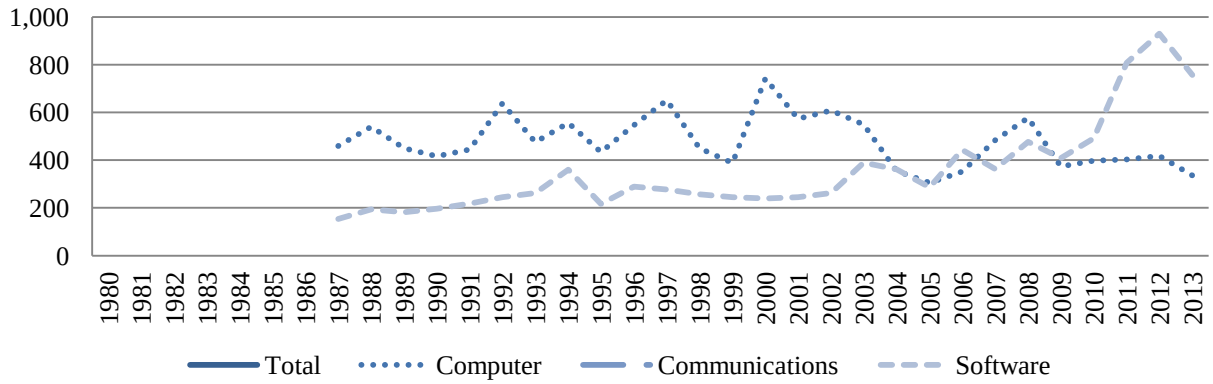
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 33: Management of Companies and Enterprises



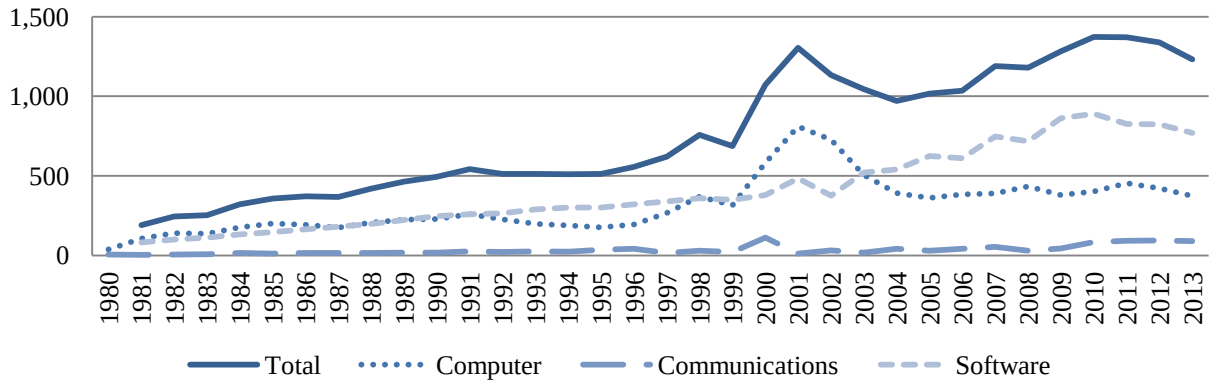
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 34: Administrative and Support, Waste Management and Remediation Services



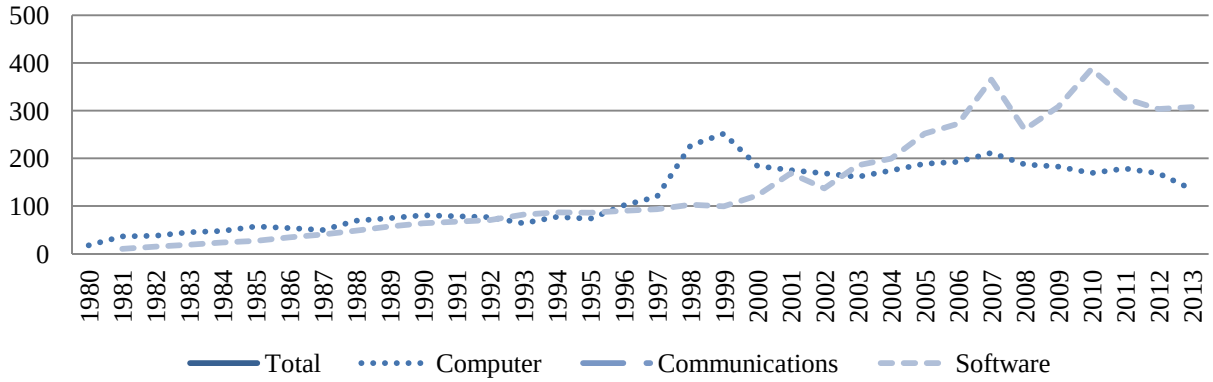
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 35: Educational Services



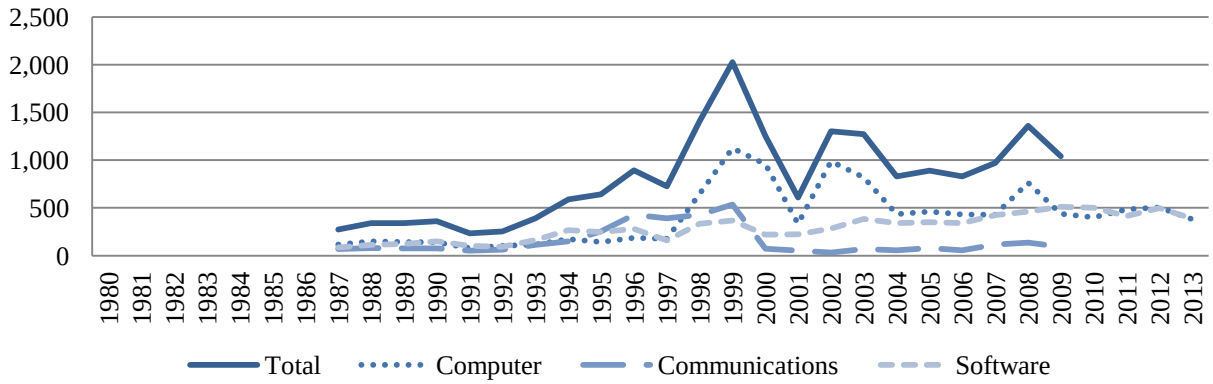
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 36: Health Care and Social Assistance



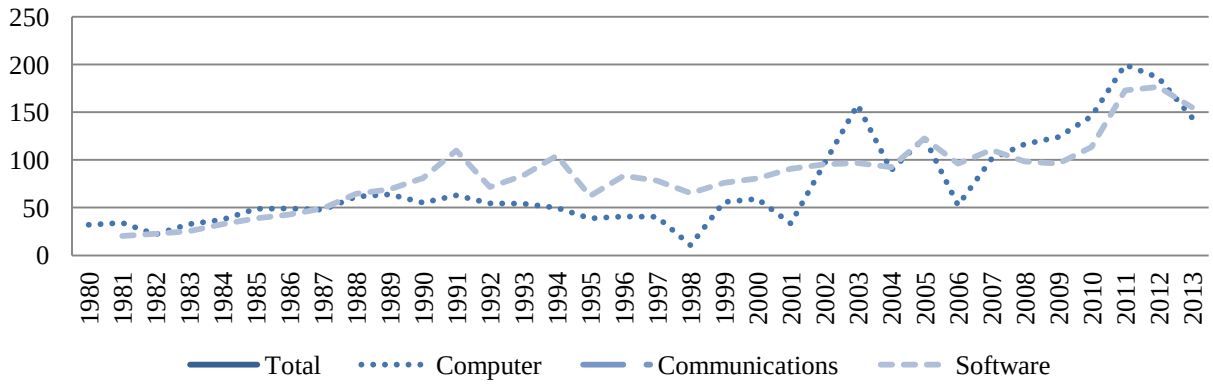
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 37: Arts, Entertainment and Recreation



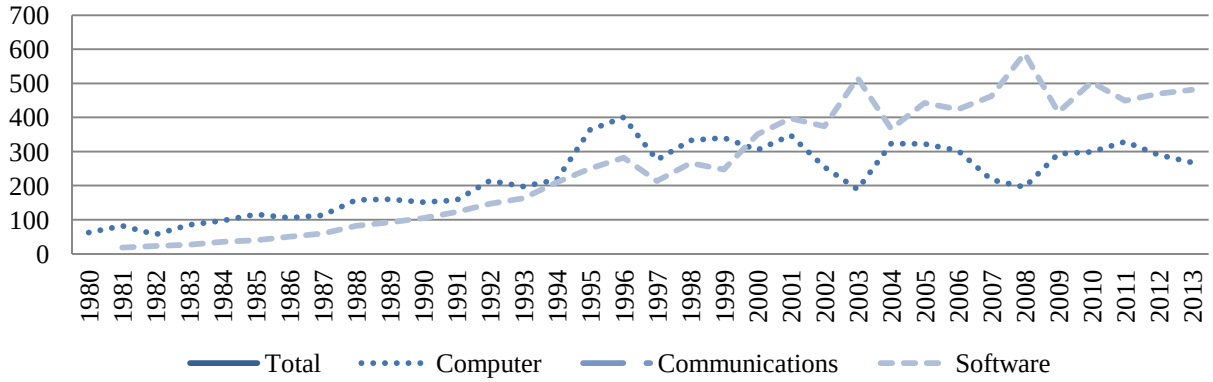
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 38: Accommodation and Food Services



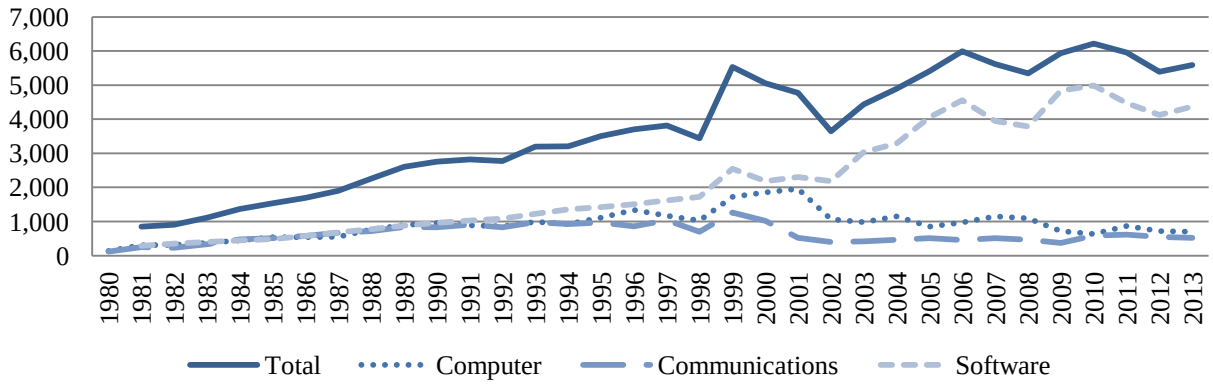
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 39: Other Services (Except Public Administration)



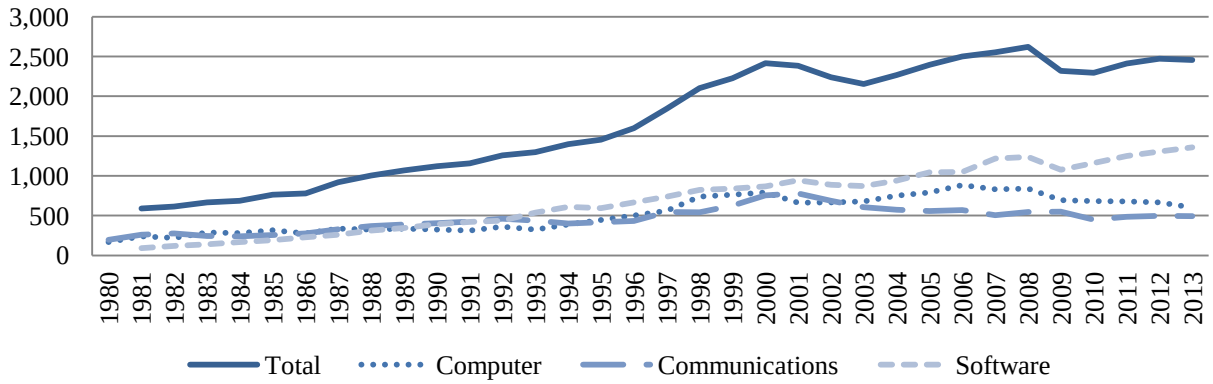
Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 40: Public Administration



Source: CSLS calculations from CSLS ICT by Industry database.

Appendix Chart 41: Business Sector



Source: CSLS calculations from CSLS ICT by Industry database.

D. ICT Investment Per Worker Growth Rates in Canada and the United States

Appendix Table 7: Real Total ICT Investment, Employment and Investment Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, Per Cent, 2002-2008

	United States			Canada		
	Investment	Employment	Investment Per Worker	Investment	Employment	Investment Per Worker
Agriculture, fishing, forestry and hunting	13.72	-1.06	14.93	6.65	-1.05	7.78
Mining and oil and gas extraction	19.51	8.50	10.14	47.36	7.84	36.65
Utilities	4.44	-0.64	5.11	.	2.54	.
Construction	5.82	1.59	4.16	.	6.15	.
Manufacturing	6.68	-1.33	8.12	12.73	-2.54	15.67
Wholesale trade	10.33	-0.37	10.74	14.23	2.55	11.40
Retail trade	12.01	0.91	11.00	19.21	1.78	17.12
Transportation and warehousing	5.46	1.43	3.98	.	1.88	.
Information and cultural industries	7.10	-0.97	8.15	4.17	0.71	3.43
Finance and insurance	9.50	1.27	8.13	19.63	2.87	16.30
Real estate and rental and leasing	7.68	0.77	6.85	11.00	3.24	7.52
Professional, scientific and technical services	10.55	1.81	8.59	3.96	3.25	0.68
Management of companies and enterprises	9.69	8.09	1.48	.	10.55	.
Administrative and support, waste management and remediation services	10.03	1.57	8.33	.	2.58	.
Educational services	12.79	1.96	10.63	11.94	2.83	8.87
Health care and social assistance	10.74	2.31	8.25	.	2.70	.
Arts, entertainment and recreation	10.48	2.00	8.31	11.16	1.39	9.63
Accommodation and food services	22.42	1.61	20.48	.	1.51	.
Other services (except public administration)	10.50	0.83	9.59	.	1.34	.
Business sector	8.87	0.77	8.03	11.61	1.61	9.84

Source: CSLS ICT database from January 2015.
Note: During this period, purchasing power parity demonstrated a 0.84 per cent per year increase.

Appendix Table 8: Real Computer Investment, Employment and Investment Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, Per Cent, 2002-2013

	United States			Canada		
	Investment	Employment	Investment Per Worker	Investment	Employment	Investment Per Worker
Agriculture, fishing, forestry and hunting	14.56	-0.74	15.41	10.12	-0.99	11.23
Mining and oil and gas extraction	23.79	7.08	15.61	33.62	5.28	26.92
Utilities	11.94	-0.63	12.66	22.60	0.88	21.53
Construction	4.90	-0.67	5.61	13.09	3.99	8.75
Manufacturing	9.77	-1.33	11.26	11.93	-2.50	14.80
Wholesale trade	8.90	-1.16	10.17	10.76	1.10	9.55
Retail trade	10.93	0.20	10.71	14.14	1.14	12.85
Transportation and warehousing	12.17	0.38	11.74	19.28	1.18	17.90
Information and cultural industries	11.71	-1.99	13.97	13.73	0.07	13.65
Finance and insurance	8.16	0.31	7.82	11.37	1.87	9.33
Real estate and rental and leasing	4.40	0.16	4.24	5.09	2.42	2.61
Professional, scientific and technical services	10.78	1.69	8.94	10.13	2.93	7.00
Management of companies and enterprises	10.40	14.32	-3.42	8.98	-3.84	13.34
Administrative and support, waste management and remediation services	11.28	1.42	9.72	7.77	1.84	5.81
Educational services	13.90	0.93	12.85	7.54	2.30	5.12
Health care and social assistance	12.12	1.90	10.03	12.49	2.76	9.47
Arts, entertainment and recreation	9.00	1.78	7.09	4.17	1.67	2.46
Accommodation and food services	17.58	1.38	15.98	17.36	1.25	15.91
Other services (except public administration)	8.90	0.61	8.24	13.32	0.98	12.22
Business sector	9.94	0.20	9.72	11.87	1.04	10.71

Source: CSLS ICT database from January 2015.
Note: During this period, purchasing power parity demonstrated a 1.13 per cent per year increase.

Appendix Table 9: Real Communications Investment, Employment and Investment Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, Per Cent, 2002-2008

	United States			Canada		
	Investment	Employment	Investment Per Worker	Investment	Employment	Investment Per Worker
Agriculture, fishing, forestry and hunting	6.33	-1.06	7.47	2.17	-1.05	3.25
Mining and oil and gas extraction	22.23	8.50	12.65	56.45	7.84	45.08
Utilities	6.33	-0.64	7.01	.	2.54	.
Construction	3.57	1.59	1.95	.	6.15	.
Manufacturing	9.11	-1.33	10.58	32.66	-2.54	36.13
Wholesale trade	2.95	-0.37	3.34	57.72	2.55	53.81
Retail trade	6.61	0.91	5.66	24.89	1.78	22.70
Transportation and warehousing	2.05	1.43	0.62	.	1.88	.
Information and cultural industries	7.27	-0.97	8.32	1.40	0.71	0.68
Finance and insurance	12.57	1.27	11.16	26.57	2.87	23.04
Real estate and rental and leasing	8.34	0.77	7.51	23.74	3.24	19.86
Professional, scientific and technical services	11.79	1.81	9.80	-9.34	3.25	-12.20
Management of companies and enterprises	4.97	8.09	-2.89	40.68	10.55	25.25
Administrative and support, waste management and remediation services	9.11	1.57	7.42	.	2.58	.
Educational services	17.22	1.96	14.97	9.27	2.83	6.26
Health care and social assistance	7.28	2.31	4.86	.	2.70	.
Arts, entertainment and recreation	9.87	2.00	7.72	37.44	1.39	35.56
Accommodation and food services	6.77	1.61	5.08	.	1.51	.
Other services (except public administration)	10.63	0.83	9.72	.	1.34	.
Business sector	7.98	0.77	7.15	4.53	1.61	2.88

Source: CSLS ICT database from January 2015.
Note: During this period, purchasing power parity demonstrated a 0.84 per cent per year increase.

Appendix Table 10: Real Software Investment, Employment and Investment Per Worker in Canada and the United States, Compound Average Annual Growth, Domestic Currency, Per Cent, 2002-2013

	United States			anada		
	Investment	Employment	Investment Per Worker	Investment	Employment	Investment Per Worker
Agriculture, fishing, forestry and hunting	13.81	-0.74	14.66	-1.24	-0.99	-0.25
Mining and oil and gas extraction	9.19	7.08	1.97	8.71	5.28	3.26
Utilities	1.90	-0.63	2.55	5.79	0.88	4.86
Construction	-3.91	-0.67	-3.26	6.78	3.99	2.68
Manufacturing	2.27	-1.33	3.65	6.18	-2.50	8.90
Wholesale trade	9.31	-1.16	10.59	6.36	1.10	5.20
Retail trade	8.29	0.20	8.08	8.0	1.14	7.08
Transportation and warehousing	2.66	0.38	2.77	8.75	1.18	7.48
Information and cultural industries	4.70	-1.99	6.82	1.17	0.07	1.09
Finance and insurance	5.71	0.31	5.38	7.59	1.87	5.62
Real estate and rental and leasing	3.72	0.16	3.55	-0.67	2.42	-3.02
Professional, scientific and technical services	5.55	1.69	3.79	8.21	2.93	5.14
Management of companies and enterprises	9.16	14.32	-4.15		-3.84	
Administrative and support, waste management and remediation services	6.78	1.42	5.28	12.77	1.84	10.73
Educational services	6.95	0.93	5.97	11.89	2.30	9.37
Health care and social assistance	5.53	1.90	3.56	10.90	2.76	7.92
Arts, entertainment and recreation	2.45	1.78	0.66	5.84	1.67	4.11
Accommodation and food services	8.60	1.38	7.13	8.07	1.25	6.74
Other services (except public administration)	2.31	0.61	1.69	4.55	0.98	3.53
Business sector	5.73	0.20	5.51	5.96	1.04	4.87

Source: CSLS ICT database from January 2015.
Note: During this period, purchasing power parity demonstrated a 1.13 per cent per year increase

E. Industry Contributions to Canada-US ICT Investment Business Sector Gap

Appendix Table 11: Nominal Total IT Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2002

Total (2002)*	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-0.28	-0.44	-0.36
Mining and oil and gas extraction	0.55	1.62	1.09
Utilities	-1.48	-1.30	-1.39
Construction	0.75	0.56	0.65
Manufacturing	16.47	18.86	17.67
Wholesale trade	6.69	7.56	7.12
Retail trade	4.68	4.75	4.71
Transportation and warehousing	-1.99	-2.18	-2.09
Information and cultural industries	23.71	20.96	22.33
Finance and insurance	17.91	14.97	16.44
Real estate and rental and leasing	-11.52	-8.63	-10.08
Professional, scientific and technical services	18.22	18.31	18.26
Management of companies and enterprises	13.16	10.80	11.98
Administrative and support, waste management and remediation services	7.66	6.90	7.28
Arts, entertainment and recreation	-1.26	-1.38	-1.32
Accommodation and food services	-0.29	-0.28	-0.28
Other services (except public administration)	0.28	0.25	0.27
Business sector	100.00	100.00	100.00
Accounted	**93.26**	**91.32**	**92.29**
Unaccounted	**6.74**	**8.68**	**7.71**

* This total is a proxy composed of only computer and software investment per worker.
Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.
Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 12: Nominal Total ICT Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2002

Total (2002)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-0.48	-0.77	-0.63
Mining and oil and gas extraction	0.95	2.78	1.86
Utilities	.	.	.
Construction	.	.	.
Manufacturing	21.20	24.27	22.73
Wholesale trade	6.75	7.63	7.19
Retail trade	5.88	5.97	5.93
Transportation and warehousing	-1.96	-2.15	-2.05
Information and cultural industries	3.34	2.95	3.14
Finance and insurance	21.17	17.69	19.43
Real estate and rental and leasing	-17.06	-12.78	-14.92
Professional, scientific and technical services	16.81	16.89	16.85
Management of companies and enterprises	17.24	14.14	15.69
Administrative and support, waste management and remediation services	.	.	.
Arts, entertainment and recreation	-1.75	-1.91	-1.83
Accommodation and food services	.	.	.
Other services (except public administration)	.	.	.
Business sector	100.00	100.00	100.00
Accounted	**72.07**	**74.71**	**73.39**
Unaccounted	**27.93**	**25.29**	**26.61**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 13: Nominal Computer Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2002

Computer (2002)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-1.05	-1.66	-1.36
Mining and oil and gas extraction	0.71	2.08	1.39
Utilities	-3.45	-3.03	-3.24
Construction	0.10	0.07	0.09
Manufacturing	14.49	16.59	15.54
Wholesale trade	10.52	11.89	11.20
Retail trade	12.23	12.41	12.32
Transportation and warehousing	-2.29	-2.50	-2.39
Information and cultural industries	18.66	16.50	17.58
Finance and insurance	43.13	36.05	39.59
Real estate and rental and leasing	-27.23	-20.40	-23.81
Professional, scientific and technical services	7.54	7.57	7.55
Management of companies and enterprises	13.19	10.82	12.01
Administrative and support, waste management and remediation services	1.18	1.06	1.12
Arts, entertainment and recreation	-7.22	-7.87	-7.54
Accommodation and food services	-0.36	-0.34	-0.35
Other services (except public administration)	2.08	1.86	1.97
Business sector	100.00	100.00	100.00
Accounted	**82.24**	**81.10**	**81.67**
Unaccounted	**17.76**	**18.90**	**18.33**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 14: Nominal Communications Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2002

Communications (2002)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	0.17	0.26	0.21
Mining and oil and gas extraction	1.32	3.88	2.60
Utilities	.	.	.
Construction	.	.	.
Manufacturing	17.62	20.17	18.89
Wholesale trade	4.05	4.58	4.31
Retail trade	8.74	8.87	8.81
Transportation and warehousing	9.32	10.21	9.77
Information and cultural industries	-27.01	-23.88	-25.45
Finance and insurance	25.10	20.98	23.04
Real estate and rental and leasing	12.51	9.38	10.94
Professional, scientific and technical services	-2.35	-2.36	-2.35
Management of companies and enterprises	4.31	3.54	3.92
Administrative and support, waste management and remediation services	.	.	.
Arts, entertainment and recreation	2.15	2.34	2.25
Accommodation and food services	.	.	.
Other services (except public administration)	.	.	.
Business sector	100.00	100.00	100.00
Accounted	**55.94**	**57.96**	**56.95**
Unaccounted	**44.06**	**42.04**	**43.05**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 15: Nominal Software Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2002

Software (2002)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-0.13	-0.21	-0.17
Mining and oil and gas extraction	0.52	1.53	1.03
Utilities	-1.10	-0.97	-1.03
Construction	0.88	0.65	0.76
Manufacturing	16.85	19.29	18.07
Wholesale trade	5.95	6.73	6.34
Retail trade	3.25	3.30	3.27
Transportation and warehousing	-1.94	-2.12	-2.03
Information and cultural industries	24.67	21.82	23.24
Finance and insurance	13.07	10.92	12.00
Real estate and rental and leasing	-8.52	-6.38	-7.45
Professional, scientific and technical services	20.26	20.36	20.31
Management of companies and enterprises	13.16	10.79	11.98
Administrative and support, waste management and remediation services	8.90	8.02	8.46
Arts, entertainment and recreation	-0.12	-0.13	-0.12
Accommodation and food services	-0.27	-0.26	-0.27
Other services (except public administration)	-0.06	-0.06	-0.06
Business sector	100.00	100.00	100.00
Accounted	**95.37**	**93.28**	**94.33**
Unaccounted	**4.63**	**6.72**	**5.67**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 16: Nominal Total IT Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2008

Total (2008)*	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-0.21	-0.32	-0.27
Mining and oil and gas extraction	0.78	2.11	1.45
Utilities	-3.11	-3.17	-3.14
Construction	0.10	0.09	0.09
Manufacturing	23.25	23.51	23.38
Wholesale trade	9.38	11.98	10.68
Retail trade	1.00	1.01	1.00
Transportation and warehousing	-5.56	-5.95	-5.75
Information and cultural industries	21.92	20.38	21.15
Finance and insurance	2.12	1.85	1.98
Real estate and rental and leasing	-12.20	-10.07	-11.14
Professional, scientific and technical services	30.73	31.98	31.36
Management of companies and enterprises	20.94	17.93	19.43
Administrative and support, waste management and remediation services	8.58	7.80	8.19
Arts, entertainment and recreation	-1.70	-1.70	-1.70
Accommodation and food services	0.62	0.56	0.59
Other services (except public administration)	-0.45	-0.40	-0.43
Business sector	100.00	100.00	100.00
Accounted	**96.16**	**97.59**	**96.88**
Unaccounted	**3.84**	**2.41**	**3.12**

* This is a proxy composed of only computer and software investment per worker.
Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.
Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 17: Nominal Computer Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2008

Computer (2008)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	4.49	6.79	5.64
Mining and oil and gas extraction	6.26	16.85	11.56
Utilities	39.52	40.18	39.85
Construction	11.94	10.98	11.46
Manufacturing	-76.65	-77.53	-77.09
Wholesale trade	-27.93	-35.70	-31.81
Retail trade	-14.14	-14.39	-14.26
Transportation and warehousing	69.07	73.91	71.49
Information and cultural industries	-75.41	-70.12	-72.76
Finance and insurance	178.06	155.55	166.80
Real estate and rental and leasing	241.10	198.97	220.03
Professional, scientific and technical services	-139.98	-145.67	-142.83
Management of companies and enterprises	-62.76	-53.73	-58.24
Administrative and support, waste management and remediation services	4.12	3.74	3.93
Arts, entertainment and recreation	34.89	34.92	34.90
Accommodation and food services	-20.81	-18.82	-19.82
Other services (except public administration)	-18.51	-16.20	-17.36
Business sector	100.00	100.00	100.00
Accounted	**153.25**	**109.74**	**131.49**
Unaccounted	**-53.25**	**-9.74**	**-31.49**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.

Appendix Table 18: Nominal Software Investment Per Worker in Canada Relative to the United States, Weighted Industry Contribution to Business Sector Gap, 2008

Software (2008)	Weighted Contribution Using US Employment Shares	Weighted Contribution Using Canadian Employment Shares	Weighted Contribution Using Average Canadian and US Employment Shares
Agriculture, fishing, forestry and hunting	-0.07	-0.11	-0.09
Mining and oil and gas extraction	0.95	2.55	1.75
Utilities	-1.85	-1.88	-1.87
Construction	0.44	0.40	0.42
Manufacturing	20.29	20.52	20.40
Wholesale trade	8.27	10.57	9.42
Retail trade	0.56	0.57	0.56
Transportation and warehousing	-3.34	-3.58	-3.46
Information and cultural industries	19.03	17.69	18.36
Finance and insurance	7.33	6.40	6.86
Real estate and rental and leasing	-4.69	-3.87	-4.28
Professional, scientific and technical services	25.67	26.71	26.19
Management of companies and enterprises	18.46	15.80	17.13
Administrative and support, waste management and remediation services	8.45	7.68	8.06
Arts, entertainment and recreation	-0.62	-0.62	-0.62
Accommodation and food services	-0.02	-0.01	-0.01
Other services (except public administration)	-0.99	-0.87	-0.93
Business sector	100.00	100.00	100.00
Accounted	**97.85**	**97.96**	**97.90**
Unaccounted	**2.15**	**2.04**	**2.10**

Source: CSLS calculations based on the CSLS ICT by Industry database and the CSLS ICT database from January 2015.

Note: Educational services and health care and social assistance have been deliberately excluded from these calculations since in January 2015 (the date of publication of the CSLS ICT database) Statistics Canada's Stock and Consumption of Fixed Non-Residential Capital program did not consider these two industries as part of the business sector.