Productivity Concepts and Trends

Productivity Concepts, Trends and Prospects: An Overview

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INTRODUCTION

The issue of productivity and the related issue of innovation continue to be high on the public policy agenda. There is especially strong interest among policy-makers in the social aspects of productivity. The objective of this second issue of *The Review of Economic Performance and Social Progress* is to examine the two-way linkages between productivity and various measures of social progress in Canada. The purpose of this paper is to provide a succinct, non-technical overview of the productivity issue, including discussion of productivity concepts, measurement issues, trends and prospects. Such information may serve as useful background for the papers in this volume.

The paper is divided into six parts. The first part looks at the reasons why productivity is important. The second discusses key productivity concepts, including the link between productivity and welfare. The third provides some theoretical perspectives on productivity growth. The fourth part briefly examines productivity measurement issues and their relevance for the productivity debate. The fifth part presents the key productivity trends and developments that have taken place in Canada and other developed countries. Finally, the sixth part briefly discusses the prospects for productivity growth.

WHY IS PRODUCTIVITY IMPORTANT?

Productivity is the relationship between the output of goods and services and the inputs of resources, human and non-human, used in the production process, with the relationship usually expressed in ratio form. Both outputs and inputs are measured in physical volumes and thus are unaffected by price changes. Multiplying quantities of the various outputs and inputs by the price each has commanded in a base year yields the comparable or constant price values that can be added up to provide measures of aggregate output and input.[1] The ratios may relate to the national economy, to an industry, or to a firm or even a plant. Output growth that exceeds growth in measured inputs — that is to say, an increase in the ratio of output to inputs — is what analysts mean when they say productivity is increasing.

Productivity growth is the most important source of long-term economic growth. From 1946 to 2001, real GDP per hour growth — the productivity of labour — accounted for 66 percent of real GDP output growth in the business sector in Canada, the remaining 34 percent being growth in total hours worked — an input that itself was growing rapidly (Table 1).

Over the long term, increasing productivity is the only way to increase the standard of living, defined as real GDP per capita. Growth in per capita income can result from: increases in the employment-total population ratio, reflecting increased labour force participation, lower unemployment or a larger share of working-age population; or improved terms of trade. But these sources of income growth are unsustainable in the long run, as they have upper bounds (except possibly for the terms of trade). Productivity growth, on the other hand, is not constrained by the size of the population or other factors, and its growth is, at least in principle, sustainable through technological advances.

Thus, trends in productivity are the key determinant of long-run trends in both absolute and relative living standards. The fall-off in real income growth in Canada and other developed economies since 1973 is a direct result of slower productivity growth. The decline in Canada's living standards in the 1990s relative to those in the United States is largely attributable to our weaker labour-productivity growth (Sharpe 2001). Slower increases in the amount of output each worker produces mean that there is slower growth in the output or income that can be shared among the total population.

The magnitude of the productivity growth estimates that economists debate — almost always below 1 percent for the aggregate economy — may seem small or even trivial to non-economists. But small differences matter, and the implications for society of a

TABLE 1

Productivity Trends in the Business Sector, 1961-2001

	Average annual rates of change									
	Real GDP	Number of Jobs	Average Hours	Hours Worked	Real GDP per Hour	Hourly Labour Compen-sation	Total Labour Compen-sation	Unit Labour Cost	Real Consumer Wage	Real Producer Wage
1946-1973	5.05	1.72	-0.73	0.98	4.03	7.51	8.54	3.38	3.90	3.42
1973-1981	3.52	2.71	-0.65	2.04	1.43	11.09	13.34	10.61	1.28	1.13
1981-1989	3.18	1.97	0.05	2.02	1.13	5.52	7.65	4.28	0.22	0.88
1989-2001	2.83	1.34	-0.07	1.26	1.56	3.14	4.42	0.80	0.85	1.34
1989-1995	1.39	0.19	-0.25	-0.06	1.47	2.70	2.65	0.26	0.04	0.65
1995-2001	4.29	2.49	0.10	2.59	1.65	3.57	6.23	1.34	1.67	2.04
1946-2001	4.07	1.82	-0.46	1.35	2.68	6.76	8.18	3.96	2.31	2.26
1973-2001	3.13	1.91	-0.20	1.70	1.40	6.04	7.83	4.52	0.79	1.15

Notes: The growth rate of the Number of Jobs plus the growth rate of Average Hours gives the growth rate of Hours Worked. The growth rate of Hours Worked plus the growth rate of Hourly Compensation gives the growth rate of Total Compensation. The growth rate of Real GDP subtract the growth rate of Hours Worked gives the growth rate of Real GDP per Hour. The growth rate of Total Compensation subtract the growth rate of Real GDP gives the growth rate of Unit Labour Cost. Real Consumer Wage is defined as Hourly Compensation deflated by CPI and Real Producer Wage is defined as Hourly Compensation deflated by the GDP deflator.
Source: Aggregate Productivity Measures, Statistics Canada, August 2002.

1-percent, as opposed to a 3-percent, trend productivity growth rate are huge. Based on the mathematical rule of 72, a 1-percent productivity growth scenario means that it will take 72 years, or three generations, for real output — and hence income — per worker to double. In contrast, under a 3-percent productivity scenario it would take only 24 years, or one generation, for real income to double. Even moving from a 1-percent to a 2-percent trend productivity growth world — a distinct possibility, as discussed later in the paper — cuts in half (to 36 years) the time needed to double living standards.

There is, of course, much more to life than productivity and the real income growth it generates, as even economists realize. The economic well-being and quality of life of the population — much broader concepts than GDP per capita — are determined by many factors, of which productivity is only one. A focus on productivity does not mean that economists consider these other determinants of well-being and quality of life unimportant. Economists study productivity because it is crucial for real income growth and important for improving economic well-being and quality of life, or at least its material aspects. They also believe that a better understanding of productivity trends and determinants can lead to the development of public policies and private-sector actions that will serve to improve productivity performance.

CONCEPTUAL ISSUES RELATED TO PRODUCTIVITY

This section reviews a number of productivity concepts essential to an understanding of the productivity debate.

Partial Versus Total Factor Productivity

A fundamental distinction is made between *partial* and *total* productivity measures. The former relate output to only one input, most often labour or capital, although intermediate goods or raw materials also regularly figure in some compilations of inputs, even though it is recognized that other inputs have contributed to output. Labour productivity is the best-known partial productivity measure. The latter relates output to a *combination* of inputs, such as capital and labour. They are known as total-factor or multifactor productivity measures and represent the growth in output not accounted for by input growth.

The most readily available and widely used measure of productivity is labour productivity, the ratio of output to some measure of labour input (employment or hours). This term sometimes creates confusion, as it can be seen to imply that the level of labour productivity or the rate of growth of labour productivity is attributable solely to the effects of labour. In fact, labour productivity reflects the influence of all factors that affect productivity, including capital accumulation, technical change and the organization of production. While the intensity of labour effort obviously does affect labour productivity, it is generally significantly less important than the amount of capital a worker has to work with or the level of production technology.

The concept of total or multifactor productivity has been developed to measure the contribution of all factors of production to productivity growth. The rates of growth of all inputs are weighted to yield one growth rate for the combined inputs. Total factor productivity (TFP) growth is defined as the growth

rate of output minus the growth rate of the combined inputs (just as labour-productivity growth equals output growth minus labour input growth). As the growth rate of the capital stock is generally greater than that of employment (and hence the capital-labour ratio is rising), the growth rate of TFP (using labour and capital as inputs) is generally less than the growth rate of labour productivity. This situation arises from the fact that the growth rate of the combined inputs of capital and labour exceeds that of labour alone.

A key issue in TFP measurement is the weighting of these inputs. Under competitive conditions, the current dollar-income share of the factor of production — labour income for hours worked and interest, gross capital income (profits and depreciation) for the capital stock — is normally considered the relative contribution of the factor to output and consequently used to weight the factor to produce an index of total input, or the growth rate of the index. When markets are not competitive, as in the case of monopolies, the weighting issue is much more complex.

The meaning of TFP is also controversial. Some economists interpret it as a measure of overall technical change, others as a measure of disembodied technological change — that is, technical change that is not embodied in new machinery and equipment — while still others argue that TFP is in no way a measure of technological change (Lipsey and Carlaw 2000).

It is incorrect to say that TFP is a superior or preferred measure of productivity compared to labour productivity, as the two concepts serve different purposes. For those interested in how efficiently all factors of production are used in the production process, TFP is the relevant productivity measure since it takes into account the productivity of factors of production other than labour, such as capital, intermediate goods and energy. For those interested in the potential of the economy to raise the standard of living, labour productivity is the relevant productivity measure: it tells us how much output or income is produced by each worker and, when combined with the total number of workers, how much total income there is to be distributed among the population.

Output Per Worker Versus Output Per Hour

Labour input can be measured either in terms of the average annual number of workers or in terms of the total number of hours worked in a year. The latter is the more appropriate for labour productivity since it represents a more precise measure of labour input than persons employed. One should always specify which concept of labour productivity is being used. The growth rates of output per worker and output per hour may differ when there is a change in the hours worked over time. Indeed, historically the large fall in average working time has meant that output per hour has grown significantly faster than output per worker.

International productivity comparisons can also differ greatly when annual hours per worker vary across countries. American workers put in more hours annually than workers in many European countries. Therefore, productivity measures based on output per worker portray US productivity levels in a much more favourable light than measures based on the more relevant output per hour. For example, in 2001 Norway's GDP per person employed was 81.5 percent of that in the United States on the basis of output per person employed, but 110.6 percent on the

basis of output per hour — a difference of 29.1 percentage points. The Netherlands also shows a large difference (28.4 points) between the two productivity measures, from 73.4 percent of the US level for output per person employed to 101.8 percent for output per hour worked (see Tables 3 and 5 below).

Productivity Levels Versus Growth Rates

A second important distinction is that between productivity levels and growth rates. The former refers to the output per unit of input at a given point. For example, in the year 2001 the level or value of output per hour in the business sector in Canada was $30.06, expressed in constant 1992 prices. The latter refers to the percentage change in levels of output per hour, expressed in constant prices, between two points in time. An example would be the 20.4-percent increase in labour productivity between 1989 and 2001, when output per hour was $24.97. One often hears the complaint that Canada's productivity is poor. This could be in reference to a low aggregate productivity level, to a low productivity growth rate, or both. Commentators should always specify whether they are referring to levels or growth rates, as the implications can differ significantly.

International comparison of productivity levels requires that levels expressed in a domestic currency be converted into a common currency. This conversion can be done using either market exchange rates or exchange rates based on purchasing power parities (PPPs) — that is, the exchange rate that equalizes the price of a basket of goods and services between two countries. For accurate comparison, it is imperative that PPPs be used, although the development of reliable PPPs is a complex matter, particularly at the industry level.[2] A range of PPPs, produced by different agencies and researchers, has resulted in a wide range of estimates for levels of relative international productivity.

The Cyclical Behaviour of Productivity

The short- to medium-term movement of productivity is determined by two influences — an underlying productivity trend and a cyclical component. Over the long term, the cyclical component is offsetting, with cyclical upturns cancelling out cyclical downturns so that actual productivity growth tends to converge on trend growth. Actual productivity growth between cyclical output peaks provides an approximation of trend productivity, although the trend may also be influenced by average capacity utilization over the cycle and differences in capacity utilization at the peaks.

The short-term behaviour of labour productivity is explained by lags in the adjustment of labour input to changes in output. If labour input adjusted simultaneously with changes in output, productivity growth would always be at trend. Lags in the adjustment of labour input, both employment and total hours worked, are caused by a number of factors, including firms' unfulfilled expectations concerning demand conditions, the existence of overhead labour that is relatively invariant to output levels, and a tendency for firms to hoard skilled labour in downturns so as not to lose their investment.

For the reasons outlined above, the rate of change in output per worker tends to move in a procyclical pattern, declining below trend in downturns and rising above trend in recoveries. The rate of change in output per hour shows a slightly more dampened procyclical

movement, as it is easier to adjust average weekly hours through short-time or overtime than to adjust employment levels. Total factor productivity, which includes the capital stock as well as labour as an input, exhibits even greater procyclical variation in movement than output per worker because of the fixity of the capital input.

The cyclical behaviour of productivity has two implications. First, one should not extrapolate long-term productivity trends from short-term developments. For example, with the Canadian economy entering a period of weak growth in 2001, due to falling aggregate demand, slower productivity growth can be expected for cyclical reasons. This does not mean that long-term productivity growth has necessarily deteriorated, as any productivity shortfall now can be recovered later in the cycle. Second, to minimize the impact of cyclical influences on productivity, growth rates should be calculated at comparable points in the cycle, preferably on a peak-to-peak basis.

THEORETICAL PERSPECTIVES ON PRODUCTIVITY GROWTH

Economic theory advances in stages. First, a simple framework based on highly restrictive and often unrealistic assumptions is developed. Then, these assumptions are gradually eliminated as the model attempts to incorporate more elements of reality. The development of the theory of economic and productivity growth from the 1950s to the 1990s has conformed to this pattern.

The modern study of economic growth and long-run productivity growth dates from the 1950s when Robert Solow, Moses Abramovitz and Dale Jorgenson identified the basic inputs of a growing economy as labour, capital and technology. Solow (1957), in a widely cited article, concluded that technological change, not labour and capital, was responsible for most economic growth. However, he did not measure the contribution of technological change to economic growth directly, but rather measured it as a residual after the contribution of labour and capital had been calculated. Solow characterized this residual as "a measure of our ignorance." In the Solow model, technological change was exogenous, or "manna from heaven," although this treatment of technology was not meant to be taken literally but rather was intended as an abstraction, to simplify and facilitate the model's focus on long-term growth.

Solow's theoretical framework for the analysis of economic growth served as the basis for the development, by Edward Denison (1962), of a growth-accounting framework that attributed economic growth to a number of sources, including increases in the education of the labour force, the contribution of capital, the shift of resources from low-productivity endeavours to the mainstream of the modern economy, gains from knowledge and economies of scale.

The limitations of both the neoclassical, or Solow, growth model and growth-accounting methodology in explaining the growth process — in particular their inability to account for the post-1973 productivity slowdown — have in recent years led to the development of more sophisticated models of economic growth by such economists as Paul Romer. A key feature of many of these models is their emphasis on knowledge as the driving force of productivity growth.

Romer (1990) points out that "the neoclassical assumptions of diminishing returns to increasing investment and perfect compe-

tition placed the accumulation of new technologies at the centre of the growth process and simultaneously denied the possibility that economic analysis could have anything to say about this process." In other words, while early versions of growth theory convincingly demonstrated the importance of studying technology, the aggregate macroeconomic models used left little room for the analysis of the sources of invention or innovation, new and improved products or processes, or organizational or structural change (Landau et al. 1996).

In recent years, the basic neoclassical model has been enhanced and expanded upon in at least five broad areas (Landau et al. 1996). These developments reflect the elimination of many of the model's restrictive and unrealistic assumptions.

- Neoclassical growth theory assumed that all firms behaved in the same manner in their effort to maximize profits. It is now widely recognized that while the profit motive is still important, behaviour can differ greatly among firms. Economists interested in economic growth are now exploring such issues as how firms learn from experience, how good management differs from bad management, how firms differ in their means of gathering and transmitting information internally, and how firms compete in international markets.
- The neoclassical model also assumed perfect competition. This is a particularly unrealistic assumption for a growth model, because in a world characterized by perfect competition firms have no incentive to undertake research and development, since they can sell at the market price all they can produce. Such a model also assumes away the important real-world issue of the appropriability of the gains from technical progress. Many models of economic growth now assume monopolistic competition and give explicit treatment to patents as a mechanism for influencing the appropriability of the gains from technical progress.
- The neoclassical model assumes that the secrets of technical progress are available to all. The implication is that productivity levels in all countries will converge on that of the technological leader, as each country avails itself of the technological knowledge. This assumption ignores the obvious point that the social ability to gain technological advantage varies greatly among nations, which is why productivity levels have not converged. Putnam (2001) has developed the concept of "social capital" as a factor of production to explain international variation in growth rates and productivity levels.
- The neoclassical model assumes that all industries are equally important. But some economists now argue that certain industries may be more important to long-run productivity growth than others because they yield a greater rate of social return through externalities (e.g., the information technology sector) or may exhibit increasing returns to scale.
- An implication of the early growth theory is that the long-term steady-state rate of growth is determined by the rate of technical progress and population growth and is independent of the rate of saving and investment. But recent research suggests that higher rates of accumulation and investment

can increase productivity growth, that there is no steady-state rate of growth and that the inputs in the growth process act independently. For example, Boskin and Lau (1992) find that the higher the capital stock, the greater the ability of technology to increase productivity, because most technology is embodied in capital goods.

Multi-faceted Determinants or Sources of Productivity

Building on the recent theoretical developments reviewed above, a large literature has developed aimed at deriving their implications for public policy. In Canada, recent contributions in this area include Harris (1999) and Sharpe (1998).

Based on a review of the cross-country growth literature, Harris (1999) identifies three proximate drivers (the Big Three) of productivity growth: investment in machinery and equipment; education, training and human capital; and openness to trade and investment. In addition, he notes that once one moves from the proximate determinants to the indirect linkages, productivity growth can be influenced by a large number of factors. His compendium of potential indirect productivity determinants includes innovation (both product and process), diffusion of technology (national and international), spatial agglomeration (e.g., Silicon Valley), external economies of scale at the industry level, government consumption (negative), management practices, public infrastructure (positive), income inequality (negative), high taxes (negative), small firms (negative), labour market flexibility (positive), exchange rate stability (positive) and low inflation (positive).

Sharpe (1998) identifies the following seven determinants of productivity growth:

- *The rate of technical progress*, determined by the rate of developing new product and process innovations and the pace of diffusing those innovations.
- *Investment in physical capital* such as machinery and equipment and structures. The more capital a worker has to work with, the greater the output he can produce. It is estimated that 80 percent of technical change is embodied in new capital equipment, particularly machinery. Without gross investment, technical progress would be all but impossible. Hence, physical investment is essential for productivity growth.
- *The quality of the workforce*, including average educational, training and experience levels. Literacy and numeracy skills as well as technical skills are essential if an industry is to benefit from technical advances and make effective use of machinery.
- *The size and quality of the natural resource base*. For example, the high level of output per hour in Alberta reflects the concentration of the oil and gas industry in this province and the high value added (which includes economic rent) per worker generated by the industry.
- *Industrial structure and intersectoral shifts*, since the aggregate level of labour productivity is a weighted average of industry labour productivity levels, where the weights are the labour input shares.
- *The macroeconomic environment* or aggregate demand conditions defined by the size of the output gap and the relationship between actual and potential output growth. Prolonged periods of insufficient demand can have a negative long-term effect on productivity growth.

- *The microeconomic policy environment,* broadly defined as the policies that affect behaviour at the firm level, including trade policy, tax policy, industrial policy, competition policy, and policies on privatization, intellectual property, regulation and foreign ownership.

There is still considerable uncertainty about the drivers of productivity. The relative and absolute contributions made by the different determinants may vary over time and across space. Many of the factors in productivity growth are interrelated and may act in synergy.

Productivity and Unemployment

Labour productivity is technically defined as the relationship between output and the employed labour force. It ignores the unemployed and others outside the labour force who would like to have a job but do not. From this perspective, conventional productivity measures do not represent an appropriate indicator of the efficient allocation or uses of labour from a societal perspective. Rising productivity can and sometimes does coexist with high or even rising unemployment, although one could argue that in such a situation societal productivity is not rising. It is very unproductive or inefficient to have a large number of workers producing zero output.

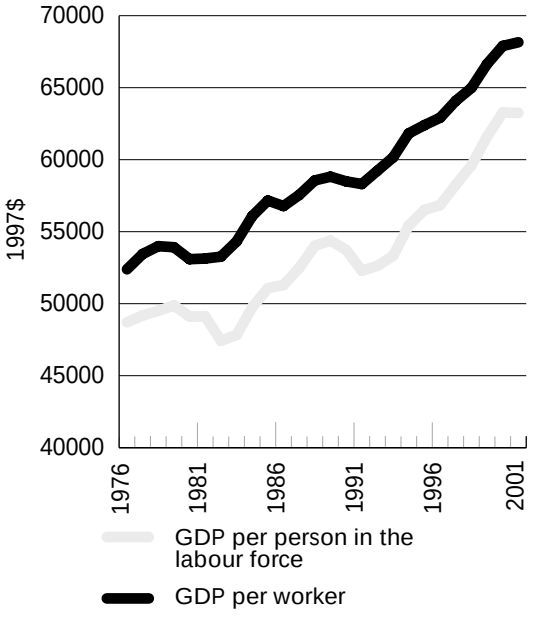
One way to deal with this issue is to develop a productivity measure that defines labour input as inclusive of the employed and unemployed. Such a measure expresses the social relationship between the labour resources that society has available for production and actual output, in contrast to the economic relationship between the labour resources actually used in production and output. Chart 1 shows trends in Canada from 1976 to 2001 for economic productivity, defined as output per person employed, and social productivity, defined as output per labour force participant. Not surprisingly, the level of social productivity is about 7-10 percent below that of economic productivity over the period, reflecting the addition of the unemployed to the denominator and no change in the numerator. The recessions of the early 1980s and early 1990s produced much larger declines in social productivity than in economic productivity. From a societal productivity perspective, economic downturns have a very negative effect on overall productivity of the labour force.

Productivity, Economic Well-Being and Happiness

Productivity growth can contribute to greater economic well-being. One approach

CHART 1

Economic Productivity (Output Per Person Employed) vs. Social Productivity (Output Per Person in the Labour Force) in Canada



Source: Labour Force Historical Review 2001(R) CD-ROM, Statistics Canada Cat. No. 71F0004XCB; and GDP data from CANSIM II v3860085, June 3, 2002.

to the measurement of economic well-being is the Index of Economic Well-being developed by the Centre for the Study of Living Standards (Osberg and Sharpe 1998, 2002*a*, 2002*b*) based on Osberg (1985). This index is based on four components of economic well-being: consumption flows; non-financial stocks of wealth; equality; and economic security in terms of low risk of unemployment, financial distress due to illness, single-parent poverty and poverty in old age. Sharpe (2002*b*) demonstrates how real income growth arising from productivity gains can lead to increased private and public consumption, higher stocks of capital, lower poverty and greater economic security.

Despite the importance of productivity for real income growth, one should retain a sense of perspective on the productivity issue. Just because productivity can contribute to higher levels of economic well-being, it does not necessarily follow that it should be the top social priority.

Two points are relevant in this regard. First, in poor countries productivity growth is absolutely crucial to raise the material standard of living to an acceptable level and reduce absolute poverty. In contrast, Canada is already a rich country with high living standards for the vast majority of the population. Increased productivity leads to higher consumption levels and greater economic well-being, but it may do little for subjective well-being or happiness. Studies have found that after a certain income level has been achieved in rich countries, further real income growth can have little if any additional impact on happiness for the overall population (Easterlin 1974, 1995). Money cannot buy happiness, at least not in the long run. Since the goal of public policy is to increase the overall well-being, not just the economic well-being, of the population, productivity should not be sold as a panacea for society's ills.

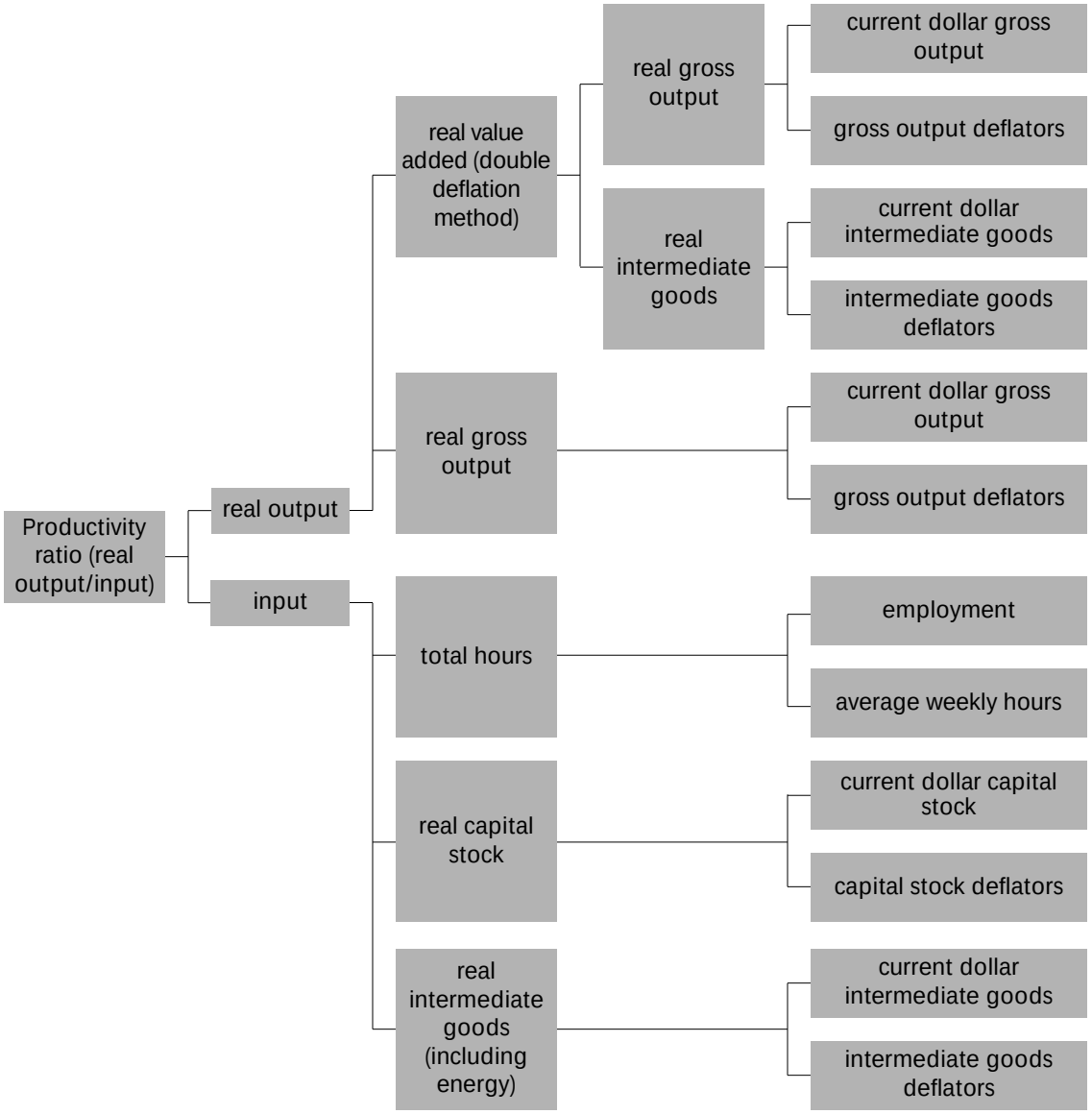
Second, productivity can provide the basis for potential increases in a number of the components of economic well-being, such as equality and economic security. But there is no mechanism whereby higher productivity growth automatically translates into less income inequality or lower poverty, as in the case of higher real wages leading to greater private consumption. For example, growing wage inequality may prevent low-skilled workers from benefiting from productivity growth. Government action may be needed to eliminate poverty and decrease social inequality.

MEASUREMENT ISSUES

Statistical agencies do not gather productivity statistics directly from economic agents. Rather, they construct productivity measures from data on inputs and outputs. Indeed, almost the entire body of economic statistics collected by statistical agencies — data on output, employment, prices, investment, raw materials, inventories — is used in the compilation of productivity statistics. An examination of the reliability of productivity statistics thus becomes, in effect, an examination of the reliability of much of the system of economic statistics.

Figure 1 is a schematic representation of the basic data requirements of productivity statistics, or the building blocks of productivity measurement. At the extreme left is the productivity ratio, defined as the ratio of real output to input. This ratio may be a partial productivity measure, such as labour

FIGURE 1
The Building Blocks of Productivity Measurement



productivity, where real output is related to only one input, or a multifactor or total factor productivity measure where an index of real output is related to an index of more than one input. Inputs in addition to labour that have been included in multifactor productivity calculations are capital, including both fixed capital and inventories, and intermediate goods, including raw materials and energy.

Either of two real output measures can be used to construct productivity indexes — real value added and real gross output. The former defines output as the total incomes of the factors of production (basically, labour and capital) in an industry, sector or economy. The latter defines output as the physical output produced by an industry, sector or economy. At the industry or sectoral level, real gross output comprises

real value added and real intermediate goods. At the aggregate level in a closed economy, real gross output is equivalent to real value added as intermediate goods are netted out.

The most appropriate output concept of industry productivity when labour or labour and capital are included as inputs is real value added. Use of real gross output may bias the results because of substitution, in the production process, between intermediate goods and labour or capital.[3] On the other hand, the most appropriate output concept when intermediate goods are included as an input is real gross output.

Real value added is calculated through a double-deflation procedure whereby real intermediate goods are subtracted from real gross output. Real gross output is calculated through the deflation of current-dollar gross output by gross output deflators. Real intermediate goods are calculated in a similar manner, from current-dollar intermediate goods and intermediate goods deflators.

Turning to the input side, labour input, most appropriately measured as total hours worked, is determined by employment and actual average weekly hours. The real capital services arising from the capital stock (fixed capital and sometimes inventories) are derived from current-dollar capital stock estimates and capital stock deflators.

From the above discussion, five basic building blocks of productivity measurement can be identified: estimates of labour input, including both employment and average weekly hours; estimates of current-dollar capital stock; estimates of current-dollar intermediate goods; estimates of current-dollar gross output; and estimates of product price indices. These product price indices are, in turn, used to derive deflators for gross output, capital stock and intermediate goods.

Productivity statistics are plagued by a number of measurement problems, the most important of which are outlined below.

Price Indices, Quality Adjustment and Hedonics

Price indices for goods and services are crucial for deflating the current value of output to produce real output and hence productivity estimates. But quality changes in goods and services over time must be integrated into price indices if true changes in real output are to be captured.[4]

The Panel to Review Productivity Statistics (1979) identifies three types of quality change. Type 1 is the change in the quantity of costly resources used to produce a product, such as the addition of a remote-control device to a television set. Type 2 occurs when a technological innovation raises the quality of a product without any increase in current resource inputs, such as when new models of computers have more memory and greater processing ability but cost the same or less than the models they replace. Type 3 quality change refers to any design change in durable goods that results in higher or lower operating costs, holding constant both the quantity of services provided by the good and the wages and prices of the inputs used in its operation. An example is the redesign of an engine to improve fuel efficiency.

Until the 1980s, statistical agencies made adjustments for Type 1 quality change but largely ignored Types 2 and 3. Since then, there has been growing recognition of the importance of these latter types of quality change, as represented by computers and more energy-efficient consumer durables, respectively, and attempts to adjust for them. The most common method of adjustment is known

as hedonics. This involves the application of a statistical regression to the different models of a given type of product available in two or more years, where the dependent variable is the price of each model and the independent variables are its measured characteristics.

The application of hedonics has produced very large decreases in the quality-adjusted price indices for computer hardware and, to a lesser degree, telecommunications equipment, leading to enormous increases in real output and hence productivity growth in these sectors. Indeed, the computer hardware sector has accounted for a highly disproportionate share of output and productivity growth in the United States and to a lesser degree in Canada, where the sector is less important. In principle, productivity-growth comparisons across countries can be greatly affected by differences in the use of hedonics by national statistical agencies. In reality, this factor does not appear to account for significant international differences in aggregate productivity growth rates, although sectoral growth rates can be affected (Pilat 2001).

Non-marketed Output

A key requirement for the development of productivity estimates is that output be measured independently of inputs. If output is measured by the quantity of inputs, productivity growth will by definition be zero. In sectors where output is not marketed, it is not possible to deflate the nominal value of output to produce real output and hence productivity estimates. This means that there are no reliable estimates of productivity growth for these sectors — primarily public administration and the publicly funded components of the education and health sectors. It is therefore best to exclude these sectors from aggregate productivity measures.

For this reason, the business sector is the most appropriate category for analysing productivity trends at the aggregate level and the sector for which official productivity statistics are produced. The wide availability of data for total employment and real GDP does mean that productivity estimates for the total economy are often referred to, although, because of the lack of measured productivity growth in the non-marketed sectors, these estimates have a downward bias.

It is in theory possible to develop productivity growth estimates for the non-business sector by measuring, in physical units, the output of the sector. Possible physical indicators include the number of graduates of the education system, the number of procedures performed in hospitals and the number of cheques processed by a government office. But such indicators may represent only part of the output of the sector and, more importantly, may exhibit significant quality changes over time. The development of reliable productivity growth estimates for the non-marketed sector is still in its early stages.

The Underground Economy

The issue of the underground economy often arises in discussions of productivity trends. It is pointed out that the underestimation of real output because of unrecorded underground activity, not offset by a commensurate underestimation of inputs, will produce a downward bias to productivity level estimates. Estimates of the size of the underground economy vary widely. The most authoritative (and lowest) estimate is that by Statistics Canada (1994), which found that the underground economy represented around 3 percent of GDP in Canada in 1992. A key reason for the small size of the underground economy relative to GDP is that Statistics Canada is aware, through

various sources, that many transactions in certain sectors, such as construction, are not reported to the tax authorities; the agency can therefore make imputations for this unreported economic activity in the national accounts.

It should also be noted that it is not the existence of the underground economy per se that produces bias in productivity growth rates, but rather changes in its relative size over time. If the size of the underground economy remains stable, productivity levels may be underestimated but productivity growth rates will be unaffected. Of the many measurement issues facing national accountants and productivity analysts, bias associated with the underground economy is certainly not the most serious.

Conceptual Problems in the Definition of Output

In certain industries in the business or marketed sector, the definition of what actually constitutes output poses conceptual problems that affect productivity estimates. For example, is the output of the banking sector the intermediation function the banks serve (as proxied by the value of the spread between what the banks earn and what they pay out in interest, net of expenses), or is it the services provided by the sector (number of accounts maintained, number of cheques processed, convenience provided by ATMs, etc.)? Other industries with conceptual problems include insurance, gambling and brokerage houses.

These conceptual issues are gradually being worked out, with the result that productivity estimates for these industries are becoming more reliable. For example, statistical agencies have changed the definition of output in the banking sector, from the first definition noted above to the second, with the result that measured productivity growth in the sector has increased.

Quality Adjustment of Inputs

A key issue in productivity research is whether inputs such as labour and capital should be adjusted for quality changes, just as output is adjusted. Statistical agencies certainly produce and release unadjusted estimates of labour and capital inputs. They also often adjust inputs for quality changes in the compilation of productivity estimates, particularly TFP estimates.

With quality adjustment, quality improvements increase the growth rate of the input and hence its contribution to output. This means that the size of the residual or TFP is reduced, shedding more light on the sources of growth. This is considered by many to be the main advantage of adjustment. The advantage of non-adjustment is that the conceptual and methodological difficulties inherent in adjustment are avoided and the productivity numbers are easier to interpret and understand.

The Importance of Statistical Revisions

Statistical agencies revise, on a regular and periodical basis, the economic series they produce. As productivity estimates draw upon a wide range of economic data, including estimates of employment, hours, nominal output, prices and capital stock, they are subject to frequent — and often significant — revisions. Indeed, these revisions are the scourge of productivity analysts, but a necessary evil since the most recent data must be used. Unfortunately, the revision of productivity data can result in the rewriting and reinterpretation of productivity trends.

Two examples illustrate this point. In May 2001, Statistics Canada released its Aggregate Productivity Measures data which showed that output per hour in the business sector advanced at a 1.2-percent average annual growth rate between 1995 and 2000, a performance character-

ized as weak by productivity analysts. Later that same month, Statistics Canada released new estimates of the national accounts using, for the first time, the Fisher chain index and capitalizing software expenditures. These changes boosted productivity growth by a very significant 0.5 percentage points, to 1.7 percent per year for the same period, and forced productivity analysts to change their characterization of productivity growth over this period.

In July 2001 the US Bureau of Labor Statistics revised its estimates on business-sector output per hour based on new national accounts data from the Bureau of Economic Analysis. Instead of increasing 2.8 percent per year over the 1995-2000 period, as originally reported earlier in the year, productivity growth was revised downward to 2.4 percent. This indicated that the acceleration in productivity growth was less than previously believed.

PRODUCTIVITY TRENDS AND DEVELOPMENTS

This section of the paper highlights a number of the developments that have characterized productivity growth in the post-war period in OECD countries and in Canada. The international trends discussed are: the post-1973 productivity slowdown, the post-war productivity convergence phenomenon, lagging productivity growth in certain service sectors, and the post-1995 productivity growth acceleration in the United States. The Canadian trends examined are: the relative decline of Canada's productivity performance, the growing Canada-US manufacturing productivity gap and sectoral productivity trends.

Three distinct productivity trends or stylized facts can be identified in the post-war period for the United States and two for other developed economies, including Canada. From 1945 to 1973, developed countries experienced a golden age of productivity growth, with labour-productivity growth advancing at a rate of 3 percent or more per year. After 1973, virtually all developed countries entered a period of slower productivity growth. The failure of productivity to pick up in the first half of the 1990s despite the introduction of information technologies led observers to coin the term "productivity paradox." Since 1995, the United States has been in a period of much stronger productivity growth, resolving the productivity paradox as least for that country.

The Post-1973 Productivity Slowdown

The most important productivity development in the post-war period has been the slowdown in labour and total factor productivity growth, a phenomenon that affected virtually all industrial countries and most industries. According to official Statistics Canada estimates, growth in output per hour in the business sector fell by nearly two-thirds, from 4.0 percent per year in the 1946-73 period to 1.4 percent in the 1973-2001 period (Table 1 and Chart 2). Growth in output per hour in the business sector averaged 1.4 percent per year in 1973-81, fell slightly to 1.1 percent in 1981-89 and rose to 1.6 percent after 1989.

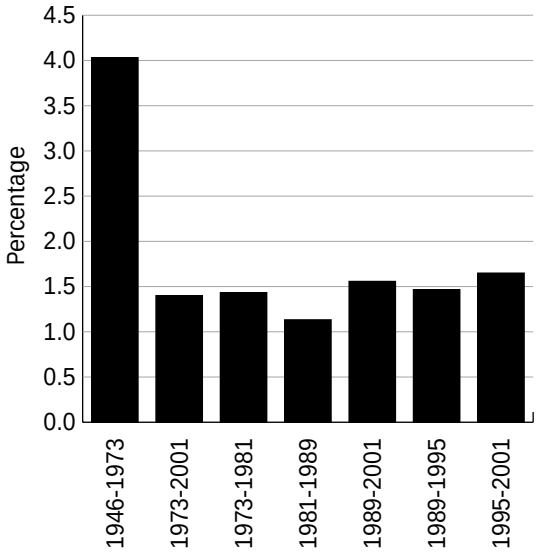
The post-1973 productivity slowdown affected most sectors of the Canadian economy (Table 2). Of the 10 one-digit SIC industries for which official data are available, eight experienced significantly lower growth in output per hour after 1973 (agriculture; fishing and trapping; logging and forestry; mining, quarrying and oil wells; manufacturing; transportation and storage; communications and

other utility industries; and retail trade). The two exceptions were construction and wholesale trade, both of which have seen an improvement in productivity growth since 1973.

After more than 20 years of debate, there is still no consensus among economists on the causes of the productivity slowdown. The view that appears to be gaining the largest number of adherents is that the slowdown reflected the ebbing or withering away of the impact of the historically unprecedented factors that came together to boost productivity growth in the immediate post-war period (e.g., the shift of the workforce out of low-productivity agriculture, increased international trade, rapid capital accumulation and diffusion of the stock of technologies and know-how built up but unexploited during the Great Depression and the Second World War). The productivity experience in the post-1973 period in North America can be seen as a return to the long-run historical trend of around 1.5 percent per year.

CHART 2

Output Per Hour in the Business Sector, Canada (Average Annual Rates of Change)



Source: Aggregate Productivity Measures, Statistics Canada, August 2002. For 1989 onwards, data are from the quarterly Aggregate Productivity Measures series, CANSIM II v1409153, July 2001.

The implications of the productivity slowdown are well recognized by government. For example, in 1994 the federal Department of Finance (1994) released the document *A New Framework for Economic Policy* (the Purple Book), which states: "At the root of the economic problem has been the failure of *productivity* to increase at the rates that prevailed during the post-war years to the mid-1970s" (p. 15).

Post-War Productivity Convergence in OECD Countries

The United States has been the world technological leader in the post-war period, with the highest level of productivity among industrial countries. On the other hand, it has experienced (until recently) one of the slowest rates of productivity growth. Economists believe this is not an accidental situation but rather reflects the dynamics of international productivity growth. Technological catch-up or convergence is seen as the major reason why most OECD countries experienced faster productivity growth than the United States in the post-war period.

Through technological catch-up, low-productivity countries have the potential of enjoying rapid (although declining) productivity growth until their productivity levels begin to converge on that of the leader. Indeed, a number of countries in the developed world have effectively exploited this potential in the post-war period. The average unweighted level of output per hour worked in OECD countries excluding the United States went from 44 percent of the US level in 1950 to 83 percent in 2001 (see Table 5 below).

TABLE 2

Trends in Labour Productivity, Output Per Hour Worked by Industry, Canada, 1961-2000

	Average annual rates of change in output per hour					
	1961-1973	1973-1981	1981-1989	1989-2000	1989-1995	1995-2000
Business Sector	3.8	1.6	1.1	1.6	1.5	1.8
Agriculture	5.9	6.6	2.4	4.6	4.3	5.0
Fishing & Trapping	2.6	-0.4	-3.0	-0.7	-1.4	0.2
Logging & Forestry	3.9	1.9	3.4	-0.1	-2.0	2.2
Mining, Quarrying & Oil Well	6.1	-6.1	3.1	1.5	3.5	-0.8
Manufacturing	4.2	1.8	2.4	2.3	3.3	1.0
Construction	0.5	3.9	-0.4	-0.6	-0.5	-0.7
Transportation & Storage	5.2	-0.5	2.7	1.8	2.1	1.4
Communication & other Utility Industries	5.8	3.1	1.7	2.3	1.3	3.5
Wholesale Trade	2.3	1.6	4.6	1.6	1.2	2.1
Retail Trade	3.6	1.3	1.1	2.0	0.3	4.0

Notes: Statistics Canada has updated the business sector and manufacturing series to 2001 consistent with the regular annual revision. All other industries will be updated later in the fall of 2002 on the basis of the North American Industry Classification System.
Source: Aggregate Productivity Measures, Statistics Canada, August 2002.

The convergence hypothesis is based on four advantages productivity laggards may exploit (Abramovitz and David 1996). (1) These countries can make use of state-of-the-art technology produced by the technological leader. (2) Because these countries have low capital-labour ratios, the marginal product of capital is high. (3) Less developed countries have considerable opportunities to shift resources out of low-productivity activities. (4) These countries can benefit from economies of scale as their markets grow.

However, there is no mechanism by which the productivity levels of poor countries automatically converge on that of the leader. Indeed, outside the industrial countries, there has been little convergence towards US productivity levels, with the exception of a number of countries in East Asia. Persistent national characteristics can inhibit laggard countries from exploiting the advantages of backwardness. These include poverty of natural resources; small domestic markets; barriers to trade; forms of economic organization or systems of taxation that reduce rewards for effort, enterprise or investment; and deeper elements of national culture that limit responses of people to economic opportunities. Throughout the Third World, deep-rooted political constraints imposed on social capability have prevented convergence, but when these constraints are removed, as has happened in East Asia, the potential for convergence can be realized.

Lagging Productivity Growth in Certain Service Industries

In general, productivity growth in the service sector has lagged behind that in the goods sector, although a number of service-sector industries, such as communications and trade, have posted respectable rates of productivity growth.[5] Service-sector productivity growth has been held back by the financial, insurance and real estate sector and,

more importantly, by community, personal and business services. Indeed, Sharpe et al. (2002) show that the education and health sectors recorded negative measured labour-productivity growth in both Canada and the United States in the 1990s, which dragged down aggregate productivity growth.

For example, between the 1989 cyclical peak and 1998, output per hour in the service sector fell 1.3 percent per year, after falling 0.5 percent per year during the 1980s. This decline in the absolute level of productivity affected all industries within the sector: accommodation, food and beverage (-1.9 percent per year); amusement and recreation services (-1.4 percent); business services (-1.1 percent); health services (-1.0 percent); education and related services (-0.6 percent); and personal, household and other services (-0.5 percent). As the service sector accounts for more than one quarter of total hours worked in the business sector, this development exercised a significant downward influence on total business-sector productivity.

One explanation for the slower productivity growth in the service sector is the greater inherent difficulty of increasing productivity in certain service industries. For example, the non-tangible nature of services limits the possibilities for mechanization, while the one-to-one personal nature of many services, such as health care — where output depends on interaction with the user — makes standardization difficult. A second explanation is that official measures of service-sector output have a serious downward bias, greater than in the goods sector. Indeed, productivity growth in the service sector, if properly measured, may not be inferior to that in the goods sector.

Specific problems in the measurement of real output and hence productivity in market-ed service industries include: conceptual difficulties in the definition of output in sectors such as banking and insurance; improvements or deterioration in quality of output that are not captured by the price indices; absence of appropriate service-sector data for productivity measurement (data coverage is much better for goods industries); difficulties incorporating completely new services into existing price indices; and the extreme heterogeneity of transactions in certain service industries, such as legal and health services, which makes price systems non-linear and not directly linked to what is received by the customer.

Post-1995 Acceleration in US Productivity Growth

Since 1995, productivity growth has picked up significantly in the United States. Between 1995 and 2001, output per hour in the business sector advanced at a 2.4-percent average annual rate, up nearly a full percentage point from the 1.5 percent of the 1989-95 period. This development has been taken by many as *prima facie* evidence of a new economy characterized by higher trend productivity growth based on information technologies (IT). Research has shown that the productivity pick-up, while greatest in the IT-producing sector, has also spread to the IT-using industries, including those in the service sector, supporting the view that IT is now having a pervasive impact on productivity (Stiroh 2001). Some economists, such as Robert Gordon (2000), argue that a significant component of this acceleration is transitory, related to the cyclical factors and the investment boom of the second half of the 1990s, and that productivity growth will be slower in the medium term. Others, such as Martin Baily (2002), believe that most of the acceleration is of a permanent nature.

Unlike the United States, the other industrial countries show no evidence of a post-1995 acceleration in productivity growth. In Canada, for example, business-sector output per hour advanced at a 1.7-percent average annual rate between 1995 and 2001 — barely above the 1.5 percent experienced over the 1989-95 period. With the acceleration in productivity growth in the United States in the second half of the 1990s, the productivity leader forged ahead of the followers and increased the productivity gap. This represents a situation of productivity divergence, in contrast to the productivity convergence of the pre-1995 period.

Canada's Relative Productivity Decline

From an international perspective, Canada has suffered a relative deterioration in its productivity performance in recent years. Data have been compiled by the Groningen Growth and Development Centre at the University of Groningen in the Netherlands. In 1973, Canada ranked second out of 22 OECD countries in terms of output per person, with 92.1 percent of the output per person employed, relative to that of the United States, the leader (Table 3). By 2001, Canada had fallen to fifth place, at 79.7 percent, behind Belgium, France, Ireland, Norway and of course the United States. In GDP per capita, Canada also fell from second to fifth over the period (Table 4). Canada's relative decline in terms of output per hour was even greater — from second to 13th place — because of the fewer hours worked per year in most European countries (Table 5). Canada's relative productivity decline largely reflects the pick-up of productivity growth in Europe, where productivity levels converged towards, and in a number of cases — Belgium, France, the Netherlands and Norway — surpassed US levels on a per-hour basis.

Data prepared by the Centre for the Study of Living Standards on Canada's aggregate labour productivity performance show that the greater deterioration relative to the United States was particularly abrupt in the second half of the 1990s. In 1976, GDP per person employed in Canada was 88.1 percent of that in the United States. In 1995, it was 85.0 percent. By 2001, however, it had fallen to 82.5 percent (Table 6 and Chart 3). The relative decline between 1995 and 1999 reflects the acceleration of productivity growth in the United States, as Canadian productivity growth has not fallen in absolute terms.

TABLE 3

Relative GDP Per Person Employed in OECD Countries

	US=100 in all years				
	1950	1973	1989	1995	2001
Australia	76.1	73.5	76.6	80.2	79.5
Austria	36.1	70.7	82.0	79.1	78.6
Belgium	63.2	82.1	98.6	100.5	94.2
Canada	91.4	92.1	88.0	85.7	79.7
Denmark	65.8	73.5	76.6	80.8	77.8
Finland	37.8	59.4	72.2	77.5	76.3
France	47.2	77.8	91.0	91.2	84.6
Unified Germany	n/a	n/a	80.8	81.5	76.5
West Germany	53.2	83.7	94.7	90.2	n/a
Greece	26.4	58.1	62.8	59.7	61.4
Ireland	37.5	51.3	75.6	82.6	90.2
Italy	39.9	67.9	80.1	85.0	77.6
Japan	19.4	59.1	74.5	74.2	69.9
Netherlands	77.0	94.5	84.7	80.6	73.4
New Zealand	n/a	79.6	66.0	64.3	57.7
Norway	52.3	64.6	77.6	86.8	81.5
Portugal	21.6	45.8	49.6	52.2	49.5
Spain	25.4	60.0	80.3	84.3	74.5
Sweden	58.9	70.0	69.0	73.9	71.6
Switzerland	85.5	93.2	83.5	78.2	73.6
Turkey	11.8	21.1	27.1	29.5	28.8
UK	65.9	66.3	71.8	74.0	70.9
US	100.0	100.0	100.0	100.0	100.0

Source: Groningen Growth and Development Centre & The Conference Board, June 13, 2002. www.eco.rug.nl/GGDC/index-dseries.html

TABLE 4
Relative GDP Per Capita in OECD Countries

	US=100 in all years				
	1950	1973	1989	1995	2001
Australia	78.5	76.6	74.0	76.9	77.6
Austria	41.4	71.9	75.4	77.2	74.6
Belgium	60.4	77.1	76.8	77.6	75.9
Canada	81.9	87.3	87.5	81.6	77.9
Denmark	75.3	86.6	82.1	83.6	80.7
Finland	45.7	68.2	75.4	65.8	71.5
France	53.2	75.9	74.2	72.4	69.7
Unified Germany	n/a	n/a	81.4	75.5	69.7
West Germany	54.5	89.6	89.2	81.9	n/a
Greece	22.1	50.7	48.2	46.0	47.2
Ireland	38.1	43.5	49.9	61.5	82.1
Italy	38.5	67.1	73.0	72.9	69.1
Japan	20.2	68.8	78.2	80.3	72.9
Netherlands	62.9	78.9	72.9	75.1	75.1
New Zealand	88.8	75.3	61.2	59.8	55.8
Norway	56.5	66.7	78.0	85.8	84.0
Portugal	22.2	45.1	46.0	48.8	49.8
Spain	26.2	54.8	53.5	54.5	56.4
Sweden	70.9	81.3	76.7	71.5	71.0
Switzerland	100.6	115.7	96.9	88.3	81.9
Turkey	16.3	19.3	18.9	20.1	17.8
UK	71.0	70.8	70.0	69.1	68.2
US	100.0	100.0	100.0	100.0	100.0

Source: Groningen Growth and Development Centre & The Conference Board, June 13, 2002. www.eco.rug.nl/GGDC/index-dseries.html

TABLE 5
Relative GDP Per Hour Worked in OECD Countries

	US=100 in all years				
	1950	1973	1989	1995	2001
Australia	81.5	73.6	77.4	81.4	82.7
Austria	37.3	70.4	89.0	93.2	96.7
Belgium	57.0	78.3	106.9	112.6	113.3
Canada	94.7	91.2	88.2	89.0	83.3
Denmark	68.9	87.5	92.9	99.1	94.3
Finland	40.3	65.5	77.0	84.6	87.0
France	50.0	79.2	106.3	109.1	102.6
Unified Germany	n/a	n/a	91.4	96.3	93.3
West Germany	48.6	85.3	106.0	108.2	n/a
Greece	24.6	51.8	60.1	57.1	59.0
Ireland	33.3	44.3	71.7	82.9	99.2
Italy	44.1	70.4	87.6	95.7	88.7
Japan	21.5	54.4	68.6	73.5	72.6
Netherlands	77.4	104.0	109.0	108.7	101.8
New Zealand	n/a	n/a	68.2	66.4	61.3
Norway	55.6	72.7	98.6	112.9	110.6
Portugal	20.2	42.9	48.5	52.7	52.6
Spain	26.8	56.3	80.7	85.5	76.3
Sweden	62.6	80.2	81.4	84.3	82.4
Switzerland	88.5	93.2	91.1	90.0	86.5
Turkey	11.0	18.8	25.9	28.2	27.7
UK	67.6	65.0	76.6	81.6	80.2
US	100.0	100.0	100.0	100.0	100.0

Source: Groningen Growth and Development Centre & The Conference Board, June 13, 2002. www.eco.rug.nl/GGDC/index-dseries.html

The factors behind Canada's relative productivity decline are vigorously debated. Certainly, from an accounting perspective, the deterioration in its productivity performance in the IT sector compared to that in the United States can explain the lion's share of the decline in recent years (Rao and Tang 2001).

The Widening Canada-US Manufacturing Productivity Gap

Canada's relative performance in manufacturing productivity has been equally poor. Since 1981, Canada has had by far the weakest productivity growth among the G7 countries in this sector. Growth in output per hour has averaged 2.1 percent per year, compared to the G7 unweighted average of 3.3 percent (Table 7 and Chart 4). In the period 1995 to 2000, Canada's productivity performance was even worse, averaging 0.9 percent per year compared to the G7 average of 2.8 percent.

These developments have produced a widening gap in Canada-US manufacturing productivity, most notably in the second half of the 1990s. Manufacturing output per hour fell from 87.5 percent of the US level as recently as 1993 to a low of 67.3 percent in 2001 (see Table 6). Manufacturing productivity has been

TABLE 6

Productivity Levels, Canada Relative to the US

	US=100 in all years	
	Real GDP per Employed Person	Output per Hour in Manufacturing
1976	88.1	90.9
1977	89.1	92.1
1978	89.0	92.5
1979	88.7	91.4
1980	87.9	89.8
1981	86.8	89.6
1982	88.1	86.3
1983	87.2	87.5
1984	87.4	92.3
1985	87.6	91.3
1986	86.0	88.7
1987	86.5	82.7
1988	86.4	79.7
1989	85.6	82.9
1990	84.7	83.2
1991	84.0	83.1
1992	83.4	85.1
1993	84.0	87.5
1994	85.1	87.0
1995	85.0	83.2
1996	84.7	80.1
1997	83.8	79.5
1998	83.3	76.1
1999	82.6	72.3
2000	82.6	69.3
2001	82.5	67.3

Source: Output per hour series based on an estimate of 79.5 for the 1997 benchmark year by Bart van Ark, Inklaar and Timmer (2000), applied to data from *International Comparisons of Manufacturing Productivity and Unit Labour Costs*, April 5, 2001, News, Bureau of Labor Statistics, US Department of Labor; and Aggregate Productivity Measures for Canada. Output per worker is from the CSLS income and productivity database, August 2002.

largely driven by trends in IT-producing industries such as manufacturers of electronic and other electrical equipment and industrial machinery and equipment in the United States. This sector is relatively more important in the United States than in Canada and, in addition, has experienced a faster growth rate (Chart 5). This situation alone accounts for the widening gap in Canada-US manufacturing productivity (Sharpe 1999; Rao and Tang 2001).[6]

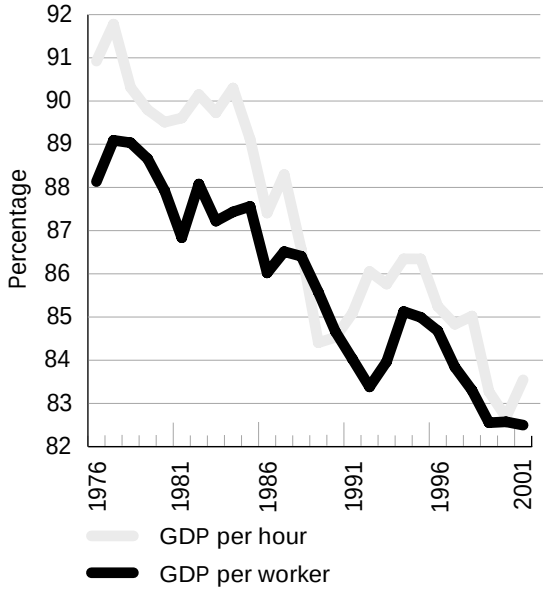
Variance in Sectoral Productivity Levels and Growth[7]

Productivity levels and growth rates vary greatly across industries. Industry-level differences in output per hour reflect a number of factors, including differences in capital intensity of production, quality of human capital, the existence of resource rents and competitive conditions. Industry-level differences in productivity growth rates reflect the pace of technological change in the sector, the ability to mechanize production, the pace of investment in both physical and human capital and competitive conditions.

In the 1989-2000 period, agriculture enjoyed the most rapid growth in output per hour (see Table 2), at an average 4.6 percent per year, followed by communications (2.3 per-

CHART 3

Labour Productivity Trends, Canada Relative to the US, 1976-2001



Source: CSLS income and productivity database, based on data from the National Accounts and Labour Force Survey for Canada and the National Income and Product Accounts and Current Population Survey for the United States; August 2002.

cent); manufacturing (2.3 percent); retail trade (2.0 percent); transportation and storage (1.8 percent); wholesale trade (1.6 percent) and mining, quarrying and oil wells (1.5 percent). Three sectors experienced negative productivity growth in the 1990s: logging and forestry (-0.1 percent per year); construction (-0.6 percent); and fishing and trapping (-0.7 percent).

PROSPECTS FOR PRODUCTIVITY GROWTH

As noted in the introduction to this paper, the shift from a 1.0-1.5-percent trend productivity world to a 2.0-2.5-percent world would have implications for a large number of economic and social variables. Real wages and incomes would be higher, as would tax revenues, allowing expansion of social programs — political circumstances permitting. If we were all collectively richer, fewer tradeoffs between competing economic and social ends would be necessary.

TABLE 7

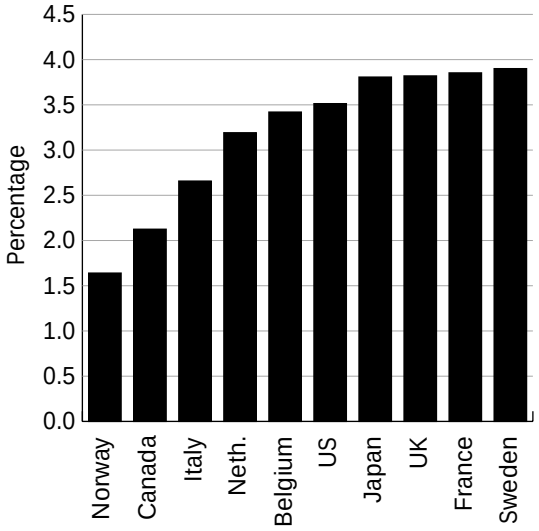
Growth in Output Per Hour in Manufacturing, Industrial Countries

	Average annual rates of change				
	1981-1989	1989-2000	1989-1995	1995-2000	1981-2000
Canada	2.25	2.03	3.00	0.88	2.12
US	3.25	3.71	2.93	4.64	3.51
Japan	3.89	3.74	3.85	3.62	3.81
France	3.74	3.93	3.76	4.14	3.85
UK	5.28	2.77	3.31	2.12	3.82
Italy	3.08	2.35	3.38	1.13	2.66
Germany (Unified)	n/a	n/a	n/a	2.85	n/a
G7 average	3.58	3.09	3.37	2.77	3.30
Belgium	4.13	2.91	2.63	3.25	3.42
Denmark	1.02	n/a	n/a	n/a	n/a
Netherlands	4.08	2.55	3.36	1.59	3.19
Norway	2.69	0.88	1.26	0.43	1.64
Sweden	3.15	4.45	4.58	4.29	3.90

Note: Only the 1995-2000 average includes Germany. Data on Unified Germany is only available beginning in 1991.
Source: International Comparisons of Manufacturing Productivity and Unit Labour Costs Trends, April 2002, Bureau of Labor Statistics, US Department of Labor.

CHART 4

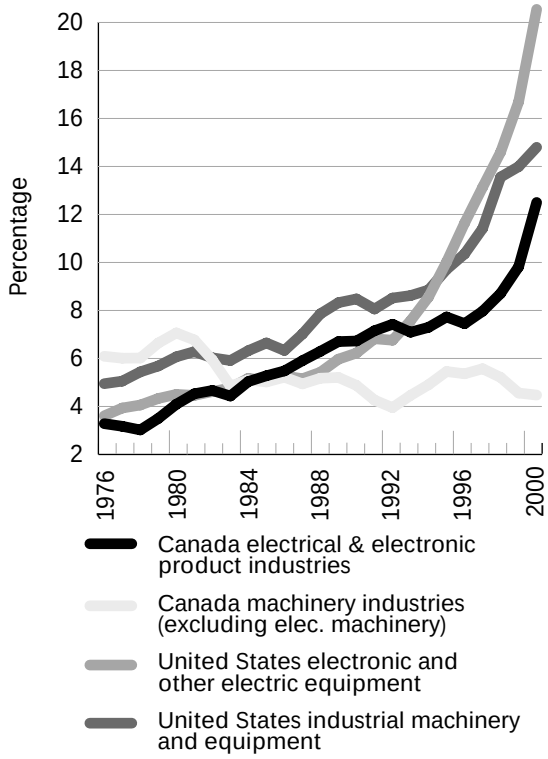
Output Per Hour in Manufacturing, Selected OECD Countries, 1981-2000 (Average Annual Growth Rates)



Source: International Comparisons of Manufacturing Productivity and Unit Labour Costs Trends, April 2002, Bureau of Labor Statistics, US Department of Labor.

From 1995 to 2001, the business sector in the United States enjoyed output-per-hour growth of 2.4 percent per year, up 1 percentage point from the 1973-95 period but below the 3.3 percent of the 1947-73 period. The million-dollar question for productivity analysts is whether the post-1995 acceleration is a permanent or temporary development. Opinions differ on this issue, depending in large part on how one views the causes of the acceleration. For economists such as Robert J. Gordon, who believe that much of the improvement in productivity growth is due to the strong cyclical conditions in the second half of the 1990s, and who see productivity growth narrowly concen-

CHART 5
Selected Industries Real GDP Share in Manufacturing, Canada-US Comparison



Source: Statistics Canada, GDP by Industry, and the National Income and Product Accounts, US Bureau of Economic Analysis.

trated in IT-producing industries with minimum productivity gains arising from investment in IT-using industries, the outlook for productivity is not rosy. They see productivity growth reverting to 1.5 percent, just slightly above the trend of the 1973-95 period. On the other hand, economists such as Dale Jorgenson and Martin N. Baily, who believe something fundamental happened to change productivity behaviour and raise trend productivity in the mid-1990s, and believe this change was associated with IT, the outlook for productivity growth is more favourable, although down somewhat from the unsustainable pace in the second half of the 1990s. Baily (2002) projects annual productivity growth in the range of 2.2-2.7 percent for the remaining years of this decade.

There was virtually no acceleration in productivity growth in the second half of the 1990s in Canada, at least relative to the first half of the decade. Business-sector output per hour advanced 1.6 percent, well below that recorded in the United States. The issue for Canada is whether it will follow the US lead and see a pick-up in productivity growth. Again, economists are divided on the issue. For example, Sharpe and Gharani (2002) project business-sector output-per-hour growth of a minimum of 2 percent per year this decade, based on the view that Canada tends to lag behind the United States and that the productivity-augmenting effect of IT investment will finally have a payoff, just as it did in the United States in the late 1990s. In other words, technological catch-up will provide the basis for stronger productivity growth in Canada. Wilson and Dungan (2002), on the other hand, foresee little acceleration in productivity growth, arguing that the smaller size of the IT sector in Canada will prevent this country from enjoying US growth rates.

CONCLUSION

This paper has presented an overview of productivity concepts, measurement issues, and productivity trends and prospects in a Canadian context. This material provides background for an understanding of productivity issues addressed in the papers in this volume. A number of messages or themes emerge. (1) Productivity is a complex, nuanced concept with several dimensions, including such aspects as the different types of productivity and the distinction between growth rates and levels. (2) For a number of reasons, the measurement of productivity is fraught

with problems and the methodologies chosen to construct productivity estimates can greatly influence those estimates. (3) The determinants of productivity growth are multi-faceted, and include both economic and social variables. (4) Canada's productivity performance in recent years has been mediocre, particularly compared to that of the United States. (5) The interests of all Canadians converge on the importance of productivity growth as it is the basis of sustained real-income growth. (6) Productivity should not be oversold as a panacea for society's problems. Productivity growth and the additional income it generates are necessary conditions, but not the only ones, for improving the quality of life and increasing the well-being of Canadians.

NOTES

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1 It should be noted that with the recent adoption by Statistics Canada of chain-Fisher indexes, the components of real GDP no longer add up exactly to real GDP.

2 The construction of PPPs requires comparisons of prices across countries. Internationally consistent surveys on the prices of goods and services in expenditure categories have been carried out by the OECD on a regular basis, so estimates of PPPs for GDP and consumer expenditure are available. However, there are no surveys of product prices, so estimates of PPPs for industry output are much harder to compile.

3 Of course, if materials in addition to labour and capital are used as inputs, the bias disappears.

4 Nordhaus (1997) provides a fascinating account of the history of the price of light, showing that on a quality-adjusted basis it has experienced an enormous long-term decline. When the quality-adjusted price of light is integrated into price indexes, he finds, over the 1800-1992 period living standards have increased by between 40 (low-bias assumptions) and 190 (high-bias assumptions) times instead of the conventionally estimated factor of 13. The implications of quality adjustment for the quantification of trends in living standards are very great.

5 See the volumes edited by Griliches (1992) and Diewert et al. (1999) for papers on productivity trends in a number of service industries.

6 For discussion of additional factors affecting the Canada-US manufacturing productivity gap, see papers from the CSLS conference on the Canada-US manufacturing productivity gap posted at www.csls.ca under past events.

7 In July 2002, the Centre for the Study of Living Standards updated its comprehensive productivity database on the basis of the North American Industry Classification System (NAICS), replacing earlier estimates based on the 1980 Standard Industrial Classification (SIC). Using Statistics Canada data on labour input, capital stock and output data, this database provides estimates of labour productivity levels (both output per worker and output per hour), capital productivity levels and TFP indexes for the years 1976-2001 inclusive for Canada (1976-98 on a 1980 SIC basis and 1987-2001 on a NAICS basis) and 1984-2001 for the 10 provinces (1984-98 on a 1980 SIC basis and 1997-2001 on a NAICS basis), giving as much industry disaggregation as confidentiality rules permit. This data base (www.csls.ca) is freely accessible to the public.

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