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The Canadian Productivity Review

Long-term Productivity Growth in Manufacturing in Canada and the United States, 1961 to 2003

by John R. Baldwin and Wulong Gu

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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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Abstract

In this paper, we provide an international comparison of the growth in Canadian and U.S. manufacturing industries over the 1961-to-2003 period. We find that average annual growth rates of labour productivity growth were almost identical in the Canadian and U.S. manufacturing sectors during this period. But the sources of labour productivity growth differed in the two countries. Intermediate input deepening was a more important source of labour productivity growth in Canada than in the United States, while investment in capital and multifactor productivity (MFP) growth were more important in the United States than in Canada. After 1996, labour productivity growth in Canada was lower than in the United States. The post-1996 slower labour productivity growth in Canada relative to the United States was due to slower growth in MFP and slower growth in capital intensity. The slower MFP growth in Canada accounted for 60% of the Canada–United States labour productivity growth difference, and slower growth in capital intensity accounted for 30%. The slower MFP growth in the Canadian manufacturing sector relative to that of the United States after 1996 was due to lower MFP growth in the computer and electronic products industry. The slower growth in the capital–labour ratio in the Canadian manufacturing compared with the United States after 1996 is related to the changes in relative prices of capital and labour inputs in the two countries.

Keywords: productivity, investment, technological progress

Executive summary

This paper provides a consistent international comparison of long-term productivity growth in manufacturing industries in Canada and the United States. While much comparative work has been done with respect to productivity growth in the manufacturing sector in the two countries in the past, this has often been on the basis of measures that are not comparable. Our approach here is to construct a measure of output growth for the Canadian manufacturing industries that is comparable to the U.S. measure used in the Bureau of Labor Statistics (BLS) productivity program.

In its system of official productivity measures for the United States, the BLS employs a measure of sectoral output that equals the value of gross output less the value of intra-sector sales and transfers. In contrast, Statistics Canada and most other statistical agencies employ a value-added concept of manufacturing output, defined as the value of gross output less the value of all intermediate purchases of goods and services.

To provide a consistent international comparison of long-term productivity growth in manufacturing industries in Canada and the United States, we have used a version of an industry productivity database for Canadian manufacturing industries that is quite comparable to the productivity database for the U.S. manufacturing industries from the BLS. In the database, output is defined as sectoral output, and labour productivity is the real sectoral output per hour worked. Labour input is measured by hours worked, which represents the total number of hours that a person devotes to work, whether paid or unpaid. Capital service input is an estimate of the service flows derived from the stock of capital assets; it is estimated from the aggregation of capital stock of various asset types within each industry, using the estimated user cost of capital as weight.

Several questions are posed in the paper.

1. What has been the history of labour productivity growth in the manufacturing sector in Canada and the United States during the 1961-to-2003 period?

From 1961 to 2003, aggregate labour productivity growth in the manufacturing sector was the same in the two countries. It increased at an annual rate of 3.2% in both countries.

The similar labour productivity growth in the two countries reflects faster growth in both output and hours worked in the Canadian manufacturing sector. The output of manufacturing grew faster in Canada than in the United States for the 1961-to-2003 period: 3.9% per year in Canada compared with 3.1% per year in the United States. The hours worked of the manufacturing sector also grew faster in Canada over the period: 0.7% per year in Canada compared with -0.1% in the United States.

From 1961 to 1996, labour productivity growth was higher in Canada than in the United States. As a result, the labour productivity level in Canada, relative to that in the United States, increased by 14 percentage points from 1961 to 1996. The faster labour productivity growth in Canada over this period reflects the faster hours worked growth and even faster real-output growth in Canada.

After 1996, aggregate labour productivity growth declined slightly in Canada while it accelerated markedly in the United States. Annual labour productivity growth in Canada declined from 3.2% for the 1961-to-1996 period to 2.8% for the 1996-to-2003 period; in contrast, annual labour productivity growth in the United States increased from 2.8% to 4.9% in these respective periods. As a result, annual labour productivity growth in Canada was 2.1 percentage points lower than in the United States for the 1996-to-2003 period.

2. What have been the sources of manufacturing labour productivity growth in Canada over the period?

Labour productivity growth can be decomposed into three components. The first is the contribution of capital deepening—or the capital deepening effect—whereby more capital services make workers more productive. The second is the contribution of intermediate input deepening—or the intermediate deepening effect—that reflects the impact of more intermediate-intensive production on labour productivity. The third component is multifactor productivity (MFP) growth, which is often associated with technological change, organizational change or economies of scale.

Intermediate input deepening is the dominant source of labour productivity growth in the Canadian manufacturing sector over the 1961-to-2003 period. Of the 3.2% annual growth in labour productivity for this period, 1.8 percentage point can be attributed to the contribution of intermediate input deepening. The growth in MFP is the second most important contributor to the labour productivity growth. It accounted for 1.1 percentage point of the 3.2% annual growth in labour productivity. Increases in capital intensity contributed the remaining 0.4 percentage point to annual labour productivity growth.

3. What have been the sources of manufacturing labour productivity growth in the United States over the period?

Labour productivity grew at an annual rate of 3.2% in the U.S. manufacturing sector. MFP growth and intermediate input deepening made similar contributions to labour productivity growth; each contributed 1.3% per year to labour productivity growth during this period, which together accounted for about 80% of labour productivity growth in the U.S. manufacturing sector. Increases in capital intensity made a significant contribution to labour productivity growth in the United States, contributing 0.6 percentage point or about 20% of the U.S. labour productivity growth from 1961 to 2003.

4. What have been the differences in the sources of manufacturing labour productivity growth in Canada and the United States over the period?

Intermediate input deepening was a more important source of labour productivity growth in Canada than in the United States, while investment in capital and MFP growth were more important in the United States than in Canada. The relatively higher effect of intermediate deepening on annual labour productivity growth in Canada compared with the United States offset the relatively lower effect of capital deepening and MFP growth in Canada. The net effect was similar rates of labour productivity growth in the two countries.

The contribution of intermediate input deepening was higher in Canadian manufacturing than in U.S. manufacturing. This accords with differences in the input intensity in the two countries. Inputs as a share of total outputs are higher in Canada—perhaps because of differences in where its manufacturing sector is in the value chain—and increases in input intensity have made a greater contribution to labour productivity growth. The evidence on intermediate input deepening in the two countries could also be the result of differences in the degree of vertical specialization of the production process—with Canada increasing specialization faster than the United States, since the former started off at a lower level.

The contribution of capital deepening was lower in Canadian manufacturing than in U.S. manufacturing. For the 1961-to-2003 period, capital deepening's effect on annual labour productivity growth was 0.4% in Canada compared with 0.6% in the United States.

MFP growth was lower in the Canadian manufacturing sector than in that of the United States. From 1961 to 2003, the aggregate MFP grew at a rate of 1.0% per year in the Canadian manufacturing sector, while it grew at a rate of 1.3% per year in the U.S. manufacturing sector.

5. What have been the factors behind the large labour productivity growth gap in favour of the U.S. manufacturing sector after the mid-1990s?

Over the 1996-to-2003 period, labour productivity growth grew at 2.8% per year in the Canadian manufacturing sector while it grew at 4.9% per year in that of the United States. The post-1996 slower labour productivity growth in Canada compared with the United States was due to slower growth in MFP and slower growth in capital intensity. The slower MFP growth in Canada accounted for 60% of the labour productivity growth difference in the two countries and

slower growth in capital intensity accounted for 30%. The remaining 10% was due to the differences in intermediate input deepening in the two countries.

The slower MFP growth after 1996 in the Canadian manufacturing sector relative to the United States was due to lower MFP growth in the computer and electronic products industry. There has been more rapid technological progress within the computer and electronic products industry in the United States compared with that in Canada.

The slower growth in the capital–labour ratio in Canadian manufacturing compared with the United States after the mid-1990s occurred as changes took place in the relative price of capital and labour inputs in the two countries. After the mid-1990s, the relative price of labour compared with that of investment increased at a slower rate in Canada than it did in the United States. This slower increase in the relative price of labour compared with capital in Canada suggests that Canadian manufacturers had a greater incentive to substitute labour for capital, which led to slower growth in capital intensity during that period in Canada.

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1 Introduction

This paper provides a consistent international comparison of long-term productivity growth in manufacturing industries in Canada and the United States. While much comparative work has been done with respect to productivity growth in the manufacturing sector in the two countries in the past, this has often been on the basis of measures that are not comparable. This paper makes use of a measure of output growth for Canadian manufacturing industries that is comparable to the U.S. measure used in the Bureau of Labor Statistics (BLS) productivity program.

In its system of official productivity measures for the United States, the BLS employs a measure of sectoral output that equals the value of gross output less the value of intra-sector sales and transfers. In contrast, Statistics Canada and most other statistical agencies employ a value-added concept of manufacturing output, defined as the value of gross output less the value of all intermediate purchases of goods and services.

We find that average annual growth rates of labour productivity were almost identical in Canadian and U.S. manufacturing over the 1961-to-2003 period. But the sources of labour productivity growth differed in the two countries. Intermediate input deepening was a more important source of labour productivity growth in Canada than it was in the United States, while investment in capital and multifactor productivity (MFP) growth were more important in the United States than they were in Canada. After 1996, labour productivity growth in Canada was slower than in the United States. The slower labour productivity growth in Canada relative to the United States was due to slower growth in MFP and slower growth in capital intensity.

Behind the overall trend in growth patterns of the aggregate manufacturing sector in Canada and the United States, there was a substantial variation across individual manufacturing industries. We find that about 80% of MFP growth in U.S. manufacturing for the 1996-to-2003 period came from computer and electronic products and transportation equipment. In Canada, the source of growth in aggregate manufacturing productivity was more evenly distributed. The largest contributor to MFP growth within the Canadian manufacturing sector was the transportation equipment industry. It accounted for about 20% of MFP growth in the Canadian manufacturing sector for the 1996-to-2003 period.

We have separately analysed the entire business sector in the two countries in Statistics Canada (2007) and find that the relative patterns of productivity growth in this broad sector were different from the patterns in manufacturing alone. The Canadian business sector was characterized by a substantial catch-up to U.S. labour productivity levels during the 1961-to-1980 period, but then the 1980-to-2006 period saw productivity growth rates that were lower than the U.S. rates. In contrast, Canada's manufacturing sector was characterised by a rate of productivity growth higher than in the United States before 1996 and a rate lower than in the United States after 1996.

This paper is organized as follows. In Section 2, we outline the data used for the international comparisons. In Section 3, we present results from a comparison of the total manufacturing sector in the two countries. The empirical findings about growth for 18 manufacturing industries in the two countries are summarized in Section 4. Section 5 concludes.

2 The data

Our analysis covers the period from 1961 to 2003 for the manufacturing sector as a whole, and the 1987-to-2003 period for 18 manufacturing industries based on the North American Industry Classification System (NAICS). We examine the growth of labour productivity, defined as sectoral output per hour worked and decompose the growth of labour productivity into three components. The first is the contribution of capital deepening—or capital deepening effect—whereby more capital services make workers more productive. The second is the contribution of intermediate input deepening—or intermediate deepening effect—that reflects the impact of more intermediate-intensive production on labour productivity. The third component is multifactor productivity (MFP) growth, which is often associated with technological change, organizational change or economies of scale.[1]

2.1 Canadian data

Productivity data for Canada are from the Canadian Productivity Accounts of Statistics Canada (Baldwin and Harchaoui 2006; Baldwin, Gu and Yan 2007).

Output is defined as sectoral output. The real sectoral output measure is a Fisher chain index that is estimated from the annual input–output tables of Statistics Canada.

Labour input is measured by hours worked, which represent the total number of hours that a person devotes to work, whether paid or unpaid. The number of hours worked is calculated as the product of the number of jobs and average hours worked. While the industry productivity database of Statistics Canada uses a measure of labour input that accounts for the effect of shifts in the experience, education and the class of workers on the total amount of labour services, in this paper we employ hours worked as a labour input measure in order to be comparable to the measure for the U.S. manufacturing industries used by the Bureau of Labor Statistics (BLS) productivity program. The BLS uses hours worked as a measure of labour input for its productivity estimates in individual manufacturing industries.

Capital service input is an estimate of the service flows derived from the stock of capital assets. The capital services measure is estimated from the aggregation of capital stock of various asset types within each industry, using the estimated user cost of capital as weight. The assets included are equipment, structures, land and inventories.

2.2 U.S. data

Productivity data for the United States are from the BLS, which publishes MFP and related variables for the aggregate manufacturing sector and 18 manufacturing industries at the 3-digit level of NAICS over the period from 1987 to 2005.[2] Those measures of output, capital, labour and intermediate inputs are quite comparable to those for the Canadian manufacturing industries, as presented above. Output is defined as sectoral output, capital input is the flow of services from the stock of capital of various assets and labour input is defined as hours worked.

The BLS publishes the MFP measures for the total manufacturing sector over the 1961-to-2000 period that are developed from data based on the 1987 Standard Industrial Classification (SIC). The SIC manufacturing sector is not perfectly comparable with the NAICS manufacturing sector.[3] For this paper, we have developed productivity and related measures for the U.S. manufacturing sector from 1961 to 2003 by linking the SIC-based measure over the period from 1961 to 1987 and the NAICS-based measure from 1987 to 2003.

While the series used for this paper are comparable, they are not estimated using identical data sources or exactly the same methodology. For example, hours worked for Canada are estimated from a household survey while hours worked for the United States are estimated from an establishment survey. The output of the Canadian industries

1. As the labour input measure used in this paper is a sum of hours worked across different types of workers and does not account for the shift in the composition of hours worked toward more experienced and more educated workers, the multifactor productivity growth estimates in this paper also include the effect of skill upgrading on labour productivity growth.
2. The methods for constructing multifactor productivity in the U.S. manufacturing sector are documented in BLS (1983) and Gullickson (1995).
3. The main difference is that the Standard Industrial Classification manufacturing taxonomy includes the publishing sector while the North American Industry Classification System manufacturing classification does not.

is valued at basic prices while the output of the U.S. industries is valued at market prices that include taxes and subsidies on products. For the long-run growth comparisons presented here, we do not deem that to be a problem. But for other studies it may be, particularly for studies on the comparison of productivity levels or for very short-term comparisons (see Footnote 8). For a discussion of differences in labour estimates, see Baldwin et al. (2005) and Maynard (2007). For a discussion of capital stock and capital services estimates, see Baldwin and Gu (2007b).

3 Productivity growth in aggregate manufacturing

3.1 Trend in labour productivity growth in Canada and the United States

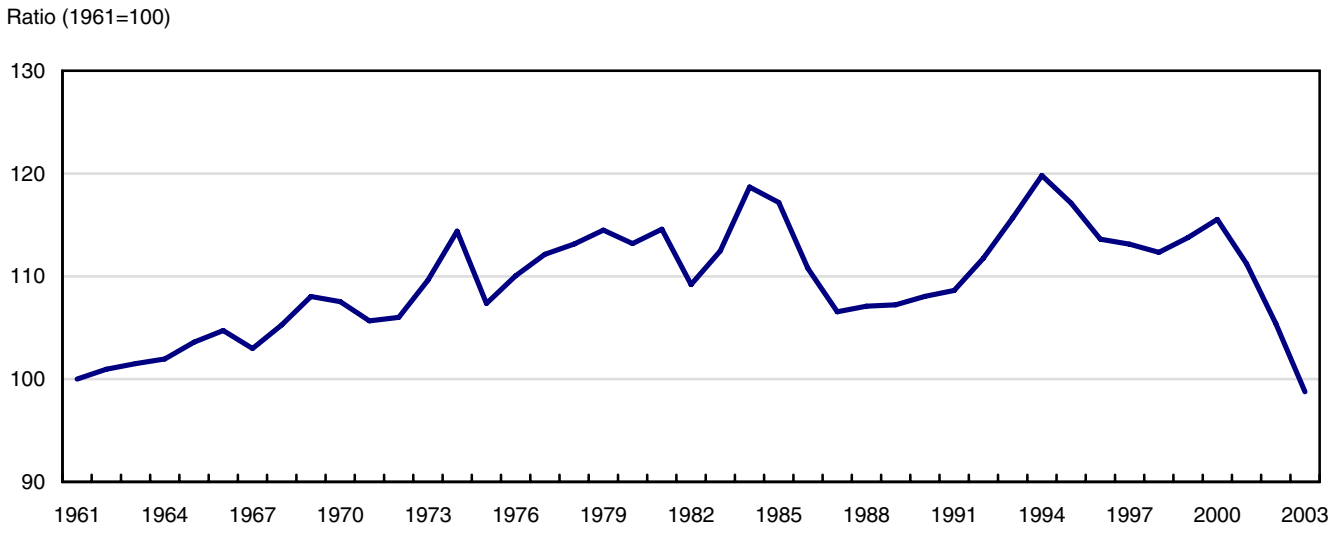
Chart 1 contains the cumulative growth in the relative Canadian-U.S. manufacturing labour productivity ratio for the period from 1961 to 2003, where labour productivity is defined as sectoral output per hour worked. It is calculated as the productivity index for Canadian manufacturing divided by the productivity index in the United States (1961=100 for both countries). A reading above 100 implies that the relative Canada–United States productivity level has increased since 1961 to a level 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. manufacturing sector. The slope of each line at a given year indicates the relative growth rate of labour productivity in the two countries. When the slope is positive, labour productivity in Canada is growing faster or declining more slowly than in the United States. The converse is indicated by a negative slope.

Chart 2 shows the Canada–United States manufacturing labour productivity growth difference calculated annually for the 1961-to-2003 period. It shows both actual and Hodrick-Prescott-filtered differences in the two countries.[4] A reading above zero indicates that manufacturing labour productivity growth in Canada is higher than that in the United States in a particular year. A reading below zero implies that the manufacturing 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 1996, when productivity growth in the Canadian manufacturing sector was higher than in the United States; and after 1996, when the United States has outperformed Canada. The labour productivity growth gap favourable to the United States was getting larger during the 1996-to-2003 period.

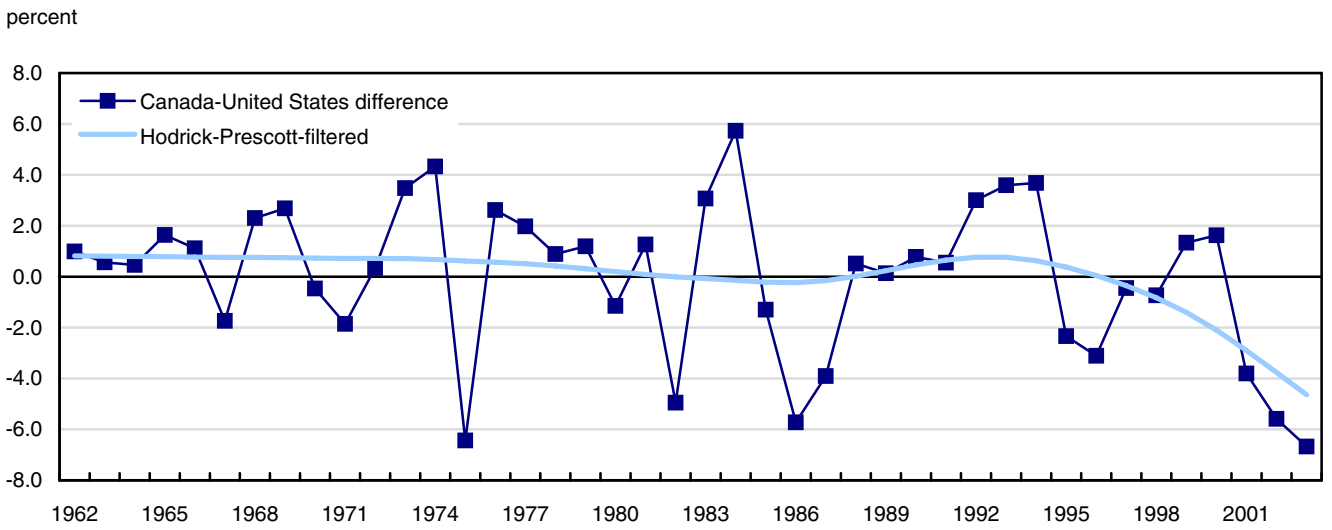
4. We have set parameter lambda to 100 for Hodrick-Prescott-filtered differences.

Chart 1
Relative Canada–United States labour productivity ratio in the manufacturing sector



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

Chart 2
Canada–United States labour productivity growth difference in the manufacturing 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 earlier Statistics Canada reports. Baldwin, Harchaoui and Maynard (2001) found that labour productivity growth measured using gross domestic product (GDP) per hour worked in Canada exceeded that of the United States up to 1980, then fell slightly behind over the subsequent 15 years, only to fall further behind in the late 1990s. Gu and Ho (2000) examined productivity growth in the Canadian manufacturing sector over the 1961-to-1995 period, using the gross output concept that is empirically similar to the sectoral output concept used in this paper. They found that growth in labour productivity, defined as gross output per hour worked, was higher in the Canadian manufacturing sector than in that of the United States over the period from 1961 to 1995. Bernstein, Harris and Sharpe (2002) found that the

Canadian manufacturing sector experienced a large increase in its labour productivity gap with the United States since 1994.

Table 1 presents the growth in labour productivity, real sectoral output and hours worked in the Canadian and U.S. manufacturing sectors. From 1961 to 2003, aggregate labour productivity growth in the manufacturing sector was the same in the two countries. It increased at an annual rate of 3.2% in both countries.

The similar labour productivity growth in the two countries reflects faster growth in output and hours worked within the Canadian manufacturing sector. The output of manufacturing grew faster in Canada than it did in the United States for the 1961-to-2003 period: 3.9% per year in Canada compared with 3.1% per year in the United States. The hours worked of the manufacturing sector also grew faster in Canada over the period: 0.7% per year in Canada compared with -0.1% in the United States.

Table 1
Annual growth in output, hours worked and labour productivity in Canadian and U.S. manufacturing

	1961 to 2003	1961 to 1996	1996 to 2003
	percent		
Labour productivity			
Canada	3.2	3.2	2.8
United States	3.2	2.8	4.9
Difference	0.0	0.4	-2.1
Output			
Canada	3.9	3.9	3.8
United States	3.1	3.3	2.0
Difference	0.8	0.6	1.8
Hours worked			
Canada	0.7	0.6	0.9
United States	-0.1	0.4	-2.8
Difference	0.8	0.2	3.7

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

From 1961 to 1996, 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 a cumulative 14 percentage points. The faster labour productivity growth in Canada over this period reflects the faster hours growth and even faster real output growth in Canada.

After 1996, aggregate labour productivity growth declined in Canada while it accelerated in the United States. Annual labour productivity growth in Canada declined slightly from 3.2% for the 1961-to-1996 period to 2.8% for the 1996-to-2003 period. Annual labour productivity growth in the United States increased markedly from 2.8% to 4.9% from one period to the other. As a result, annual labour productivity growth in Canada fell 2.1 percentage points behind the United States. The slower labour productivity growth in Canada relative to that in the United States for the 1996-to-2003 period was a result of faster output growth and a much faster hours growth in Canada.

3.2 Sources of aggregate labour productivity growth for Canada

In this section, we use standard growth accounting techniques to examine the sources of aggregate labour productivity growth in the Canadian manufacturing sector. The decomposition allows the sources of growth to be compared across countries.

Labour productivity growth can be decomposed into contributions from capital deepening, intermediate input deepening and multifactor productivity (MFP) growth. The contribution of capital deepening is defined as the product of the nominal output share of capital and the growth rate of capital services per hour worked. The contribution of intermediate input deepening is defined as the product of nominal output share of intermediate inputs and the growth rate of intermediate input per hour worked.

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

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

where Δ denotes the change between periods *t*-1 and *t*; *Y* denotes real sectoral output; *K,* capital services; *H,* hours worked; *U,* intermediate inputs; *MFP,* multifactor productivity; $\overline{s}_{Kt}$ is the average share of capital services in nominal output in periods *t* and *t*-1; and $\overline{s}_{Ut}$ is the average share of intermediate inputs in nominal output in periods *t* and *t*-1. (For details on growth accounting, see Jorgenson, Ho and Stiroh 2005; Baldwin and Gu 2007a).

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 (or the capital deepening effect), whereby more capital services make workers more productive. It is the product of increases in the capital–labour ratio and the share of output going to capital. The second term is the contribution of intermediate input deepening (or the intermediate deepening effect), which reflects the impact of more intermediate-intensive production on labour productivity. It is the product of increases in the intermediate input–labour ratio and the share of output going to intermediate inputs. The third term is MFP growth, which increases labour productivity growth on a point-for-point basis. While often associated with technological change, it also includes efficiencies gains that come from organizational changes and the exploitation of economies of scale as well as all other unmeasured factors. For example, the omission of some aspects of capital (e.g., intangible capital) from the measure of physical capital (machinery, buildings and infrastructure) intensity will find their way, in either a positive or negative fashion, into the measures of MFP.

A more restrictive version of the sources of labour productivity growth equation uses the value-added output concept and it decomposes labour productivity growth into contribution of capital deepening and MFP growth. We have chosen to use the more comprehensive measure of output in this paper—that is, sectoral output—because of differences in the input intensity of manufacturing between Canada and the United States (see Baldwin, Jarmin and Tang 2002) and our interest in whether changes in input intensity have contributed differentially to productivity growth in Canada and the United States.

An important feature of the sectoral-output approach in Equation (1) compared with the value-added approach is the explicit role of intermediate inputs (See Jorgenson, Ho and Stiroh 2005 for a more detailed discussion). This is critical, because intermediate inputs may be the primary component of some industry's output. For example, semiconductor products are key intermediate inputs to industries that produce computers and telecommunication equipment and play a key role in the improvements in the quality and performance of the products of those industries. The failure to quantify intermediate inputs, such as semiconductors, leads us to miss the importance of intermediate inputs for the industries that use them.

The production process may differ substantially in terms of its position in the value chain. Those parts of the production process early in the chain take raw materials and transform them into intermediate products. Those parts of the production process that are later in the chain transform intermediate products into final consumer products.

Differences in input intensity may be related to the stage of production. High raw-materials content may, for technical reasons, be associated with little value added because it relies on relatively unskilled workers or less capital and thus will have high input-to-value-added ratios. Indeed, manufacturing industries in Canada that are associated with natural resources are characterized by high input-to-value-added ratios (see Baldwin and Rafiquzzaman 1994). Later stages in the production chain are sometimes seen to require more skilled workers and more capital and, therefore, produce more value added or gross output per worker.

Whatever is the case, technological progress can proceed quite differently in the different stages, with regards to how material is transformed. The decomposition outlined in Equation (1) can be used to investigate whether the Canadian manufacturing sector increased its output per worker more so than did that of the United States by making progressively greater use of intermediate inputs.

Table 2 presents the productivity growth estimates and the decomposition outlined in Equation (1) for the Canadian manufacturing sector as a whole. It should be noted that the choice of the output concept affects the estimate of the absolute level of productivity growth. Baldwin and Gu (2007a) find that MFP based on value added rose 1.8% per year in the Canadian manufacturing sector for the 1961-to-2002 period. MFP based on sectoral output grew at 0.8% per year. MFP based on gross output had the lowest growth rate: it grew at 0.6% per year during that period.[5]

Intermediate input deepening is the dominant source of labour productivity growth in the Canadian manufacturing sector over the 1961-to-2003 period. Of the 3.2% annual growth in labour productivity for the period, 1.8 percentage point can be attributed to the contribution of intermediate input deepening. The Canadian manufacturing sector has become more intermediate-input intensive over time.

The growth in MFP is the second most important contributor to labour productivity growth. It accounted for 1.1 percentage point of the 3.2% annual growth in labour productivity. Increases in capital intensity contributed the remaining 0.4 percentage point to annual labour productivity growth.

Table 2
Sources of annual labour productivity growth in the manufacturing sector in Canada

	1961 to 2003	1961 to 1996	1996 to 2003
	percent		
Output per hour worked	3.2	3.2	2.8
Contribution of capital deepening	0.4	0.4	0.2
Contribution of intermediate input deepening	1.8	1.8	1.8
Multifactor productivity growth	1.0	1.0	0.9

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

Over the 1961-to-1996 period, output per hour grew at an annual rate of 3.2%. Of the 3.2% growth in manufacturing labour productivity, 1.8 percentage point can be attributed to the contribution of intermediate deepening, 1.0 percentage point to increases in MFP and 0.4 percentage point to increases in capital intensity.

Over the 1996-to-2003 period, manufacturing labour productivity growth declined to 2.8% per year. The decline in manufacturing labour productivity growth for this period is mainly the result of a decline in the contribution of capital deepening and, to a lesser extent, a slight decline in MFP growth.

3.3 Sources of aggregate labour productivity growth for the United States

A similar decomposition of U.S. manufacturing productivity growth is presented in Table 3. The trend in labour productivity growth in the U.S. manufacturing sector differed from that in Canada. There was a large acceleration in labour productivity growth in the U.S. manufacturing sector after 1996, while there was a slight decline in labour productivity growth in Canada for that period.

5. The multifactor productivity growth (MFP) estimates in that paper are based on a measure of labour input that accounts for the effect of shifts in the composition of hours worked toward more experienced and more educated workers. As such the MFP estimates in that paper are not comparable to the estimates presented in this paper.

Table 3
Sources of annual labour productivity growth in the manufacturing sector in the United States

	1961 to 2003	1961 to 1996	1996 to 2003
	percent		
Output per hour worked	3.2	2.8	4.9
Contribution of capital deepening	0.6	0.5	0.9
Contribution of intermediate input deepening	1.3	1.2	1.9
Multifactor productivity growth	1.3	1.1	2.1

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

From 1961 to 2003, labour productivity grew at an annual rate of 3.2% in the U.S. manufacturing sector. MFP growth and intermediate deepening made a similar contribution to labour productivity growth. MFP growth and intermediate deepening each contributed 1.3% per year to labour productivity growth over this period, together accounting for about 80% of labour productivity growth in U.S. manufacturing. Increases in capital intensity made a significant contribution to labour productivity growth in the United States, contributing 0.6 percentage point or about 20% of the U.S. labour productivity growth from 1961 to 2003.

The large acceleration in labour productivity growth after 1996 mostly reflects an acceleration in MFP growth. This suggests that technological progress or other factors became more rapid in the U.S. manufacturing sector after 1996. Increases in capital deepening and intermediate deepening also contributed to the post-1996 acceleration in the U.S. manufacturing productivity growth.

There are a number of differences in the three components of manufacturing labour productivity growth in Canada and the United States over the 1961-to-2003 period.

1. MFP growth was lower in the Canadian manufacturing sector than in that of the United States. From 1961 to 2003, the aggregate MFP grew at a rate of 1.0% per year in the former while it grew at a rate of 1.3% per year in the latter.

2. The contribution of capital deepening was lower in Canadian manufacturing than in U.S. manufacturing. For the 1961-to-2003 period, capital deepening's effect on annual labour productivity growth was 0.4% in Canada compared with 0.6% in the United States.

3. The contribution of intermediate input deepening was higher in Canadian manufacturing than U.S. manufacturing. The relatively higher effect of intermediate deepening on annual labour productivity growth in Canada compared with the United States offset the relatively lower effect of capital deepening and MFP growth in Canada. The net effect is one of similar rates of labour productivity growth in the two countries.

The relatively larger contribution of intermediate input deepening in Canadian manufacturing has also been found in Gu and Ho (2000) and Ho, Rao and Tang (2004). In addition, we find that the share of intermediate input in the nominal output was higher in Canadian manufacturing throughout the period. The relatively higher intermediate input intensity in Canada was pervasive across industries. In 2003, the share of intermediate inputs in nominal output was higher in Canada than in the United States in 15 out of the 18 manufacturing industries at the North American Industry Classification System 3-digit level of aggregation, particularly in the computer, electronic products and transportation equipment industries.

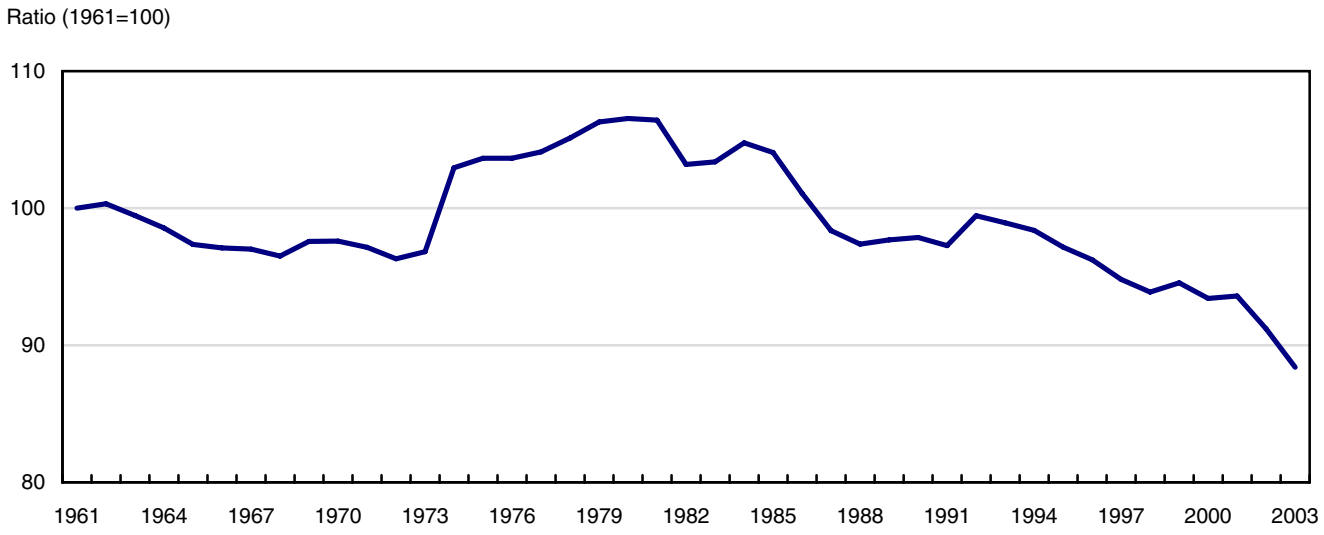
The higher contribution of intermediate input deepening may be the result of the position of Canadian manufacturers at the low end of the value chain compared with U.S. manufacturers. Another possibility is that vertical specialization has been lower in Canada—that Canadian plants tended to be more diversified, producing more of many parts of the supply chain—because the smaller size of the Canadian market worked against specialization. The various free-trade agreements with the United States and Mexico gave Canadian manufacturers access to larger markets and led to increased levels of inputs relative to outputs as plants became more specialized and moved intermediate parts back and forth across the U.S.-Canadian border. Canadian plants began to focus more intensively on a

narrower part of the production process—buying intermediate inputs and then shipping them on to others. Baldwin, Jarmin and Tang (2002) find that this vertical disintegration of production occurred mainly among large manufacturing firms in Canada.

3.4 Sources of the Canada–United States differences in aggregate labour productivity growth

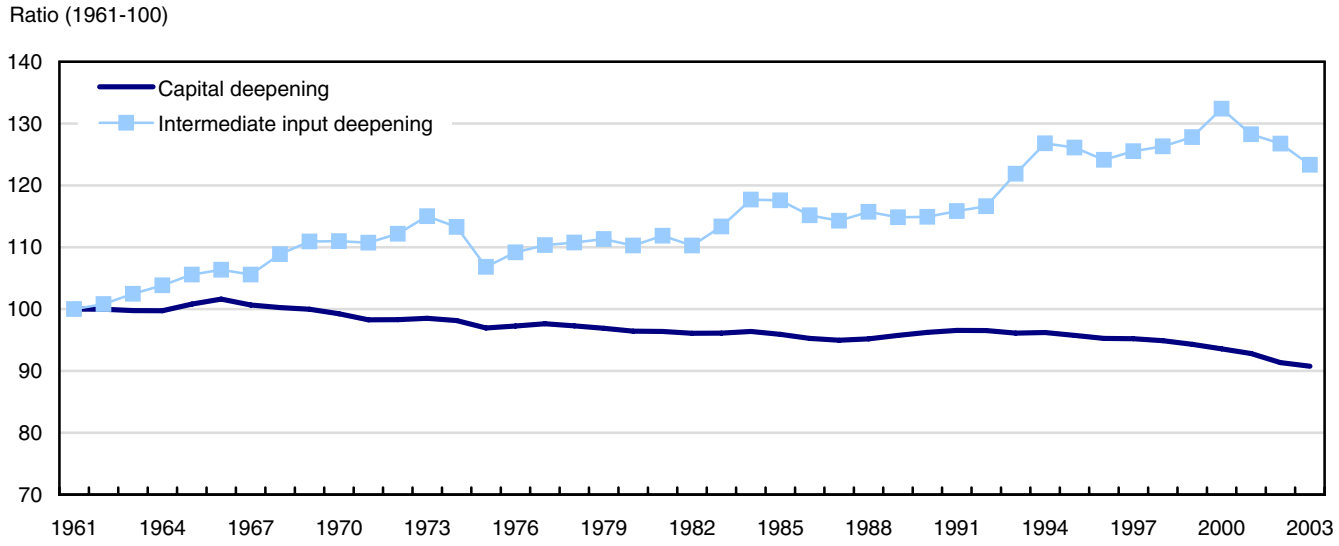
In this section, we decompose the manufacturing productivity growth difference into three parts: the difference in capital deepening, the difference in intermediate deepening and the difference in MFP growth.

Chart 3
Relative Canada–United States multifactor productivity ratio in the manufacturing sector, 1961 to 2003



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

Chart 4
Relative Canada–United States capital deepening and intermediate input deepening in the manufacturing sector, 1961 to 2003

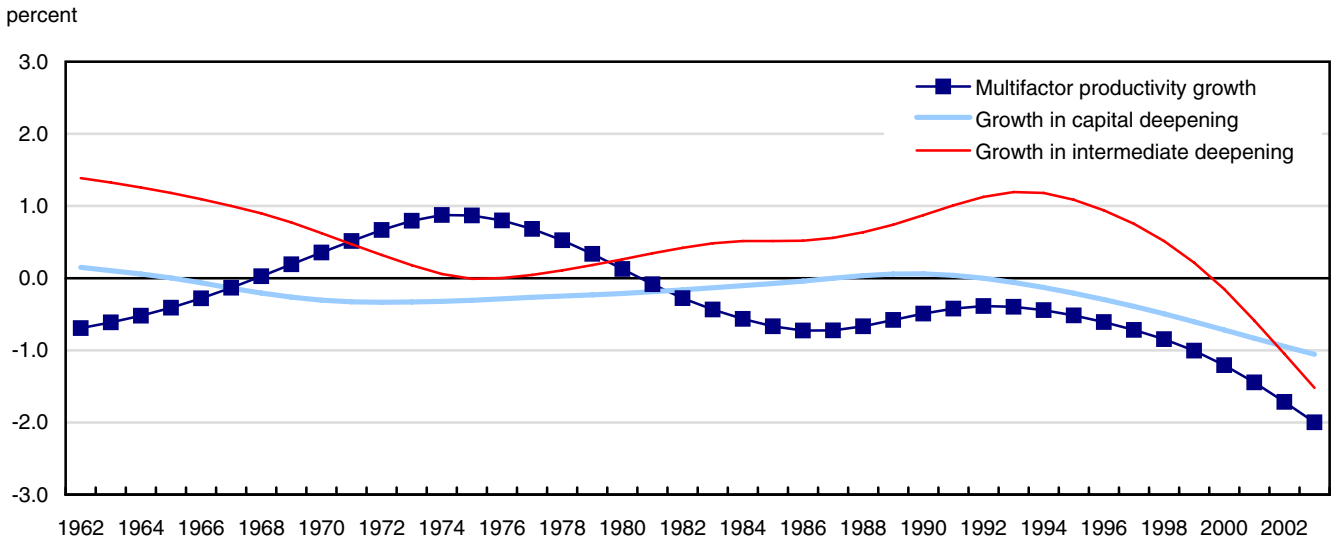


Source(s): Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

Before presenting the decomposition results, we show in Chart 3 the cumulative growth in the relative Canada–United States MFP ratio in the manufacturing sector and in Chart 4 the relative Canada–United States capital deepening effect and intermediate deepening effect (in both cases 1961=100). Chart 5 contains the Hodrick-Prescott-filtered Canada–United States difference in the annual growth of MFP, capital deepening effect and intermediate deepening effect for the manufacturing sector.

MFP growth was higher in the Canadian manufacturing sector than in that of the United States before 1980 and lower after 1980. The result is that by 2003, the Canada–United States MFP-level gap expanded by 12 percentage points, relative to its value in 1961.

Chart 5
Trend in Canada–United States difference in growth of multifactor productivity, capital deepening and intermediate input deepening



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

The capital deepening effect—defined as the contribution of capital services per hour worked to labour productivity growth—tended to increase at a slower rate in Canada than it did in the United States. The difference was small before the early 1990s but became larger afterwards.

The intermediate input deepening effect was higher in the Canadian manufacturing sector over the past four decades, except during the 2000s. This accords with a Canadian manufacturing sector that is both earlier in the value-added production chain and is more material intensive as well as one that was initially less specialized in terms of the stages of the production process.

Table 4 presents the decomposition of Canada–United States manufacturing sector labour productivity growth differences. The Canada–United States difference in labour productivity growth is decomposed into three components: the difference in intermediate input deepening, the difference in capital deepening and the difference in MFP growth. They are calculated as the differences in the three components of labour productivity growth between Canada, as shown in Table 2, and the United States, as shown in Table 3. A number of findings emerge from the results.

1. Labour productivity growth in the Canadian manufacturing sector was similar to that in the U.S. manufacturing sector in the 1961-to-2003 period. This reflects higher intermediate input deepening in Canada, which was offset by lower MFP growth and lower capital deepening in the Canadian manufacturing sector.

2. Before 1996, labour productivity growth was higher in the Canadian manufacturing sector than in the United States. This was a result of a larger intermediate input deepening effect in Canada. The capital deepening effect and MFP growth were similar in the two countries for the period prior to 1996.[6]

3. After 1996, labour productivity growth was much slower in the Canadian manufacturing sector than in the United States. This was a result of slower MFP growth and a lower capital deepening effect in Canada. Intermediate input deepening was similar in the two countries.

6. Annual growth in real gross domestic product (value added) per hour was 3.1% in the manufacturing sector for Canada and the United States over the period from 1961 to 2003.

4. There was little difference in the capital deepening effect in the two countries before 1996. After 1996, the capital deepening effect in Canada was less than in the United States.

5. There was little difference in MFP growth in the two countries before the mid-1990s. After 1996, MFP growth was much slower in Canada than in the United States.

6. The intermediate input deepening effect was much higher in Canada than in the United States before 1996. After 1996, intermediate input deepening was similar in the two countries.

Table 4
Decomposition of the labour productivity growth difference in the manufacturing sector (Canada minus United States)

	1961 to 2003	1961 to 1996	1996 to 2003
	percent		
Output per hour worked	0.0	0.4	-2.1
Contribution of capital deepening	-0.2	-0.1	-0.7
Contribution of intermediate input deepening	0.5	0.6	-0.1
Multifactor productivity growth	-0.3	-0.1	-1.2

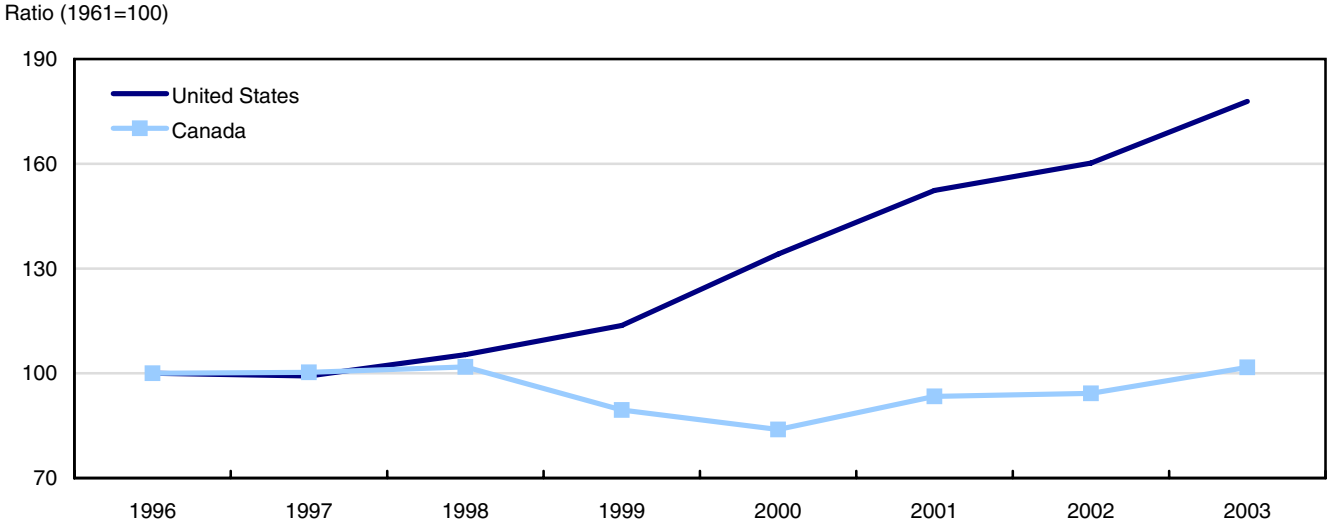
Note(s): Figures may not sum due to rounding.
Source(s): Statistics Canada, Canadian Productivity Accounts; Bureau of Labor Statistics.

The slower growth in the capital–labour ratio in Canadian manufacturing compared with the United States after the mid-1990s has been linked to the changes in relative prices of capital and labour inputs in the two countries (Bernstein, Harris and Sharpe 2002). After the mid-1990s, the relative price of labour compared with capital increased at a slower rate in Canada than in the United States, as is shown in Chart 6. This slower increase in Canada suggests that Canadian manufacturers had more incentive to substitute labour for capital, which led to slower growth in capital intensity during that period in Canada.

The slower rates of growth in the relative price of labour and capital in Canada compared with the United States over the 1996-to-2003 period were a result of slower rates of growth in hourly compensation and higher rates of growth in the price of capital in the Canadian manufacturing sector. Over that period, hourly compensation rates in the manufacturing sector rose at a rate of 2.6% in Canada, while they rose at a rate of 5.6% in the United States. The price of capital input in the manufacturing sector increased at a rate of 2.3% in Canada, while it declined at a rate of 2.7% per year in the United States. The increases in the price of capital in Canada relative to the United States may be linked to the depreciation of the Canadian dollar relative to the U.S. dollar over that period. As a large portion of machinery and equipment in Canada is imported from the United States, the depreciation of the Canadian dollar increased the price of machinery and equipment in Canada.

The slower growth in the capital–labour ratio in Canada compared with the United States after the mid-1990s may also reflect the effect of slower MFP growth in Canada. In Statistics Canada (2007), a Granger causality test is carried out between relative capital intensity growth and relative MFP growth in the Canadian and U.S. business sectors. The results 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. The evidence is consistent with the Solow neoclassical growth model, wherein investment is induced by technological progress and slower technological progress—or MFP growth—leads to lower investment.

Chart 6
Trends in relative prices of labour and capital services in manufacturing in Canada and the United States, 1996 to 2003



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

4 A comparison across 18 manufacturing industries

The previous discussion of growth in aggregate manufacturing masks a wide variation in growth among industries. In this section, we turn to the performance of individual industries during the 1987-to-2003 period, for which consistent industry data are available for both Canada and the United States.[7]

Table 5 shows the contribution to labour productivity growth from three main components in Canadian and U.S. manufacturing industries during the 1987-to-2003 period. These components are the contribution of capital deepening, intermediate input deepening and multifactor productivity (MFP) growth.

Over the 1987-to-2003 period, annual labour productivity growth and MFP growth in the manufacturing sector were lower in Canada than in the United States. Labour productivity grew at 3.3% per year in Canada and it grew at 3.8% per year in the United States. MFP grew at 0.7% per year in Canada and at 1.4% in the United States. The lower labour productivity growth in Canada occurred in 8 out of the 18 industries. The lower MFP growth in Canada occurred in 6 out of the 18 industries, particularly in the computer and electronic products industry.

7. The industry productivity database for the United States is available for 18 North American Industry Classification System 3-digit manufacturing industries over the period from 1987 to 2005. Comparable data for Canada are available for 1961 to 2003.

Table 5
Sources of annual labour productivity growth by industry, 1987 to 2003

	Sectoral output per hour worked	Capital deepening	Intermediate input deepening	Multifactor productivity
	percent			
Canada				
Food and beverage and tobacco products	2.1	0.2	1.6	0.3
Textile mills and textile product mills	2.4	0.2	1.8	0.3
Apparel and leather and applied products	2.1	0.3	1.2	0.6
Wood products	2.7	0.3	1.6	0.7
Paper products	2.9	0.4	1.8	0.6
Printing	1.4	0.4	1.3	-0.3
Petroleum and coal products	1.5	0.1	1.2	0.2
Chemical manufacturing	3.6	0.7	2.0	0.8
Plastics and rubber products	2.2	0.0	1.1	1.0
Non-metallic mineral products	1.8	0.2	1.0	0.6
Primary metal	4.0	0.2	2.6	1.1
Fabricated metal products	1.1	-0.2	0.5	0.7
Machinery	2.3	0.2	1.4	0.7
Computer and electronic products	8.7	0.9	6.3	1.3
Electrical equipment, appliances and components	3.0	0.6	2.1	0.3
Transportation equipment	4.5	0.3	3.3	0.8
Furniture and related products	2.5	0.2	1.3	0.9
Miscellaneous manufacturing	2.5	-0.1	1.4	1.3
Total manufacturing	**3.3**	**0.3**	**2.2**	**0.7**
United States				
Food and beverage and tobacco products	1.2	0.2	1.3	-0.3
Textile mills and textile product mills	3.2	0.3	1.7	1.2
Apparel and leather and applied products	2.5	1.0	0.1	1.4
Wood products	1.3	0.1	1.0	0.1
Paper products	2.2	0.4	1.7	0.1
Printing	0.8	0.4	0.2	0.2
Petroleum and coal products	3.3	0.2	2.3	0.7
Chemical manufacturing	2.1	0.9	1.4	-0.2
Plastics and rubber products	2.9	0.5	1.6	0.8
Non-metallic mineral products	1.4	0.3	0.4	0.7
Primary metal	2.4	0.1	1.6	0.6
Fabricated metal products	1.6	0.3	1.0	0.3
Machinery	2.8	0.8	2.6	-0.6
Computer and electronic products	13.4	0.7	2.5	9.9
Electrical equipment, appliances and components	2.8	0.8	2.8	-0.8
Transportation equipment	3.1	0.4	2.7	0.0
Furniture and related products	1.9	0.3	1.1	0.5
Miscellaneous manufacturing	3.1	0.3	1.5	1.2
Total manufacturing	**3.8**	**0.6**	**1.7**	**1.4**

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

Table 6
Sources of annual labour productivity growth by industry, 1996 to 2003

	Sectoral output per hour worked	Capital deepening	Intermediate input deepening	Multifactor productivity
	percent			
Canada				
Food and beverage and tobacco products	2.5	0.1	2.0	0.4
Textile mills and textile product mills	4.5	0.2	3.2	1.1
Apparel and leather and applied products	2.4	0.0	1.6	0.8
Wood products	4.1	0.3	1.7	2.0
Paper products	2.4	-0.6	1.3	1.6
Printing	3.9	0.4	2.5	1.0
Petroleum and coal products	-2.1	0.0	-2.0	-0.1
Chemical manufacturing	4.6	1.1	2.6	0.9
Plastics and rubber products	2.3	-0.2	1.5	0.9
Non-metallic mineral products	3.3	0.0	1.5	1.9
Primary metal	3.2	0.3	1.9	1.1
Fabricated metal products	2.9	-0.1	1.6	1.4
Machinery	2.5	0.0	1.9	0.6
Computer and electronic products	4.5	1.3	2.6	0.6
Electrical equipment, appliances and components	2.8	0.6	2.3	-0.1
Transportation equipment	4.3	0.2	3.3	0.7
Furniture and related products	3.2	0.0	2.3	0.9
Miscellaneous manufacturing	6.2	-0.3	3.8	2.6
Total manufacturing	**2.8**	**0.2**	**1.8**	**0.9**
United States				
Food and beverage and tobacco products	1.3	0.1	1.7	-0.5
Textile mills and textile product mills	5.0	0.4	2.7	1.8
Apparel and leather and applied products	2.1	1.6	-1.0	1.6
Wood products	2.6	0.3	1.3	0.9
Paper products	3.3	0.4	2.5	0.4
Printing	1.7	0.6	0.5	0.5
Petroleum and coal products	3.6	0.2	2.2	1.1
Chemical manufacturing	3.5	1.0	1.8	0.6
Plastics and rubber products	4.1	0.8	2.4	0.8
Non-metallic mineral products	2.1	0.8	0.5	0.8
Primary metal	2.8	0.3	1.4	1.0
Fabricated metal products	2.1	0.6	1.5	0.0
Machinery	3.8	1.3	2.4	0.1
Computer and electronic products	14.3	0.7	2.0	11.3
Electrical equipment, appliances and components	3.2	1.1	0.8	1.3
Transportation equipment	5.6	0.6	3.7	1.2
Furniture and related products	3.1	0.5	1.7	0.9
Miscellaneous manufacturing	4.0	0.5	2.2	1.2
Total manufacturing	**4.9**	**0.9**	**1.9**	**2.1**

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

An important development in Canadian and U.S. manufacturing growth since the 1980s has been the rapid growth of labour productivity in the computer and electronic products industry that produces information technology goods. The computer and electronic products industry shows rapid MFP growth in the United States, but not in Canada. In the United States, MFP grew at about 10% per year in the computer and electronic products over the 1987-to-2003 period. In Canada, this industry also had the highest MFP growth rate among manufacturing industries, but its MFP growth rate was much lower at 1.3% per year.

Intermediate input deepening is the dominant source of labour productivity growth in both the Canadian and U.S. manufacturing industries. Of the two remaining sources of labour productivity growth, MFP growth was more important than capital deepening in both countries. MFP growth made a larger contribution to labour productivity growth in 16 of the 18 industries in Canada, and in 10 out of the 18 industries in the United States.

Since the mid-1990s, productivity growth in the Canadian manufacturing sector has been slower than in that of the United States. Table 6 shows that in the 1996-to-2003 period, annual labour productivity growth was 2.8% in Canada compared with 4.9% in the United States. Annual MFP growth was 0.9% in Canada compared with 2.1% in the United States. The table shows labour productivity growth, capital deepening, intermediate input deepening and MFP growth for the 18 manufacturing industries over the 1996-to-2003 period. The lower productivity growth in

Canada relative to the United States was most noticeable in the computer and electronic products, and petroleum and coal products industries.[8]

4.1 An industry decomposition of aggregate manufacturing productivity

To identify the industry sources of aggregate MFP growth in the manufacturing sector as a whole, and aggregate MFP growth differences between the two countries, we decompose aggregate MFP growth into the contributions of each industry. We have constructed aggregate MFP growth of manufacturing as a weighted average of industry productivity growth rates (see Ezaki and Jorgenson 1995, Domar 1961). The weights are equal to the average shares of industry nominal sectoral output in total manufacturing over the period. The contribution of each industry to aggregate MFP growth is measured as that industry's productivity growth rate multiplied by its average share of manufacturing sectoral output.

8. From 2000 to 2003, productivity growth was lower in Canada than in the United States in most manufacturing industries. Such widespread differences are due to the differences in source data used. Canada uses a labour force estimate of hours worked, which showed little changes over the period, while the United States uses an employer survey estimate. If the employer survey were used in Canada, there would be little difference in labour productivity growth between the two countries.

Table 7
An industry decomposition of aggregate manufacturing productivity growth in Canada and the United States, 1996 to 2003

	Average weights	Multifactor productivity growth	Aggregate multifactor productivity contribution
	percent		
Canada			
Food and beverage and tobacco products	15.1	0.4	0.06
Textile mills and textile product mills	1.5	1.1	0.02
Apparel and leather and applied products	2.0	0.8	0.02
Wood products	6.1	2.0	0.12
Paper products	7.4	1.6	0.12
Printing	2.7	1.0	0.03
Petroleum and coal products	7.4	-0.1	-0.01
Chemical manufacturing	8.7	0.9	0.08
Plastics and rubber products	5.1	0.9	0.05
Non-metallic mineral products	2.3	1.9	0.04
Primary metal	7.6	1.1	0.08
Fabricated metal products	5.9	1.4	0.08
Machinery	5.9	0.6	0.04
Computer and electronic products	5.4	0.6	0.03
Electrical equipment, appliances and components	2.3	-0.1	0.00
Transportation equipment	23.6	0.7	0.17
Furniture and related products	2.4	0.9	0.02
Miscellaneous manufacturing	1.7	2.6	0.04
Total	**...**	**...**	**0.98**
United States			
Food and beverage and tobacco products	17.4	-0.5	-0.09
Textile mills and textile product mills	2.6	1.8	0.05
Apparel and leather and applied products	2.1	1.6	0.03
Wood products	3.0	0.9	0.03
Paper products	5.3	0.4	0.02
Printing	3.3	0.5	0.02
Petroleum and coal products	7.4	1.1	0.08
Chemical manufacturing	14.0	0.6	0.08
Plastics and rubber products	5.6	0.8	0.04
Non-metallic mineral products	2.9	0.8	0.02
Primary metal	4.3	1.0	0.04
Fabricated metal products	8.0	0.0	0.00
Machinery	8.6	0.1	0.01
Computer and electronic products	12.0	11.3	1.36
Electrical equipment, appliances and components	3.5	1.3	0.05
Transportation equipment	16.2	1.2	0.19
Furniture and related products	2.3	0.9	0.02
Miscellaneous manufacturing	3.7	1.2	0.04
Total	**...**	**...**	**2.00**

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

Table 7 presents the industry decomposition results for MFP growth of the manufacturing sector as a whole in Canada and the United States for the 1996-to-2003 period. We have chosen the period so as to examine the industry sources of the MFP growth gap in favour of the United States that emerged over that period. The sum of industry contributions to aggregate MFP growth is 1.0% for Canada and 2.0% for the United States. When we compare this estimate of the MFP growth with that derived from an aggregate production function for total manufacturing, as was shown in Table 6, we find that the two estimates are almost identical. The slight difference in these estimates arises from the reallocations of inputs and outputs across industries.

The gains in U.S. manufacturing productivity were heavily concentrated within two industries: computer and electronic products and transportation equipment. In contrast, the gains in Canadian manufacturing were more dispersed. In the United States, the computer and transportation equipment industries accounted for about 80% of MFP growth in total manufacturing for the period. In Canada, the largest contributor to the MFP growth in the total manufacturing sector was the transportation equipment industry. It accounted for about 20% of MFP growth in the Canadian manufacturing sector for the 1996-to-2003 period.

The decomposition in Table 7 allows us to examine the contribution of industries to aggregate MFP growth gap in the Canadian and U.S. manufacturing sectors over the 1996-to-2003 period. The contribution of an industry to the aggregate MFP growth gap is the difference in the contribution of the industry to the MFP growth between the two countries. We find that the MFP growth difference is entirely due to the difference in the performance of the computer and electronic products industry. The Canadian computer and electronic products industry experienced much slower MFP growth and was smaller than that in the United States.

5 Conclusion

In this paper, we apply a similar methodology to provide an international comparison of long-term productivity growth in Canadian and U.S. manufacturing industries. When this is done, we find that average annual growth rates of labour productivity were almost identical in the Canadian and U.S. manufacturing sectors during the 1961-to-2003 period. But the sources of labour productivity growth differed in the two countries. Intermediate input deepening was a more important source of labour productivity growth in Canada than in the United States, while investment in capital and multifactor productivity (MFP) growth were more important in the United States than in Canada.

An important feature of the Canadian manufacturing sector has been the higher intermediate-input intensity and the higher growth of intermediate inputs compared with the U.S. manufacturing sector during the period up to the mid-1990s. This concords with the greater input intensity of the Canadian manufacturing sector and may suggest that Canadian manufacturers are at the low end of the value chain compared with U.S. manufacturers. Another possibility is that specialization of production has been less in Canadian manufacturing because more manufacturing steps were combined within the plant. Free trade has been accompanied by a dramatic increase in the extent to which especially large plants have focused increasingly on a smaller number of stages in production.

After 1996, labour productivity growth was much slower in Canada than in the United States. From 1996 to 2003, labour productivity growth grew at 2.8% per year in the Canadian manufacturing sector while it grew at 4.9% per year in the United States. The post-1996 slower labour productivity growth in Canada was due to slower growth in MFP and slower growth in capital intensity. The slower MFP growth in Canada accounted for 60% of the Canada–United States labour productivity growth difference, and slower growth in capital intensity accounted for 30%. The remaining 10% was due to the differences in intermediate-input deepening in the two countries. The slower MFP growth in the Canadian manufacturing sector relative to that of the United States after 1996 was due to lower MFP growth in the computer and electronic products industry.

The slower growth in the capital–labour ratio in Canadian manufacturing compared with that of the United States after the mid-1990s occurred simultaneously with changes in relative prices of capital and labour inputs in the two countries. After the mid-1990s, the relative price of labour compared with that of investment increased at a slower rate in Canada than in the United States. This slower increase in the relative price of labour compared with capital in Canada means that Canadian manufacturers had less of an incentive to substitute capital for labour, which led to slower growth in capital intensity during that period in Canada.

The slower MFP growth in the computer and electronic products industry in Canada after the mid-1990s has been examined by a number of previous studies. Eldridge and Sherwood (2000) and Trefler (1999) argue that the MFP growth gap of the Canadian computer and electronic products industry is real. There has been more rapid technological progress in the computer and electronic products industry in the United States compared with that in Canada.

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