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

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ABSTRACT

In 2011, business sector investment per worker in information and communications technology (ICT) in Canada was only 57.8 per cent of the U.S. level, indicating an ICT investment per worker gap of 42.2 percentage points. Numerous explanations have been advanced to explain this gap, one of which is that the ICT investment data from Statistics Canada and the Bureau of Economic Analysis are not strictly comparable. We compare the methodology used to measure ICT investment in Canada and the United States and find that issues related to measurement account for approximately 4 percentage points (10 per cent) of the gap. The gap is concentrated in the software component of ICT investment (90 per cent) and in a small number of ICT-intensive industries, in particular information and cultural industries. The article concludes that the Canada-U.S. ICT investment per worker gap is largely the result of industry-specific factors that affect software investment.

IN 2011, BUSINESS SECTOR INVESTMENT per worker in information and communications technology (ICT) in Canada was only 57.8 per cent of the U.S. level. Software investment, the largest component of ICT investment in both countries, was only 39.8 per cent of the U.S. level. These observations are a part of a persistent phenomenon identified in a series of studies conducted by the Centre for the Study of Living Standards (CSLS) showing that ICT investment per worker in Canada is significantly below the U.S. level.[2] This low level of ICT investment per worker is troubling, as investment—and ICT investment in particular—increases labour productivity, an important determinant of potential economic growth and a measure by which the United States has also consistently outperformed Canada over the last decade.

Several factors have been posited as the source of the gap in ICT investment per worker, including differences in economic and industrial structure; relative costs and prices; attitudes and culture; framework variables such as education, taxes, and competitiveness; and, finally, measurement error in the level of investment in either or both countries. The primary focus of this article is to explore the extent to which differences in measurement methodology contribute to the observed gap in ICT investment per

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2 For detailed discussions of how the ICT investment per worker gap has evolved over time and some discussion of the factors underlying the gap, see CSLS (2005); Sharpe (2006); Sharpe and Arsenault (2008a); Sharpe and Arsenault (2008b); Sharpe and de Avillez (2010); Sharpe and Moeller (2011); and Sharpe and Andrews (2012).

worker, in order to better inform policymakers concerned about the strength of investment in Canada. An understanding of the causes of the Canada-U.S. ICT investment per worker gap is essential for the development of policies to reduce the gap.

This article is organized as follows. The first section briefly describes trends in the Canada-U.S. ICT investment gap over time. The second section provides several decompositions of the ICT investment per worker gap, identifying which components of ICT investment and which industries make the largest contributions to the gap. The third section highlights non-measurement factors that contribute to the gap. The fourth section focuses on comparisons of different elements of the methodologies used to construct the ICT investment time series in Canada and the United States. It identifies differences in definitions, and provides estimates for the degree to which the gap is over- or under-estimated due to measurement error. The fifth and final section concludes.[3]

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

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

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

Our key indicator for comparing Canada's performance in ICT investment to that of the United States is the Canada-U.S. relative level of ICT investment per worker, which is calculated as the ratio between nominal business sector ICT investment per worker in Canada and in the United States. Following the generally accepted OECD definition of information and communications technology, ICT investment is defined as investment in computers, software, and telecommunications equipment. To convert ICT investment per worker in Canada to U.S. dollars, we use purchasing power parity (PPP) estimates, which take into account differences in the prices of goods and services between the two countris.[5] The Canada-U.S. ICT investment per worker gap is simply 100 minus the Canada-U.S. relative level of ICT investment per worker.[6]

3 This article is accompanied by a set of Appendix Tables that provide more details on the estimates. The Appendix Tables are available on the CSLS website at www.csls.ca/res_reports.asp. Additionally, the CSLS maintains a database on ICT investment and capital stock by industry in Canada and the United States based on publicly-available data from Statistics Canada and the U.S. Bureau of Economic Analysis. This database is publicly available at www.csls.ca/data/ict.asp.

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

As noted earlier, the Canada-U.S. ICT investment per worker gap in 1987 was very similar across all three components, but this is no longer the case (Table 1). Since 1987, software investment per worker has declined significantly relative to the United States, from a high of 70.3 per cent of the U.S. level in 1994, to 39.8 per cent of the U.S. level in 2011. At the same time, computer investment per worker increased from 62.6 per cent in 1987 to 108.8 per cent of the U.S. level by 2011. Investment in communications equipment has also increased, from 55.9 per cent of the U.S. level in 1987 to 72.9 per cent of the U.S. level in 2011. Meanwhile, total ICT investment per worker has generally been close to 60.0 per cent during the entire period. The divergence in the ICT investment per worker gap by component begins in the mid-1990s, and continues to 2011. This is a very dramatic shift in the composition of the ICT investment per worker gap, from a relatively uniform gap across all components, to no gap at all in computers, an extremely large gap in software, and a substantial but smaller gap in communications equipment.

Another key trend is that the level of ICT investment per worker in Canada relative to that of the United States grew significantly faster in the 2000-2011 period than it did in the 1987-2000 period. The relative level peaked in 2006 at 65.24 per cent, falling precipitously in 2009 during the recession. Since then, the level of ICT investment per worker in Canada has increased relative to the United States (Sharpe and de Avillez, 2010; Sharpe and Andrews, 2012; Capeluck, 2013). Chart 1 illustrates that the gap in total ICT investment per worker has fluctuated significantly over time but still remains relatively close to its level in 1987; it also shows the dramatic evolution of the composition of the gap by component for the 1987-2011 period.

Table 1

Business Sector ICT Investment per Worker in Canada (PPP adjusted) Relative to the United States, 1987 and 2000-2011

(per cent of U.S. investment)

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

Source: Appendix Table 1c.

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

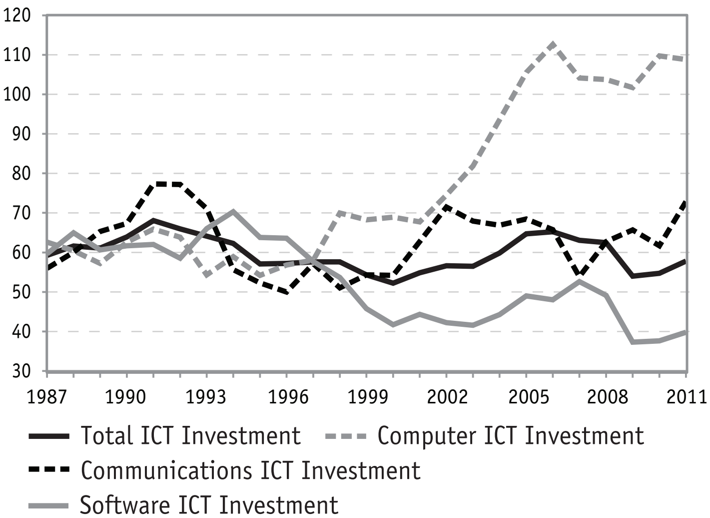
It is interesting to note that the Canada-U.S. ICT investment per worker gap appears to be uniquely a business sector phenomenon. In the non-business sector, ICT investment per worker in the two countries was approximately the same in 2007.[7]

5 Ideally, the PPP estimates used to calculate the Canada-U.S. ICT investment per worker gap would refer specifically to ICT investment. Unfortunately, such estimates do not exist. The closest alternative is the machinery and equipment (M&E) PPP calculated by Statistics Canada, which is the PPP used in this article to estimate the Canada-U.S. ICT investment per worker gap. In general, ICT can be seen as a subcategory of M&E. As such, using the M&E PPP instead of the ICT PPP (which is unavailable) provides a reasonable, albeit imperfect alternative to the more precise measure of the ICT gap.

6 There are, of course, ways to compare ICT investment in Canada and the United States without using labour input, and these measures also point to a large Canada-U.S. ICT investment gap.

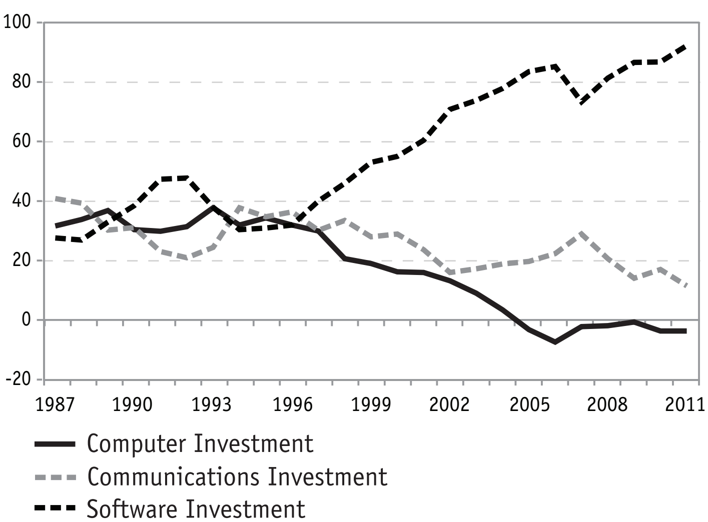
7 This is the only year for which OECD data on ICT investment allow us to perform this calculation. U.S. data do not uniquely identify non-business ICT investment in any year.

Chart 1
ICT Investment per Worker in Canada Relative to the United States, Business Sector, 1987-2011
(per cent)



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

Chart 2
Relative Contribution to the Total ICT Investment per Worker Gap by Component, 1987-2011
(per cent)



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

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

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

Decomposition by Component

Software investment is the largest component of ICT investment, accounting for 48.5 per cent and 64.5 per cent of of total ICT investment in Canada and in the United States, respectively, in 2011. The difference in software investment per worker accounted for 92.2 per cent of the gap, meaning that software investment was almost wholly responsible for Canada's low level of ICT investment per worker relative to the United States (Table 2). This observation motivates our investigation in this article of the methods used to measure different types of software investment.

In 1987, the relative contribution of each component to the gap was very similar. Since 1995, there has been a consistent trend towards the concentration of the gap in the software component (Chart 2).

Table 2
Decomposition of the Canada-U.S. ICT Investment Gap by Component, Canada and the United States, Business Sector, 2011

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

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

Given the role of software investment in the total Canada-U.S. ICT investment per worker gap, it is important to break down software investment by type of software. Statistics Canada's Input-Ouput tables break down software investment into three components: pre-packaged, own-account, and custom-designed software.

In 2009 (the last year for which data were available), pre-packaged software represented less than 20 per cent of total software investment in Canada, while in the United States it accounted for almost 30 per cent of software investment. The importance of own-account software investment was also smaller in Canada than it was in the United States (34.0 per cent of total software investment vs. 38.5 per cent, respectively). Over 45 per cent of software investment in Canada was in the form of custom-designed software (vs. 32 per cent in the United States).

Table 3 provides a detailed decomposition of the Canada-U.S. ICT investment gap in 2009, taking into account the different types of software investment. Based on these data, own-account software investment was responsible for fully 35.1 per cent on the total ICT investment per worker gap in 2009. Pre-packaged software makes a slightly smaller contribution of 31.2 per cent to the gap in 2009. At 10.5 per cent, the contribution of custom software to the gap is significantly smaller than the contribution of the two other software components.

Decomposition by Industry of Total ICT Investment per Worker Gap

The ICT investment per worker gap can be decomposed by industry in Canada and the United States for a direct comparison between industries.[8] Furthermore, we can also compare the gap in each industry by ICT components to determine whether the large gap in software investment per worker is a persistent trend across industries, or whether it is concentrated in particular industries.

Due to the lack of availability of 2011 estimates of communications investment for many industries, we perform this decomposition for 2009. The industries included in this decomposition comprise 82.0 per cent of business sector employment in the United States.

As Table 4 shows, information and cultural industries constitute the largest contributor to the gap, followed by finance and insurance and professional, scientific, and technical services. This industry breakdown of the Canada-U.S. ICT investment per worker gap also highlights a number of other important facts:

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

Table 3

Relative Contribution to the Canada-U.S. ICT Investment per Worker Gap of Software Investment Components, 2009

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

Source: Appendix Table 3a.

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

- There is a massive variation in ICT investment per worker at the two-digit NAICS level for both Canada and the United States. Focusing our attention on Canada, the industry with the lowest level of ICT investment per worker in 2009 was agriculture, forestry, fishing and hunting ($311), while the industry with the highest level was information and cultural industries ($16,530).
- For two-digit NAICS industries, there is a large variation in the Canada-U.S. relative levels of ICT investment per worker, which ranged from 22.8 per cent in mining and oil and gas extraction in 2009 and 279.4 per cent in the case of professional, scientific and technical services. In two industries, Canada's ICT investment per worker levels were more than double of the U.S. levels.
- Although the Canada-U.S. relative level of ICT investment per worker for the business sector was 54.0 per cent in 2009, only five industries had relative levels below or at the business sector average. Two of these industries were, however, ICT-intensive industries: information and cultural industries, where Canada's ICT investment per worker level relative to the U.S. was 53.8 per cent; and professional, scientific and technical services where the Canada-U.S. relative was only 26.5 per cent.

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

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

Labour Productivity

Labour productivity is an important determinant of income per capita, which in turn

Table 4

Decomposition of Total ICT Investment per Worker Gap by Business Sector Industry, 2009

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

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

affects ICT investment per worker. In this sense, differences in labour productivity explain part of the Canada-U.S. ICT investment per worker gap. Holding constant ICT investment as a share of GDP, a country with higher labour productivity (defined here as PPP-adjusted nominal GDP per worker)[9] will have a higher level of ICT investment per worker compared to a country with a lower labour productivity level.

In fact, according to CSLS calculations, the Canada-U.S. ICT investment per worker gap would have been 12.6 percentage points lower in 2011 if the two countries had had the same labour productivity level.[10] This represents slightly less than a third of the ICT gap of 42.2 per cent in 2011, in line with the average contribution of labour productivity to the ICT gap throughout the 1987-2011 period. The higher ICT share of GDP in the United States

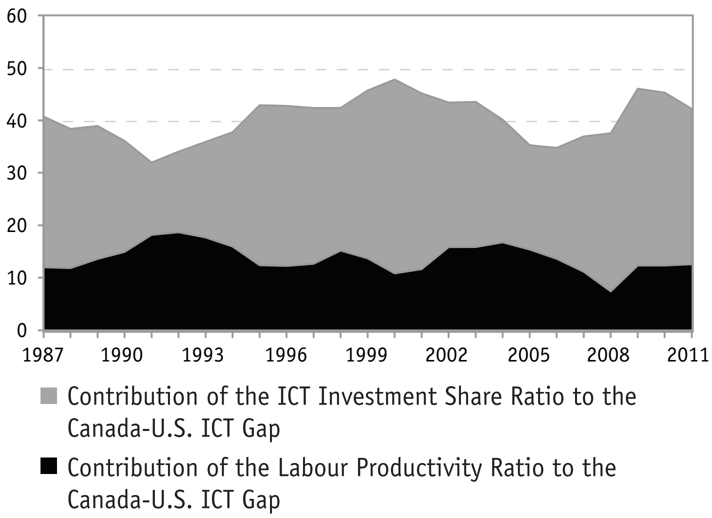
9 The reader should keep in mind that labour productivity levels are sometimes defined in real terms—either as real GDP per hour worked or as real GDP per worker. In this section, however, we defined it in nominal terms because we are interested in the *level* of nominal income being generated per worker.

10 For details, See Rai and Sharpe (2013).

Chart 3

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

(percentage points)



Source: CSLS calculations based on Appendix Tables.

accounted for the remaining two-thirds of the Canada-U.S. ICT gap. Chart 3 plots the contribution of each of these two factors over the past 25 years. Despite some significant fluctuations over the period (especially in the early 1990s), the contribution of labour productivity differentials to the Canada-U.S. ICT gap has remained fairly stable over time.

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

Industrial Structure

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

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

Table 5

Canada-U.S. Relative Level of ICT Investment per Worker, Actual x Simulated, 2011

(PPP-adjusted U.S. dollars, U.S. employment share weights)

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

Source: CSLS calculations based on data from the CSLS ICT database.

Notes: For details on how the simulated estimates were calculated, refer to Appendix Tables.

Table 5 presents the simulated level of ICT investment per worker in Canada using U.S. employment shares as weights, and compares it to the actual level in 2011. Using U.S. weights, business sector ICT investment per worker in Canada was $2,629, 4.1 per cent higher than the actual level of $2,525. Converting these figures to PPP-adjusted U.S. dollars, we find that if Canada had the U.S. employment shares, its business sector ICT investment per worker level would have been 60.2 per cent of the U.S. level, while its *actual* level was only 57.8 per cent that of the United States, a difference of 2.4 percentage points.

Despite many similarities, there are small but significant differences in the way the two countries allocate labour. In Canada, for instance, mining and oil and gas extraction in Canada represents 2.1 per cent of business sector employment versus 0.8 per cent in the United States, a difference of 1.3 percentage points. Accommodation and food services, on the other hand, represents a higher employment share in the United States than in Canada (9.7 per cent versus 8.4 per cent, respectively), again a difference of 1.3 percentage points.

Table 6 shows how each industry contributed to the overall effect of industrial structure on the Canada-U.S. ICT investment per worker gap in 2011. Recall from Table 13 that the simulated ICT investment per worker level (using U.S. weights) in 2011 was greater than the actual level by $104. The industries that contributed the most to this difference were: finance and insurance ($46); management of companies and enterprises ($45);[11] and information and cultural industries ($38). Note that these three industries had above-average ICT investment per worker levels, which magnified their overall contribution to the total industrial structure

Table 6
Industry Contributions to the Difference between Actual and Simulated ICT Investment per Worker Level in Canada, 2011

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

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

Source: CSLS calculations based on the CSLS ICT database.

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

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

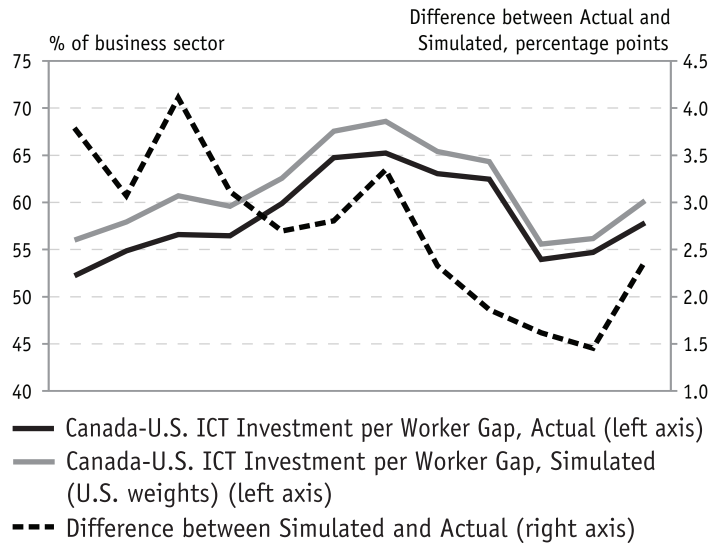
Although the impact of industrial structure on the Canada-U.S. ICT investment per worker gap was still significant, it is interesting to note that its magnitude declined from its pre-2007 levels. Chart 4 plots Canada's ICT investment per worker level relative to that of the United States from 2000 to 2011. The difference between the two series reached a peak in 2002, when the Canada-U.S. ICT investment per worker relative was 56.6 per cent versus the sim-

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

ulated value of 60.7 per cent, a difference of 4.1 percentage points. There was an increase in the difference between the two series in 2011, but it is still too early to tell if this represents a change in trend or whether it simply reflects temporary fluctuations.

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

Chart 4
Canada-U.S. ICT Investment per Worker Relative, Actual x Simulated, 2000-2011
(PPP-adjusted U.S. dollars)



Source: CSLS calculations based on the CSLS ICT database.

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

Our analysis in the preceding section has explained a significant portion of the ICT investment per worker gap, but approximately 65 per cent of the gap still remains unexplained. Of the factors that we reviewed, we explain approximately one-fifth of the gap through quantifiable differences between Canada and the United States, particularly greater U.S. labour productivity (12 percentage points or 30 per cent) and differences in industrial structure (2.5 percentage points or 5 per cent). Because much of the gap remains unexplained, we now turn our attention to comparing measurement methodologies in Canada and the United States to determine to what degree the estimates we use to compute the gap are comparable. We look both for inconsistencies in what the two countries are estimating, and sources of error in how they produce their estimates that could affect our estimate of the ICT investment per worker gap.

This section proceeds as follows. First, we begin with a quick overview of the main data sources used to calculate the Canada-U.S. ICT investment per worker gap. Next, we provide a discussion of definitions of ICT commodities, business sector investment in ICT, and business sector employment. We include a discussion based on the reporting guides of the surveys used to collect data on ICT investment in both countries, and discuss differences in the definitions of business sector employment and investment. We also discuss differences in the composition or size of the business sector in Canada and the United States, which is a measurement issue for the purposes of comparing business sector ICT investment per worker. Second, we review the design of the surveys used in the two countries and compare sample methodology and coverage, response rates, and coefficients of variation. Finally, we discuss in great detail the estimation of own-account software, i.e. software developed by the employees of a firm for internal use, and compare the estimates of own-account software in the two countries. Own-account software is the most difficult component of software to estimate, and as software investment accounted for 92.2 per cent of the ICT investment per worker gap in 2011, this is an important area of research.

Data Sources

For both Canada and the United States, comparing ICT investment per worker requires estimates of: (a) business sector ICT investment; (b) employment in the business sector, and by industry; and (c) purchasing power parity (PPP).

For Canada, our main source of ICT investment estimates is Statistics Canada's Fixed Capital Flows and Stocks (FCFS) program,[12] which are in turn constructed using estimates from the Capital and Repair Expenditure Survey (CES). For the United States, ICT investment estimates come from the Bureau of Economic Analysis (BEA), more especificaly the BEA's Fixed Asset Accounts. These estimates are primarily constructed using data from the Annual Capital and Expenditure Survey (ACES) and the Information Communications Technology (ICT) Survey.

Employment estimates for Canada are obtained from Statistics Canada's Labour Force Survey (LFS), while for the United States they are obtained from the Current Population Survey (CPS). Finally, official PPP estimates are obtained from Statistics Canada.

Differences in Definitions

There are two sets of definitions that are important to our estimates of the business sector ICT investment per worker gap. First, there are the definitions of ICT components, that is, computers, communications equipment, and software. We examined the reporting guides accompanying the surveys used by statistical agencies in both countries to determine to what degree the definitions of these components differ, if at all. Second, the definition of the business sector used by Statistics Canada's FCFS program is important in the calculation of business sector ICT investment per worker, as it affects both investment and employment estimates.

ICT Component Definitions

In addition to a harmonized industry classification system (NAICS), Canada and the United States have harmonized definitions of trade commodities. However, the definitions of commodity classes for private fixed investment are not harmonized; the Bureau of Economic Analysis' (BEA) Fixed Asset Accounts and Statistics Canada's FCFS program report private non-residential fixed investment for asset types that do not follow exactly the same definition. It is therefore possible that the values reported for investment for a particular ICT asset type will not refer to the same groups of commodities in the two countries. We examined the definitions of the assets that comprise ICT in order to determine whether definitional differences pose a challenge for comparing ICT investment in Canada and the United States. Despite some ambiguities, we found no major definitional differences that would cause ICT estimates from Canada and the United States to not be comparable.

12 Additional ICT investment data for Canada are obtained from the Canadian Productivity Accounts (CPA) and the Input-Output (IO) Tables.

Business Sector Definitions

Our interest in ICT investment per worker has been confined to the business sector because business sector investment is an important determinant of productivity. In order for our estimates of the Canada-U.S. business sector ICT investment per worker gap to be accurate, it must be the case that the definition of the business sector in Canada and the United States is the same. Unfortunately, this is not the case—Statistics Canada's FCFS tables, our primary source of investment data for Canada, do not use the same definition of the business sector as the BEA Fixed Asset Accounts, our primary source of investment data for the United States. Rai and Sharpe (2013) show that this mismatch in definitions has most likely led to a understament of the gap.

Differences in Data Collection Methodologies

Our analysis of the investment surveys used in Canada and the United States did not find any significant differences in the surveys themselves that would affect our estimate of the gap. Rai and Sharpe (2013) discuss five elements of data collection: survey sample frame, sample size, sample stratification, quality control and analysis, and non-sampled entities. In regard to survey sample frame, all three surveys consist of a random sample drawn from the respective business registry. In both countries, the business registry covers approximately 97 per cent of all businesses. One important difference, however, is that in Canada, all government entities as well as private entities are included in the sample frame; in the United States, government estimates do not contain the same detail as private data. The government fixed assets data do not support as detailed a breakdown as the private fixed assets data, and do not allow for the identification of ICT investment. This is not a measurement issue for comparing the business sector in the two countries, but it does mean that it is not possible to produce comparable estimates of ICT investment for the total economy in Canada and the United States. This, in turn, means that our focus on the business sector is also necessary.

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

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

Finally, we found that both agencies had several methods of dealing with the challenges posed by non-sampled entities. These entities would explicitly be excluded from Statistics Canada's estimates, which exclude very small establishments that cannot be sampled with certainty. Statistics Canada estimates the investment values for these entities using administrative data, including tax data.

Similarly, the BEA uses administrative data for non-employer establishments; where establishment-level data are not possible to estimate, the BEA uses activity-level data for any non-manufacturing establishment as a proxy. Overall, both agencies reported that this issue would only affect establishments comprising between 2.5 and 3.0 per cent of firm revenue, leading us to conclude that the impact of collection on the estimates is negligible.

Differences in Software Investment Measurement Methodology

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

Measurement of Pre-packaged Software

Investment per worker in pre-packaged software in Canada, which was just 26.4 per cent of the U.S. level, was responsible for 31.2 per cent of the total gap in business sector ICT investment per worker on its own in 2009 (the most recent year for which detailed data are available). We review the methodology used by Statistics Canada and the Bureau of Economic Analysis to estimate investment in pre-packaged software, and discuss any differences thereof.

Commodity-flow Methodology for Pre-packaged Software Investment

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

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

To this amount, CSNA adds the margins on domestic sales[13] (based on IO benchmarks) and the value of imports (using Balance of Payments (BOP) and merchandise trade data). This new figure is equal to the total domestic supply of software. From total domestic supply, the CSNA subtracts the value of exports (again from trade data) and the value of personal expenditure by households on software, from Statistics Canada's Annual Survey of Household Spending. This new figure is total domestic expenditure on software – the only remaining adjustment before arriving at final investment in software is to

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

remove intermediate spending, which is largely software purchased to be embedded in hardware. To estimate intermediate spending on pre-packaged software, the CSNA deducts the input expense of the software publishing industries based on IO estimates.

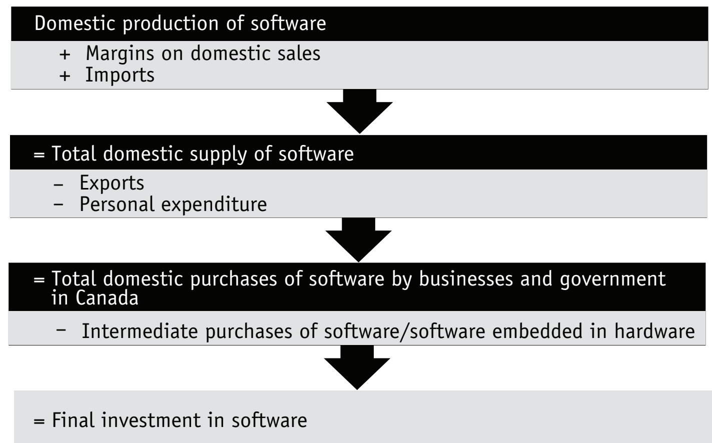
The methodology used by the BEA in the United States is essentially the same. The BEA begins with total domestic production, based on data from the Census Bureau's quinquennial Census of Services Industries and Census of Manufacturers in its benchmark year; in non-benchmark years, the BEA uses receipts of industries involved in producing software from survey data. From this total, they deduct intermediate purchases and changes in inventory. Data on intermediate purchases are based on input-output estimates from the computer manufacturing industry based on the census of manufacturers; in non-benchmark years, the shares are assumed to be the same as the most recent benchmark year. Inventory changes are based on IO estimates in benchmark years only; the value of inventory changes in non-benchmark years is assumed to be zero due to a lack of data. This adjustment is equal to the total domestic supply of software for final use; the BEA deducts exports from and adds imports to domestic supply in order to produce an estimate of total final investment in software.

Differences in the Estimation of Pre-packaged Software Investment

There are two main differences in the estimation of pre-packaged software investment in Canada and the United States.

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

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



Source: CSLS based on Jackson (2002).

Second, the BEA explicitly adjusts for changes in inventory in benchmark years, while the CSNA at Statistics Canada makes no adjustment for inventory changes in any year. Data from U.S. benchmark years indicate that inventory changes have traditionally been very small, below 0.2 per cent of the value of purchased software in benchmark years, so the magnitude of this discrepancy is likely to be extremely small. This is unsurprising, considering that when designing their methodology, the BEA believed it was valid to omit this step for every non-benchmark year.[14] This is because most changes in inventory will already be accounted for through production and sales data.

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

14 Benchmark years are based on the quinquennial censuses, thus occuring every five years.

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

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

Measurement of Custom-designed Software

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

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

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

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

Non-capitalized Purchases of Software

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

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

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

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

Measurement of Own-account Software

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

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

Cost-based Methodology for Own-account Software Investment

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

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

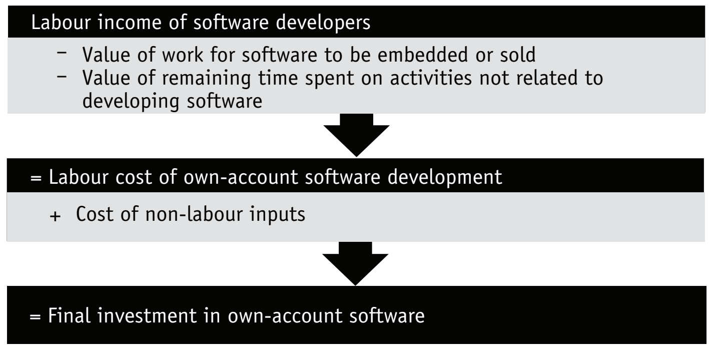
From Figure 2, there are four values that must be computed for the methodology used in Canada: (1) the labour cost of software developers, (2) the proportion of their labour cost that produces software for sale or embedding in hardware, (3) the proportion of their labour cost not spent on developing own-account software, and (4) the cost of other inputs. The methodology and data required in the United States are essentially the same.[15]

Each step in this process is based on data from either the census or surveys, except for the two deductions. The first deduction, for embedded software and software for final sale, is slightly

15 The BEA methodology for current-year quarterly estimates is different from what is described here, but our focus is on the annual estimates, which follow this methodology.

different in the two countries; we leave this issue for the next section. The second deduction subtracts 50 per cent of the remaining labour income of software developers, on the basis that software developers only work on developing own-account software for about half of their time. This is based on Boehm (1981), which found that software developers in the United States used 62 per cent of their time to develop software. The BEA and Statistics Canada arbitrarily reduced the share to 50 per cent, on the basis that this is an approximate exercise. They were also motivated by a belief, when this methodology was developed following the 1981 study this share is taken from (Boehm, 1981), that own-account software was becoming less important.

Figure 2
Methodology for Own-account Software Investment in the CSNA



Differences in the Estimation of Own-account Software Investment

Table 7 reveals one difference in the methodologies used to estimate own-account software investment in Canada and the United States. This difference refers to the deduction for embedded software and software for final sale: in Canada, this deduction is based on an estimate that software developers account for roughly 1 per cent of all wages, salaries and supplementary income in industries not engaged in producing software for sales or embedding it in hardware. The CSNA uses this percentage to cap the labour cost of software developers in software producing and developing industries, on the basis that any labour cost above this amount must be for the purpose of producing software to be embedded or sold. The BEA performs the same adjustment, but it is based on 1 per cent of the employment of software developers, not 1 per cent of their income. Given different average wages, this will result in a different share of income being excluded. However, both Canada and the United States have verified and adjusted these shares using survey data, so any inconsistency resulting from this difference in methodology will reflect a real difference in the production of own-account software in Canada and the United States.

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

Impact of Wages on Own-account Software Investment Estimates

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

However, the fact that U.S. salaries are greater for software developers is a conceptual challenge to this cost-based approach to valuing own-account software. In theory, a software developer with the same skill level could earn more, and contribute to a greater level of own-account software investment, simply by virtue of being employed in the United States. This could occur even if a software developer in each country produced precisely the same software for

Table 7

Data Sources for Own-account Software Estimates in Canada and the United States

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

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

their employer to use. In this case, the greater level of investment in the United States does not reflect differences in software investment, but instead only reflects the fact that software developers in the United States earn a salary premium relative to their counterparts in Canada. This section explores this conceptual challenge, examining how own-account software investment in Canada would change if software developers in Canada earned U.S. wages.

Our methodology to produce an estimate of how this wage gap has affected the Canada-U.S. ICT investment per worker gap is as follows. We use employment and wage data from 2005 to establish a wage gap; 2005 is chosen because it was a census year in Canada, so we have the greatest level of detail for employment and average earnings in this year. Second, we use the wage gap and the data we have for own-account software investment for 1998-2009 to see what impact the difference in wages between Canada and the United States for software developers had based on that data. This allows us to provide an estimate of the difference in wages of software developers and its impact on the Canada-U.S. ICT investment per worker gap.

Differences in the Labour Cost of Software Developers

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

The software developers in Statistics Canada's cost-based methodology correspond to NOC 2006 C071-75. The same data for the United States is provided in 2006 for the Standard Occupation Classification (SOC) codes that the BEA informed us they use in their cost-based methodology. The BLS Occupation Employment Statistics, from which we have taken these estimates, is the source of data used by the BEA to estimate own-account software. The SOC code numbers have changed since 2006, but they are substantially the same otherwise.

Based on these data and GDI PPP of 0.86 in 2005, software developers earned 52.31 per cent more in the United States, $74,910 in the United States compared to $49,183 in Canada.[16]

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

It is surprising that own-account software investment per worker is so much lower in Canada than the United States given that there are relatively more software developers in Canada. This difference could be explained in part by a larger share of software developers in Canada working in industries that only sell or embed software in hardware. The wage difference, of course, also explains part of this discrepancy, but not all of it. Further research is required to determine precisely why own-account software investment per worker is so much lower in Canada than the United States despite greater employment of software developers.

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

Contribution of Salary Differences to the Gap

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

Using the adjusted values of own-account software, the total Canada-U.S. ICT investment per worker gap shrinks by approximately 4 percentage points in each year. This represents about 10 per cent of the total Canada-U.S. ICT investment per worker gap.

16 We use GDI PPP instead of exchange rates to convert investiment estimates in Canada to U.S. dollars because PPPs reflects differences in prices, providing a more accurate comparison of the labour costs of employing software developers incurred by firms in Canada and in the United States .

Table 8
Summary of Factors Contributing to the Canada-U.S. ICT Investment per Worker Gap

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

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

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

Conclusion

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

The article is able to quantify a significant proportion of the gap. In 2011, ICT investment in the business sector in Canada was 57.8 per cent of the U.S. level, a gap of 42.2 percentage points. The largest proximate cause of the gap was the higher labour productivity level in the United States. *Ceteris paribus*, the gap would be 12 percentage points (30 per cent) lower if Canada had the same level of labour productivity as the United States. Canada's industrial structure, with a smaller employment share in information and finance industries (which have very high levels of ICT investment per worker) accounted for about 2 percentage points (or 5 per cent) of the gap. We summarize these findings in Table 8.

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

The remaining 24 percentage points (or 55 per cent) of the gap cannot be easily quantified and likely reflect factors such as: the smaller average firm size in Canada; better awareness of the benefits of ICT investment in the United States; differences in the education of managers; and potential differences in business attitudes and culture. It is important to recognize that Canada's ICT investment per worker is comparable to that of most other OECD countries.[17] Our gap is with the United States, not other countries. It is also important to note that we still have a large gap with the United States by a variety of other measures, including: the ICT investment share of GDP; the ICT investment share of total investment; ICT investment per hour worked; ICT capital stock per worker; and ICT capital stock per hour worked. In other words, the gap is robust across different measures of relative ICT investment performance.

Future research on this subject should be motivated by two key findings in this article. First, we consistently find that information and cultural industries and professional, scientific, and technical services make very large contributions to the gap. This strongly implies that the Canada-U.S. ICT investment per worker gap is the result of industry-specific factors. Any explanation of the gap must therefore include an explanation of why ICT investment per worker (and software investment per worker in particular) in these two industries is so much lower in Canada than in the United States.

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

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17 For details on international comparisons of ICT investment between Canada and other OECD countries, see Rai and Sharpe (2013).