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The Canadian Productivity Review

Productivity: What Is It? How Is It Measured? What Has Canada's Performance Been Over the Period 1961 to 2012?

by John R. Baldwin, Wulong Gu, Ryan Macdonald and Beiling Yan

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.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	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
*	significantly different from reference category ($p < 0.05$)

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by

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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 Canadian Productivity 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 papers in the series often include results derived from multivariate analysis or other statistical techniques. It should be recognized that the results of these analyses are subject to uncertainty in the reported estimates.

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Note:

This paper is an update of Baldwin and Gu (2008a).

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Abstract

This paper provides an overview of the productivity program at Statistics Canada and a brief description of Canada's productivity performance. The paper defines productivity and the various measures that are used to investigate different aspects of productivity growth. It describes the difference between partial productivity measures (such as labour productivity) and a more complete measure (multifactor productivity) and the advantages and disadvantages of each. The paper explains why productivity is important. It outlines how productivity growth fits into the growth accounting framework and how this framework is used to examine the various sources of economic growth. The paper briefly discusses the challenges that face statisticians in measuring productivity growth. It also provides an overview of Canada's long-term productivity performance and compares Canada to the United States—both in terms of productivity levels and productivity growth rates.

Keywords: productivity growth, Canada–United States productivity levels, terms of trade effects

1 Introduction

The productivity program at Statistics Canada produces a range of summary statistics on productivity and an industry database composed of outputs and inputs. The program also produces analysis that provides the public with an understanding of the portfolio of products and background issues. This paper includes an overview of the definitions of productivity and a history of Canadian productivity growth and updates an earlier paper (Baldwin and Gu 2008a) in order to track long-run trends from 1961 to 2012. More detail on productivity measurement can be found in Baldwin and Gu (2013).

2 What is productivity?

Productivity measures the efficiency with which an economy transforms inputs into outputs. Statistics Canada produces summary statistics to capture various aspects of this process.

The least complex are partial measures of productivity—that consider a single input like labour or capital. Labour productivity is measured as gross domestic product (GDP) per hour worked. Capital productivity is measured as GDP per unit of capital.

More complex measures take into account more than one input simultaneously; for example, labour and capital taken together. These are called multifactor productivity (MFP) measures and are measured as GDP per unit of a combined bundle of labour and capital.

MFP measures were devised to allow analysis of the underlying changes in the economy—to allow analysts to better understand the forces that are driving growth than simple partial measures provide. For example, understanding the growth process requires that we understand the sources of labour productivity growth.

Growth in labour productivity is intrinsically of interest because of its close relationship over time with changes in real labour compensation. Of interest is the cause of that growth. Growth in labour productivity may come from applying more capital (machinery and equipment, structures) to the production process or from technological change. And to the extent that the sources of growth from these two sources can be decoupled, the effect of policies that affect these two differentially can be evaluated. MFP measures are used to do just this.

Productivity can be measured either in level or growth terms—as is GDP. But as with GDP, most attention is focused on productivity growth—and a great deal of attention is devoted to comparisons of productivity growth across countries.

3 Why is productivity growth important?[1]

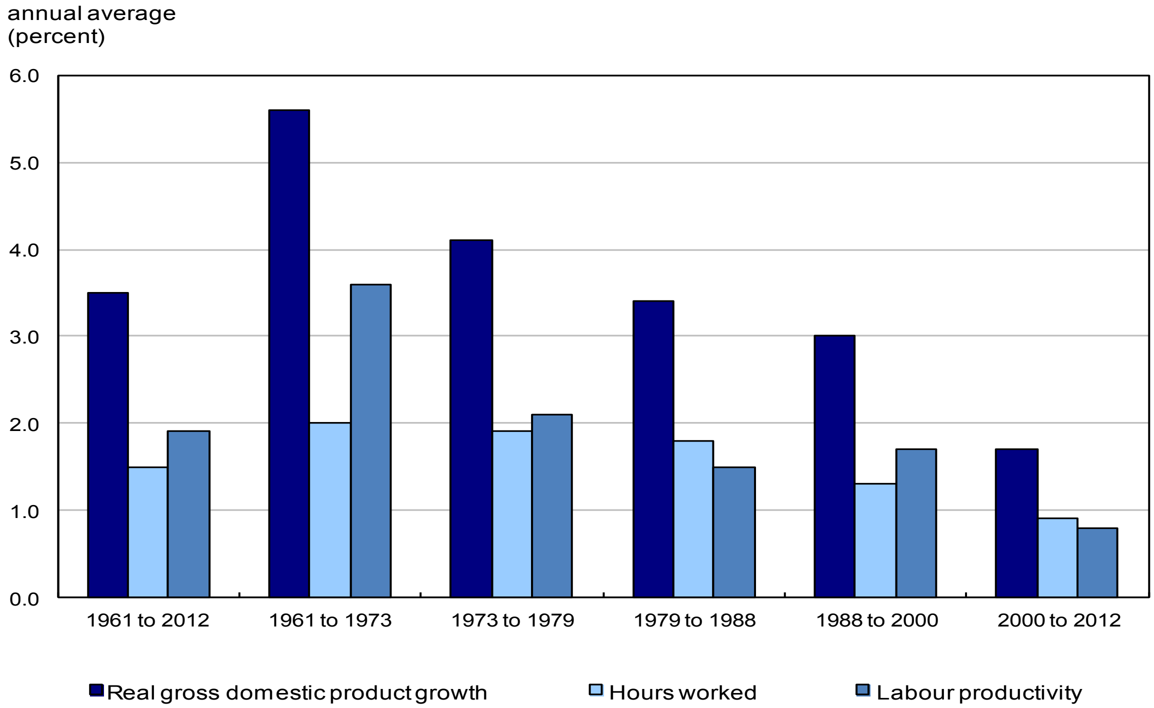
Productivity growth is closely related to growth in our standards of living. Output growth must come either from growth in inputs and/or from growth in productivity. Indeed, this is the principle that underlies the basic method of estimating productivity growth. Productivity growth occurs when the growth in outputs is in excess of that of inputs, such as labour.

Chart 1 contains the average annual growth of real gross domestic product (GDP) in the business sector[2] over the 1961-to-2012 period, as well as its various sub-periods, which reflect different economic cycles. Over the whole period, output growth increased at 3.5% per year on

1. For a more extensive discussion of the issues in this section, see Statistics Canada (2007b).
2. The business sector is the total economy excluding non-commercial activities and the owner-occupied proportion of residential housing.

average. This growth was higher during the 1960s, averaging 5.6% annually. Beginning in the 1970s, output growth experienced a steady slowdown, and averaged 4.1% during the 1970s, down to 3.4% in the 1980s, 3.0% in the 1990s and 1.7% in the 2000s.

Chart 1
Trend in real gross domestic product, labour productivity and hours worked, business sector



Source: Statistics Canada, Canadian Productivity Accounts.

Output growth can be driven by the increase in the resources devoted to production or the efficiency with which these resources are employed. Consider the case of labour input. Output will increase if there are more total hours worked, or if workers produce more per hour worked (if labour productivity goes up):

$$GDP = (GDP / Hours) * (Hours), \quad (1)$$

where *Hours* is the total number of worker-hours.

Chart 1 depicts changes in each of these components over time. For the entire 1961-to-2012 period, labour productivity advanced at a 1.9% annual average, accounting for slightly more than half of the increase in GDP growth. The rest is attributed to hours, which increased at 1.5% per year on average.

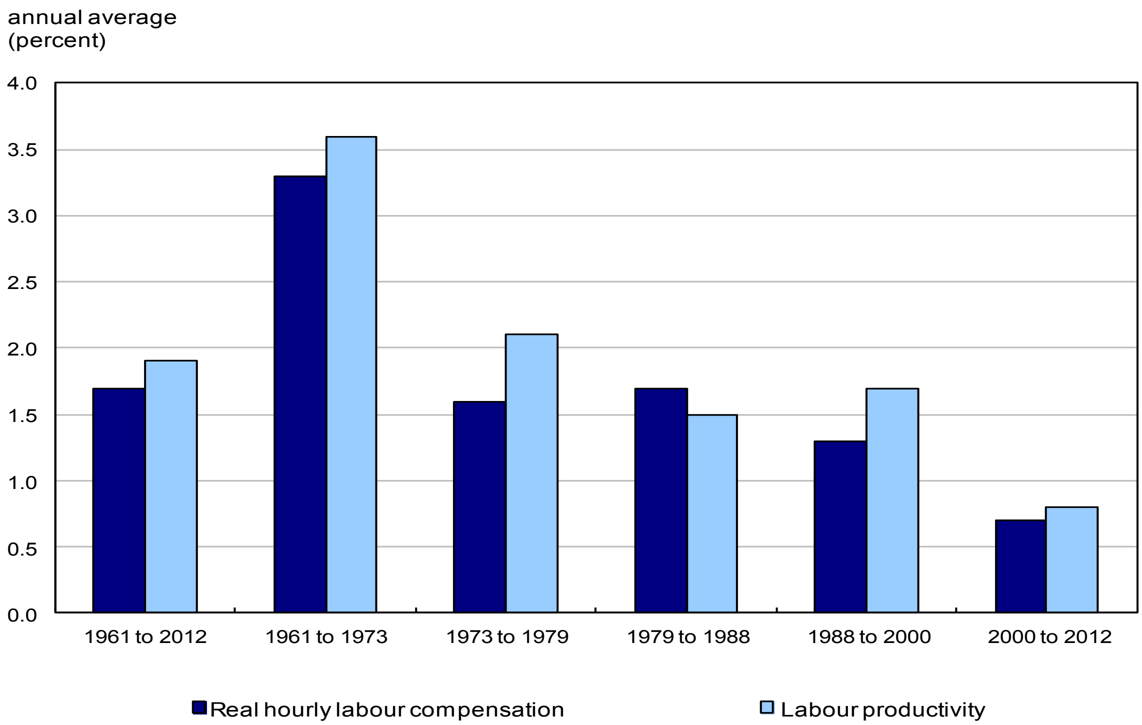
Aggregate GDP measures the returns to both labour and capital. Distributional concerns lead to questions about whether the share going to labour increases over time and, in particular, how productivity growth is related to real income.

It is often claimed that productivity growth raises living standards. But how does this actually come about? The most direct way in which productivity improvements benefit people is by raising their real incomes. If higher productivity means lower costs, and these savings are passed on in lower prices, consumers will be able to purchase goods and services at lower cost.

The increased spending that these higher real incomes allow produces flow-on effects throughout the economy.

To see the relationship, Chart 2 compares the trend in labour productivity and real hourly labour compensation over time.[3] The picture that emerges is that real hourly labour compensation and labour productivity are closely related in the long run. Most of the increase in productivity was passed through to an increase in real hourly labour compensation.[4] The deterioration in labour productivity over time translated into a slowdown in the growth in real hourly labour compensation.

Chart 2
Growth in labour productivity and real compensation, business sector



Source: Statistics Canada, Canadian Productivity Accounts.

4 Where does the growth in labour productivity come from?

Since increases in labour productivity are associated with higher economic growth, higher standards of living and higher real incomes, analysts have investigated the sources of improvements in labour productivity.

There are many reasons behind the growth in labour productivity—increases in the number of machines and amount of equipment available to workers, a higher proportion of skilled workers, increases in plant scale, changes in organizational structure, and improvements in technology.

3. Real hourly labour compensation is derived from the System of National Accounts concept of labour compensation divided by the gross domestic product implicit price deflator for the business sector.
4. See also Baldwin, Durand and Hosein (2001) for a study on how productivity growth at the industry level is passed on to product prices.

The Canadian Productivity Accounts uses the growth accounting framework that has been adopted by the Organisation of Economic Co-operation and Development in its recommendations regarding productivity measurement.[5] The Canadian Productivity Accounts can be used to divide labour productivity growth into the part coming from increases in capital intensity, increases in skill levels of workers (referred to here as a change in labour composition),[6] as well as from all other sources—what is referred to as multifactor productivity (MFP) growth:

$$\Delta GDP / Hours = (\Delta MFP) + S_k * \Delta(Capital / Hours) + S_l * \Delta LC, \tag{2}$$

where $\Delta GDP / Hours$ is the growth in labour productivity, and ΔMFP is the growth in multifactor productivity, S_k is the share of gross domestic product (GDP) accruing to capital; $\Delta(Capital / Hours)$ is the growth in the amount of capital (machines, buildings and engineering structures) available per hour worked; S_l is the share of GDP accruing to labour; and ΔLC is the growth in the measure of labour skills.[7]

Labour productivity can grow as a result of increases in capital intensity per worker. For example, stronger investment in information technology can raise capital intensity. As information technology has become less expensive, firms have substituted information technology for labour and other forms of capital.

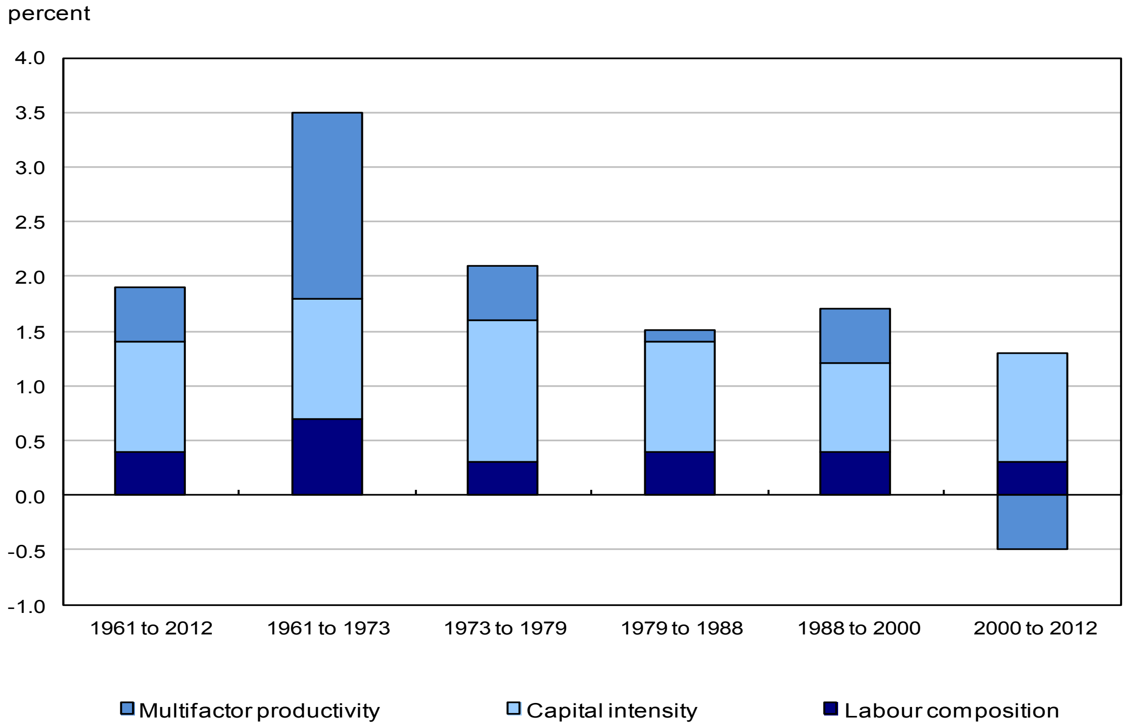
Labour productivity can grow also as a result of an increase in the proportion of skilled workers in the workforce. Upgrading workers' skills through education or increased experience can increase labour productivity. Canadian companies can upgrade their workers' skills through formal schooling, on-the-job experience or retraining.

MFP captures all other effects. It is the residual factor capturing a host of influences—amongst them, changes in technology.

This framework is used to decompose the growth in labour productivity into the proportions that come from increases in capital intensity, labour skill levels, and MFP (Chart 3). Over the period from 1961 to 2012, increases in capital intensity contributed to 1.0% of the 1.9% increase in labour productivity, higher labour skills to 0.4%, and MFP, 0.5%.

5. See http://www.oecd.org/std/productivity-stats/2352458.pdf.
6. See Gu et al. (2003).
7. For a discussion of the growth accounting framework used to generate this formula, see Baldwin and Gu (2007b).

Chart 3
Sources of labour productivity growth, business sector



Source: Statistics Canada, Canadian Productivity Accounts.

The deterioration in labour productivity growth, from the 1960s to the 1970s, resulted primarily from the slowdown in MFP growth, from 1.7% to 0.5%, and, to a lesser extent, a slowdown in the growth in labour composition because of slower growth in skilled labour (from 0.7% to 0.3%). The contribution made by capital intensity increased from 1.1% to 1.3%.

The slowdown in labour productivity, from the 1970s to the 1980s, from 2.1% down to 1.5%, was primarily the result of a decline in the growth in capital intensity, as well as to a decline in MFP performance.

Labour productivity performance in the 1990s reflected a turnaround in MFP growth. The contributions of capital intensity and labour composition have remained virtually unchanged since the 1980s.

The post-2000 period has seen a further decline in labour productivity growth. This decline resulted from a decline in MFP growth. The decline in MFP growth accounted for almost all the decline in labour productivity growth, from the 1988-to-2000 period to the 2000-to-2012 period.

5 Producing summary productivity statistics: what are the problems?

5.1 With the concepts?

The Canadian Productivity Accounts produce several different measures of productivity growth. While partial productivity measures are relatively simple to understand, they have been surpassed in the world of practical analysis by the more complex multifactor productivity (MFP) measure. While this has now become the standard among experts,[8] the MFP is an analytic construct, and is derived using specific assumptions regarding the nature of the economy. Being an analytic construct, the concept of MFP is more difficult for the average user of Statistics Canada's products to understand. And the assumptions embedded in the growth accounting framework mean that its validity, in the eyes of some users, relies on their acceptance of these assumptions.

The Canadian Productivity Accounts have responded to these issues by providing detailed descriptions of the methodology used in developing the measures,[9] and by examining the extent to which alternate approaches yield significantly different measures of MFP growth.[10]

The second major problem with MFP estimates is that they capture what we cannot explain: they are a residual calculated after other measurable factors have been taken into account. To some analysts, this is not a problem, since they want a measure of the externalities that are bestowed on an economy by disembodied technological progress. But, even here, guidance is needed on the factors underlying this component: changes in plant scale or production-run-length economies, firm reorganizations relating to offshoring and outsourcing, new technologies, intangible capital. To meet demands in this area, Statistics Canada has responded with studies using business microdata in each of these areas.[11]

5.2 With measurement?

In an economy as large and diverse as that of Canada, it is a Herculean task to calculate a summary statistic for productivity that, in 2012, summed up the efforts of 17.9 million workers, employed in thousands of establishments that produce about $1.8 trillion in output. Statistics Canada does these calculations in its productivity program, which uses an integrated set of data sources produced by the System of National Accounts.

Statistics Canada produces productivity statistics as part of a regular production program. It is not something done as an occasional research exercise, as it is in many other countries. The production process for the Canadian Productivity Accounts is embedded within the System of National Accounts. The Canadian Productivity Accounts play an important role as an integrator of data from different sources within the agency.

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8. See The Economist (2004).
9. See *Productivity Growth in Canada*, Catalogue no. 15-204, and the various publications in the Canadian Productivity Review series, Catalogue no. 15-206.
10. Baldwin, Gaudreault and Harchaoui (2001) examine the use of parametric as opposed to non-parametric techniques. Baldwin and Gu (2007a) examine the impact of using alternate techniques of estimating the cost of capital when deriving estimates of capital services. Statistics Canada (2007c) examines the impact of alternate depreciation rates.
11. See Baldwin and Gu (2013, 2008b, 2006), Gu and Wang (2013), Baldwin, Gu and Macdonald (2010, 2012a, 2012b), Baldwin and Yan (2014), Baldwin and Gellatly (2007), Macdonald (2008). This and other papers can be found in the Economic Analysis (EA) Research Paper Series, the Analytical Studies Branch Research Paper Series and The Canadian Productivity Review, and are summarized in the Update on Economic Analysis section on Statistics Canada's website.

Statistics Canada's integrated national accounts provide the foundations on which the productivity accounts are based. Because they are integrated across several dimensions—from the demand side, from the income side, and from the industry accounts—along with detailed input–output tables, there is a solid foundation on which to build the productivity accounts. For example, estimates of productivity using the demand side are reconcilable to those coming from the industry side.

The Canadian Productivity Accounts puts together an integrated set of data on outputs, inputs, labour and capital contributions to the production process. Statistics Canada's Productivity Accounts first build off an integrated set of production accounts, generating gross domestic product from final demand and, at the industry level, with one set of integrated, coherent accounts. The Productivity Group takes this integrated set of accounts and produces a set of estimates of labour services and capital services that are coherent with the output estimates. For example, on the labour side, the Productivity Group chooses amongst various data sources; e.g. household versus employer surveys, which each give different estimates of labour inputs. The group then ensures the boundaries of the labour sources agree with the boundaries of the industry data, and produces a set of labour inputs (by estimating jobs and hours-worked separately and then multiplying them together). In the case of capital services, the group takes investment data from a survey of investment, reconciles and modifies them to accord with the boundaries of the System of National Accounts, and estimates capital services that make use of rates of return that are derived from the System of National Accounts estimates of profits, or from the surplus taken from the input–output tables.

Statistics Canada's productivity program also provides quality assurance across all input sources by improving the overall coherence of these products. Analysis in the productivity program, as is the case elsewhere in the National Accounts, is an extension of the particular nature of the production process. The production process in the Canadian Productivity Accounts combines data from different sources. To construct official data series, this production process confronts data from one source (for example, industry value-added) with data from another (for example, labour inputs). In the end, this comparative process serves to bring a variety of sources into coherence with one another. Data that are generated from production surveys are subject to both response and non-response errors. By examining how one series compares with another (for example, how employment estimates from the Labour Force Survey compare with those from the Survey of Employment, Payroll and Hours), analysts in the Productivity Accounts can assess whether the survey error in one or the other data source is unusually large in one period. If so, analysts can adapt the estimate that is most appropriate for the creation of a time series that is not only consistent over time, but is also coherent with the other data that are being used in the estimates of productivity.

The Productivity Accounts develop and maintain a large database in support of the productivity program—what some refer to as the KLEMS (Capital, Labour, Energy, Materials and Services) database. KLEMS integrates time series data on gross output, materials inputs, service inputs, energy purchases, labour, investment and capital. Each of these data series is calculated in both nominal dollars and in real (constant) dollars. Price indices are collected for each of these series. Finally, KLEMS classifies these series using four different levels of aggregation—corresponding to the S, M and L levels used in Statistics Canada's Input–Output Accounts.

6 International productivity comparisons

Data that may be fit for one purpose—that meet acceptable quality standards in one area—may not be fit for others. And statistics may be developed for one purpose, but users may begin to employ them for other purposes, for which they were not designed and for which they may be less than ideal.

The evolution of the Canadian productivity program provides an example of just such a transition. Statistics Canada's productivity accounts were originally developed to provide information on productivity *growth rates* in Canada—first with regard to labour productivity and then to multifactor productivity (MFP) (what academics often refer to as total factor productivity). In a world of increasing globalization, user demand for international comparisons has increased. Providing estimates for international comparisons that meet acceptable quality standards poses particular challenges.

The productivity program at Statistics Canada initially focused on providing information products that compare Canada–United States productivity *growth* rates, choosing U.S. estimates that are closest to the Canadian ones. Despite differences between the two countries in sources used, these differences remain sufficiently stable over time that they generally do not provide a major problem for comparisons of Canada–United States *growth* rates.

But the summary statistics produced by the official productivity programs of the two countries turn out to be less than ideal for analyzing differences in productivity levels. Analysts have used data that are employed in the growth programs to generate cross-country comparisons of levels.

While the data that were being used for this purpose were not generated for purposes of estimating differences in levels, statistical agencies have to respond to users' needs since *relevance* is an important aspect of quality of product.

In Canada, users have requested guidance on the quality of comparisons of Canada–United States productivity levels. Statistics Canada has produced a set of studies examining alternatives that can be used to estimate the level of relative productivity—both labour productivity and MFP. Statistics Canada found that, despite the relative similarity in the statistical systems of the two countries, improved harmonization of data sources and methodology was required to produce better estimates of the relative level of Canada–United States productivity.

Studies have pointed out several problems with many previous attempts to compare Canada–United States levels of labour productivity.[12] First, at times, studies were not using measures of gross domestic product (GDP) that were comparable. GDP is measured at market prices, at basic prices, and at factor cost. And the level of GDP that is produced by these estimates can vary by up to 16%. Second, comparisons of levels of GDP across countries need to take into account differences in price levels, if relative values of output are to be transformed into relative levels of real output. For this purpose, purchasing power parities (PPPs) are necessary, and the existing PPPs are sufficiently imprecise as to produce estimates of relative levels of output with quite large confidence intervals around them. Finally, and most importantly, obtaining accurate estimates of relative labour input provides particular challenges. Differences exist in the way that labour input is calculated in the official productivity programs of both countries. These differences have led to a substantial downward bias in the relative Canadian level of labour productivity, when it is derived from the 'official' sources of labour productivity from each country. The estimate of total hours worked comes from the product of the number of jobs and the number of hours worked per job. The estimate of hours worked per job that is derived from a labour force (household) survey is generally higher than that derived from an employer survey.

12. See Baldwin et al. (2005) and Maynard (2007b).

The Canadian productivity program relies on the former while the U.S. productivity program relies on the latter. When comparable sources are used for both countries (whether they be household or employer surveys), the relative labour intensity in Canada increases by between 5% and 10%, relative to the estimate derived from each country's official estimates used in their productivity growth programs.

While there are fewer problems with comparisons of productivity growth rates than levels, Statistics Canada also provides guidance on comparisons of productivity growth rates. One study focused on quantifying the confidence intervals that should be applied to estimates of the growth rates of GDP that are used in estimating both labour productivity and MFP (Baldwin and Hachaoui 2001). Another quantified the effect of using alternative methods on the estimates of capital services and MFP growth in the business sector (Baldwin and Gu 2007a). A third (Baldwin and Gu 2013) asks whether using different levels of industry detail affect Canada–United States comparisons of MFP growth rates.

7 Canada–United States levels

The debate about Canada's productivity gap often revolves around its contribution to a gross domestic product (GDP) per capita gap. GDP per capita differences between Canada and the United States can be examined using the following identity:

$$GDP / POP = (GDP / HRS) * (HRS / EMP) * (EMP / POP) \quad (3)$$

This identity decomposes relative GDP per capita $(GDPCAP)$ into the product of relative labour productivity (GDP / HRS), relative effort (the hours worked per job [or per employee]), and the relative per capita employment rate (the ratio of the number of employees [or jobs] to the total population). The equation can be rewritten in the following manner:

$$GDPCAP = PROD * EFFORT * EMPRATE \quad (4)$$

The amount available for consumption per person in a country $(GDPCAP)$ will be higher when productivity $(PROD)$ is higher, when employees work longer hours (what is referred to here as $EFFORT$), and when a larger proportion of the population is employed $(EMPRATE)$. The variables $EFFORT$ and $EMPRATE$ can also be grouped together in a variable that captures the number of hours worked per capita.

Over the period from 1981 to 2012, the level of GDP per capita in Canada averaged only 84.5% of GDP per capita in the United States (Chart 4). In other words, the output gap in favour of the United States was 15.5% in terms of GDP per capita. But the gap between Canada and the United States in labour productivity was much less—at only 10.1% of the U.S. productivity level. This means that the average difference in labour productivity over this period accounted for 65% of the total percentage-point difference in the GDP per capita of the two countries. That is, if work intensity was the same in the two countries, around one third of the difference in GDP per capita would disappear. Over this period, hours worked per capita in Canada were only 94% of the hours worked per capita in the United States.

When this relative GDP per capita is decomposed into the three components mentioned earlier, substantial differences between Canada and the United States can be found in each of the two former areas. Over the period from 1981 to 2012, hours worked per job in Canada was only 96.2% of hours worked per job in the United States. Jobs per potential member of the labour force (population older than 15) in Canada averaged 95.7% of the U.S. job rate. The relative Canada–United States labour force ratios—the number of individuals who are older than 15 divided by the total population—averaged 102.2% over the entire period. This reflects the fact that the population is older on average in Canada than in the United States. This ratio has continuously increased over time, moving from 100.0% in 1994 to 104.0% in 2012.

Chart 4
Canada–United States relative gross domestic product per capita, labour productivity, and work intensity, for the total economy

Sources: Statistics Canada, Canadian Productivity Accounts and CANSIM table 051-0001; and Bureau of Economic Analysis, National Income and Product Accounts.

8 Levels of multifactor productivity

In order to understand the factors that drive differences in levels of labour productivity between Canada and the United States, additional work is required to derive estimates of relative volume of inputs other than labour. The most important element required for transforming relative labour productivity into relative multifactor productivity (MPF) is an estimate of relative capital intensity. Once again, data sources and methodology, both in Canada and the United States, need to be harmonized. Perhaps the most important choice here is that of depreciation estimates—since capital is estimated as the sum of past investments minus the depreciation that has taken place.

Canada and the United States do not use exactly the same depreciation estimates—though both countries employ used asset prices to estimate the rate at which investments in new assets decline in value (i.e., depreciate) over time. Canada has a comprehensive set of price data that are associated with its investment survey. The United States makes use of a myriad of sources (trade data) to estimate its depreciation rates. The resulting estimates for Canada and the United States differ slightly for machinery and equipment, and more for buildings and engineering structures.[13]

13. Canada also has estimates of expected length of life that it uses to confirm the estimates it derives from used asset price data. See Statistics Canada (2007c).

There are differences between Canada and the United States with respect to the importance of different types of physical capital. Despite the attention that is paid to machinery and equipment, they account for no more than 25% of total capital in Canada in 1999. In contrast, buildings account for over 55%.

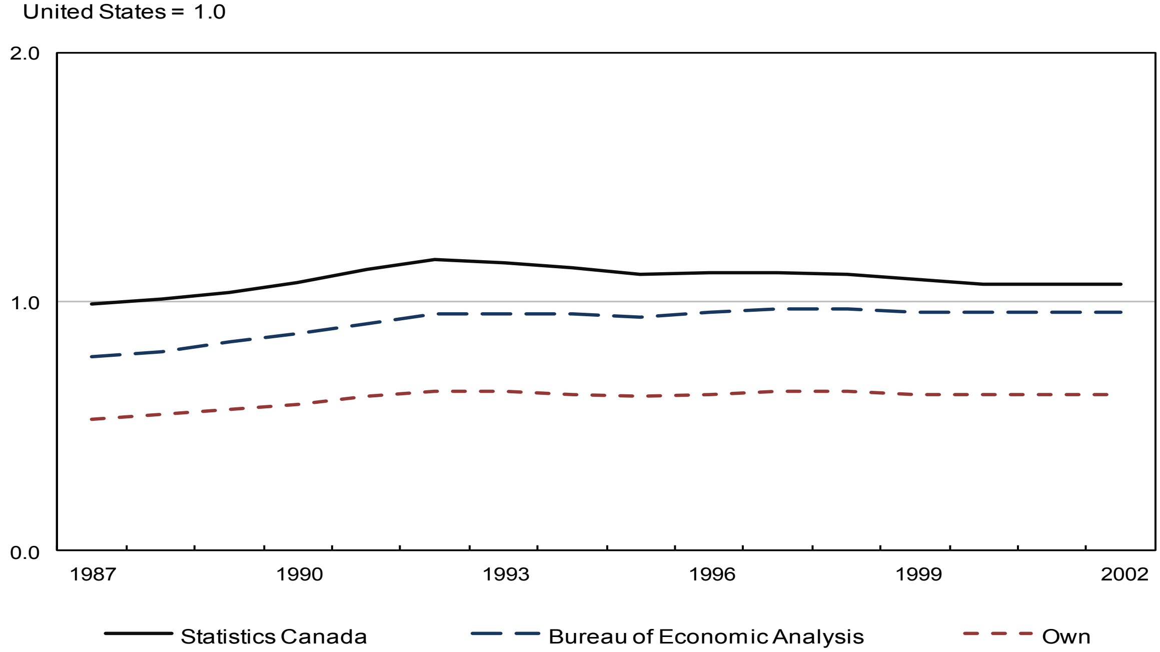
Large amounts of capital are also devoted to engineering construction in Canada. In fact, at 20%, the share of engineering construction is almost as large as that of machinery and equipment. These assets underpin the utilities sector, pipelines, railways, airports, communications, and the oil and gas sector.

As previously discussed, capital stocks in both countries are the accumulation of these investments over time, which are summed using the perpetual inventory method. However, if different service lives and different depreciation rates are used to compare Canada and the United States, the relative level and trend may be distorted. Thus, previous comparisons of capital intensity between Canada and the United States, using unadjusted depreciation rates, may partly reflect different methodologies. Depreciation rates in the United States that are used by the Bureau of Economic Analysis (BEA) are sometimes lower than those used in the Canadian productivity program, particularly in engineering structures and in building structures.

Differences in the ratio of capital to gross domestic product (GDP) are provided in Chart 5 using the depreciation rate of Statistics Canada, that of the Bureau of Economic Analysis, and that based on the each country's respective depreciation rates. The line labeled 'Own' depicts the course of the total capital-to-GDP ratio if we use the productivity estimate from the Canadian productivity program and the BEA productivity program. Chart 5 also contains the capital–output ratios using common depreciation rates (either Canadian or U.S. rates) to produce capital stocks for both countries. Using common rates raises Canada's relative capital intensity. We first apply BEA depreciation rates to the Canadian stock, and compare capital intensities between the two countries. Based on common BEA depreciation rates, Canada's relative capital intensity becomes higher than that based on its 'own' depreciation rates. To undertake a sensitivity analysis, we also apply Statistics Canada's depreciation rates, used in its productivity program, to BEA capital stocks. Interestingly, Canada's relative capital intensity rises further with Statistics Canada's depreciation rates.[14] Thus, the magnitude of the difference between Canada's capital intensity and the U.S. capital intensity is also sensitive to the choice between BEA and Statistics Canada depreciation rates.

14. These results apply to all asset types in both 1997 and current dollars.

Chart 5
Canada's total capital stock intensity relative to the United States, business sector (in 1997 dollars)



Note: "Own" is calculated using the depreciation rates from both sources mentioned below.
Sources: Statistics Canada, Canadian Productivity Accounts; and Bureau of Economic Analysis, National Income and Product Accounts.

However, an examination of capital-to-GDP ratios by asset class reveals substantial differences (Chart 6). Canada's engineering capital-to-GDP ratio is higher than that of the United States, and has been growing relatively larger over time.[15] Building capital intensity is slightly higher in the early 1990s, but has fallen behind recently. Machinery and equipment (M&E) was about the same in the early 1990s but, it too, has fallen slightly behind.[16]

The evidence on relative capital intensity can be used to generate a measure of the relative value of capital services and then, combined with the level of relative labour productivity, to generate a measure of the relative MFP in Canada, as opposed to the United States (see Table 1). The aggregate level of MFP in the Canadian business sector was 80.3% of that of the United States in 1999. The aggregate level of labour productivity in the Canadian business sector was 84.2%.[17]

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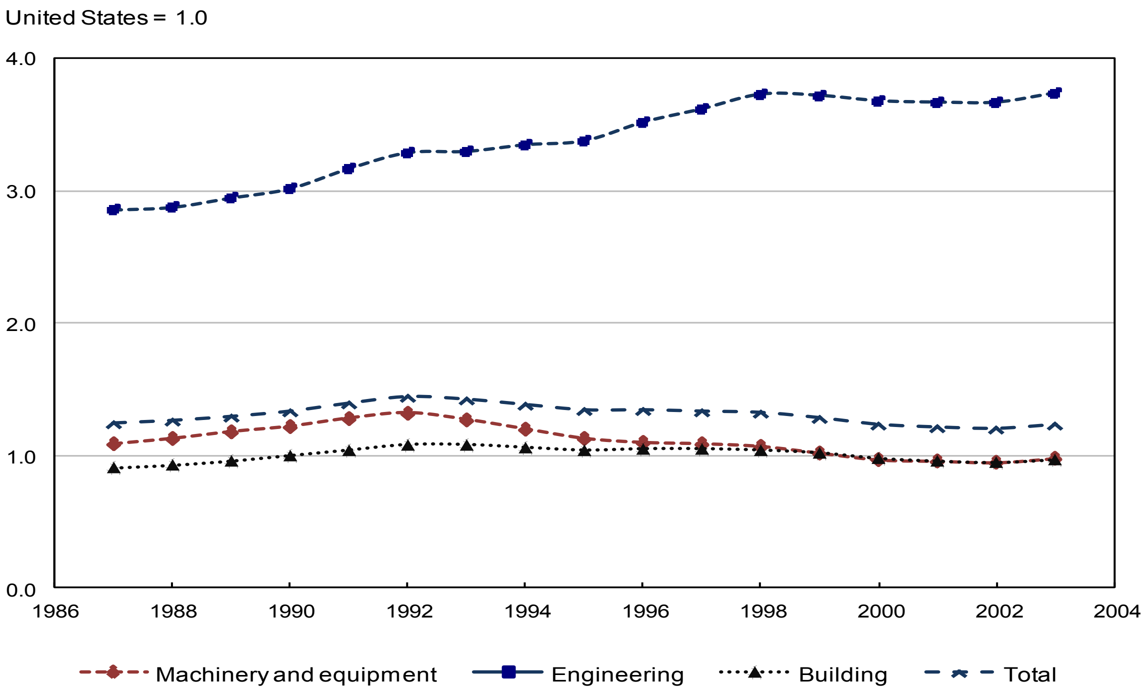
15. This trend has been ongoing for a long time. Baldwin and Gorecki (1986) report that, in manufacturing, the Canadian/U.S. ratio of machinery and equipment was relatively stable between 1961 and 1979, but structures and engineering have increased in relative terms.
16. These differentials have been updated using investment data which show broadly the same trends (Baldwin, Liu, and Gu 2014).
17 The difference in the level of labour productivity in the business sector is larger than the difference in the total economy, as shown in Chart 4. For the total economy, the level of labour productivity in Canada was more than 90% of that in the United States in 1999.

Table 1
Relative Canada–United States productivity levels for the business sector

Business sector	1999
	percent
Labour productivity levels	84.2
Multifactor productivity levels	80.3

Sources: Statistics Canada, Canadian Productivity Accounts; Bureau of Economic Analysis, National Income and Product Accounts; and Bureau of Labor Statistics, Productivity Statistics.

Chart 6
Canada's total capital stock intensity relative to the United States, business sector, using Statistics Canada's depreciation rates (in 1997 dollars)



Sources: Statistics Canada, Canadian Productivity Accounts; and Bureau of Economic Analysis, National Income and Product Accounts.

Labour productivity differences between Canada and the United States have been decomposed into contributions from MFP and capital intensity (Table 2). MFP and M&E were the main contributors to the lower level of labour productivity, in Canada, relative to that in the United States. The ratio of buildings and engineering structure capital to labour was higher in Canada, reducing the gap in the relative level of Canadian labour productivity. The results (Table 2) show that the aggregate level of labour productivity in the Canadian business sector was 15.8% behind that of the United States, in 1999. The lower level of MFP in Canada lowered the relative level of labour productivity in Canada by 19.7%. The lower level of the M&E capital–labour ratio lowered the relative labour productivity in Canada by 3%, while the higher level of the structure capital–labour ratio increased Canadian labour productivity by 9%. Differences in MFP account for the majority of the differences in the level of labour productivity.

Table 2
Sources of Canada–United States labour productivity differences in the business sector, 1999

	Labour productivity	Contributions of		
		Multifactor productivity	Material and equipment per hour	Structure per hour
	percent			
Business sector	-15.8	-19.7	-3.0	9.0

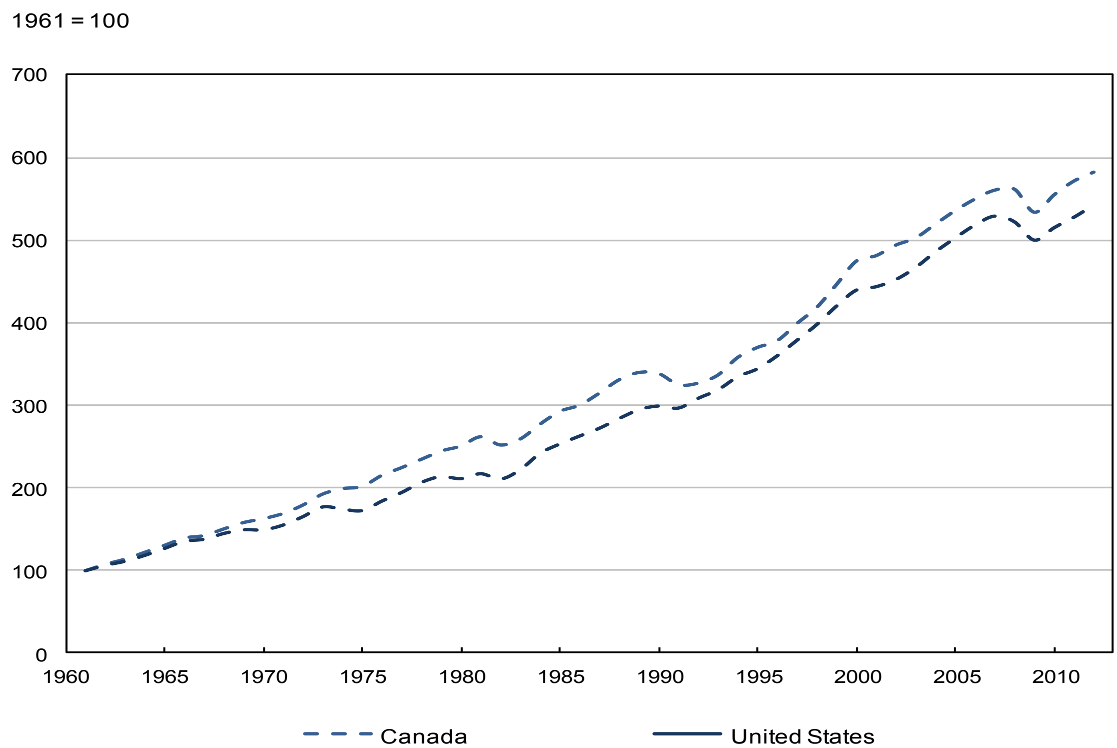
Sources: Statistics Canada, Canadian Productivity Accounts; Bureau of Economic Analysis, National Income and Product Accounts; and Bureau of Labor Statistics, Productivity Statistics.

9 Long-term trends

The estimates of the level of Canada–United States productivity can be combined with long-run trends in growth rates to generate a picture of differences in the growth process in the two countries.

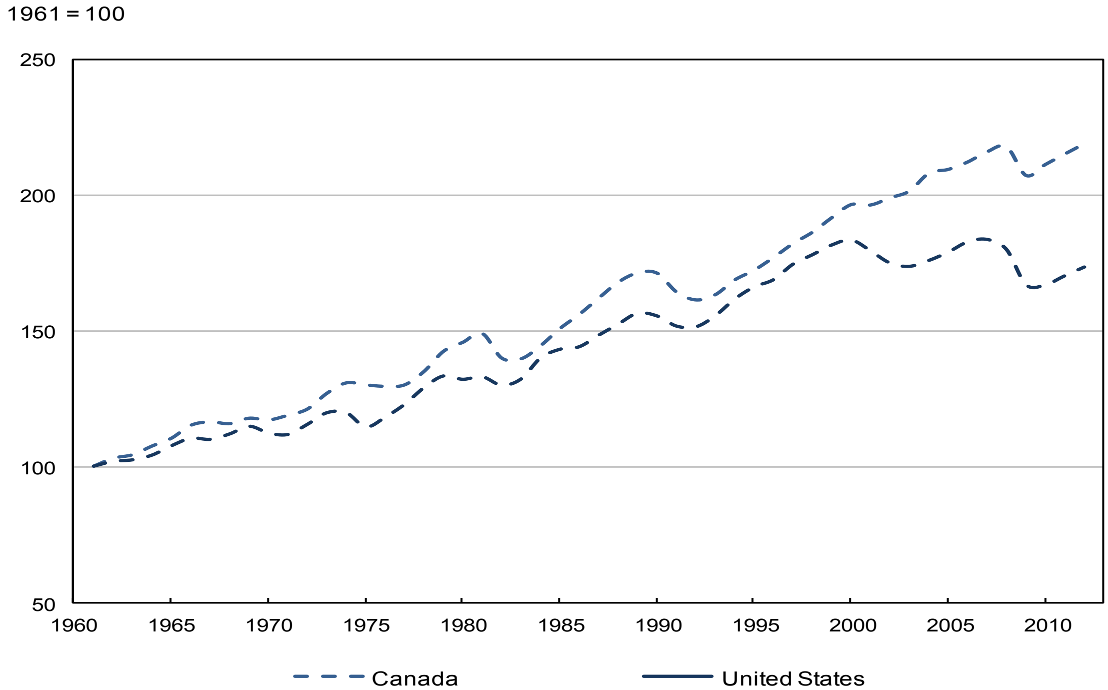
The cumulative growth in business-sector gross domestic product, labour inputs and labour productivity, over the post-1961 period, are presented in Charts 7, 8, and 9 respectively—with 1961 being set equal to 100 in both countries.

Chart 7
Real gross domestic product trend, business sector



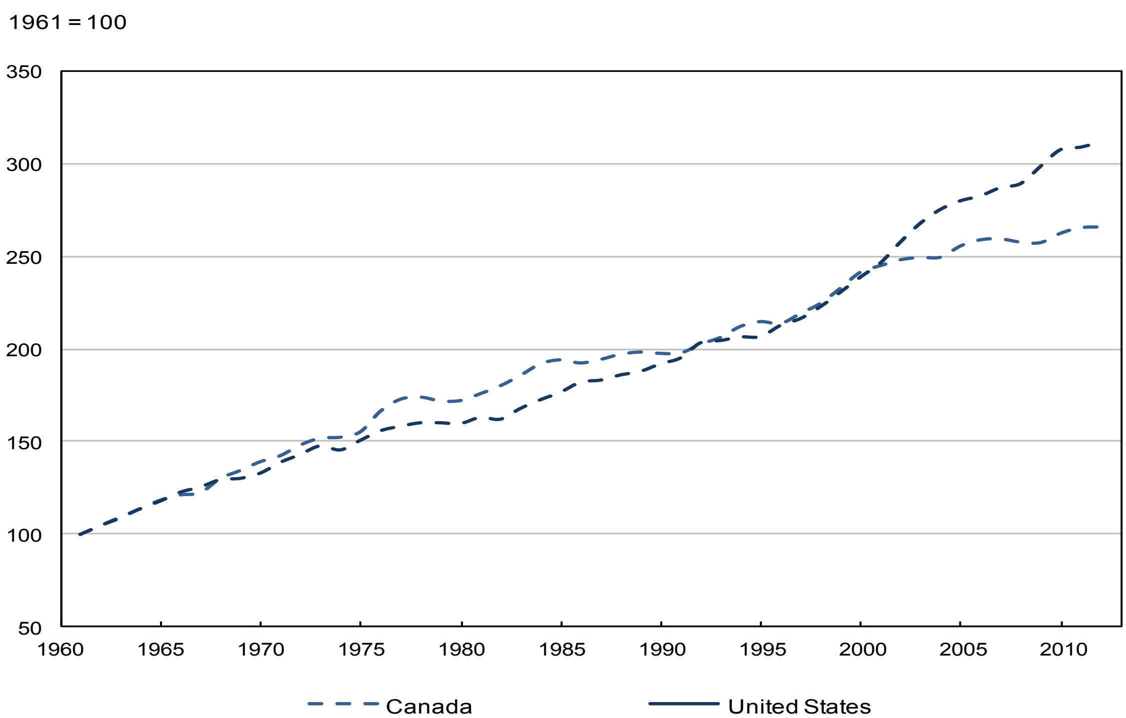
Sources: Statistics Canada, Productivity Program; and Bureau of Labor Statistics, Productivity Statistics.

Chart 8
Hours worked, business sector



Sources: Statistics Canada, Productivity Program; and Bureau of Labor Statistics, Productivity Statistics.

Chart 9
Labour productivity trend, business sector

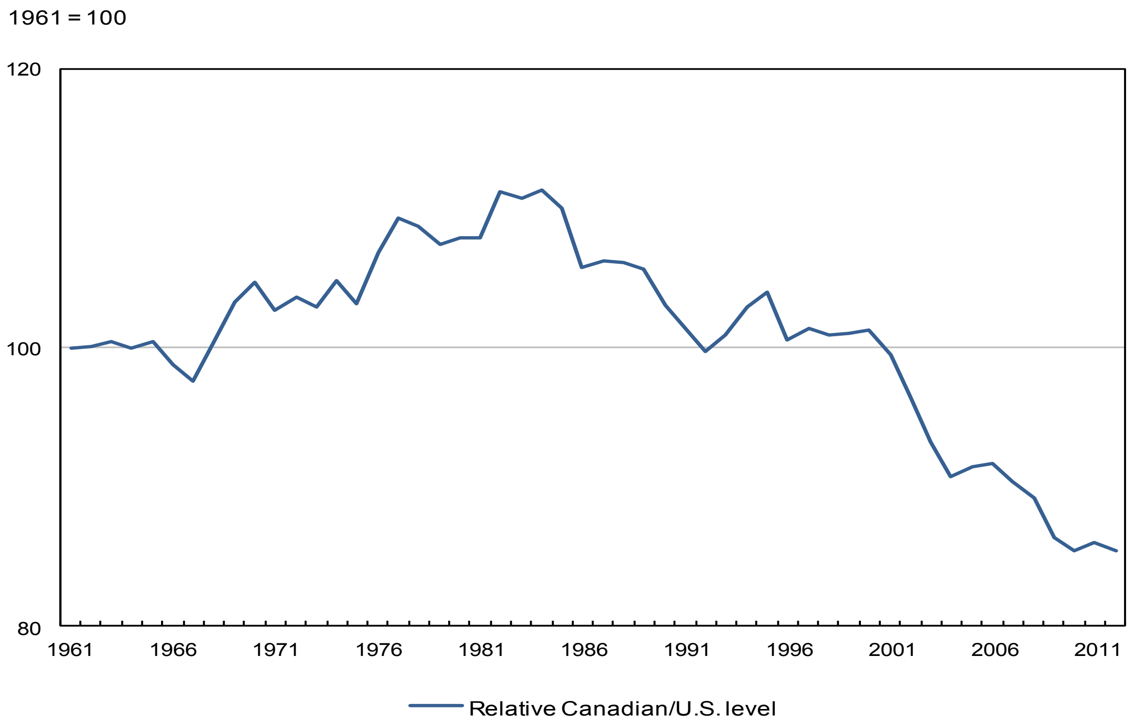


Sources: Statistics Canada, Productivity Program; and Bureau of Labor Statistics, Productivity Statistics.

Canadian output growth exceeded that in the United States in the 1970s, kept up with the U.S. output growth in the 1980s, experienced a greater slowdown in the early 1990s, and then broadly paced that of the United States in the 1990s and 2000s (Chart 7). In contrast, labour input grew at a more rapid pace in Canada than in the United States in most decades, with the largest divergences occurring after 2000.

Labour productivity grew more quickly in Canada during the earlier period, reaching a zenith around 1985, coming back to the same relative level around 1990, staying the same throughout the 1990s and, since then, falling behind (see Chart 10).

Chart 10
Relative Canada–United States labour productivity level in the business sector, 1961 to 2012

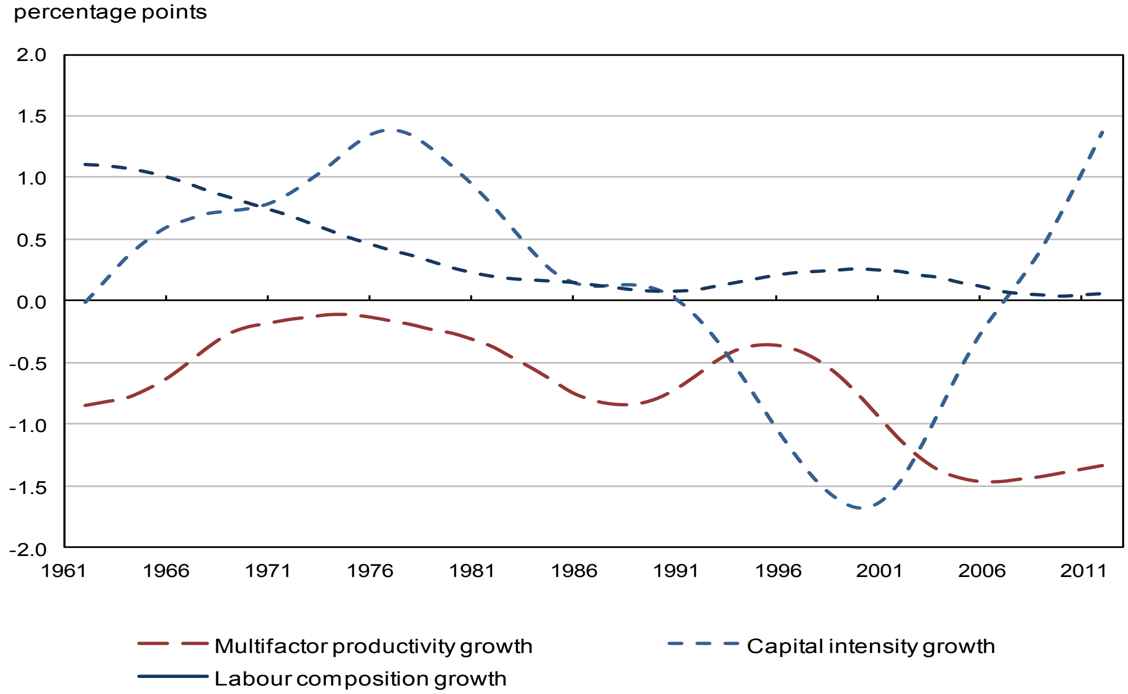


Sources: Statistics Canada, Productivity Program; and Bureau of Labor Statistics, Productivity Statistics.

The differences in labour productivity performance can be decomposed using the growth accounting framework into differences in multifactor productivity (MFP) growth, differences in the growth in capital intensity, and differences in skill upgrading (what the growth accounting framework refers to as changes in the composition of labour).[18] Chart 11 tracks the relative difference in each of these components.

18. For further details, see Statistics Canada (2007a).

Chart 11
Trend in Canada–United States difference in growth of multifactor productivity, capital intensity and labour composition, business sector



Sources: Statistics Canada, Productivity Program; and Bureau of Labor Statistics, Productivity Statistics.

The following conclusions can be drawn. The Canada–United States labour productivity growth gap in favour of the United States, over the period from 1961 to 2012, owes much to the MFP growth gap, which existed throughout the period. Over the period from 1961 to 2012, annual labour productivity growth in the Canadian business sector was slightly, but not significantly, lower (0.3 percentage points) than in the U.S. business sector. The annual MFP growth in Canada was 0.7 percentage points lower than in the United States (Baldwin and Gu 2014).

The investment gap varied across the entire period. Early in the period, the contribution of capital deepening to business sector productivity growth was higher in Canada than in the United States. After the mid-1980s, Canada's rate of growth in capital intensity fell behind but then moved ahead. Over the entire period the increase in capital deepening was about the same and did not contribute to the gap in labour productivity growth.

The contribution of labour composition to business sector labour productivity growth was higher in Canada than in the United States, over much of the period from 1961 to 2012—though the advantage declined later in the period. Over the period from 1961 to 2012, a more rapid shift towards more educated and more experienced workers occurred in Canada, which raised the labour productivity growth by 0.4 percentage points per year in the Canadian business sector, relative to that of the U.S. business sector. Therefore, this component did not contribute to the gap in labour productivity growth either.

10 Setting productivity in perspective[19]

Summary statistics relating to productivity indicate how efficiently an economy is transforming its inputs into output. But they are far from comprehensive in terms of delineating how well off Canadians are.

Evaluations of an economy's productivity performance are made using a measure of real gross domestic product (GDP), which represents the constant dollar income (labour income plus profits) that an economy generates through domestic production, with the volume or constant dollar indices being calculated from the prices of domestic goods and services produced.

This measure does not account for who receives the income (domestic or foreign residents), how much capital is used up through production, or how relative price shifts of exports versus imports (terms of trade) affect the volume of goods and services that can be purchased with the income.

Modifications can be made to traditional estimates of GDP to account for these factors. The performance of the Canadian economy can also be examined using the resulting alternate measures—gross domestic income (GDI), gross national income (GNI) and net national income (NNI).

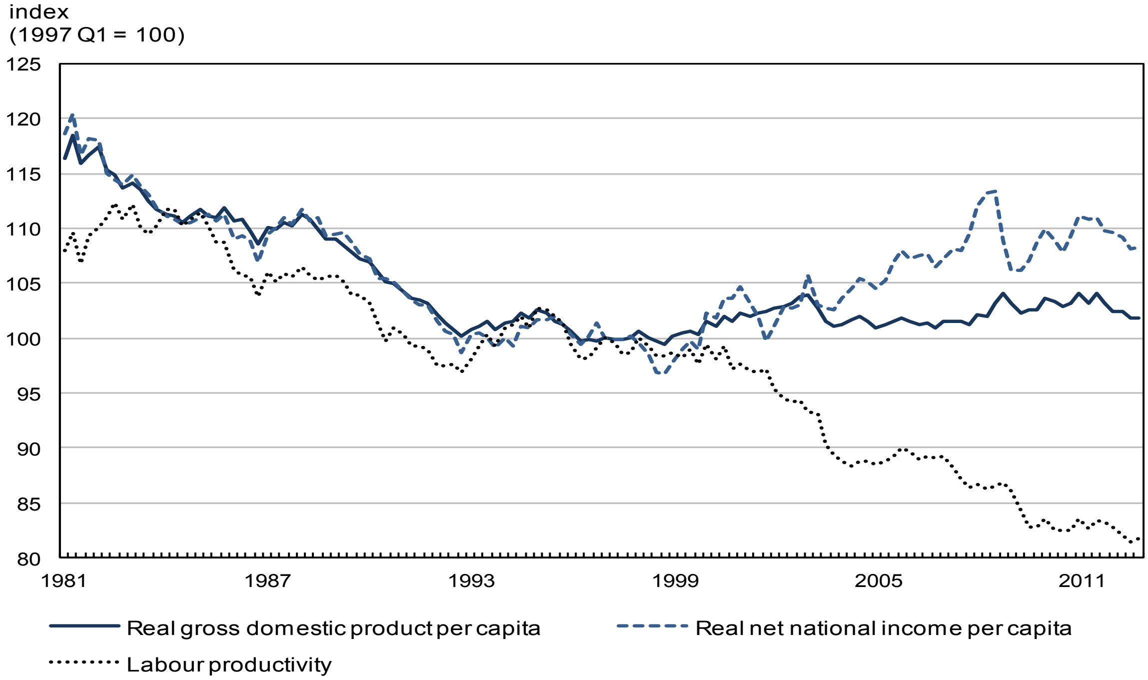
When the concept of real income is widened to include changes in the purchasing power of earned income, the relevant measure is real GDI. Changes in purchasing power come from changes in relative prices of exports and imports—one of which is the terms of trade.

Real GDI is a constant dollar measure of the purchasing power of income generated by domestic production in Canada, taking into account changes in the relative levels of import and export prices. However, Canadians invest abroad and foreigners invest in Canada. As a result, not all of the incomes earned in Canada accrue to Canadians, and some of the income earned in other countries is owed to Canadians. When these international income flows are combined with real GDI, the resultant real income aggregate is real GNI.

For purposes of comparison, measures of real GDP per capita and real GNI per capita, in Canada relative to the United States, are presented in Chart 12. In real terms, the Canadian economy lagged behind the U.S. economy prior to 2000, as relative GDP per capita and relative GNI per capita fell about 18 percentage points over the 1980s, and then leveled off in the 1990s. Through the 2000s, relative real GDP per capita then increased slightly, while relative real GNI increased by around 7 percentage points. Relative productivity also declined—falling in the 1980s, pausing in the 1990s and then resuming its decline after 2000. The difference between GDP and productivity growth, after 2000, occurred because the Canadian labour market was much more buoyant than the U.S. labour market. Hours worked per capita increased more rapidly in Canada than in the United States—driven by a much larger increase in number of jobs per capita.[20]

19. For further discussion of this issue, see Macdonald (2007).
20. See Maynard (2007a).

Chart 12
Economic performance of Canada relative to the United States, quarterly estimates



Note: Real gross domestic product and real net national income per capita are for the economy as a whole while labour productivity is for the business sector. 1997 Q1: first quarter of 1997.
Sources: Statistics Canada, Productivity Program and Canadian System of National Accounts; and Bureau of Economic Analysis, National Income and Product Accounts.

In the period before 2002, all of the measures indicate a long-term decline in the relative performance of the Canadian economy after 1981. However, this changed with the commodity boom that Canada has experienced since 2000. Prices of exports also increased relative to the prices of imports. Canadian receipts of income from abroad increased dramatically relative to payments abroad. The joint effect of these events has led to an increase in real income growth in Canada relative to its GDP growth. And this also has affected Canada–United States comparisons. Canada had a strong terms-of-trade improvement post 2000, due to rising commodity prices, an appreciating currency, and falling world prices for manufactured goods that contributed greatly to real income growth. The U.S. measures of real income were much less affected by trading gains.

As a result, comparisons of the relative per capita performance of the two countries hinges crucially on whether or not the terms of trade and international income flows are incorporated into the analysis. If the terms of trade are excluded, and relative real GDP per capita growth (or relative productivity growth) is the focus, Canada's economic performance seems to lag that of the United States, from 2002 to 2012. From 2000 to 2012, U.S. labour productivity grows 31.6%, while Canadian labour productivity rises 9.5%. Once changes in labour markets, resource prices, the exchange rate and international investment income are taken into account, real income per capita in the United States increases by 11.0%, which is similar to the 10.6% growth in real GDP per capita. However, the Canadian adjusted measure of real income per capita growth rises 17.4%, about twice labour productivity growth in Canada and 6.5 percentage points more than real GNI per capita growth in the United States.

References

Baldwin, John R., René Durand, and Judy Hosein. 2001. "Restructuring and Productivity Growth in the Canadian Business Sector." In *Productivity Growth in Canada*. Statistics Canada Catalogue no. 15-204-X. Ottawa: Statistics Canada.

Baldwin, John R., Valérie Gaudreault, and Tarek M. Harchaoui. 2001. "Productivity growth in the Canadian manufacturing sector: A departure from the standard framework." In *Productivity Growth in Canada.* Statistics Canada Catalogue no. 15-204-X. Ottawa: Statistics Canada.

Baldwin, John R., and Guy Gellatly. 2007. *Innovation Capabilities: Technology Use, Productivity Growth and Business Performance: Evidence from Canadian Technology Surveys*. The Canadian Economy in Transition Series, no. 16. Statistics Canada Catalogue no. 11-622-M. Ottawa: Statistics Canada.

Baldwin, John R., and Paul K. Gorecki. 1986. *The Role of Scale in the Canada-U.S. Productivity Differences in the Manufacturing Sector: 1970-79.* Volume 6. Research Program of the Royal Commission on the Economic Union and Development Prospects for Canada. Toronto: University of Toronto Press.

Baldwin, John. R., and Wulong Gu. 2006. *The Impact of Trade on Plant Scale, Production-Run Length and Diversification.* Economic Analysis Research Paper Series, no. 38. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2007a. *Multifactor Productivity in Canada: An Evaluation of Alternative Methods of Estimating Capital Services*. The Canadian Productivity Review, no. 9. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2007b. *Investment and Long-term Productivity Growth in the Canadian Business Sector, 1961 to 2002.* The Canadian Productivity Review, no. 6. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu, 2008a. *Productivity: What Is It? How Is It Measured? What Has Canada's Performance Been?* The Canadian Productivity Review, no. 17. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John. R., and Wulong Gu. 2008b. *Firm Turnover and Productivity Growth in the Canadian Retail Trade Sector.* Economic Analysis Research Paper Series, no. 53. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu, 2013. *Multifactor Productivity Measurement at Statistics Canada.* The Canadian Productivity Review, no. 31. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John R., and Wulong Gu. 2014. *Revisions to the Multifactor Productivity Accounts.* The Canadian Productivity Review, no. 035. Statistics Canada Catalogue no. 15-206-X. Ottawa. Statistics Canada.

Baldwin, John. R., Wulong Gu, and Ryan Macdonald. 2010. *Integrated Productivity Accounts: Contributions to the Measurement of Capital*. The Canadian Productivity Review, no. 27. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John. R., Wulong Gu, and Ryan Macdonald. 2012a. *The New Investment Paradigm.* Economic Insights, no. 7. Statistics Canada Catalogue no. 11-626-X. Ottawa: Statistics Canada.

Baldwin, John. R., Wulong Gu, and Ryan Macdonald. 2012b. *Intangible Capital and Productivity Growth in Canada.* The Canadian Productivity Review, no. 29. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Baldwin, John R., and Tarek M. Harchaoui, 2001. “The Precision of Productivity Measures.” In *Productivity Growth in Canada.* Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada. Chapter 3

Baldwin, John R., Huju Liu, and Wulong Gu. 2014. *Investment Intensity in Canada and the United States*. Economic Analysis Research Paper Series. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada. Forthcoming.

Baldwin, John R., Jean-Pierre Maynard, Marc Tanguay, Fanny Wong, and Beiling Yan. 2005. *A Comparison of Canadian and U.S. Productivity Levels: An Exploration of Measurement Issues.* Economic Analysis Research Paper Series, no. 28. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

Baldwin, John R., and Beiling Yan. 2014. *Global Value Chains and the Productivity of Canadian Manufacturing Firms*. Economic Analysis Research Paper Series, no. 90. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

The Economist. November 6, 2004, p. 80.

Gu, Wulong, Mustapha Kaci, Jean-Pierre Maynard, and Mary-Anne Sillamaa. 2003. “The changing composition of the Canadian workforce and its impact on productivity growth.” In *Productivity Growth in Canada – 2002*. John R. Baldwin and Tarek M. Harchaoui (eds.). Statistics Canada Catalogue no. 15-204-X. Ottawa: Statistics Canada.

Gu, Wulong, and Weimin Wang. 2013. *Productivity Growth and Capacity Utilization in Canadian Business Industries.* Economic Insights, no. 31. Statistics Canada Catalogue no. 11-626-X. Ottawa: Statistics Canada.

Macdonald, Ryan. 2007. *Canadian and U.S. Real Income Growth Pre and Post 2000: A Reversal of Fortunes*. Economic Analysis Research Paper Series, no. 48. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

Macdonald, Ryan. 2008. *An Examination of Public Capital's Role in Production*. Economic Analysis Research Paper Series, no. 50. Statistics Canada Catalogue no. 11F0027M. Ottawa: Statistics Canada.

Maynard, Jean-Pierre. 2007a. *A Comparison of GDP per Capita in Canada and the United States from 1994 to 2005*. Insights on the Canadian Economy, no. 16. Statistics Canada Catalogue no. 11-625-M. Ottawa: Statistics Canada.

Maynard, Jean-Pierre. 2007b. *The Comparative Level of GDP Per Capita in Canada and the United States: A Decomposition into Labour Productivity and Work Intensity Differences.* The Canadian Productivity Review, no. 8. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Statistics Canada. 2007a. *Long-term Productivity Growth in Canada and the United States, 1961-2005.* The Canadian Productivity Review, no. 13. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Statistics Canada. 2007b. *Productivity Performance in Canada, 1961 to 2005*. The Canadian Productivity Review, no. 11. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.

Statistics Canada. 2007c. *Depreciation Rates for the Productivity Accounts*. The Canadian Productivity Review, no. 5. Statistics Canada Catalogue no. 15-206-X. Ottawa: Statistics Canada.