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# Long-term Productivity Growth in Canada and the United States

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## The Canadian Productivity Review

# Long-term Productivity Growth in Canada and the United States

1961 to 2006

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## Symbols

The following standard symbols are used in Statistics Canada publications:

| | |
|---|---|
| . | not available for any reference period |
| .. | not available for a specific reference period |
| ... | not applicable |
| 0 | true zero or a value rounded to zero |
| 0s | value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded |
| p | preliminary |
| r | revised |
| x | suppressed to meet the confidentiality requirements of the *Statistics Act* |
| E | use with caution |
| F | too unreliable to be published |

## The Canadian Productivity Review

**The Canadian Productivity Review** is a series of applied studies that address issues involving the measurement, explanation, and improvement of productivity. Themes covered in the review include, but are not limited to, economic performance, capital formation, labour, prices, environment, trade, and efficiency at both national and provincial levels. The Review publishes empirical research, at different levels of aggregation, based on growth accounting, econometrics, index numbers and mathematical programming. The empirical research illustrates the application of theory and techniques to relevant public policy issues.

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The level of uncertainty will depend on several factors: the nature of the functional form used in the multivariate analysis; the type of econometric technique employed; the appropriateness of the statistical assumptions embedded in the model or technique; the comprehensiveness of the variables included in the analysis; and the accuracy of the data that are utilized. The peer group review process is meant to ensure that the papers in the series have followed accepted standards to minimize problems in each of these areas.

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# Abstract

This paper compares long-run growth in labour productivity in Canada and the United States from 1961 to 2006. Over the entire period labour productivity in both countries grew at about the same rate. But Canadian growth exceeded that of the United States up to the early 1980s. Since then, U.S. labour productivity growth has exceeded Canadian growth. The gap has widened, particularly after 2000. The paper also decomposes labour productivity growth into three components—that arising from increases in capital intensity, from increases in the skill level of the labour force (due to changes in labour composition) and a residual (multifactor productivity growth). The first two components (both arising from investment, one in machinery and structures, the other in training) were more important in Canada. The third (the residual often referred to as technological progress) was larger in the United States.

**Keywords:** productivity, investment, technological progress, skill upgrading

# Analysis

## Introduction

Productivity statistics are often used to compare performance across countries. Interest in productivity growth often focuses not just on how well Canada is doing, but whether it is gaining on or falling behind its major trading partners. Intercountry differences are useful in understanding the reasons for differences in the standard of living, the competitiveness of national industries and the causes of trends in the exchange rate. In this paper, we examine the evidence on the course of labour productivity growth in the Canadian business sector comparing it with that of our major trading partner—the United States.

Baldwin, Harchaoui and Maynard (2001) provided a comparison of long-term productivity growth between the Canadian and the U.S. business sectors over the period from 1961 to 1997.[1] The paper noted that international comparisons of productivity growth are invariably somewhat imprecise because of differences in methodology used in different countries. Inputs and outputs are not always measured in the same way. For example, labour can be measured as the number of jobs, the number of people employed or the number of hours worked. Adjustments to any of these three can be made to handle changes in the 'quality' of workers. Capital can be measured as gross or net of depreciation.

The first objective of this paper is to update earlier results that examined Canada–United States productivity growth differences (Baldwin, Harchaoui and Maynard 2001). A substantial productivity growth gap has opened up in the post-2000 period (Statistics Canada 2007a). Second, we examine the contribution that investment, skill upgrading and technological progress make to aggregate labour productivity growth in the two countries. The difference in the economic structures in the two countries suggests that there might be differences in the sources of labour productivity growth in the two countries. Third, we assess the roles that investment in equipment and structures, investment in human capital and technological progress play in accounting for differences in Canada–United States labour productivity growth.

The Canadian and U.S. statistical agencies have adopted a number of changes in the official productivity measures since the paper by Baldwin, Harchaoui and Maynard (2001). Those changes have made the productivity statistics in the two countries more comparable. First, both Statistics Canada and the U.S. Bureau of Labor Statistics (BLS) have capitalized software expenditures (Jackson 2002). Second, both Statistics Canada and BLS have adopted chain indices in the productivity accounts. Third, Statistics Canada has adopted capital input and labour input measures that account for the compositional changes in capital stock (long- versus short-lived assets) and hours worked (more- versus less-educated workers).[2]

There are still a number of differences in the measures in the two countries. First, Canada uses gross domestic product (GDP) at basic prices to measure productivity while the BLS uses GDP at market prices. This creates a bias favourable to U.S. productivity growth as GDP at market prices tends to grow faster than GDP at basic prices. The results for the Canadian business sector show that real GDP at market prices grew 0.1 percentage point faster than GDP at basic prices from 1961 to 2002. Second, real GDP for the U.S. business sector is constructed from the final demand side of the national accounts, and real GDP for the Canadian business sector is constructed from the production side of the National Accounts. The discrepancy in the final-demand and production-side measures of GDP growth in the U.S. business sector has become larger in recent years (Fraumeni et al. 2006, Triplett and Bosworth 2004), which gives a slight upward bias to U.S. estimates compared with Canadian estimates. Third, the labour input measure is not perfectly comparable. While labour input in Canada and the United States takes into

1. *A large number of studies have compared the long-term growth difference between Canada and the United States (Jorgenson and Lee 2001, Crawford 2002, Faruqui et al. 2003).*
2. *For discussions on the methods for estimating labour input and capital input, see Statistics Canada (2002).*

account the difference in education and experience, the labour input measure in the United States also accounts for the difference between male and female workers that is not attributable to the measurable differences in the labour force characteristics.

Comparisons of productivity growth are best made over long time periods. Year-to-year growth rates are often severely affected by economic cycles and do not provide a very good measure of long-term movements in relative efficiency. For this reason, most of the paper focuses on long-run differences.

## The data

Our analysis covers the period from 1961 to 2006, with an emphasis on 2000 to 2006, when a large productivity growth difference emerged favouring the United States. The focus of our analysis is on the growth of labour productivity, defined as output per hour worked, and its three main contributors: capital deepening, labour compositional changes and multifactor productivity (MFP) growth. MFP growth captures the effects of various factors such as technological progress, returns to scale and organizational changes.

### Canadian data

Productivity data for Canada are from the Canadian Productivity Accounts of Statistics Canada (Baldwin and Harchaoui 2006). The real gross domestic product (GDP) data in the business sector are estimated from a Fisher chain index up to the most current year for which the input–output tables are available (currently 2003). For the post-reference years, the real GDP in the business sector is based on a measure of real GDP at basic prices published by the Industry Accounts Division at Statistics Canada.

Hours worked represents the total number of hours that a person devotes to work, whether paid or unpaid. Labour input is hours worked multiplied by a labour composition index. The number of hours worked is calculated as the product of the number of jobs times average hours worked, which are derived from household and establishment surveys. The labour composition index estimates the effect of shifts in the experience, education and the class of workers on the total amount of labour services provided by total hours worked (Statistics Canada 2002).

Capital services input is an estimate of the service flows derived from the stock of capital assets. The capital services measure is based on the bottom-up approach. This approach involves three steps. These are the estimation of capital stock, the aggregation of capital stock of various asset types within each industry to estimate industry capital services, and the aggregation of capital services across industries to derive capital services in the business sector (Baldwin and Gu 2007).

### U.S. data

Productivity data for the United States are from the U.S. Bureau of Labor Statistics (BLS). The BLS publishes MFP and related variables for the private business and private non-farm business sectors. For the purpose of this paper, we will focus on the productivity performance of the U.S. private business sector and compare it with the Canadian business sector.[3] The methods for constructing MFP in the U.S. private business sector are documented in BLS (1983, 1997).

BLS publishes the MFP measures for the private business sector over the period from 1987 to 2006 that are developed from data based on the 1997 North American Industry Classification System (NAICS). It also publishes the MFP measures for the period from 1948 to 2002 that are developed from data based on the 1987 Standard Industry Classification (SIC). The two measures are not perfectly comparable, as the business sector MFP measure is aggregated from industry detail data that are largely unavailable on a NAICS basis before 1987. For this paper, the MFP measures for the U.S. business sector from 1961 to 2006 are obtained by linking the SIC-based measure over the period from 1961 to 1987 and the NAICS-based measure, from 1987 to 2006.

3. *In the remainder of the paper, we will refer to the U.S. private business sector as the U.S. business sector.*

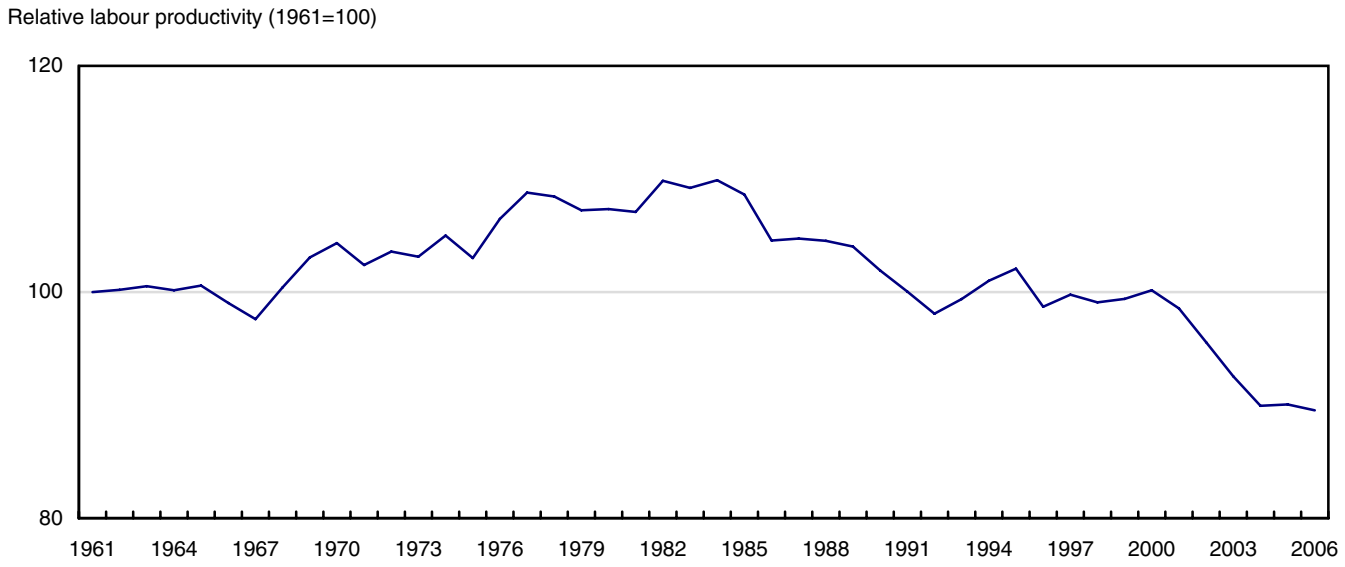
## Canada–United States relative labour productivity growth in the business sector

Chart 1 shows the relative Canada–United States business sector labour productivity levels for the period from 1961 to 2006. It shows the productivity index for the Canadian business sector divided by productivity index in the United States (1961=100 for both countries). A reading above 100 implies that the relative Canada–United States productivity level is above the relative level in the base period (1961). A decrease in the relative index implies that productivity growth in Canada has been slower than productivity growth in the U.S. business sector.

Chart 2 shows the Canada–United States business sector labour productivity growth difference for the period from 1961 to 2006. It shows both actual and Hodrick–Prescott-filtered differences in the two countries. A reading above zero indicates that aggregate labour productivity growth in Canada is higher than that in the United States. A reading below zero implies that the aggregate labour productivity growth in Canada was lower than in the United States.

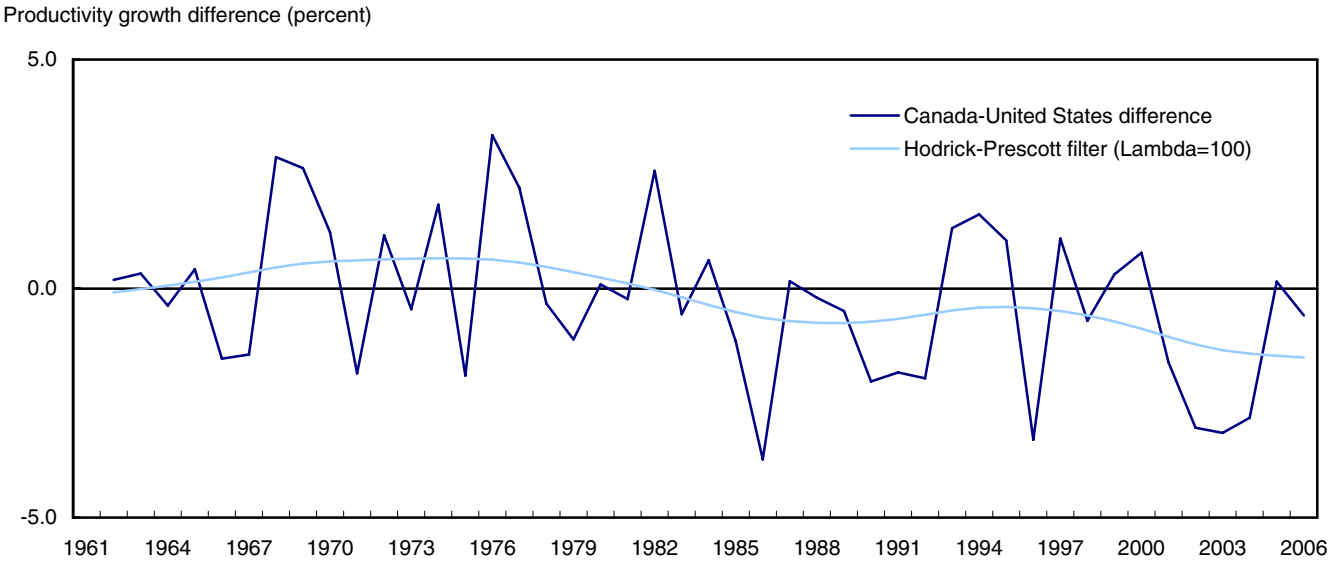
From charts 1 and 2, two distinct time periods can be identified: from 1961 to 1980, productivity growth in the Canadian business sector was higher than that in the United States; while after 1980, the United States has outperformed Canada. The labour productivity growth gap favourable to the United States was getting larger in the 2000s. The result is that by 2006, the Canada–United States productivity-level gap expanded by 10 percentage points relative to its value in 1961.

**Chart 1**
**Relative Canada–United States labour productivity level in the business sector, 1961 to 2006**




**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

**Chart 2**
**Canada–United States labour productivity growth difference in the business sector**




**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

Our finding on relative Canada–United States labour productivity growth is consistent with that of Baldwin, Harchaoui and Maynard (2001). In 2001, the GDP data for the United States was revised to reflect the capitalization of software expenditures, but the GDP data for Canada was not. Using the data that were published around 2000, they find that the Canada–United States productivity level gap in 1997 expanded, leaving Canada behind by about 10 percentage points relative to 1961.

As part of the 2001 revision of the Canadian System of National Accounts, business purchases and government expenditures for software, including own-account production of software are now recognized as investment instead of intermediate inputs. The value added estimates in this paper reflect the results of the recent revision. The recognition of business expenditures on software as investment turns out to have slightly positive effect on the growth rate of real value added for the business sector (Faruqui et al. 2003). After the revision to the Canadian and U.S. data, the Canada–United States productivity growth difference in the period from 1961 to 1997 is essentially zero.

Table 1 presents the growth in labour productivity, real gross domestic product (GDP) and hours worked in the Canadian and U.S. business sectors. From 1961 to 2006, aggregate labour productivity increased at an annual rate of 2.1% in Canada and at 2.3% in the United States. The slower labour productivity growth in Canada relative to the United States reflects the slightly higher real GDP growth and much higher growth in hours worked in Canada.

**Table 1**
**Growth in real gross domestic product, hours worked and labour productivity in the Canadian and the U.S. business sectors**

| | 1961 to 2006 | 1961 to 1980 | 1980 to 1996 | 1996 to 2006 |
|---|---|---|---|---|
| | annual rate (percent) | | | |
| **Labour productivity growth** | | | | |
| Canada | 2.1 | 2.9 | 1.3 | 1.8 |
| United States | 2.3 | 2.5 | 1.8 | 2.8 |
| Canada minus United States | -0.2 | 0.4 | -0.5 | -1.0 |
| **Real gross domestic product growth** | | | | |
| Canada | 3.8 | 4.9 | 2.5 | 3.8 |
| United States | 3.7 | 4.0 | 3.4 | 3.6 |
| Canada minus United States | 0.1 | 0.9 | -0.8 | 0.2 |
| **Hours worked** | | | | |
| Canada | 1.7 | 2.1 | 1.3 | 2.0 |
| United States | 1.4 | 1.5 | 1.6 | 0.8 |
| Canada minus United States | 0.4 | 0.5 | -0.3 | 1.1 |

**Note(s):** Figures may not sum due to rounding.
**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

From 1961 to 1980, labour productivity growth in Canada was higher than in the United States. As a result, the labour productivity level in Canada, relative to that in the United States, increased by 7 percentage points from 1961 to 1980. The faster labour productivity growth in Canada over this period reflects the faster hours growth and even faster real GDP growth in Canada at that time.

From 1980 to 1996, the aggregate labour productivity growth declined in both Canada and the United States. But the deceleration was much faster in Canada than in the United States. As a result, annual labour productivity growth in Canada was 0.5 percentage point lower than in the United States. The slower labour productivity growth in Canada from 1980 to 1996 is a result of slower hours growth and much slower output growth in Canada.

From 1996 to 2006, the business sector labour productivity growth increased for both Canada and the United States.[4] The acceleration in labour productivity growth was slower in Canada. The annual labour productivity growth in Canada increased by 0.5 percentage point between the periods from 1980 to 1996 and 1996 to 2006. The annual labour productivity growth in the United States increased by 1.0 percentage point between these two periods.

The business sector labour productivity growth in Canada was 1.0 percentage point lower than in the United States over the period from 1996 to 2006. The slower labour productivity growth in Canada reflects the slightly higher output growth and much higher hours growth in Canada.

## Decomposing aggregate labour productivity growth

In this section, we use standard growth accounting techniques to examine the sources of aggregate labour productivity growth. The labour productivity growth can be decomposed into contributions from capital deepening, labour compositional changes and multifactor productivity (MFP) growth. The contribution of capital deepening is defined as the product of nominal output share of capital and the growth rate of capital services per hour worked. The contribution of labour compositional changes is the product of the nominal output share of labour and changes in labour composition. It captures the effect of investment in worker skills and human capital on labour productivity growth.

The sources of labour productivity growth can be expressed algebraically as:

4. *The sources of this labour productivity growth acceleration have been well documented (Harchaoui and Tarkhani 2004; Jorgenson, Ho and Stiroh 2005).*

$$\textbf{(1)} \qquad \Delta \ln\left(\frac{Y_t}{H_t}\right) = \overline{s}_{Kt}\Delta \ln\left(\frac{K_t}{H_t}\right) + \overline{s}_{Lt}\Delta \ln\left(\frac{L_t}{H_t}\right) + \Delta \ln(MFP_t)$$

where $\Delta$ denotes the change between periods *t*-1 and *t*. *Y* denotes real gross domestic product (GDP), *K* capital services, *H* hours worked, *L* labour services and *MFP* multifactor productivity, $\overline{s}_{Kt}$ is the average share of capital services in nominal GDP in periods *t* and *t*-1, $\overline{s}_{Lt}$ is the average share of labour input in nominal GDP in periods *t* and *t*-1. (For details on the growth accounting, see Jorgenson, Ho and Stiroh 2005; Baldwin and Gu 2007).

Equation (1) shows the three main sources of labour productivity growth. The first term on the right-hand side is the contribution of capital deepening, whereby more capital services make workers more productive. The second term is the contribution of labour compositional changes. The third term is MFP growth, which increases labour productivity growth on a point-for-point basis.

Table 2 presents the decomposition results for Canada. Investment and capital deepening are the dominant source of labour productivity growth in the Canadian business sector over the last four decades. The increase in worker skills and MFP growth are also important contributors to the labour productivity growth. From 1961 to 2006, labour productivity grew at an annual rate of 2.1% in the Canadian business sector. Of the 2.1% growth, 1.2 percentage points can be attributed to the contribution of capital deepening, 0.4 percentage point to the contribution of changes in labour composition and 0.4 percentage point to increases in MFP growth.

**Table 2**
**Sources of business sector productivity growth, Canada**

| | 1961 to 2006 | 1961 to 1980 | 1980 to 1996 | 1996 to 2006 |
|---|---|---|---|---|
| | annual rate (percent) | | | |
| Output per hour worked | 2.1 | 2.9 | 1.3 | 1.8 |
| Contribution of capital deepening | 1.2 | 1.6 | 0.9 | 0.9 |
| Contribution of labour composition | 0.4 | 0.5 | 0.4 | 0.4 |
| Multifactor productivity growth | 0.4 | 0.7 | 0.0 | 0.6 |

**Note(s):** Figures may not sum due to rounding.
**Source(s):** Statistics Canada, Canadian Productivity Accounts.

Labour productivity growth was highest from 1961 to 1980. Over that period, output per hour grew at annual rate of 2.9%. Of the 2.9% growth in the business sector labour productivity, 1.6 percentage points can be attributed to the contribution of capital deepening, 0.5 percentage point to the contribution of labour composition and 0.7 percentage point to increases in MFP growth.

From 1980 to 1996, aggregate labour productivity growth declined to 1.3% per year. The source of this decline has been the subject of numerous studies. Those studies ascribe the slowdown to a decline in the rate of capital accumulation and a decline in MFP growth associated with a reduction in the benefits from increasing returns to scale, and lack of technological progress in mature industries.

Our results confirm the findings from previous studies. The decline in the aggregate labour productivity growth from 1980 to 1996 is a result of a decline in the contribution of capital deepening and a decline in MFP growth. The decline in MFP growth associated with the slow rate of technological progress is the most important contributor to slower labour productivity growth.

After the mid-1990s, labour productivity growth accelerated in the Canadian business sector. From 1996 to 2006, output per hour grew at annual rate of 1.8%. Of the 1.8% growth in business-sector labour productivity, 0.9 percentage point can be attributed to the contribution of capital deepening, 0.4 percentage point to the contribution of labour composition and 0.6 percentage point to increases in MFP growth.

The productivity growth acceleration after the mid-1990s has been well documented in previous studies (Harchaoui and Tarkhani 2004; Ho, Rao and Tang 2004; Department of Finance 2005; Macklem 2003). Our results show that the labour productivity growth acceleration is due to the increase in MFP growth in Canada. A number of recent studies at the industry level for Canada suggest that the pickup in MFP growth is related to rapid technological process and organizational changes in the industries that have invested in information and communication technologies (Gu and Wang 2004; Harchaoui and Tarkhani 2004; Ho, Rao and Tang 2004)

A similar decomposition of U.S. aggregate productivity growth is presented in table 3. The trend in labour productivity growth in the U.S. business sector is similar to that in Canada. There was rapid labour productivity growth in the U.S. business sector over the period from 1961 to 1980, followed by slower labour productivity growth from 1980 to 1996 and a recent pickup after 1996.

**Table 3**
**Sources of business sector productivity growth, United States**

| | 1961 to 2006 | 1961 to 1980 | 1980 to 1996 | 1996 to 2006 |
|---|---|---|---|---|
| | annual rate (percent) | | | |
| Output per hour worked | 2.3 | 2.5 | 1.8 | 2.8 |
| Contribution of capital deepening | 0.8 | 0.9 | 0.7 | 1.0 |
| Contribution of labour composition | 0.2 | 0.1 | 0.4 | 0.3 |
| Multifactor productivity growth | 1.2 | 1.5 | 0.7 | 1.5 |

**Note(s):** Figures may not sum due to rounding.
**Source(s):** Bureau of Labor Statistics.

From 1961 to 2006, output per hour grew at an annual rate of 2.3% in the U.S. business sector. MFP growth is the most important source of labour productivity growth in the U.S. business sector. MFP growth was 1.2% per year over this period, which accounted for 53% of the business sector productivity growth in the United States. Capital deepening is the second most important source of the aggregate labour productivity growth in the United States. It contributed 0.8 percentage point or 36% of the U.S. business sector labour productivity growth from 1961 to 2006. The contribution of labour composition was 0.2 percentage point over the period.

There are a number of differences in the sources of aggregate labour productivity growth in Canada and the United States over the 1961-to-2006 period.

1. The most important source of labour productivity growth is capital deepening in the Canadian business sector, whereas in the U.S. business sector the most important source is MFP growth associated with technological progress. From 1961 to 2006, more than half of the business sector labour productivity growth in Canada can be attributed to capital deepening. In the United States more than half of the business sector labour productivity growth comes from MFP growth.

2. The contribution of capital deepening to labour productivity growth is higher in Canada than in the United States from 1961 to 2006. Capital deepening contributed 1.2 percentage points per year to labour productivity growth in Canada and it contributed 0.8 percentage point per year in the United States. The difference was largest in the 1961-to-1980 period. During that period, the contribution of capital deepening to annual labour productivity growth was 0.7 percentage point higher in Canada than in the United States.

3. MFP growth was lower in the Canadian business sector than in the U.S. business sector. From 1961 to 2006, aggregate MFP grew at an annual rate of 0.4% per year in the Canadian business sector while it grew at an annual rate of 1.2% per year in the U.S. business sector. The difference was largest in the 1980-to-1996 period.

4. The contribution of labour composition and worker skills to aggregate labour productivity growth was higher in Canada than in the United States. From 1961 to 2006, increases in worker skills and labour compositional changes contributed 0.4 percentage point per year to the business sector labour productivity growth in Canada. It contributed 0.2 percentage point per year to the business sector labour productivity growth in the United States.

The relatively larger contribution of labour compositional changes to aggregate labour productivity growth in Canada is not a result of the slight methodological difference in the construction of labour composition index in the two countries. The labour composition index in Canada does not reflect the gender composition of hours worked—because it is felt that gender wage differentials are more likely to reflect discrimination than real productivity differences. However, the labour composition index in the United States takes into account the effect of the shift in the gender composition of hours worked. The difference arising from different treatments of gender wage differences is not important for the comparisons made here. Jorgenson, Ho and Stiroh (2005) and Harchaoui and Tarkhani (2004) have used a similar methodology to construct a labour composition index for Canada and the United States and they find that the growth of the labour composition index was higher in Canada than in the United States.

## Decomposing the Canada–United States aggregate labour productivity growth gap

Using equation (1), the aggregate labour productivity growth gap between two countries *A* and *B* can be expressed as

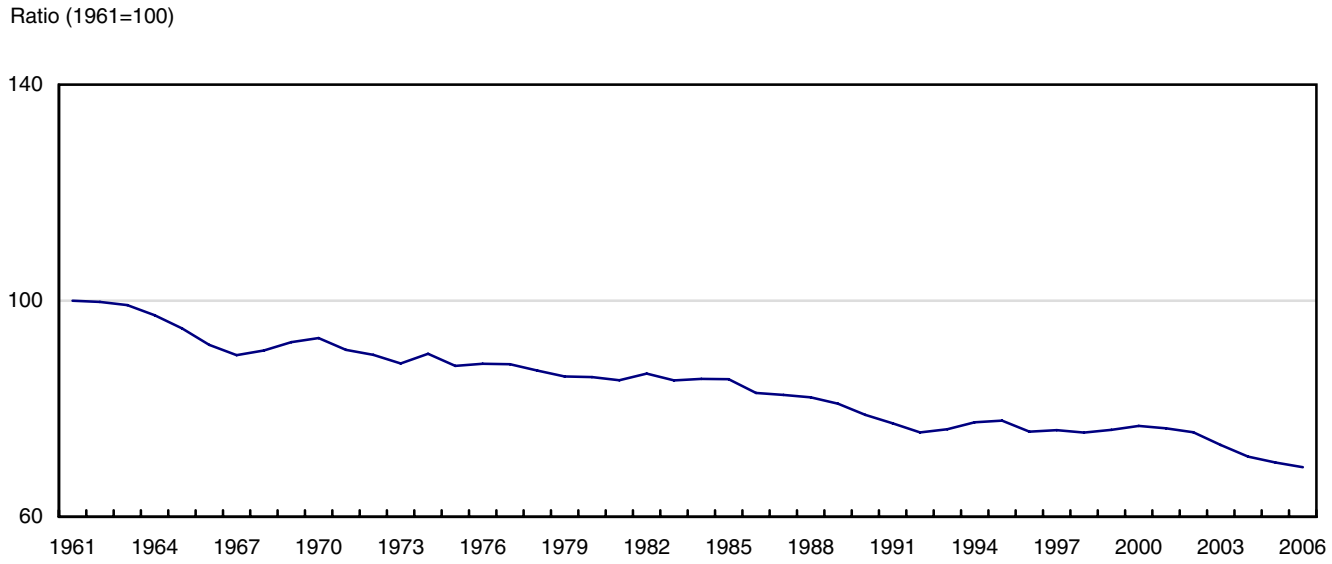
$$\Delta \ln\left(\frac{Y_t}{H_t}\right)^A - \Delta \ln\left(\frac{Y_t}{H_t}\right)^B = \left(\overline{s}_{Kt}^A \Delta \ln\left(\frac{K_t}{H_t}\right)^A - \overline{s}_{Kt}^B \Delta \ln\left(\frac{K_t}{H_t}\right)^B\right) + \left(\overline{s}_{Lt}^A \Delta \ln\left(\frac{L_t}{H_t}\right)^A - \overline{s}_{Lt}^B \Delta \ln\left(\frac{L_t}{H_t}\right)^B\right) + \left(\Delta \ln(MFP_t)^A - \Delta \ln(MFP_t)^B\right). \quad \textbf{(2)}$$

In equation (2), we decompose the aggregate productivity growth gap into three parts: an ‘investment’ gap, a ‘worker-skill’ gap and a ‘multifactor productivity (MFP) growth’ gap. The investment gap captures the differences in the contribution of capital deepening to labour productivity growth between the two countries. The worker-skill gap captures the difference in the contribution of labour composition to labour productivity growth across countries. The MFP-growth gap is the difference in MFP growth in the two countries.

Before presenting the decomposition results, we show in chart 3 the relative Canada–United States MFP level in the business sector and in chart 4 the relative Canada–United States capital intensity and labour composition index (in both cases 1961=100). Chart 5 shows the Hodrick–Prescott-filtered Canada–United States difference in the annual growth of MFP, capital intensity and labour composition index for the business sector.

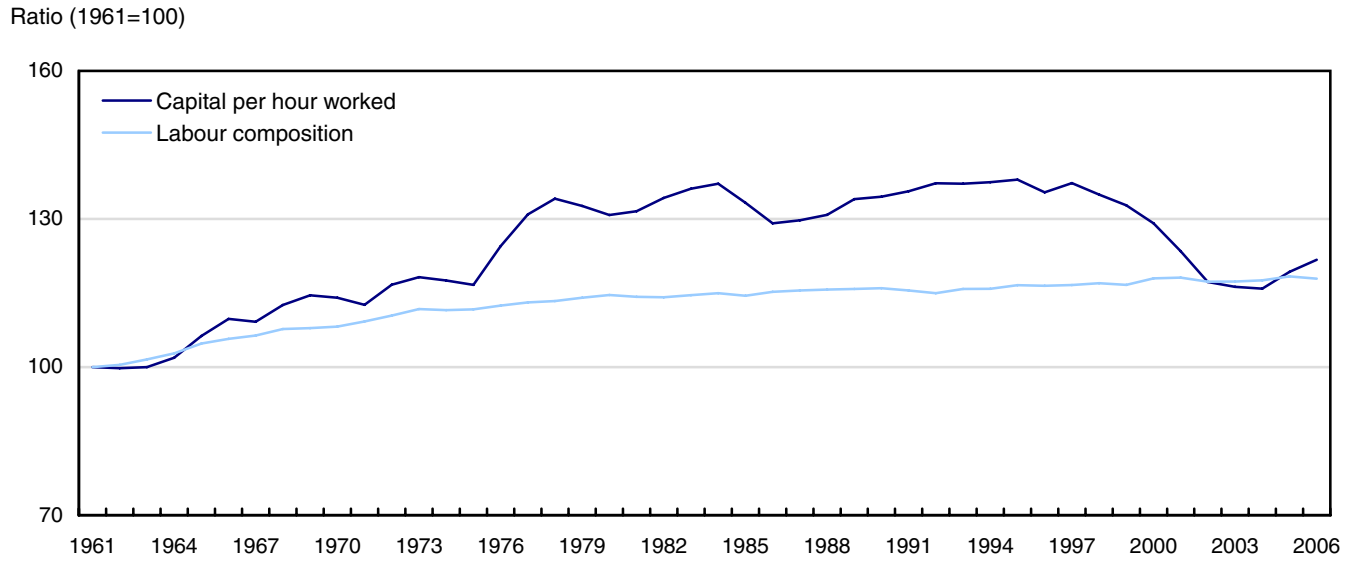
MFP growth was lower in the Canadian business sector than in the U.S. business sector over the last four decades. The result is that by 2006, the Canada–United States MFP-level gap expanded by 30 percentage points relative to its value in 1961.

**Chart 3**
**Relative Canada–United States multifactor productivity level in the business sector, 1961 to 2006**



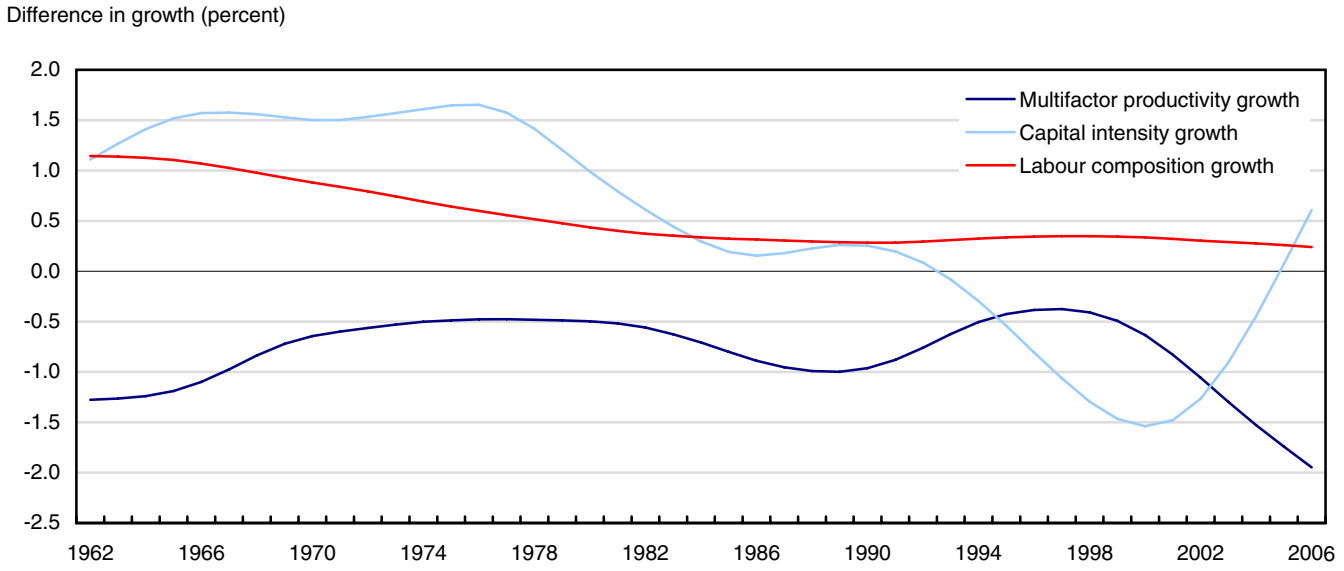

**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

**Chart 4**
**Relative Canada–United States capital intensity and labour composition in the business sector, 1961 to 2006**




**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

**Chart 5**
**Trend in Canada–United States difference in growth of multifactor productivity, capital intensity and labour composition**




**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

Capital intensity (defined as capital services per hour worked) increased faster in Canada than in the United States before the early 1990s. Capital intensity in Canada relative to that in the United States increased by 37 percentage points over the period from 1961 to 1992.

After the early 1990s, the relative capital intensity declined in the Canadian business sector. As a result, the cumulative advantage in Canadian capital intensity declined by about 16 percentage points over the period from 1992 to 2006.

The labour composition index increased faster in Canada than in the United States during the last four decades. In 2006, the Canada–United States labour composition level gap favourable to Canada had expanded by 18 percentage points relative to its value in 1961. The shift toward more educated and more experienced workers was more rapid in the Canadian business sector than in the U.S. business sector during the last four decades.

Chart 5 shows that the difference in MFP growth rates has been relatively constant until 2000. The Canadian advantage in capital deepening has fallen steadily since the mid-1970s and turned negative in the 1990s. The Canadian advantage in terms of labour composition fell steadily from 1961 to around 1985.

Chart 5 shows that the Canada–United States differences in MFP growth appear to be related to the differences in capital intensity growth over time. If MFP growth reflects technological progress and technology adoption, for example, it is likely that investment and more skilled workers will lead to high MFP growth. To examine this possibility, we have calculated the correlation matrix for the differences in annual MFP growth between Canada and the United States, differences in annual capital intensity growth, and differences in annual labour compositional changes. The results show that capital intensity growth and labour compositional changes are not correlated with MFP growth.

To further examine the potential effects of investment and skill upgrading on MFP growth, we have carried out Granger causality tests between capital intensity growth, labour compositional changes and MFP growth. The results show that skill upgrading is not related to MFP growth. In contrast, the differences in annual MFP growth in the two countries are related to the differences in capital intensity growth in the subsequent periods. But the differences in capital intensity growth are not related to subsequent differences in MFP growth. This may suggest

that MFP growth—often associated with factors such as disembodied technological process, organizational changes and scale economies—leads to increased investment in tangible assets in the subsequent period.

Table 4 presents the decomposition of Canada–United States business sector labour productivity growth gap, using equation (2). A number of findings emerge from the results:

1. The Canada–United States labour productivity growth gap in favour of the United States over the period from 1961 to 2006 is the result of the MFP growth gap. From 1961 to 2006, annual labour productivity growth in the Canadian business sector was 0.2 percentage point lower than that in the U.S. business sector. The annual MFP growth in Canada was 0.8 percentage point lower than in the United States. The slower MFP growth in the Canadian business sector was responsible for the slower labour productivity growth from 1961 to 2006.

2. There was no investment gap in Canada over the period from 1961 to 1996. The contribution of capital deepening to business sector productivity growth was higher in Canada than in the United States.

3. An investment gap opened up in Canada after 1996. From 1996 to 2006, the slower rate of capital contribution and the investment gap accounted for 0.1 percentage point or 10% of the Canada–United States aggregate labour productivity growth gap.[5]

4. There is no evidence of a growing skill gap in Canada over the period from 1961 to 2006. The contribution of labour composition to the business sector labour productivity growth was higher in Canada than in the United States from 1961 to 2006. Over this period, a more rapid shift toward more educated and more experienced workers occurred in Canada that raised the labour productivity growth by 0.2 percentage point per year in the Canadian business sector relative to that of the U.S. business sector.

**Table 4**
**Decomposition of the aggregate labour productivity growth gap (Canada minus United States)**

| | 1961 to 2006 | 1961 to 1980 | 1980 to 1996 | 1996 to 2006 |
|---|---|---|---|---|
| | annual rate (percent) | | | |
| Output per hour worked | -0.2 | 0.4 | -0.5 | -1.0 |
| Contribution of capital deepening | 0.4 | 0.7 | 0.2 | -0.1 |
| Contribution of labour composition | 0.2 | 0.4 | 0.0 | 0.0 |
| Multifactor productivity growth | -0.8 | -0.8 | -0.8 | -0.9 |

**Note(s):** Figures may not sum due to rounding.
**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

The slower labour productivity growth in the Canadian business sector over the period from 1996 to 2006 is a result of the slower labour productivity growth over the 2000-to-2006 period, as shown in table 5. Over the period from 1996 to 2000, the business sector labour productivity growth was higher in Canada. MFP growth was also higher in Canada over that period.

5. *The large Canada–United States capital intensity gap after the mid-1990s is documented in Rao, Tang and Wang (2003). Capital intensity in their paper is measured by capital stock per worker. In this paper, capital intensity is defined as capital services per hour worked. They find that the increase in the rental–wage ratio in Canada relative to that in the United States and the resulting decrease in the substitution of capital for labour in Canada were major factors behind the slower growth of capital intensity in Canada after the mid-1990s.*

**Table 5**
**Decomposition of aggregate labour productivity growth gap**

| | 1996 to 2006 | 1996 to 2000 | 2000 to 2006 |
|---|---|---|---|
| | percent | | |
| **Canada** | | | |
| Output per hour worked | 1.8 | 3.1 | 1.0 |
| Contribution of capital deepening | 0.9 | 1.1 | 0.8 |
| Contribution of labour composition | 0.4 | 0.4 | 0.3 |
| Multifactor productivity growth | 0.6 | 1.6 | -0.1 |
| **United States** | | | |
| Output per hour worked | 2.8 | 2.7 | 3.0 |
| Contribution of capital deepening | 1.0 | 1.2 | 0.9 |
| Contribution of labour composition | 0.3 | 0.3 | 0.4 |
| Multifactor productivity growth | 1.5 | 1.2 | 1.7 |
| **Canada minus United States** | | | |
| Output per hour worked | -1.0 | 0.4 | -1.9 |
| Contribution of capital deepening | -0.1 | -0.1 | -0.1 |
| Contribution of labour composition | 0.0 | 0.2 | -0.1 |
| Multifactor productivity growth | -0.9 | 0.3 | -1.8 |

**Note(s):** Figures may not sum due to rounding.
**Source(s):** Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

Over the 2000-to-2006 period, labour productivity growth in the Canadian business sector was much lower than that in the U.S. business sector. The Canada–United States labour productivity growth gap was 1.9 percentage points per year from 2000 to 2006 (Statistics Canada 2007a).

The main contributor to the Canada–United States labour productivity growth gap from 2000 to 2006 was the slower MFP growth in Canada. Our estimates show that slower relative MFP growth in Canada accounted for 1.8 percentage points or 92% of the Canada–United States labour productivity growth gap. The difference in changes in worker skills and capital intensity was not an important factor behind the labour productivity growth difference in the two countries.

A number of potential explanations have been put forward for the poor labour productivity growth in Canada after 2000 (Rao, Sharpe and Smith 2005; OECD 2006). All attempt to explain the fall in the multifactor residual. One explanation that has been offered is that profits in Canada have been at record highs while profits in the United States have been at near-record lows since 2000. With the record high profits, it is argued that businesses in Canada may become complacent regarding investments, workplace re-organizations and the introduction of new technologies. In contrast, the near-record low profits in the United States may have prompted employers to downsize employment levels to reduce costs. But both these explanations rely on some model that assumes effort is inversely proportional to organizational slack—and these models do not have widespread support. Second, it is sometimes argued that the boom in commodity prices that has occurred over the past several years may be a factor behind the poor productivity performance in Canada. The high commodity prices have stimulated the exploration and development of more costly deposits. In effect, lower grade deposits are mined as prices go up and the change in the composition of output thus detrimentally affects productivity. While no doubt partly true, it is difficult to ascribe the large fall in MFP to this factor alone. The third explanation has to do with exchange rate appreciation and a loss of export markets for manufacturers. The loss of scale economies may have forced plants back up the cost curve and reduced productivity. More work needs to be done at the industry level to examine the relative importance of these different arguments.

## Conclusion

Productivity growth in the economy is an important contributor to improvements in our standard of living. It is affected by small, incremental changes in a host of factors that occur on the plant floor and other parts of a firm. These include new production techniques, changes in plant size and changes in organization, as well as other factors that are associated with acquiring and creating new knowledge.

These changes are generally not cataclysmic. Even momentous changes involving new technologies take time to implement. The changes are relatively steady, when measured over long cycles. Since 1961, the annual growth rates of labour productivity have averaged very close to 2% per year in both Canada and the United States.

Over the 1961-to-2006 period, aggregate labour productivity increased at an annual rate of 2.1% in Canada and at 2.3% in the United States. These differences fall within the bounds arising from measurement differences and measurement error. The slightly lower labour productivity growth in Canada relative to that of the United States reflects similar real gross domestic product growth in the two countries and slightly faster growth in hours worked in Canada.

The sources of labour productivity growth are different in the two countries. The dominant source of labour productivity growth is investment in equipment and structures in Canada, whereas in the United States the dominant source of labour productivity growth is multifactor productivity (MFP) growth—often described as being associated with factors such as technological process and workplace re-organizations.

Canada did not suffer a gap in the growth of capital intensity over the early part of the 1961-to-1996 period. The contribution of capital deepening to business sector productivity growth was actually higher in Canada than in the United States. This served to reduce the gap in labour productivity growth between Canada and the United States.

It is, however, true that this changed later in the period. An investment gap opened up in Canada after 1996. Over the period from 1996 to 2006, the slower rate of capital contribution and the investment gap accounted for 0.1 percentage point or 10% of the Canada–United States aggregate labour productivity growth gap.

The decomposition does not show that Canada suffered from a slower upgrading of its workforce. The contribution of labour composition to business sector labour productivity growth was higher in Canada than in the United States from 1961 to 2006. The shift toward more educated and more experienced workers was more rapid in Canada during the last four decades.

The one gap between Canada and the United States that was noticeable was MFP growth. The annual MFP growth in Canada was 0.8 percentage point lower than in the United States over the 1961-to-2006 period. In 2006, the Canada–United States MFP level gap expanded by 30 percentage points relative to its value in 1961.

MFP growth comes from a host of factors—some are related to events on the plant floor that include new production techniques and changes in plant size; others relate more to activities at the firm level, such as changes in organization as well as other factors that are associated with creating new knowledge. But it is important to note that MFP is a residual. The fact that labour productivity was more or less the same in the two countries, but that the contribution of capital deepening and labour composition was higher in Canada, necessitates that the contribution from MFP was lower in Canada. The interesting question is whether these differences stem from differences in measurement or from a trade-off between capital deepening and multifactor productivity growth, which is related to structural differences in the two economies.

The recent poor labour productivity growth in Canada relative to that in the United States is mainly a result of slower MFP growth. Our estimates show that slower MFP growth in Canada accounted for 1.8 percentage points or 92% of the Canada–United States labour productivity growth gap over the period from 2000 to 2006. Understanding why multifactor productivity growth slowed requires more detailed industry analyses.

# Appendix I

## Bibliography


Baldwin, John R., Tarek M. Harchaoui and Jean-Pierre Maynard. 2001. "Productivity growth in Canada and the United States." *In Productivity Growth in Canada.* Catalogue no. 15-204-XIE1999000. Ottawa: Statistics Canada.

Baldwin, John R. and Tarek M. Harchaoui. 2006. "The integration of the Canadian Productivity Accounts within the System of National Accounts: Current status and challenges ahead." *In A New Architecture for the U.S. National Accounts.* 439–470. Dale W. Jorgenson, J. Steven Landefeld and William D. Nordhaus (eds.). Chicago: The University of Chicago Press.

Baldwin, John R., and Wulong Gu. 2007. *Investment and Long-term Productivity Growth in the Canadian Business Sector, 1961 to 2002.* Canadian Productivity Review. Catalogue no. 15-206-XIE2007006. Ottawa: Statistics Canada.

Bureau of Labor Statistics (BLS). 1983. *Trends in Multifactor Productivity, 1948–1981.* The BLS Bulletin 2178. Washington, D.C.: U.S. Department of Labor.

Bureau of Labor Statistics (BLS). 1997. *BLS Handbook of Methods.* Bulletin 2490. Washington, D.C.: U.S. Department of Labor.

Crawford, Allan. 2002. "Trends in productivity growth in Canada." Spring. 19–32. *Bank of Canada Review.* Ottawa: Bank of Canada.

Department of Finance. 2005. "Canada's Productivity Performance: An International Perspective." Presentation slides.

Faruqui, Umar, Wulong Gu, Mustapha Kaci, Mireille Laroche and Jean-Pierre Maynard. 2003. "Differences in productivity growth: Canadian-U.S. business sectors, 1987–2000."*Monthly Labor Review*. 126, 4: 16–29.

Fraumeni, Barbara M., Michael J. Harper, Susan G. Powers and Robert E. Yuskavage. 2006. "An integrated BEA/BLS production account: A first step and theoretical considerations." In *A New Architecture for the U.S. National Accounts*. 355–435. Dale W. Jorgenson, J. Steven Landefeld and William D. Nordhaus (eds.). Chicago: The University of Chicago Press.

Gu, Wulong, and Weimin Wang. 2004. "Information technology and productivity growth: Evidence from Canadian industries." In *Economic Growth in Canada and the United States in the Information Age.* Dale W. Jorgenson (ed.). Industry Canada Research Monograph. Ottawa: Industry Canada.

Harchaoui, Tarek M., Faouza Tarkhani, Chris Jackson and Philip Armstrong. 2002. "Information technology and economic growth in Canada and the U.S."*Monthly Labor Review.* 125, 10: 3–12.

Harchaoui, Tarek M., and Faouzi Tarkhani. 2004. *Whatever Happened to Canada-U.S. Economic Growth and Productivity Performance in the Information Age?* Economic Analysis (EA) Research Paper Series. Catalogue no. 11F0027MIE2004025. Ottawa: Statistics Canada.

Ho, Mun, Someshwar Rao and Jianmin Tang. 2004. "Sources of output growth in Canadian and U.S. industries in the Information Age." In *Economic Growth in Canada and the United States in the Information Age.* D.W. Jorgenson. (ed.). Industry Canada Research Monograph. Ottawa: Industry Canada.

Inklaar, Robert, Marcel P. Timmer and Bart van Ark. 2006. *Canada's Productivity in Goods Production and Services in International Comparative Perspective.* Working Paper 2007-01. Working Paper Series. Ottawa : Industry Canada.

Jackson, Chris. 2002. *Capitalization of Software in the National Accounts*. Income and Expenditure Accounts Technical Series. Catalogue no. 13-6042002037. Ottawa: Statistics Canada.

Jorgenson, Dale W., Mun S. Ho and Kevin J. Stiroh. 2005. *Productivity, Volume 3: Information Technology and the American Growth Resurgence.* Cambridge, Mass.: The MIT Press.

Jorgenson, Dale W., and Frank C. Lee (eds.). 2001. *Industry-level Productivity and International Competitiveness between Canada and the United States.* Industry Canada Research Monograph. Ottawa: Industry Canada.

Macklem, Tiff. 2003. "Future productivity growth in Canada: Comparing to the United States."*International Productivity Monitor*. 7: 50–58. Centre for the Study of Living Standards. Ottawa: Industry Canada.

Organisation for Economic Co-operation and Development (OECD). 2006. *OECD Economic Survey: Canada.* Vol. 2006, Issue 10. Paris: OECD Publishing.

Rao, Someshwar, Jianmin Tang and Weimin Wang. 2003. "Canada's recent productivity record and capital accumulation." *International Productivity Monitor*. 7: 24–38. Centre for the Study of Living Standards. Ottawa: Industry Canada.

Rao, Someshwar, Andrew Sharpe and Jeremy Smith. 2005. "An analysis of the labour productivity growth slowdown in Canada since 2000." *International Productivity Monitor*. 10: 3–23. Centre for the Study of Living Standards. Ottawa: Industry Canada.

Robidoux, Benoît, Frank C. Lee and Tony Fisher. 2006. "Where did Canada's Productivity Growth Go in the Early 2000s: An Industry Perspective?" Presentation at the 40th annual meeting of the Canadian Economics Association in May 2006. Concordia University, Montréal.

Statistics Canada. 2002. *Productivity Growth in Canada - 2002.* John R. Baldwin and Tarek M. Harchaoui (eds.). Catalogue no. 15-204-XIE2001000. Ottawa: Statistics Canada.

Statistics Canada. 2007a. "Labour productivity, hourly compensation and unit labour cost."*The Daily.* June 12, 2007. Catalogue no. 11-001-XIE. Ottawa: Statistics Canada.

Statistics Canada. 2007b. *Productivity Performance in Canada, 1961 to 2005.* The Canadian Productivity Review. Catalogue no. 15-206XIE. Ottawa: Statistics Canada. Forthcoming.

Triplett, Jack E., and Barry P. Bosworth. 2004. *Productivity in the U.S. Services Sector: New Sources of Economic Growth.* Washington, D.C.: Brookings Institution Press.