The Contribution of ICTs to Productivity Growth in Canada and the United States in the 1990s

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In the 1990s, labour productivity and real incomes grew at a significantly slower pace in Canada than in the United States, its southern neighbour and largest trading partner. As a result, the productivity and real income level gaps between the two countries have widened. These trends are quite unexpected and worrisome, especially in view of the dramatic increase in Canada's outward orientation, partly due to FTA/NAFTA, and the implementation of a number of structural reforms.

Canada's relatively poor productivity performance has been blamed on many factors such as the widening of investment and innovation gaps, the weak Canadian dollar, slower adoption of information and communication technologies, relatively poor management strategies and practices, stronger labour unions, and heavier tax burdens. Although there is some empirical evidence to suggest that many of these factors might have contributed to Canada's relatively weak productivity performance, it is extremely difficult, if not impossible, to disentangle accurately the contribution of each factor to the productivity problem because they all interact and influence productivity in a complex manner.

There now seems to be a broad consensus that information and communication technologies (ICTs) played a dominant role in the revival of U.S. productivity growth in the 1990s, especially in the second half [Jorgenson (2001), Jorgenson and Stiroh (2000), Oliner and Sichel (2000), and Pilat and Lee (2001)]. This renaissance of U.S. productivity is commonly attributed to the New Economy — a radical transformation of business strategies and production processes by the use of ICTs in both ICT-producing and ICT-using industries. Muir and Robidoux (2001) and Macklem and Yetman (2001) examine the impact of ICTs on the Canadian economy from two different perspectives: business cycles and inflation. This article analyses the contribution of ICTs to Canada's productivity growth in the 1990s and examines their role in the widening of the Canada-US productivity and real income level gaps. In addition, it will provide a short to medium-term perspective on Canada's productivity performance.

Our empirical results show that Canadian ICT-producing industries experienced a large increase in productivity in the 1990s. But the contribution from this source to aggregate productivity growth was significantly smaller in

Canada than in the United States, because the ICT-producing sector is much smaller and its productivity grew at a significantly slower pace. Furthermore, productivity improvements in ICT-using industries were much smaller in Canada than in the United States. The short to medium term outlook for productivity growth in Canada does not look very promising because of the current economic slowdown in North America and elsewhere, particularly in ICT-producing industries, and the large negative impact of the slowdown on machinery and equipment (M&E) investment in Canada, especially ICT investment.

The article is organized in the following way. In section two, we analyse aggregate labour productivity growth in Canada, the United States and other OECD countries. An analysis of the trends in the output and employment structure of ICT-producing industries in Canada and the United States is provided in section three. The contribution of ICT-producing industries to aggregate labour productivity growth in the two countries in the 1990s is examined in section four. Trends in M&E and ICT investment and productivity performance in ICT-using industries in the two countries are examined in section five. The last section summarizes the key findings and explores the medium-term prospects for productivity growth in Canada and the Canada-U.S. productivity and real income level gaps.

An Overview of Canada's Productivity Performance

Productivity growth is the fundamental determinant of growth in real incomes, and a key driver of economic well-being and quality of life in all countries. In addition, relative productivity performance is a key determinant of international competitiveness of a country in the medium-to-longer term, especially for a small open economy such as Canada. Since 1973, OECD countries have experienced slower productivity growth. This slowdown has been blamed for a number of problems, including sluggish economic growth, stagnant real wages, increased unemployment, budget deficits, and social unrest.

Table 1
Labour Productivity* Growth in the Business Sector in Canada and the United States
(average annual per cent rate of change)

	1981-1989	1989-1995	1995-2000	1989-2000
Canada	1.1	1.5	1.7	1.6
United States	1.7	1.5	2.6	2.1

* Real GDP per hour worked.

Sources: Statistics Canada and U.S. Bureau of Labor Statistics.

In this section, we provide a brief overview of Canada's productivity growth in the past two decades and compare it with the performance of the United States and other OECD countries. This information will provide useful background for our later analysis of the role of ICTs in both producing and using industries in Canada and the United States.

Canadian business sector labour productivity, measured as GDP per hour worked, increased at an average annual rate of 1.7 per cent during the second half of the 1990s[1], compared to 1.5 per cent in the first half. But labour productivity in the United States increased at a considerably faster pace than in Canada during the second half of the 1990s, accelerating 1.1 percentage points to 2.6 per cent (Table 1). As a result, the Canada-U.S. aggregate labour productivity level gap increased from 15 per cent in 1995 to 18 per cent in 2000 (Chart 1). However, the per capita income level gap remained more or less constant over this period because of a larger increase in the employment rate in Canada (Sharpe, 2001). In

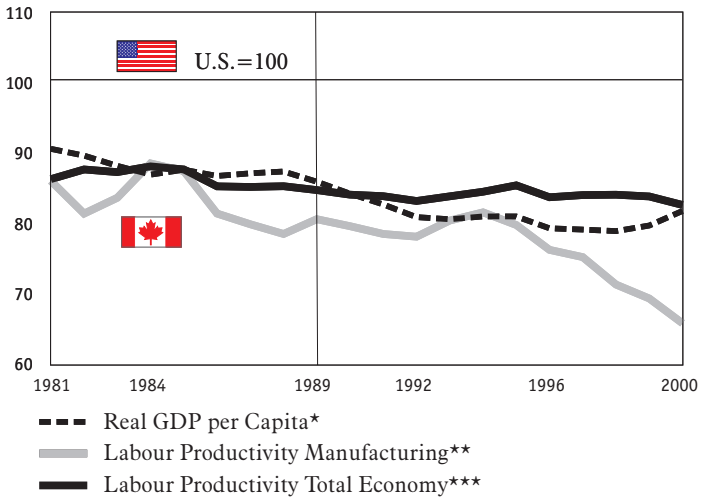
addition, in the 1990s, per capita real personal disposable income in Canada increased by a mere 0.5 per cent per year, compared to 1.6 per cent in the United States.

Fortunately, Canada's productivity performance did not lag behind that of the United States in all industries.[2] In the 1990s, Canadian primary industries outperformed their U.S. counterparts by a wide margin. Labour productivity in this sector increased at an average annual rate of 2.9 per cent in Canada, compared to only 1.3 per cent in the United States (Table 2). In the construction industry, labour productivity actually declined marginally in both countries. On the other hand, Canada lagged badly behind the United States in manufacturing. Labour productivity in the U.S. manufacturing sector increased by 4.3 per cent per year in the second half of the 1990s, more than three times the Canadian growth rate of 1.3 per cent. As a result, the Canada-U.S. manufacturing labour productivity level gap increased from 21 per cent in 1995 to 35 per cent in 2000 (Chart 1).

These broad productivity trends provide some general support for the thesis that Canada did not benefit from the production and use of ICTs as much as the United States in the second half of the 1990s. However, this situation is not unique to Canada. Labour productivity growth did not pick up significantly in the latter half of the 1990s in most OECD countries (Table 3), and indeed actually slowed in many countries. These trends are puzzling and worrisome and raise some important questions. Why was the United States virtually the only country to register a productivity revival in the second half of the 1990s? What accounts for the superior productivity performance of Canadian primary industries? What factors explain the relatively weak performance in Canada and other OECD countries?

At least seven explanations are possible for the relatively weak productivity performance in Canada and other OECD countries. These include: a smaller size of the ICT-producing sector; slower productivity growth in ICT-producing industries; permanently weaker growth in ICT investment in ICT-using industries; a lag relative to the United States in the growth of ICT investment in ICT-using industries; a lagged and/or weaker productivity response to the increase in ICT investment in ICT-using industries; greater negative impact of other factors such as the business cycle and adverse supply shocks on productivity; and greater difficulties in measuring service sector output. In this article, we will examine in some detail the first five explanations for slower productivity growth in Canada and the widening of the Canada-U.S. labour productivity level gap.

Chart 1
Canada-U.S. Productivity and Real Income Gaps



* Real GDP, PPP based.

** Real GDP per hour worked, based on the methodology developed by the Centre for the Study of Living Standards.

*** Real GDP per hour worked, PPP based.

Source: Statistics Canada, U.S. Bureau of Labour Statistics, and U.S. Bureau of Economic Analysis.

The Size and Structure of the ICT-producing Sector

In this section and the next we will examine the contribution of the ICT sector to Canada's productivity growth and its role in the widening

Table 2

Labour Productivity* Growth by Industry in Canada and the United States

(average annual per cent rate of change)

Industry	Canada			United States		
	1989-95	1995-99	1989-99	1989-95	1995-99	1989-99
Primary industries	3.1	2.5	2.9	1.5	1.1	1.3
Construction	-0.8	0.5	-0.3	-0.1	-0.9	-0.4
Manufacturing (total)	3.2	1.3	2.4	3.2	4.3	3.6
Primary Metal	4.2	2.6	3.6	3.7	5.4	4.4
Paper & Allied	5.5	2.0	4.1	0.1	2.7	1.1
Lumber & Wood	-0.5	-0.4	-0.4	-2.7	-2.7	-2.7
Transportation Equipment	4.9	3.4	4.3	2.3	0.7	1.6
Stone, Clay & Glass	-0.8	4.7	1.4	2.9	1.5	2.4
Rubber & Plastics	6.9	1.7	4.8	3.5	2.9	3.3
Furniture & Fixtures	6.0	5.6	5.9	1.6	1.4	1.5
Food and Beverage	3.4	-1.5	1.4	2.8	-3.4	0.3
Chemicals	4.8	0.3	3.0	3.6	3.4	3.5
Tobacco	0.8	-2.4	-0.5	1.9	-15.5	-5.4
Misc. Manufacturing	4.3	4.2	4.2	-0.5	-0.7	-0.4
Leather	-4.2	-11.4	-7.1	4.6	1.2	3.3
Fabricated Metal	9.6	7.2	8.6	2.3	-0.1	1.3
Textiles**	3.7	-1.0	1.8	3.1	2.5	2.9
Printing & Publishing	-2.1	-1.0	-1.6	-2.9	-1.7	-2.4
Petroleum Refining	11.3	-4.0	4.9	0.3	9.4	3.8
Machinery Except Electrical***	4.1	-2.6	1.4	5.4	14.1	8.8
Electrical & Electronic Equip.***	8.9	8.4	8.7	13.1	20.4	15.9
Services	0.9	1.5	1.1	0.9	2.3	1.2
Transportation & Warehousing	2.0	1.3	1.7	2.5	1.7	2.2
Communications	3.0	7.6	4.8	5.1	2.7	4.1
Utilities	1.2	1.4	1.3	2.5	2.4	2.5
Wholesale trade	1.1	3.2	1.9	2.8	7.8	4.8
Retail trade	0.3	3.1	1.4	0.7	4.9	2.4
FIRE****	2.5	1.6	2.2	1.7	2.7	2.1
Total Economy	1.0	1.6	1.2	1.2	2.4	1.7

* Real GDP per worker.

** Including primary textile mills, apparel and other textile products.

*** Computer and office equipment are included in machinery in the United States and in electrical & electronic equipment in Canada.

**** Finance, insurance and real estate.

Sources: Compilations based on data from Statistics Canada and U.S. Bureau of Economic Analysis.

of the manufacturing and the aggregate Canada-U.S. labour productivity level gaps. In this article, we use the OECD definition of the ICT sector, which includes ICT manufacturing as well as ICT services industries.[3]

A Profile of the Canadian ICT Sector

The ICT sector is a key and very dynamic component of the Canadian economy. In 2000, the sector's contribution to GDP was $52 billion ($1992). In the second half of the 1990s, real out-

Table 3
Labour Productivity* Growth in Selected OECD Countries
(average annual per cent rate of change)

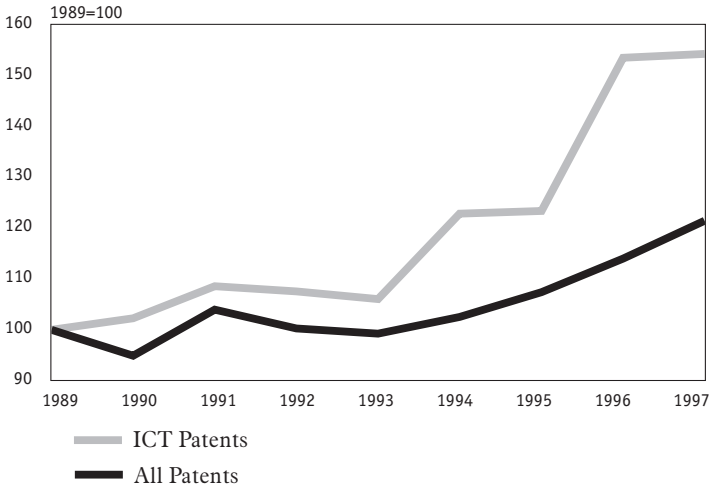
Countries	1989-95	1995-2000
Australia	1.7	2.6
Austria	1.5	1.5
Belgium	1.7	1.7
Canada	1.1	1.2
Denmark	2.4	1.0
Finland	2.4	2.5
France	1.3	1.3
Germany	2.2**	1.8
Greece	0.4	2.3
Iceland	0.9	2.3
Ireland	2.4	3.2
Italy	2.1	0.8
Japan	1.2	1.2
Luxembourg	1.9	1.1
Netherlands	0.7	0.8
New Zealand	0.0	1.2
Norway	3.1	1.5
Portugal	1.6	1.4
Republic of Korea	4.9	4.1
Spain	2.2	0.5
Sweden	2.5	2.0
Switzerland	0.1	1.1
Turkey	2.4	1.9
United Kingdom	2.0	1.5
United States	1.2	2.4

* Real GDP per worker.

** 1991-95.

Source: Industry Canada compilations based on OECD Economic Outlook.

Chart 2
Patents Granted for ICT Applications*



* Canadian patent applications granted in the United States.

Source: U.S. Patent and Trademark Office

put in the ICT sector grew at an average annual rate of 12 per cent, compared to 3.8 per cent for the overall economy. As a result, its share of real GDP increased from 3.7 per cent in 1995 to 5.6 per cent in 2000. The ICT sector is also a major employer. In 2000, about half a million persons worked in the sector, an increase of over 40 per cent since 1990.

It is also a R&D intensive sector. In the 1990s, ICT sector nominal R&D spending increased 10 per cent per year, reaching $4.9 billion in 2000. Currently, the ICT sector accounts for over 45 per cent of total private sector R&D in Canada. Likewise, ICT-related Canadian patent applications granted in the United States increased at a considerably faster pace than all Canadian patent applications granted in the United States in the 1990s (Chart 2).

The ICT sector is also one of the most skill-intensive sectors. In both ICT manufacturing and services industries, the percentage of workers with a university degree is significantly above the national average. For instance, in the software and computer services industry, half of all employees have a university degree, over two and half times the national average.

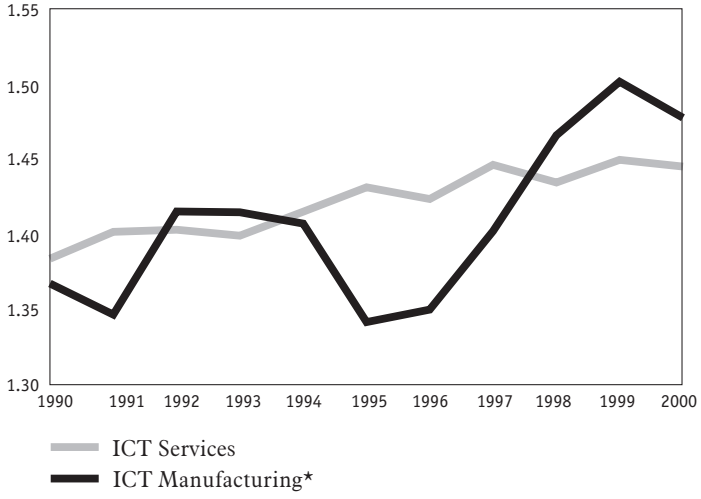
Reflecting the high skill levels, employees in the ICT sector are well paid. In 2000, the average wage in the sector was almost 50 per cent higher than the average wage of all Canadian industries. This premium increased significantly in the 1990s (Chart 3).

Canada's international trade in ICT products also increased considerably in the 1990s. More than three quarters of ICT manufactured products are exported, reaching almost $40 billion in 2000. They currently represent about 10 per cent of Canada's total merchandise exports,

Chart 3

Relative Weekly Earnings of ICT Sector Employees

(All Industries = 1.00)



* Excluding record player, radio, TV receiver and instruments.

Source: Statistics Canada.

compared to around 7 per cent in 1990. Similarly, the share of ICT manufactured products in total merchandise imports increased from 15 per cent in 1990 to 18 per cent in 2000. This large and growing two-way trade in ICT products implies increasing product specialization and bodes very well for continuation of a healthy productivity growth and dynamism in the Canadian ICT sector.

The Structure

The industrial structure of the ICT sector also changed dramatically in the 1990s. For instance, the importance of office machines in the ICT sector more than tripled, reaching 8.1 per cent of the real output of this sector in 2000 (Chart 4). Similarly, the share of computer services almost doubled. On the other hand, the importance of telecom services declined sharply. But they still represent 41 per cent of the sector's output, compared to 54 per cent in 1990. More importantly, ICT services industries still contribute close to 75 per cent of ICT sector output.

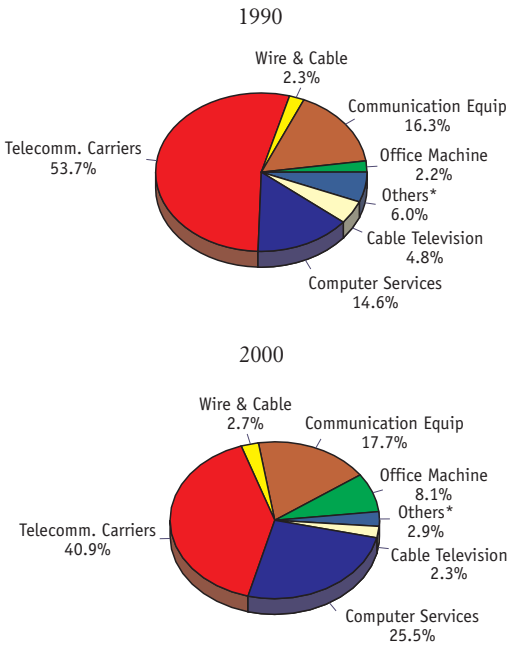
Similarly, the employment structure of the ICT sector has greatly changed (Chart 5). The share of computer services in ICT sector employment more than doubled, reaching 38 per cent in 2000. This increase came at the expense of telecom services. It is interesting to note that despite a three-fold increase in its real GDP share, the share of office machines in ICT sector employment in the 1990s declined somewhat to 4.2 per cent, implying huge productivity improvements in this sector.

Unlike its small output and employment shares, ICT manufacturing accounted for 70 per cent of the R&D undertaken by the ICT sector in 2000. However, telecommunication equipment manufacturers carry out almost half of all R&D done in the ICT sector. Computer equipment and other communication and electronic equipment producers contribute around 20 per cent of the ICT sector R&D. Similarly, exports of telecommunication and computer equipment account for over 50 per cent of all ICT manufactured exports. Electronic parts and components contribute another 20 per cent to ICT goods exports.

Canada-U.S . Comparisons

An analysis of the size, dynamism and the structure of the ICT sector in Canada and the United States can shed light on Canada's relatively weak productivity performance. In 1999, the United States accounted for almost 50 per cent of total ICT sector value added in OECD countries, compared to Canada's 2.9 per cent, implying a much larger share of overall business sector GDP — 8.7 per cent versus 6.5 per cent. Similarly, the ratio of value added to gross output in the ICT sector is significantly smaller in Canada than in the United States (41 per cent versus 49 per cent), reflecting greater assembly of imported components. More importantly,

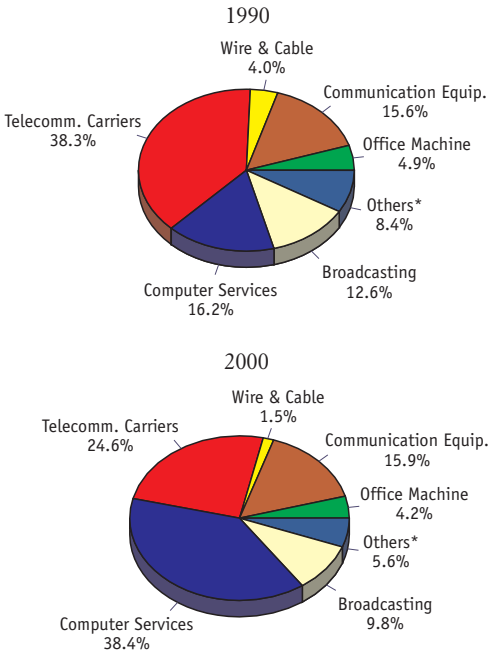
Chart 4
Real GDP Share of ICT Industries in Canada
(1992 $)



* Including consumer electronics and instruments industries.

Source: Industry Canada estimation based on data from Statistics Canada.

Chart 5
Employment Share of ICT Industries in Canada



* Including consumer electronics and instruments industries.

Source: Industry Canada estimation based on data from Statistics Canada.

labour productivity in the Canadian ICT sector is almost 40 per cent below the U.S. level. This explains why the ICT sector accounts for a larger share of business sector employment in Canada than in the United States (4.6 per cent versus 3.9 per cent).

The United States accounts for over 50 per cent of total ICT sector R&D in OECD countries, compared to Canada's 2.7 per cent. The proportion of R&D to value added in the ICT sector is significantly lower in Canada than in the United States (8.9 per cent versus 10.3 per cent). Similarly, the shares of ICTs in total merchandise exports and imports are considerably lower in Canada. For instance, in 1997, ICT exports accounted for only 7.2 per cent of Canadian merchandise exports, compared to 15.2 per cent in the United States.

In summary, the ICT sector in Canada is smaller, less innovative and less productive, suggesting that these factors might have played a role in the recent widening of the Canada-U.S. aggregate labour productivity gap.

Differences and changes in the industrial structure of employment and output, and relative productivity levels within the ICT sector itself between the two countries could also contribute to the differences in productivity growth between the two countries. Here, we examine the structural changes in the ICT manufacturing sector in the two countries. A similar analysis is not possible for the ICT services sector because there are no comparable data for the United States.

ICT manufacturing accounts for a much larger share of the ICT sector in the United States than in Canada. In 1998, it accounted for 3 per cent of nominal GDP, more than double the share in Canada. Although the composition of real value added in the ICT manufacturing sec-

Table 4
Distribution of Real ($1992) GDP in ICT Manufacturing Industries*
(Per cent)

Industry	Canada			United States		
	1989	1995	2000	1989	1995	2000
Computer and office machine	10.1	22.9	31.4	30.6	29.4	29.0
Consumer electronics	5.0	1.5	0.3	4.1	2.3	0.3
Communication and other electronics	85.0	75.6	68.3	65.3	68.3	70.8

* Excluding instruments.

Sources: Statistics Canada and U.S. Federal Reserve.

Table 5
Distribution of Employment in ICT Manufacturing Industries*
(Per cent)

Industry	Canada			United States		
	1989	1995	2000	1989	1995	2000
Computer and office machine	20.3	18.1	20.4	32.9	28.0	26.2
Consumer electronics	7.8	3.1	2.4	6.2	6.7	5.8
Communication and other electronics	71.9	78.8	77.2	60.9	65.3	68.0

* Excluding instruments.

Sources: Statistics Canada and U.S. Bureau of Labor Statistics.

tor was very similar between the two countries in 2000, the share of computers and office machines has more than tripled in Canada since 1989, reaching 31 per cent in 2000, compared to a stable share of around 30 per cent in the United States (Table 4).

The employment structure, however, is significantly different between the two countries. The communication equipment and other electronics industry accounted for 77 per cent of employment in the ICT manufacturing sector in 2000, compared to 68 per cent in the United States. On the other hand, the computer equipment industry's share was 6 percentage points higher in the United States. As expected, the employment share of the ICT manufacturing sector in the total economy was considerably lower in Canada than in the United States, 0.6 per cent versus 1.0 per cent.

In 2000, the labour productivity level in Canadian ICT manufacturing industries, expressed in 1992 dollars, was 2.5 times the economy-wide average, compared to a stunning ratio of 15.7:1 in the United States (also expressed in 1992 dollars).[4] More importantly, this relative productivity advantage saw a fifteen fold increase in the United States from 1989-2000, compared to an increase of less than 150 per cent in Canada.

In both countries, the computer equipment industry was more productive than communication equipment and other electronics industries in the 1990s, but the advantage was significantly greater in Canada than in the United States. In

Table 6
Relative Labour Productivity Levels in ICT Manufacturing Industries (1992 $)
(Aggregate Manufacturing = 1.00)

Industry	Canada			United States		
	1989	1995	2000	1989	1995	2000
Computer and office machine	0.5	1.5	3.3	0.7	2.0	9.2
Communication and other electronics	1.3	1.2	1.8	0.8	2.0	8.7
ICT Manufacturing*	1.1	1.2	2.2	0.8	1.9	8.4

* Excluding instruments.

Sources: Compilations based on data from Statistics Canada, U.S. Bureau of Labour Statistics and Federal Reserve.

2000, more importantly, the average labour productivity level in the United States was more than eight times higher than the average for the overall manufacturing sector, compared to just two times higher in Canaada (Table 6).

Contribution of the ICT Sector to Economic Growth

In this section, we will analyse the contribution of the ICT-producing sector to output and labour productivity growth in Canada and the United States.

Output Growth

Between 1995 and 2000, the real output in the Canadian ICT manufacturing sector increased at an average annual rate of 17 per cent per year, compared to 10.5 per cent in ICT services. During this period, real GDP increased by 3.8 per cent per annum. Given that the ICT sector represented 5.6 per cent of real output in 2000, the 12 per cent annual growth rate for the sector implies that almost 14 per cent of overall economic growth in the second half of the 1990s was directly attributable to the ICT sector.[5]

As pointed out earlier, data on U.S. ICT services industries are not available. But the data on the ICT manufacturing sector in the two countries suggest that the ICT sector's contribution to economic growth during the second half of the 1990s was probably even larger in the United States than in Canada. During this period, real GDP of the ICT manufacturing sector grew at a remarkable 45 per cent per year in the United States, implying that more than one-third of U.S. economic growth in the latter half of the 1990s came from this source (Table 7).

Labour Productivity Growth

Labour productivity (GDP per worker) during the 1995-2000 period increased at an average annual rate of 5.8 per cent in the Canadian ICT sector, a slight increase from the 5.3 per cent pace during the first half of the decade. Between 1995 and 2000, total economy output per worker in Canada increased by only 1.7 per cent per year, indicating that more than a quarter of aggregate productivity growth was the direct result of strong productivity growth in the ICT sector. It is important to note that despite accounting for only 25 per cent of the output of the ICT sector, ICT manufacturing accounted

Table 7
GDP and Labour Productivity (LP)* in the ICT-Producing Sector in Canada and the United States
(average annual per cent rate of change)

	Canada		United States	
	1989-1995	1995-2000	1989-1995	1995-2000
Real GDP Growth in ICT Manufacturing	5.2	17.2	17.7	45.2
Real GDP Growth in ICT Services	5.6	10.5	NA	NA
Real GDP Growth in ICT Sector	5.5	12.0	NA	NA
Real GDP Growth for Total Economy	1.5	3.8	2.3	4.1
LP Growth in ICT Manufacturing	6.5	13.7	19.7	42.5
LP Growth in ICT Services	4.9	3.5	NA	NA
LP Growth in ICT Sector	5.3	5.8	NA	NA
LP Growth for Total Economy	1.0	1.7	1.2	2.5

* GDP per worker.

Sources: Statistics Canada; U.S. Bureau of Labor Statistics and Federal Reserve Board.

for more than 60 per cent of the total contribution of the ICT sector to aggregate labour productivity growth because of its much superior productivity growth. Labour productivity in this component of the ICT sector increased at an annual rate of 13.7 per cent, compared to 3.5 per cent in the ICT services sector (Table 7).

In the United States, labour productivity in ICT manufacturing increased by 42.5 per cent per annum during the second half of the 1990s, compared to a growth rate of 19.7 per cent in the first half of the decade (Table 7). This accounted for more than 50 per cent of the U.S. aggregate labour productivity annual growth rate of 2.5 per cent in the second half of the 1990s.

The next important question is: what was the combined contribution of the larger size and faster productivity growth in the ICT manufacturing sector in the widening of the Canada-U.S. manufacturing and aggregate and labour productivity gaps during the past five years? The productivity trends in the two countries imply that most of the difference in aggregate labour productivity growth between Canada and the United States, hence the widening of the aggregate labour productivity level gap during the second half of the last decade, was due to the large differences in the size and productivity growth of the ICT manufacturing sector in the two countries. The two factors contributed more or less equally to the widening of the aggregate labour productivity gap. Similarly, they were also entirely responsible for the dramatic widening of the Canada-U.S. manufacturing labour productivity gap during this period. As a matter of fact, our results suggest that without the superior productivity performance in primary industries, the aggregate labour productivity level gap between Canada and the United States would have widened even more.

Productivity Performance in ICT-using Industries

In the two previous sections we analysed the contribution of ICT-producing industries to Canada's output and productivity growth in the 1990s and examined their role in the widening of the Canada-U.S. aggregate economy and manufacturing labour productivity gaps. In this section, we will look at the investment and productivity performance of ICT-using industries in both Canada and the United States.

In the second half of the 1990s, the aggregate ratio of ICT investment to employment in Canada increased at an annual rate of 20.6 per cent, compared to 11.7 per cent in the first half of the 1990s and 8.8 per cent in the 1980s. Further, the ICT investment intensity increased significantly across all major industries during the 1992-97 period (Table 8). The increase was particularly strong in service industries. For instance, in wholesale trade, retail trade and finance, insurance and real estate industries, the ICT investment intensity increased at annual rates between 17 and 27 per cent.

In addition, ICT investment intensity is generally much higher in service-producing industries than in goods-producing industries (Table 9). For instance, in finance, insurance and real estate, the ICT investment intensity in 1997 was twice that of the aggregate intensity, whereas in primary industries it was only 10 per cent of the average. As expected, the ICT investment intensity was more than ten times that of the aggregate intensity in communications and other utilities.

Table 8
ICT Investment*/Employment in Canadian and U.S. Industries
(average annual per cent rate of change)

Industry	Canada	United States		
	1992-97	1992-97	1989-95	1995-99
Primary industries	19.3	12.7	12.2	9.9
Manufacturing	12.0	9.4	8.1	26.3
Construction	9.6	18.7	21.0	24.4
Transportations	21.8	19.0	14.1	20.1
Communications and other utilities	9.1	9.2	5.3	13.5
Wholesale	22.6	27.3	12.1	26.5
Retail	26.6	11.0	9.6	30.5
Finance, insurance and real estate	16.8	18.3	6.7	26.0
Business services	2.6	15.5	-0.3	38.8

* Excluding software.

Sources: Statistics Canada and U.S. Bureau of Economic Analysis.

Table 9
Relative ICT Investment*/Employment Ratio in Canadian Industries, 1997
(Average=1.00)**

Industry	Relative ICT Investment/Employment
Primary industries	0.1
Manufacturing	0.4
Construction	0.1
Transportations	0.5
Communications and other utilities	10.7
Wholesale	0.7
Retail	0.2
Finance, insurance and real estate	2.0
Business services	1.2

* Excluding software.

** Business sector excluding service industries not included in the table.

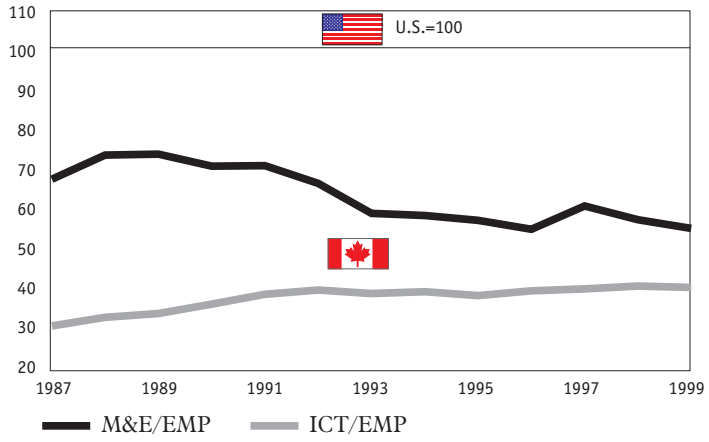
Source: Statistics Canada.

Canadian Experience

The acceleration in ICT investment contributed to a large increase in the aggregate ratio of M&E investment to employment in the latter half of the 1990s. It increased at 9.3 per cent per year, compared to a meagre 0.7 per cent in the first half of the 1990s. Like ICT investment, M&E investment intensity increased in the second half of the 1990s at a considerably faster pace in service-producing industries than in goods-producing industries. During the 1995-99 period the M&E investment intensity of the aggregate manufacturing sector actually declined while that of the communications industry increased by 23 per cent per year (Table 10).

The key question is: did the increase in ICT and M&E investment intensities translate into superior productivity performance in the latter half of the 1990s? As expected, labour productivity in service industries increased at a considerably faster pace in the second half of the 1990s compared to the first half — productivity growth averaged 1.5 per cent per year during the 1995-99 period, compared to only 0.8 per cent per year during the 1989-95 period (Table 2).

Chart 6
Canada-U.S. Investment Intensity Gaps in the Business Sector



Notes: U.S. Investment is converted into Canadian dollars using the machinery and equipment PPP.

Source: Statistics Canada and U.S. Bureau of Economic Analysis.

Furthermore, in wholesale and retail trade industries, labour productivity growth in the second half of the 1990s increased by over 3 per cent per year, compared to only 1.3 per cent in the manufacturing sector. Similarly, the communications sector, with the largest increase in ICT and M&E intensities, registered robust productivity growth of 7.6 per cent per year over the period.

Canada-U.S. Comparisons

In this sub-section, we will compare and contrast the investment and productivity performance of ICT-using industries in Canada with those of the United States. In the 1990s, aggregate ICT investment intensity increased at a significantly faster pace in Canada than in the United States (Chart 6). However, the opposite is true for M&E investment, especially in the first half of the 1990s. During the 1989-95 period, M&E investment intensity in Canada increased by a meagre 0.7 per cent per year, compared to 9.3 per cent in the United States. As a result, the aggregate M&E investment gap between Canada and the U.S. increased from 33 per cent in 1987 to 46 per cent in 1999. During the same period, the ICT investment gap declined from 71 per cent to 61 per cent (Chart 6). The ICT investment intensity increased by more than 20 per cent per year in all major U.S. industries during the second half of the 1990s, except in primary industries and communications and other utilities (Table 8).

Stronger ICT and M&E investment, as expected, resulted in superior productivity performance in the United States in manufacturing and service industries. For instance, in the first half of the 1990s, productivity growth in service industries in the two countries increased by a mere 0.9 per cent per year, but in the second half, service sector productivity increased by 2.3 per cent per year in the United States, compared to only 1.5 per cent in Canada (Table 2). Most major service industries registered a productivity growth of over 2 per cent per year in the United States.

The productivity growth gap was even larger in the manufacturing sector in the second half of the 1990s: in Canada, labour productivity growth averaged only 1.3 per cent per year while in the United States it averaged a healthy 4.3 per cent. However, as mentioned in section four, almost all of the widening of the Canada-U.S. labour productivity gap in manufacturing was due to the huge productivity growth gap in the ICT producing industries, represented here by the two machinery industries: electrical and electronic equipment and non electrical machinery. During the second half of the 1990s, labour productivity in the U.S. electrical and electronic equipment industry increased at an annual rate of 20.4 per cent, almost two and a half times faster than in Canada. Similarly, in the U.S. non-electrical machinery industry, labour productivity increased by 14.1 per cent per year, while in Canada it declined by 2.6 per cent per year (Table 2).

In short, ICT and M&E investment intensities increased dramatically in service industries in both countries, resulting in increased productivity growth. But, the pickup in ICT and M&E invest-

Table 10
M&E Investment*/Employment in Canadian and U.S. Industries
(average annual per cent rate of change)

Industry	Canada		United States	
	1989-95	1995-99	1989-95	1995-99
Primary industries	1.8	1.6	4.7	2.8
Construction	3.5	2.6	3.5	7.7
Manufacturing	-1.6	-2.7	4.9	12.2
Transportation & Warehousing	6.8	11.5	8.1	13.4
Communications	1.4	23.0	6.8	11.2
Utilities	-7.1	-1.4	0.7	2.6
Wholesale trade	11.7	5.5	12.2	13.4
Retail trade	6.7	12.2	3.4	15.1
FIRE	-2.4	18.2	3.5	16.7

* Excluding software.

Sources: Statistics Canada and U.S. Bureau of Economic Analysis.

ment intensities as well as productivity was significantly larger in the United States. However, the productivity growth deficit in service industries was offset somewhat by superior Canadian productivity performance in primary industries.

Conclusion

The main objective of this article has been to examine the contribution of ICTs to labour productivity growth in Canada in the 1990s and compare Canada's experience with the U.S. record. Our analysis leads to three main conclusions:

- the ICT-producing sector in Canada registered strong growth in output, employment and productivity in the 1990s, especially in the second half of the decade. It accounted for almost one quarter of aggregate labour productivity growth in the latter half of the 1990s;
- the contribution of ICT manufacturing industries to Canadian aggregate labour productivity growth during this period was less than half that in the United States. More importantly, the large differences in the size and productivity growth of ICT manufacturing between the two countries accounted for all of the widening of the manufacturing and economy-wide labour productivity level gaps between Canada and the United States; and
- in both countries, ICT and M&E investment per worker increased at a significantly faster pace in service industries in the latter half of the 1990s. Increased investments translated into higher productivity growth in these industries in the two countries. But, once again, the investment and productivity gains were significantly better in the United States than in Canada. Fortunately, Canada's superior productivity performance in primary industries offset somewhat the weaker productivity growth in other sectors.

What are the implications of our findings for Canada's labour productivity growth and for the Canada-U.S. labour productivity gap in the short to medium-term? We think that, on balance, the medium-term outlook for Canada's productivity growth and the Canada-U.S. productivity gap is not very promising. This is due to the dramatic economic slowdown in the ICT-producing sector in the United States, Canada and other OECD countries and the negative impact of the current economic slowdown on ICT and M&E

investment in both ICT-producing and ICT-using industries in Canada and other OECD countries.

In view of the sharp slowdown in economic activity and considerable excess capacity in ICT-producing industries, the contribution from this sector to Canada's aggregate labour productivity growth in the short term is expected to be quite modest. What about over the next five years? In our view, even in the optimistic scenario, the contribution would be similar in magnitude to that experienced during the second half of the 1990s. Given the persistence of a relative size advantage by the United States, even if Canada's ICT-producing industries experience as strong productivity growth as their U.S. counterparts, this source would likely contribute to the widening of the Canada-U.S. labour productivity level gap in the short-to-medium term.

What about productivity growth in ICT-using industries? Primary industries in Canada will likely continue to register healthy productivity growth. Given the strong growth in ICT and M&E investment intensities in the second half of the 1990s, Canadian service industries should also enjoy reasonable productivity growth over the next five years, at least as good as in the last five years. But the current economic slowdown and its negative impact on capacity utilization and M&E investment could adversely impact labour productivity growth in these industries. For instance, ICT and M&E investment in the United States declined in the first two quarters of 2001 at annual rates of 17 per cent and 10 per cent respectively. In Canada, the decline was modest, but could well accelerate in the second half of the year. In view of weak economic growth and investment performance and low capacity utilization, labour productivity growth in service industries could average only around 1 per cent per year over the course of the first half of this decade. For the same reasons, productivity growth in non-ICT manufacturing industries is also expected to be modest.

The United States is likely to continue to enjoy a productivity growth advantage in service industries. But we expect this advantage to be offset by Canada's superior productivity performance in primary industries, as in the second half of the 1990s. On balance, it would not be surprising to see the economy-wide Canada-U.S. labour productivity gap widen somewhat during the next five years because the relatively smaller contribution to aggregate productivity growth from ICT-producing industries would imply further widening of the manufacturing productivity gap. Unless there is a strong revival in service sector productivity in Canada or a remarkable productivity perfomanace in primary industries, the Canada-U.S. productivity level gap is likely to widen further over the coming years.

In sum, Canada's labour productivity growth is expected to remain modest in the first half of this decade, averaging perhaps 1.5 per cent per year. The economy-wide Canada-U.S. aggregate labour productivity gap could widen further during this period, but at a significantly slower pace than during the past five years. This sober medium-term perspective strongly suggests that closing the innovation and investment gaps, and improving the dynamism and flexibility of the Canadian economy are all key to raising Canada's productivity growth and our standard of living (Conference Board of Canada (2000); Rao et al. (2001)).

Notes

* The views expressed here are those of the authors only and do not represent either Industry Canada or the Government of Canada. We are thankful to Andrew Sharpe for many useful comments and suggestions. We are grateful to Renée St-Jacques for her encouragement and suggestions. The recently launched joint research project between Dale Jorgenson of Harvard University, Industry Canada and Statistics Canada will develop more comparable sets of data on about 40 industries for Canada and the United States and undertake an in-depth analysis of the role of ICTs in economic growth in the two countries. Email: rao.someshwar@ic.gc.ca.

1 It should be noted that the changes introduced by Statistics Canada in May 2001 in the methodology used to construct the national accounts, in particular the treatment of software purchases as investment and not intermediate inputs, have boosted the average annual rate of growth of business sector output per hour 0.5 percentage points from 1.2 per cent to 1.7 per cent over the 1995-2000 period. Consequently, labour productivity growth in the second half of the 1990s in Canada was significantly stronger than originally believed.

2 Unlike the estimates for business sector productivity in Table 1, Statistics Canada has not yet incorporated the methodological change of treating software as part of investment into the productivity estimates by industry found in Table 2.

3 ICT manufacturing industries include computer, office machine, communication equipment, instruments, consumer electronics, and communications, energy wire and cable industries. However, in this study we exclude instruments due to data constraints. ICT services-producing industries include computer and related services, cable television, telecommunication carriers, and other telecommunication industries. Due to data constraints, cable television is replaced by a broader sector: telecommunication-broadcasting industries.

4 It should be noted that constant price labour productivity levels are very sensitive to both the base year and the use of hedonic techniques for quality adjustment. For example, the massive price declines in the computer sector based on these hedonic techniques resulted in very large increases in the real output of the sector and very high constant price productivity levels even though competitive forces keep the current price productivity level of the sector in line with those of other sectors. When the constant price output series are rebased, the constant price productivity levels in sectors with above average productivity gains fall towards their current price productivity levels and of course are identical in the new base year. Because of this situation, some productivity analysts believe labour productivity levels are most appropriately measured in terms of current prices.

5 For the purpose of calculating the contribution to a sector's output to total output, we use the identity: $Y_t = Y_{i,t} + Others_t$, where Y_t and $Y_{i,t}$ respectively denotes the sum of industry GDP by industry and ICT GDP in constant dollars. The sum of GDP by industry will not equal the official aggregate GDP since estimates of GDP by industry in constant dollars are not additive when based on the Fisher Chain Index.

For any given period from t to t+1, the contribution of a sector to GDP growth, θ, is calculated as following:

where S^Y is the GDP share of ICT and G^Y is the output growth rate.

$$\theta = \frac{\frac{Y_{i,t+1}-Y_{i,t}}{Y_t}}{\frac{Y_{t+1}-Y_t}{Y_t}} = \frac{\frac{Y_{i,t}}{Y_t}\frac{Y_{i,t+1}-Y_{i,t}}{Y_{i,t}}}{\frac{Y_{t+1}-Y_t}{Y_t}} = S^Y_{i,t}\frac{G^Y_i}{G^Y}$$

Thus, the contribution of a sector to total output growth over a period is calculated as the product of the sector's output share in the first year of the period and the sector's output growth rate, divided by the total economy output growth rate.

The calculation of a sector's contribution to productivity growth is more complex. Following the above GDP identity, the productivity contribution, δ, is defined as:

where S^L is the employment share and P is the productivity level.

$$\delta = \frac{(Y_{i,t+1}/L_{t+1} - Y_{i,t}/L_t)/(Y_t/L_t)}{(Y_{t+1}/L_{t+1} - Y_t/L_t)/(Y_t/L_t)} = \frac{(S^L_{i,t+1}\,P_{i,t+1} - S^L_{i,t}\,P_{i,t})/P_t}{(P_{t+1} - P_t)/P_t}$$

Thus, the contribution of a sector to total labour productivity growth over a period depends not only on the relative productivity growth of this sector to total economy, but also on the change of employment share of that sector.

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