# Productivity Developments Abroad

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In recent years, the U.S. economy has surprised observers by growing briskly, even as inflation has remained quiescent. During 1996–99, for example, U.S. real gross domestic product (GDP) grew at 4.2 percent annually, whereas inflation, measured by the consumer price index, averaged only 2.3 percent. This impressive performance of the economy reflects in part an acceleration in recorded labor productivity. After having averaged 1.4 percent per year from 1973 to 1995, output per hour in the nonfarm business sector rose almost 2.6 percent from 1996 to 1999. This acceleration has allowed many firms to increase output without experiencing significant increases in unit costs.

The most prominent explanation for the pickup in productivity growth centers on new developments in the high-technology sector—in particular, the proliferation of computer and information technology. Insofar as most of the recent technological advances in this area are available to businesses worldwide, it is natural to expect them to contribute to faster productivity growth abroad as well.[1]

The availability of new technologies on a worldwide basis need not, however, translate into an automatic improvement in productivity performance. An economy's structure, institutions, and regulations influence the rapidity with which technological advances are adopted and the extent to which adoption of these advances leads to heightened efficiency. In this article we review the recent productivity trends in foreign industrial countries to examine whether they, too, are experiencing an improvement comparable to that seen in the United States. (In this study, we will not focus on the *level* of productivity but, rather, on trends in the *growth rate* of productivity.)

Our main finding is that, with only a few exceptions, labor productivity in foreign industrial countries does not appear to have accelerated in the latter half of the 1990s. Thus, labor productivity in the United States has changed from increasing less rapidly than that of most foreign industrial countries to rising more rapidly. In this article, we also consider factors that may account for this divergence in productivity trends and discuss the extent to which this difference is likely to persist.

Our conclusions need to be tempered, however, for several reasons. First, there are significant problems in data comparability and availability (such as measures of capital). Moreover, much of the data are published with a considerable delay. Difficult conceptual issues, especially with respect to measurement of the high-tech sector, make it difficult to ascertain the role of information technology as an engine of productivity growth abroad. Also, because the sample period is rather brief, the task of identifying a change in trend productivity growth is complicated. On the whole, these difficulties suggest that there is much room for further work on this important topic.

## DEFINING PRODUCTIVITY

Labor productivity—the output of workers per unit of time—is a commonly used and straightforward measure of productivity (see box ''Measures of Productivity''). The growth rate of labor productivity is approximately equal to the difference between the growth rate of output and the growth rate of the number of hours worked in the economy.

If output is produced by two factors, labor and capital, then the growth of labor productivity, in turn, depends upon the rate of ''capital deepening'' and the

1. For a more detailed discussion of the role of information technology as an explanation for the recent pickup in U.S. productivity growth, see Robert Gordon, ''Does the 'New Economy' Measure Up to the Great Inventions of the Past?'' *Journal of Economic Perspectives* (forthcoming); Alan Greenspan (remarks before the New York Association for Business Economics, New York, N.Y., June 13, 2000), available on line at http://www.federalreserve.gov/boarddocs/speeches/2000/20000613.htm; Stephen Oliner and Daniel Sichel, ''The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?'' *Journal of Economic Perspectives* (forthcoming); and Dale W. Jorgenson and Kevin Stiroh, ''Raising the Speed Limit: U.S. Economic Growth in the Information Age,'' *Brookings Papers on Economic Activity, 1:2000,* pp. 125–211.

## Measures of Productivity

Measures of productivity address the question of how much output is produced, on average, by different factors of production. The measure of productivity that is most commonly used is labor productivity because it is easy to calculate and interpret: How much output is produced, on average, by each unit of labor employed in production. We express this idea as

$$LP = Y/L,$$

where *LP* is labor productivity, *Y* is the amount of output, and *L* represents the amount of labor input. Because the focus of our study is on productivity growth rather than the level of productivity, we construct

$$lp = y - l,$$

where lowercase variables represent the growth rates of the corresponding uppercase variables.

The growth of labor productivity, in turn, can be decomposed into the contributions of "capital deepening"—the growth of the capital–labor ratio—and the growth of "multifactor productivity"—increases in productivity attributable to technological advances or improvements in production arrangements rather than to increases in factor inputs. Estimating the contributions of capital deepening and multifactor productivity to labor productivity growth requires making assessments about the relative importance of capital, labor, and multifactor productivity in the production process. In particular, it requires specifying the form of the production function:

$$Y = F(K, L, MFP),$$

where *Y* is the amount of output, and the expression *F*( ) indicates the maximum amount of output that can be produced with given amounts of capital stock (*K*), labor, (*L*), and multifactor productivity (*MFP*).[1]

Multifactor productivity growth is estimated as the difference between output growth and the growth of total factor inputs—that is, the combined growth of the factors of production: labor and capital. Total input growth can be calculated as a weighted average of labor and capital growth, with the marginal contributions of each of these factors to output being used as the weights. In principle, the marginal contribution of labor and capital to output depends upon the form of the production function, and there is no consensus on the exact specification of this function. In practice, a production function is often used that carries the implication that the marginal contribution of each factor of production is proportional to the share of total production that it receives as compensation. Thus, total input growth can be expressed as

$$q = wl \cdot l + wk \cdot k,$$

where *q* represents the combined growth of productive inputs, *wl* is the weight of labor (usually the share of labor compensation in total income), *l* is the growth rate of labor input, *wk* is the weight of capital (usually the share of capital compensation in total income), and *k* is the growth rate of capital services, which we assume to be proportional to the capital stock. Given the measure of overall input growth, we define multifactor productivity growth as

$$mfp = y - q = y - [wl \cdot l + wk \cdot k],$$

where *mfp* is multifactor productivity growth, and *y* is the growth of output. Thus, in this framework, any increase in the growth of output in excess of the contribution of factor inputs would be attributed to an increase in multifactor productivity growth.

Rearranging the last equation slightly, output growth can be expressed as a function of total factor input growth—the weighted growth of labor and capital—and multifactor productivity growth:

$$y = q + mfp = [wl \cdot l + wk \cdot k] + mfp.$$

Subtracting the growth of labor input, *l*, from both sides, and keeping in mind that $wl = 1 - wk$, this relationship can be further rearranged to decompose labor productivity growth into two components: (1) $(k - l) \cdot wk$, or the rate of capital deepening adjusted by the contribution of capital to the production process, and (2) *mfp*. Therefore, we have

$$y - l = (k - l) \cdot wk + mfp.$$

If capital is relatively unimportant—that is, if the *wk* term is small, then labor and multifactor productivity growth would be virtually identical. Similarly, if the capital–labor ratio remains essentially fixed, then the growth rates of labor and multifactor productivity would, again, be virtually identical. If, however, capital is an important factor and the capital–labor ratio is not fixed, then labor and multifactor productivity growth need not move together.

1. The role of land in the production process is generally ignored.

growth of ''multifactor productivity.'' Capital deepening refers to a rise in the ratio of capital to labor, that is, an increase in the amount of capital—machines, structures, and infrastructure—available to workers. For a given level of technology, capital deepening raises workers' ability to produce more output with the same level of effort.[2]

Multifactor productivity growth refers to increases in the productive capacity of the economy that are not attributable to increases in the contributions of labor and capital inputs. Increases in multifactor productivity may reflect advances in technology, but they may also reflect any other developments that result in greater efficiency, such as reorganization of tasks in a firm or improvements in distribution channels used to deliver goods and services. In either case, an acceleration in multifactor productivity allows labor to be more productive even if the capital–labor ratio is fixed.

Measuring multifactor productivity requires first estimating the contribution of the factors of production—capital and labor—to aggregate output. Developing such a measure involves specifying the economy's production function, that is, the way in which the economy transforms inputs of capital, labor, and other potential factors into final products.[3]

2. Early studies on productivity include Robert Solow, ''Technical Change and the Aggregate Production Function,'' *Review of Economics and Statistics*, vol. 39 (August 1957), pp. 312–20; Edward F. Denison, *Why Growth Rates Differ: Postwar Experience in Nine Western Countries* (The Brookings Institution, 1967); Simon Kuznets, *Economic Growth of Nations: Total Output and Production Structure* (Harvard University Press, 1971); Dale W. Jorgenson, Frank M. Gollop, and Barbara M. Fraumeni, *Productivity and U.S. Economic Growth* (Harvard University Press, 1987); and Dale W. Jorgenson, ''Productivity and Economic Growth'' in Ernst R. Berndt and Jack E. Triplett, eds., *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth* (University of Chicago Press, 1990).

More recent work includes Wolodar Lysko, ''Manufacturing Multifactor Productivity in Three Countries,'' *Monthly Labor Review*, vol. 118 (July 1995), pp. 29–38; Chrys Dougherty and Dale W. Jorgenson, ''International Comparisons of the Sources of Economic Growth,'' *American Economic Review* (May 1996, Papers and Proceedings, 1996), pp. 25–29; Jeremy Greenwood, Zvi Hercowitz, and Per Krusell, ''Long-Run Implications of Investment-Specific Technological Change,'' *American Economic Review*, vol. 87 (June 1997), pp. 342–62; Stefano Scarpetta, Andrea Bassanini, Dirk Pilat, and Paul Schreyer, ''Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level,'' OECD Economics Department Working Paper, no. 248; and Paul Schreyer, ''The Contribution of Information and Communication Technology to Output Growth: A Study of the G-7 Countries,'' OECD Science, Technology, and Industry Working Paper, 2000/2 (OECD, 2000).

3. For surveys of the literature on production functions, see Dale W. Jorgenson, ''Econometric Methods for Modeling Producer Behavior,'' in Zvi Griliches and Michael D. Intriligator, *Handbook of Econometrics*, vol. 3 (New York: North-Holland, 1986); and Ulrich Kohli, *Technology, Duality, and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports* (University of Michigan Press, 1991).

Conventional models of the production function suggest that one reasonable means of measuring the growth rate of total factor inputs is to add the growth rate of labor to that of capital, each weighted by its share in the value of production. The resulting sum constitutes a measure of total input growth, which can be subtracted from output growth to estimate multifactor productivity growth. Thus, any increase in the growth of output in excess of total input growth would be attributed to an increase of multifactor productivity growth.

## *Estimating Productivity Growth*

Estimating labor and multifactor productivity growth for many countries requires data on a range of variables: output, employment, labor hours, capital, and labor's share of output. The choice of data series for these variables is frequently constrained by the need to obtain recent statistics that are comparable across countries. For the United States, a complete and conceptually consistent data set is available from the Bureau of Labor Statistics (BLS).[4] Similar data are not available for many of the other countries in this study.[5]

Because this study emphasizes comparisons across countries, we supplement the BLS data for the United States with data from the Organisation for Economic Co-operation and Development (OECD) on output, labor, capital, and factor shares for seventeen industrialized countries (including the United States). Most of these data are collected for the business sector, defined as ''the institutional sector whose primary role is the production and sale of goods and services.''[6] Hence, this data set nets out the general government sector from our measures of output, capital, and employment. Focusing on the business sector avoids the potential for distortion in measures of productivity due to the complexities involved in assigning a market value to the associated flow of goods and services in the government sector. Also, the OECD has standardized its definition of the business sector across OECD countries to enhance the comparability of the data.

4. The BLS documents describing the multifactor productivity series are available on line at http://www.bls.gov/mprhome.htm.

5. Complete and conceptually consistent data sets on labor and multifactor productivity are also published for Australia and Canada by their respective national statistical agencies.

6. For our purposes, the business sector data ideally would exclude the flow of services from owner-occupied dwellings in the household sector. But the OECD definition of output includes the flow of services because of data limitations in various OECD countries.

## *Trends in Output and Factor Inputs*

Table 1 reports average annual growth rates for business sector GDP, labor hours, capital stock, and factor shares for selected periods: 1981–89, 1990–98, 1990–95, and 1996–98 for the seventeen industrialized countries examined here.[7] For the United States, it includes the data both from the BLS and from the OECD. It also shows figures for 1996–99, although for the OECD data the calculations are based on our own estimates of growth in hours per worker. By and large, average growth rates for the 1996–98 and 1996–99 periods are quite similar in the BLS and the OECD data sets.

### GDP Growth

For the United States, based on BLS data, the average annual growth rate of business GDP over 1996–98 is 4.9 percent (table 1), an increase of 2.3 percentage points relative to the first half of the 1990s and of 1.2 percentage points compared with the 1980s; the OECD-based estimates of U.S. output growth are quite similar to those of the BLS. For the foreign industrial countries, Finland, Ireland, and Norway show a greater increase in output growth over 1996–98 relative to either the first half of the 1990s or the 1980s. Other countries with a sizable increase of growth in the late 1990s relative to the earlier periods are Australia, Canada, the Netherlands, and Spain.

### Labor Growth

The measure of labor that is used corresponds to business sector employment adjusted by hours per worker. Accounting for changes in hours worked, as opposed to merely accounting for changes in the number of employees, is important. First, from a secular standpoint, the past two decades have seen a decline in the number of hours worked per employee in foreign industrial economies. Thus, abstracting from the role of hours worked would overstate the amount of growth of labor input and understate labor productivity growth. Second, from a cyclical standpoint, hours per worker change over time relative to trend, as they provide firms with another means with which to vary labor input.

The OECD measure of labor hours per worker is for the overall economy instead of for the business sector. Ideally, we would prefer a measure of hours worked that corresponds to the OECD definition of the business sector, but such series are not available. However, the mismatch in the measure of hours is probably more relevant for estimating the level of productivity than for estimating the growth rate of productivity, unless the government and business sectors had significant differences in the trends of hours per worker.

For the United States, over 1996–98 the average annual growth rate of labor hours, based on BLS data for the nonfarm business sector, is 2.5 percent, which is higher than the averages for the 1980s (2.1 percent) and the early 1990s (1.0 percent).[8] For the United States, the OECD data follow a similar pattern, with growth rates of 2.2 percent, 2.1 percent, and 1.4 percent respectively.[9]

Turning to foreign countries, we find that growth in labor hours also picked up in 1996–98, relative to the earlier periods, for many countries. Growth rates of labor hours in Canada, Denmark, Finland, France, Ireland, Italy, the Netherlands, Norway, Spain, and the United Kingdom over 1996–98 are higher than during 1990–95 and the 1980s. However, in many industrial countries, hours worked declined between the 1980s and the early 1990s.

### Capital Growth

The OECD data use a gross capital stock measure from which the full value of an asset is subtracted when it is retired from production. For the United States, the BLS-based measure of capital is a net capital stock measure (that is, net of period-by-period depreciation). With this measure, individual types of capital are aggregated according to their marginal product weights, as proxied by user costs for different types of capital.[10]

For the United States, the average annual growth rate of capital according to the BLS-based data over 1996–98 was 5.3 percent (table 1); this growth rate

7. We adopt the convention that the average annual growth rate for output over, for example, 1996–98 refers to the mean growth rate from the 1995 output level to the 1998 output level.

8. The BLS adjusts its measure of labor inputs for changes in labor quality. Here we report the BLS measure without the labor-quality adjustments.

9. Unlike the OECD, the BLS definition of the nonfarm business sector excludes government enterprises such as the Postal Service.

10. The BLS-based data for capital are from Oliner and Sichel, ‘‘The Resurgence of Growth in the Late 1990s.’’ They construct a measure of capital through 1999 that is consistent with both BLS methodology and the October 1999 comprehensive revisions of the U.S. national income and product accounts. Since that paper was finalized, the U.S. national accounts have been revised further. That revision would raise the growth rate of capital slightly over 1996–99.

1. Average growth rates for GDP, labor hours, and capital stock, and labor's share of GDP, in the Group of Seven and other OECD countries, selected periods, 1981–99

Percent

| Country and measure of growth or share | 1981–89 | 1990–98 | 1990–95 | 1996–98 | 1996–99[1] |
|---|---|---|---|---|---|
| *United States* | | | | | |
| BLS data[2] | | | | | |
| GDP | 3.64 | 3.30 | 2.52 | 4.86 | 4.84 |
| Labor hours | 2.06 | 1.51 | 1.04 | 2.47 | 2.30 |
| Capital stock | 4.36 | 3.87 | 3.16 | 5.30 | 5.59 |
| Labor share | .68 | .68 | .68 | .67 | .67 |
| OECD data | | | | | |
| GDP | 3.44 | 3.13 | 2.41 | 4.55 | 4.43 |
| Labor hours | 2.10 | 1.69 | 1.41 | 2.24 | 2.08 |
| Capital stock | 2.90 | 2.40 | 1.90 | 3.41 | 3.70 |
| Labor share | .67 | .66 | .66 | .66 | .66 |
| *Canada* | | | | | |
| GDP | 3.25 | 2.11 | 1.51 | 3.31 | 3.53 |
| Labor hours | 1.81 | .84 | .17 | 2.19 | 2.59 |
| Capital stock | 5.74 | 4.12 | 3.86 | 4.64 | 4.85 |
| Labor share | .66 | .70 | .70 | .70 | .70 |
| *France* | | | | | |
| GDP | 2.40 | 1.70 | 1.30 | 2.50 | 2.53 |
| Labor hours | –.95 | –.42 | –.94 | .62 | .91 |
| Capital stock | 2.57 | 2.41 | 2.58 | 2.06 | 2.17 |
| Labor share | .67 | .61 | .62 | .61 | .61 |
| *Germany*[3] | | | | | |
| GDP | n.a. | 1.68 | 1.62 | 1.77 | 1.72 |
| Labor hours | n.a. | –.43 | –.62 | –.18 | –.41 |
| Capital stock | n.a. | 2.65 | 2.95 | 2.25 | 2.33 |
| Labor share | n.a. | .64 | .66 | .62 | .62 |
| *Italy* | | | | | |
| GDP | 2.36 | 1.54 | 1.59 | 1.45 | 1.38 |
| Labor hours | .04 | –.51 | –1.09 | .64 | .71 |
| Capital stock | 2.78 | 2.82 | 2.87 | 2.72 | 2.73 |
| Labor share | .68 | .64 | .65 | .62 | .62 |
| *Japan* | | | | | |
| GDP | 4.09 | 1.84 | 2.15 | 1.21 | 1.31 |
| Labor hours | .95 | –.64 | –.73 | –.45 | –.76 |
| Capital stock | 5.84 | 4.46 | 4.88 | 3.62 | 3.31 |
| Labor share | .77 | .72 | .72 | .72 | .72 |
| *United Kingdom* | | | | | |
| GDP | 3.54 | 2.61 | 2.37 | 3.08 | 2.78 |
| Labor hours | .22 | .88 | .60 | 1.46 | 1.29 |
| Capital stock | 1.69 | 2.73 | 2.64 | 2.92 | 3.10 |
| Labor share | .69 | .69 | .70 | .67 | .69 |
| *Australia* | | | | | |
| GDP | 3.97 | 3.69 | 3.09 | 4.90 | 4.78 |
| Labor hours | 2.50 | 1.31 | 1.29 | 1.33 | 1.61 |
| Capital stock | 3.96 | 3.48 | 3.02 | 4.42 | 4.44 |
| Labor share | .65 | .62 | .62 | .62 | .62 |

NOTE. In this and subsequent tables, the G-7 countries are listed first.

1. Uses authors' estimates for labor hours in 1999 for OECD data.

2. Data for the nonfarm business sector of the United States. Observations for GDP and labor hours are from the U.S. Bureau of Labor Statistics; data for capital stock and labor share are for nonfarm business as computed by Oliner and Sichel, "The Resurgence of Growth in the Late 1990s." They include software in their measure of investment expenditure and extend the BLS data beyond 1997.

3. Calculations for Germany use growth rates starting in 1992 to avoid the distortions induced by the German Unification during 1990–91.

1.—Continued

Percent

| Country and measure of growth or share | 1981–89 | 1990–98 | 1990–95 | 1996–98 | 1996–99[1] |
|---|---|---|---|---|---|
| *Belgium*[4] | | | | | |
| GDP | 1.96 | 2.05 | 1.79 | 2.56 | 2.39 |
| Labor hours | .61 | .15 | –.37 | 1.20 | 1.33 |
| Capital stock | 2.84 | 3.14 | 3.26 | 2.90 | 2.93 |
| Labor share | .64 | .64 | .64 | .63 | .63 |
| *Denmark*[5] | | | | | |
| GDP | 2.01 | 2.97 | 2.82 | 3.27 | 2.74 |
| Labor hours | –.06 | .33 | –.82 | 2.63 | 1.88 |
| Capital stock | 3.02 | 2.91 | 2.69 | 3.35 | 3.42 |
| Labor share | .69 | .63 | .63 | .63 | .63 |
| *Finland*[6] | | | | | |
| GDP | 3.54 | 1.68 | –.46 | 5.94 | 5.51 |
| Labor hours | –.29 | –2.05 | –4.18 | 2.20 | 2.34 |
| Capital stock | n.a. | .35 | –.14 | .67 | .85 |
| Labor share | .71 | .69 | .71 | .65 | .64 |
| *Ireland*[7] | | | | | |
| GDP | 3.91 | 7.28 | 5.84 | 10.14 | 9.87 |
| Labor hours | –.10 | 3.20 | 1.67 | 6.24 | 5.79 |
| Capital stock | 2.58 | 2.97 | 2.28 | 4.34 | 4.74 |
| Labor share | .76 | .68 | .70 | .64 | .63 |
| *Netherlands*[8] | | | | | |
| GDP | 2.00 | 3.02 | 2.66 | 3.75 | 3.65 |
| Labor hours | –1.35 | 1.02 | –.24 | 3.55 | 3.31 |
| Capital stock | 1.66 | 2.29 | 2.08 | 2.70 | 2.78 |
| Labor share | .61 | .60 | .61 | .60 | .60 |
| *Norway* | | | | | |
| GDP | 1.17 | 2.84 | 2.10 | 4.33 | 3.15 |
| Labor hours | –.26 | .14 | –1.03 | 2.48 | 1.73 |
| Capital stock | 3.02 | 1.66 | 1.05 | 2.87 | 2.69 |
| Labor share | .72 | .68 | .67 | .68 | .69 |
| *Spain*[9] | | | | | |
| GDP | 2.70 | 2.31 | 1.67 | 3.57 | 3.69 |
| Labor hours | –1.10 | .38 | –.86 | 2.86 | 3.34 |
| Capital stock | 5.63 | 4.27 | 4.47 | 3.87 | 4.00 |
| Labor share | .67 | .61 | .62 | .60 | .60 |
| *Sweden* | | | | | |
| GDP | 2.43 | 1.63 | 1.21 | 2.47 | 2.93 |
| Labor hours | .90 | –.42 | –.88 | .51 | 1.19 |
| Capital stock | 2.93 | 2.24 | 2.10 | 2.51 | n.a. |
| Labor share | .69 | .68 | .68 | .68 | .68 |
| *Switzerland*[10] | | | | | |
| GDP | 1.93 | .82 | .46 | 1.52 | 1.52 |
| Labor hours | n.a. | –.86 | –.88 | –.81 | –.35 |
| Capital stock | 3.58 | 3.18 | 3.30 | 2.94 | 3.04 |
| Labor share | .67 | .69 | .69 | .70 | .69 |

4. Data for Belgium's growth of labor hours start in 1984.

5. Data for Denmark's growth of labor hours start in 1984, and data for capital-stock growth start in 1988.

6. Data for Finland's growth of capital stock start in 1994.

7. Data for Ireland's growth of labor hours start in 1984.

8. Data for the Netherland's labor share start in 1987.

9. Data for Spain's growth of capital stock start in 1989.

10. Data for Switzerland's growth of labor hours start in 1991.

n.a. Not available.

exceeded the corresponding growth rates over the 1980s and the early 1990s. The OECD measure of the growth of the U.S. capital stock follows much the same pattern but is consistently below the growth rate of U.S. capital in the BLS-based data. The main reason for this difference in growth rates is that, as noted, the BLS-based data aggregate individual types of capital by their user costs. As a result, the BLS data capture the effect of shifts in the composition of the capital stock toward types of capital with higher productivities, such as those embodying computer technology. The OECD data do not capture such compositional shifts because they do not weight different types of capital by their user costs. Although we would prefer to use a series of capital for the foreign industrial countries comparable to the BLS series, we do not have access to sufficiently disaggregated data to construct such a measure.[11]

Among foreign industrial countries, only five have growth rates of capital during 1996–98 that, as in the United States, exceeded their own 1981–95 averages: Australia, Denmark, Ireland, the Netherlands, and the United Kingdom. Canada, Norway, and Sweden experienced a pickup in capital growth in the late 1990s relative to the early 1990s, but not relative to the 1980s. Capital growth declined in 1996–98 relative to the earlier periods for Japan, France, Spain, and Switzerland; for Italy and Belgium, capital growth was relatively unchanged.

### Factor Shares in Compensation

Even after data on labor and capital have been compiled, the problem remains of weighting their separate contributions so that a single aggregate measure of productive inputs can be estimated, thereby allowing for the calculation of multifactor productivity. Here we follow the general practice of setting these weights equal to the share of the value of production received by each factor as compensation for its services. Labor's share is calculated as the fraction of the value of GDP in the business sector that is paid to workers in that sector in the form of compensation; the share for capital is constructed as one minus the share for labor.

For the United States, labor's share (compensation) in the business sector has been roughly two-thirds of the value of production for the past two decades regardless of the source of data (table 1); other countries exhibit labor shares that are rather similar to that of the United States. The exception is Japan, where the share has exceeded 70 percent for the past twenty years. For France, Denmark, Spain, and Ireland, the labor share has shown a marked tendency to decline over time.

## *Trends in Labor and Multifactor Productivity Growth*

### Labor Productivity

For the United States, the average annual growth rate of U.S. labor productivity over 1996–98 based on BLS data was 2.4 percent, compared with 1.5 percent for 1990–95 and 1.6 percent for the 1980s (table 2). This pickup in U.S. labor productivity growth is evident in the OECD data as well. Specifically, the average annual growth rate of U.S. labor productivity was 2.3 percent in 1996–98, compared with 1.0 percent for the 1990–95 period and 1.3 percent for the 1980s.

Only two of the foreign industrial economies in our sample, Australia and Switzerland, show a rise in labor productivity growth over 1996–98 compared with the earlier periods. For Australia, the acceleration in labor productivity was particularly strong: an increase of 2 percentage points in 1996–98 over its average in the 1980s. In contrast, labor productivity growth slowed in Canada, Japan, and the major European countries in the latter half of the 1990s relative to both the 1981–89 and the 1990–95 periods. In most smaller European countries, such as Belgium, Denmark, and the Netherlands, labor productivity also decelerated in the latter half of the 1990s relative to the two earlier periods. In a few countries, including Finland, Ireland, and Sweden, labor productivity growth was relatively unchanged in the most recent period compared with the earlier periods.

On the whole, table 2 shows that, based on OECD data, during the 1980s and the first half of the 1990s, U.S. labor productivity growth was below labor productivity growth in every foreign Group of Seven (G-7) country. However, in the latter half of the 1990s, the situation reversed: Labor productivity growth in the United States was higher than that in foreign G-7 countries. Furthermore, of the foreign countries included in table 2, only Australia, Finland, Ireland, and Switzerland had a higher rate of labor productivity growth than the United States in the 1996–98 period.

### Capital Deepening and Multifactor Productivity

As noted earlier, the growth of labor productivity depends on both the rate of capital deepening and the growth of multifactor productivity. For most countries, recent movements in the rate of capital deepening have been in the same direction as movements in labor productivity growth. For the United States, capital deepening rose in the latter half of the 1990s relative to the 1981–95 period regardless of data source. However, the contribution of U.S. capital deepening is significantly higher with BLS data than with OECD data because of differences in the measures of capital growth drawn from these data sources, as shown in table 1. Unlike the U.S. experi-

11. One study, discussed later in this article, that does construct a measure of capital, using the same methodology as the BLS, for the G-7 countries is Schreyer, "The Contribution of Information and Communication Technology to Output Growth." A drawback to his series is that they extend only to 1996.

2. Average growth rate of productivity estimates, in the Group of Seven and other OECD countries, selected periods, 1981–99

Percent

| Country and productivity estimate | 1981–89 | 1990–98 | 1990–95 | 1996–98 | 1996–99[1] |
|---|---|---|---|---|---|
| *United States* | | | | | |
| BLS data[2] | | | | | |
| Labor productivity | 1.59 | 1.78 | 1.47 | 2.42 | 2.57 |
| Capital deepening | .73 | .77 | .68 | .96 | 1.11 |
| MFP | .86 | 1.01 | .79 | 1.46 | 1.47 |
| Of which labor quality | .34 | .39 | .42 | .32 | .31 |
| OECD data | | | | | |
| Labor productivity | 1.31 | 1.43 | 1.02 | 2.26 | 2.30 |
| Capital deepening | .25 | .24 | .16 | .40 | .54 |
| MFP | 1.09 | 1.20 | .85 | 1.91 | 1.80 |
| *Canada* | | | | | |
| Labor productivity | 1.42 | 1.26 | 1.34 | 1.10 | .92 |
| Capital deepening | 1.31 | .96 | 1.08 | .73 | .67 |
| MFP | .14 | .31 | .26 | .39 | .27 |
| *France* | | | | | |
| Labor productivity | 3.41 | 2.12 | 2.26 | 1.86 | 1.61 |
| Capital deepening | 1.10 | 1.09 | 1.35 | .57 | .50 |
| MFP | 2.26 | 1.03 | .89 | 1.31 | 1.12 |
| *Germany*[3] | | | | | |
| Labor productivity | n.a. | 2.13 | 2.26 | 1.96 | 2.14 |
| Capital deepening | n.a. | 1.09 | 1.22 | .91 | 1.06 |
| MFP | n.a. | 1.03 | 1.02 | 1.04 | 1.07 |
| *Italy* | | | | | |
| Labor productivity | 2.33 | 2.09 | 2.72 | .81 | .67 |
| Capital deepening | .87 | 1.18 | 1.36 | .82 | .82 |
| MFP | 1.45 | .88 | 1.32 | –.01 | –.14 |
| *Japan* | | | | | |
| Labor productivity | 3.12 | 2.48 | 2.89 | 1.64 | 2.07 |
| Capital deepening | 1.15 | 1.44 | 1.56 | 1.21 | 1.23 |
| MFP | 2.00 | 1.03 | 1.31 | .46 | .85 |
| *United Kingdom* | | | | | |
| Labor productivity | 3.37 | 1.72 | 1.78 | 1.60 | 1.47 |
| Capital deepening | .42 | .53 | .57 | .44 | .54 |
| MFP | 2.90 | 1.20 | 1.21 | 1.18 | .95 |
| *Australia* | | | | | |
| Labor productivity | 1.45 | 2.37 | 1.79 | 3.52 | 3.12 |
| Capital deepening | .45 | .82 | .64 | 1.16 | 1.06 |
| MFP | 1.01 | 1.57 | 1.15 | 2.41 | 2.11 |
| *Belgium*[4] | | | | | |
| Labor productivity | 2.32 | 1.90 | 2.18 | 1.35 | 1.05 |
| Capital deepening | .82 | 1.06 | 1.28 | .63 | .60 |
| MFP | 1.51 | .83 | .87 | .73 | .46 |
| *Denmark*[5] | | | | | |
| Labor productivity | 2.53 | 2.67 | 3.69 | .62 | .86 |
| Capital deepening | n.a. | .94 | 1.27 | .27 | .56 |
| MFP | n.a. | 1.70 | 2.37 | .37 | .31 |
| *Finland*[6] | | | | | |
| Labor productivity | 3.85 | 3.82 | 3.91 | 3.66 | 3.10 |
| Capital deepening | n.a. | n.a. | n.a. | –.54 | –.53 |
| MFP | n.a. | n.a. | n.a. | 4.28 | 3.70 |
| *Ireland*[7] | | | | | |
| Labor productivity | 5.14 | 4.01 | 4.10 | 3.81 | 3.96 |
| Capital deepening | n.a. | –.14 | .15 | –.71 | –.39 |
| MFP | n.a. | 4.22 | 4.01 | 4.62 | 4.47 |
| *Netherlands*[8] | | | | | |
| Labor productivity | 3.40 | 2.07 | 2.98 | .23 | .35 |
| Capital deepening | n.a. | .49 | .90 | –.33 | –.21 |
| MFP | n.a. | 1.51 | 1.99 | .54 | .55 |
| *Norway* | | | | | |
| Labor productivity | 1.44 | 2.72 | 3.18 | 1.80 | 1.39 |
| Capital deepening | .92 | .48 | .66 | .12 | .29 |
| MFP | .50 | 2.23 | 2.48 | 1.73 | 1.13 |
| *Spain*[9] | | | | | |
| Labor productivity | 3.89 | 1.96 | 2.58 | .70 | .34 |
| Capital deepening | n.a. | 1.48 | 2.01 | .40 | .26 |
| MFP | n.a. | .45 | .52 | .31 | .08 |
| *Sweden* | | | | | |
| Labor productivity | 1.52 | 2.06 | 2.11 | 1.96 | 1.73 |
| Capital deepening | .61 | .81 | .89 | .65 | n.a. |
| MFP | .92 | 1.23 | 1.19 | 1.32 | n.a. |
| *Switzerland*[10] | | | | | |
| Labor productivity | n.a. | 1.31 | .66 | 2.38 | 1.90 |
| Capital deepening | n.a. | 1.18 | 1.21 | 1.13 | 1.03 |
| MFP | n.a. | .10 | –.57 | 1.20 | .84 |

NOTE. The sum of capital deepening growth and multifactor productivity (MFP) growth does not always add up to labor productivity growth because of rounding errors.

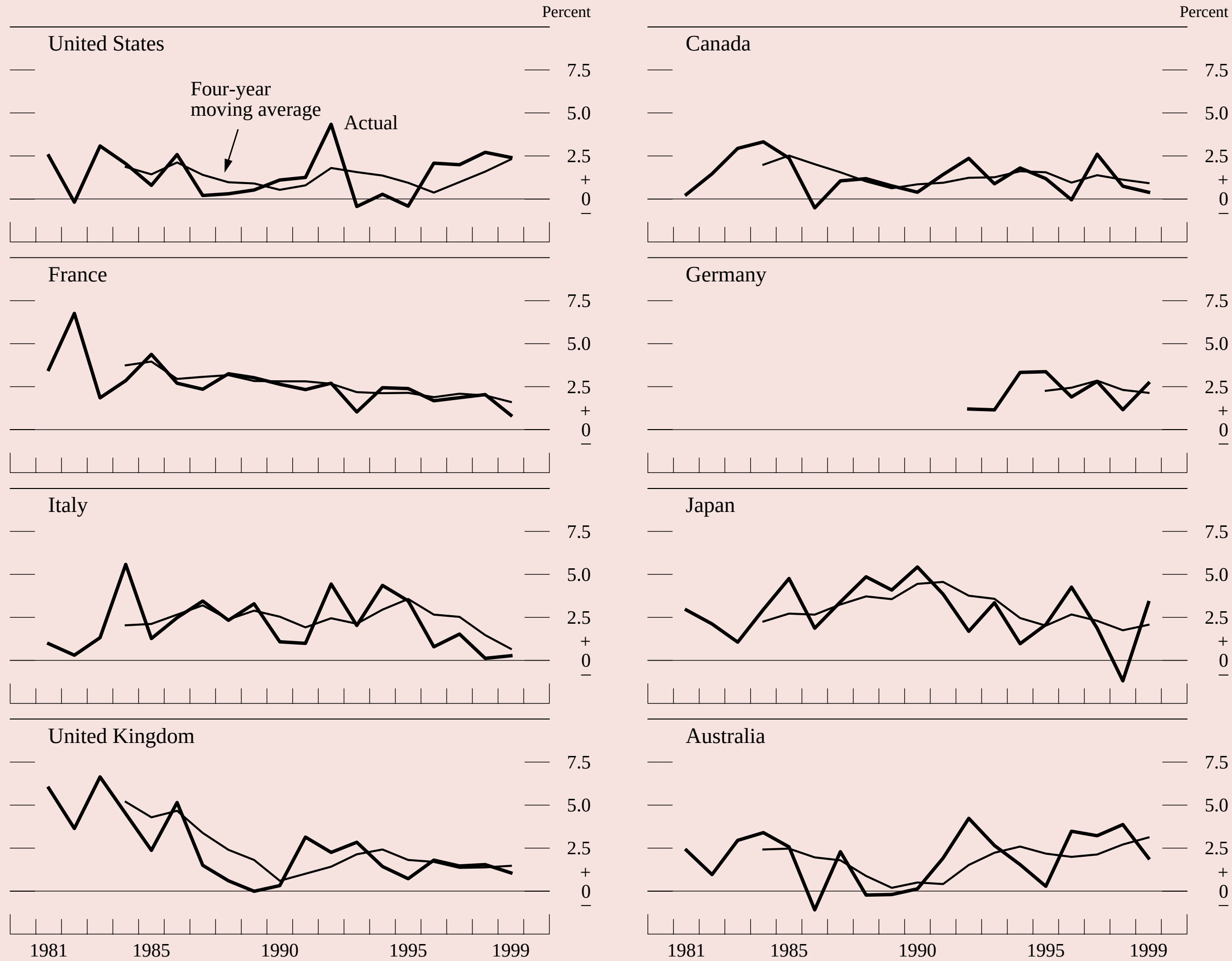
1. Uses authors' estimates for labor hours in 1999 for OECD data.
2. Measures of labor productivity, capital deepening, and MFP reported here are those in Oliner and Sichel, "The Resurgence of Growth in the Late 1990s," plus their estimated growth of labor quality.
3. Calculations for Germany use growth rates starting in 1992 to avoid the distortions induced by the German Unification during 1990–91.
4. Data for Belgium's growth of labor hours start in 1984.
5. Data for Denmark's growth of labor hours start in 1984, and data for capital-stock growth start in 1988.
6. Data for Finland's growth of capital stock start in 1994.
7. Data for Ireland's growth of labor hours start in 1984.
8. Data for the Netherland's labor share start in 1987.
9. Data for Spain's growth of capital stock start in 1989.
10. Data for Switzerland's growth of labor hours start in 1991.

n.a. Not available.

ence, capital deepening in most foreign economies slowed in 1996–98 compared with 1981–95. The slowdown was particularly sharp in Ireland, the Netherlands, and Spain, and somewhat more moderate in Canada, France, and Germany. A notable exception to the slowing of capital deepening abroad was Australia.

The results for multifactor productivity growth are also consistent with the pattern of labor productivity growth. The results using the BLS-based data show a pickup in U.S. multifactor productivity growth from around 0.8 percent in the 1981–95 period to close to 1.5 percent in 1996–98. The OECD data also show a pickup in U.S. multifactor productivity growth, from around 1.0 percent in the 1981–95 period to close to 1.9 percent in 1996–98. The difference in estimated multifactor productivity growth rates for the United States stems from the differences in estimated growth rates of capital deepening in the two U.S. data sources; with labor productivity growth about the same in the two data sets, the higher rate of capital deepening in the more conceptually accurate BLS data, compared with the OECD data, leads to a lower estimated rate of multifactor productivity growth.

1. Growth rates of labor productivity in the Group of Seven and other OECD countries, 1981–99




NOTE. Calculations for the United States use the OECD data; results for Germany use growth rates starting in 1992 to avoid the distortions induced by the German unification during 1990–91. Calculations for growth rates (actual) for Belgium, Denmark, and Ireland start in 1984.

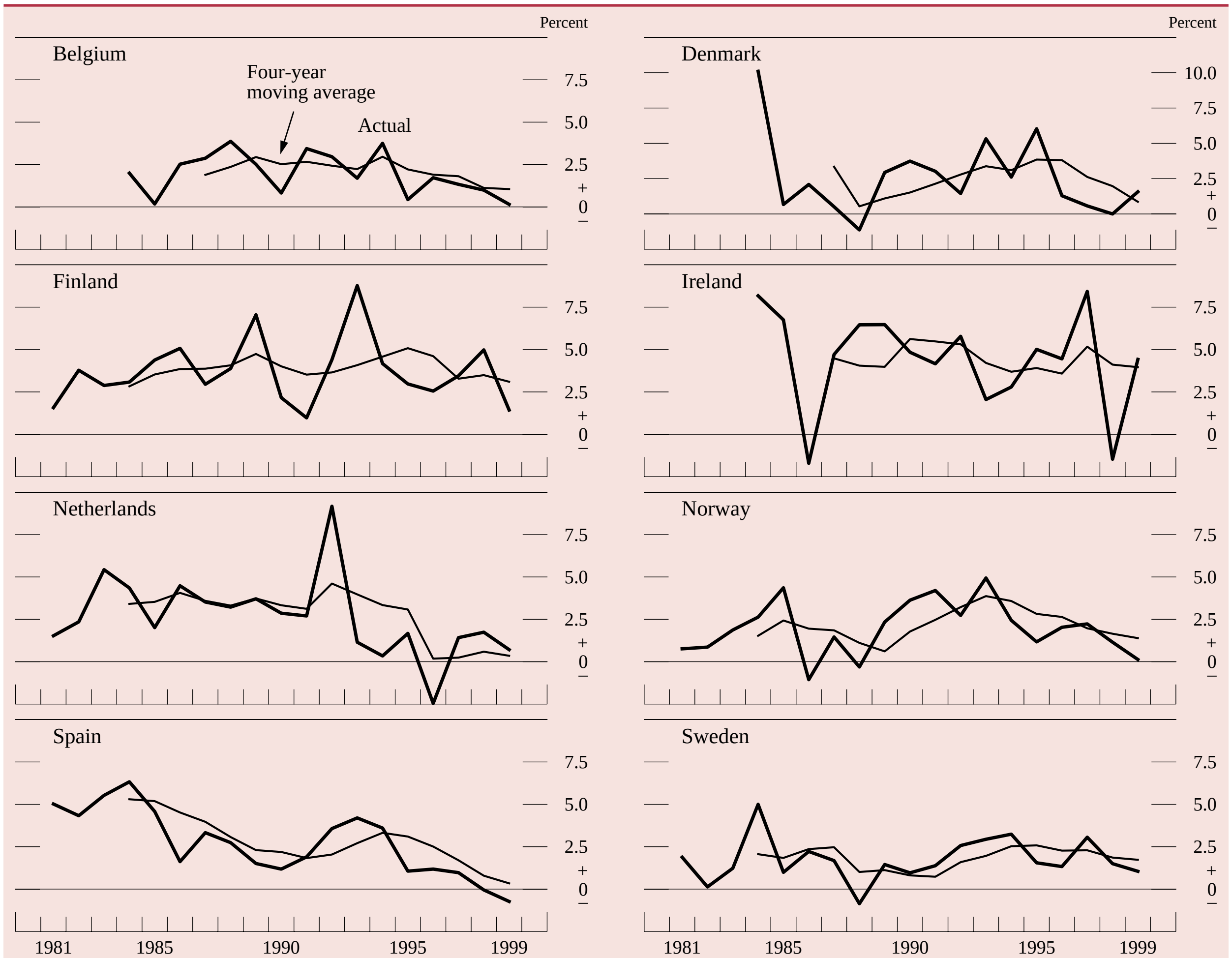
In contrast to the results for the United States, most of the foreign G-7 countries—the exception is Canada—experienced slowing multifactor productivity growth in the latter half of the 1990s relative to the 1981–95 period. Multifactor productivity growth also slowed in Belgium, the Netherlands, and Spain. Both Australia and Sweden experienced an acceleration in multifactor productivity, with the Australian pickup particularly sharp.

An important question is which component—capital deepening or multifactor productivity—was the driving force behind the 1.0 percentage point acceleration in U.S. labor productivity recorded in the BLS-based data from 1990–95 to 1996–98. Table 2 shows that in the BLS data, capital deepening accounts for 0.3 percentage point and that multifactor productivity accounts for 0.7 percentage point.[12] The OECD data yield comparable results, although these data do not embody quality adjustments for capital to the same extent as the BLS data.

Among the foreign industrial countries, the results indicate that changes in the growth rate of labor productivity have been dominated, for the most part, by changes in the growth rate of multifactor productivity. The exceptions to this pattern are Belgium, Canada, and Spain, where movements in the growth rate of capital deepening are important for explaining changes in the growth of labor productivity. Changes in multifactor productivity growth rates thus appear to have played the preeminent role in accounting for divergences in the movements of growth in U.S. and foreign labor productivity.

12. As indicated earlier, the recent annual revision of the U.S. national account implies a little more capital deepening than reported by Oliner and Sichel. Also, the above estimate of the change of multifactor productivity growth includes the change in the growth rate of labor quality over these two periods, which was −0.1 percent.

1.—Continued




## Sensitivity to Period Selection

In an examination of the data in table 2, one question that comes to mind is whether movements in measured average productivity growth from period to period accurately reflect underlying movements in productivity performance or, alternatively, reflect largely the choice of time periods used to make the average growth rate calculations. Chart 1 shows annual growth rates for labor productivity for the countries in our study. For some countries, year-to-year movements in labor productivity are extremely volatile, a fact that is masked by period averages. This fact further supports the possibility that period averages of growth rates may not appropriately characterize underlying trends in productivity performance.

Even so, in the United States it is clear that the recent surge in measured productivity growth did not occur until the mid-1990s (for both BLS and OECD data) and since then has remained consistently high. Hence, a focus on 1996–98 as the period when productivity performance broke with its prior historical trend certainly makes sense for the United States.[13]

For many of the foreign economies shown in chart 1, 1995 does not represent a comparable break date in productivity performance. Thus, the question arises whether the improved performance of measured U.S. productivity growth relative to that of foreign economies might not be merely an artifact of the periods chosen to calculate the growth comparisons. To put it another way, if an alternative year

13. One motivation to use 1995 as the cut-off date for comparisons is the abrupt change in the rate of decline in prices for computer and peripheral equipment: from an annual average rate of 15 percent over 1990–95 to 30 percent over 1995–98; see Robert Gordon's article ''Not Much of a New Economy,'' in the *Financial Times*, July 26, 2000. This abrupt change in price declines is credited with accelerating the pace of adoption of computers and the increased growth rate of labor productivity; see the interview with Dale Jorgenson in Steve Liesman, ''Further Gains in Productivity Are Predicted—Economists Say Study Has Made Them Believers in the New Economy,'' *Wall Street Journal*, August 1, 2000.

were chosen as a potential break date in productivity performance—say, 1993, so that productivity growth in 1994–99 would be compared with growth in 1980–93—might not a step-up in productivity growth be discerned for many foreign industrial countries as well?

In fact, a closer look at chart 1 fails to support this hypothesis. To abstract somewhat from year-to-year movements in productivity growth, a four-year moving average of productivity growth (which includes the current and three previous years) is also shown for each of the countries in this chart. These series make clear that for most foreign industrial countries, it is impossible to identify a point at which the moving averages started moving up on a sustained basis—that is, a break date in the past decade such that productivity growth after that date is discernibly higher than growth before that date.[14] Overall, our failure to discern a pickup of productivity growth in most foreign industrial countries does not appear to be an artifact of the periods chosen to calculate productivity.

The conclusions reached from table 2 and chart 1 raise two questions. First, what accounts for the failure of productivity growth abroad to rise, especially given the pickup in U.S. productivity growth? (In fact, in some countries, productivity growth seems to be trending down.) Second, is this divergent performance likely to be sustained? Although no definitive answers to these questions exist, the following sections survey the range of available evidence and explanations.

## *Explaining Differences in Productivity Growth*

To account for the recent divergence in the patterns of U.S. and foreign labor productivity growth, we group the existing hypotheses into three categories: cyclical, methodological, and structural.

### *Cyclical Considerations*

One of the factors that is considered important in explaining productivity growth is the cyclical position of the economy. With the U.S. economy growing rapidly in recent years while foreign industrial economies have generally been growing more slowly, it is possible that some part of the divergence in productivity performance may be attributable to differences in cyclical positions.

One way that a cyclical pickup in activity may lead to a corresponding uptick in productivity involves ''factor hoarding.'' This phenomenon arises from firms' tendency to adjust the intensity with which labor and capital are used before adjusting the number of workers or machines. During recessions, firms may choose not to lay off workers or reduce their hours to an extent commensurate with reduced production schedules; this unwillingness to lay off workers is referred to as ''labor hoarding.'' In consequence, output may decline by more than labor hours during recessions, as (unobservable) labor effort falls, leading to declines in measured labor productivity. Conversely, during subsequent recoveries, output has a tendency to rise more than labor hours as employees work harder, thereby boosting measured labor productivity.

Similarly, a firm may choose to decrease the number of hours or the speed at which it uses a particular piece of equipment during a period of economic slack. As a result, the measured capital input will tend to fall less than the effective use of the capital stock, which will depress measures of multifactor productivity growth, while the reverse holds true during economic recoveries. Thus one would like to use a measure of the capital inputs that would adjust for rates of capacity utilization. The best measures of capacity utilization are available for the manufacturing sector, but these are not, unfortunately, suitable for use in this analysis. By definition, business sector capital includes the capital of firms in the service sector, a sector that makes up a large share of activity in most industrialized countries and for which data on capacity utilization are not available.

To examine the role of cyclical considerations in the determination of labor productivity growth, we review the four-year moving averages of growth rates of labor productivity shown in chart 1. Although such moving averages do not necessarily correspond to trends in labor productivity adjusted for cyclical influences, they do make it easier to identify visually a long-term trend in the underlying series, with cyclical influences minimized.[15] Trends in labor productivity growth in many foreign industrial countries during 1996–99 appear to be a continuation of ongoing downward trends rather than the result of cyclical influences.

Specifically, as shown in chart 1, the countries with a relatively long-term decline in labor productivity

14. The one exception to this pattern is Australia, where productivity growth picked up in the early 1990s.

15. We considered the robustness of our findings by computing trend productivity growth using a Hodrick–Prescott filter; the conclusions are robust to this alternative method.

growth are France, the United Kingdom, the Netherlands, and Spain. For other countries, such as Italy, Japan, Belgium, Finland, and Norway, the decline in trend productivity growth started in the early 1990s, whereas Canada, Ireland, and Sweden showed a relatively unchanged level of productivity growth. Australia is the only foreign country in our sample that showed a rising trend in productivity growth, an observation that confirms the results shown in table 2. Because the trend has been rising since the early 1990s, it suggests that factors other than the business cycle have been important.[16]

The pickup in labor productivity growth in the United States may be due in part to cyclical factors, but chart 1 suggests that the increase of U.S. labor productivity growth relative to foreign growth, as shown in table 2, is not due solely to cyclical factors. Nevertheless, not enough time has elapsed to allow a firm judgment as to whether the recent divergence in U.S. and foreign productivity performance reflects a secular shift.

## *Methodological Considerations*

The much stronger measured productivity performance in the United States relative to the foreign countries in recent years does not reflect only the more conceptually accurate statistics embodied in the BLS data set (table 2). Even based on the OECD data set, measured productivity growth moves up appreciably in the United States in recent years. Nevertheless, despite the efforts of the OECD to enhance cross-country comparability of measures of output and input, methodological differences in national statistical agencies could still play a role in comparisons of the movements of U.S. and foreign productivity growth. Two methodological considerations that affect our measures of productivity growth are the method for measuring quality change in price indexes and the evolution of the system of national accounts.

### Quality Change and Price Measurement

Calculations of capital deepening and multifactor productivity growth depend on measures of real output and of real capital. Because the data used to estimate output and investment are collected on a nominal basis, price indexes must be calculated to deflate these nominal figures to a real (constant-price) basis. This adjustment can be difficult when changes in prices reflect changes in quality. One method for measuring quality change in prices is to use hedonic pricing. This method seeks to identify the quality component of a product's price by redefining goods according to their characteristics and computing a quality-adjusted price based on those characteristics. For example, for computers, hedonic pricing derives a price for a bundle of computing power from the observed price of a computer ‘‘box’’ by estimating a relationship between the observed price and characteristics such as processor speed and memory size. With the rapid advancement in product development and quality change in high-tech goods, hedonic price indexes have gained increasing, albeit still limited, use among industrial countries (table 3).

Countries that do not use hedonic price indexes for goods such as computers, whose quality has changed rapidly over time, tend to understate output growth for these goods. If the price of a good reflects a quality improvement and is not quality adjusted, then the price change will be overstated and the output change understated. As a result, labor productivity growth will tend to be understated for countries that do not use hedonic price indexes relative to those countries that do make these quality adjustments. Because both the change in output and the change in the capital stock will be understated for countries that do not make this type of quality adjustment, the effect on multifactor productivity of using hedonic price indexes is less clear to the extent that computers are both an output and a capital input.

Can the failure of many foreign countries to use hedonic price indexes for computer products explain the relatively lower measured productivity performance abroad? Probably not. First, many of the countries that do use hedonic indexes, including Denmark, France, and Japan, still show declines in productivity growth. Second, in many of the countries that do not employ hedonic indexes, including Germany and Italy, a relatively small fraction of their output is composed of computers and other products related to information technology. Furthermore, other methodological differences between the United States and many foreign industrial countries, such as the use in the United States of chain-weighted instead of fixed-weight price indexes (table 3), may offset, to some extent, the effect of not using hedonic price indexes.

16. For a detailed discussion of Australia's productivity performance, see David Gruen and Glenn Stevens, ‘‘Australian Macroeconomic Performance in the 1990s,’’ Reserve Bank of Australia Working Paper (July 2000). They argue that Australia's good performance in the 1990s is due to deregulation and privatization of ‘‘old economy’’ sectors rather than to advances in the information technology sector.

## Evolution of National Income Accounting Systems

International comparisons of productivity are also affected by the ongoing transition from the 1968 System of National Accounts (SNA68) to the 1993 System of National Accounts (SNA93), developed under the auspices of the United Nations, and from the 1979 European System of National Accounts (ESA79) to the 1995 system (ESA95).[17] The changes to national accounts introduced by these new systems are fairly substantial and include broadening the concept of investment to include expenditures such as software and mineral exploration, reclassifying some social expenditures as government consumption instead of private consumption, and providing a more comprehensive treatment of the financial services sector. In addition, both SNA93 and ESA95 recommend greater use of chain-weighted price indexes.

The changeover to the new systems ultimately will lead to greater international comparability of productivity measures. At present, however, our measures of productivity are complicated by the changeover, not only across countries but also over time for some countries, because implementation has been gradual and is not uniform. In a number of countries, the changes required by the new system have been implemented only over a short range of historical data and represent only preliminary estimates of the national accounts on the new basis. Table 3 shows the current national accounting system used in many countries and also lists the starting dates for which the data became available on the new basis for these countries. Some countries, such as Sweden and Spain, have published data in terms of the new accounts system only for the latter portion of our sample, while other countries have made these data available for the full sample period (1980–99). For those countries that have revised data only for the latter part of the sample, the early part of the sample is based on the old national accounts system, SNA68 or ESA79.

For each country, the switch to the new accounting system raises both the level and growth rates of GDP relative to the old accounting system. The quantitative effect varies from country to country, with the OECD estimating that, relative to the old system, the new accounting system raises the level of GDP in 1996 from as little as 0.3 percent in Belgium to as much as 5.1 percent in Denmark. Therefore, in a country such as Denmark, where the changeover to the new accounting system occurred in 1988, the effect of this change will tend to raise output growth in the 1990s relative to the 1980s. Other countries where the changeover affects our data in the middle of the sample include Italy, Finland, and Sweden. For these countries, labor productivity growth will tend to be biased down in the 1980s relative to the

3. Features of national accounts in the Group of Seven and other OECD countries

| Country | Expenditure accounts | Chain-weighted | Benchmark/ base year | Hedonic price index used for computers |
|---|---|---|---|---|
| United States | NIPA | Yes | 1996 | Yes |
| Canada | SNA93 starting from 1955 | Yes | 1992 | Yes |
| France | ESA95 starting from 1978 | Yes | 1995 | Yes [1] |
| Germany | ESA95 starting from 1991 | No | 1995 | No |
| Italy | ESA95 starting from 1988 | No | 1995 | No |
| Japan | SNA68 | No | 1990 | Yes |
| United Kingdom | ESA95 starting from 1987 | Yes | 1995 | No |
| Australia | SNA93 starting from 1959 | Yes | 1997/98 | Yes [2] |
| Belgium | ESA95 starting from 1980 | No | 1995 | No |
| Denmark | ESA95 starting from 1988 | No | 1990 | Yes [2] |
| Finland | ESA95 starting from 1988 | No | 1995 | No |
| Ireland | ESA95 starting from 1990 | No | 1995 | No |
| Netherlands | ESA95 starting from 1995 | Yes | 1995 | No |
| Norway | SNA93 starting from 1978 | Yes | 1996 | No |
| Spain | ESA95 starting from 1995 | No | 1995 | No |
| Sweden | ESA95 starting from 1993 | No | 1995 | Yes [2] |

NOTE. NIPA refers to the national income and product accounts of the United States; SNA93, to the 1993 United Nations System of National Accounts, which represents a major revision to the 1968 United Nations System of National Accounts; and ESA95, to the 1995 European System of National Accounts.

1. Hedonic price index used for microcomputers only.
2. Uses current U.S. hedonic index, exchange-rate adjusted.

SOURCE. OECD and national statistical agencies.

17. The 1995 European System of National Accounts (ESA95) is designed to be consistent with SNA93 and is used by European Union member states. It further enhances the comparability of national account data among members of the European Union.

1990s simply because of the transition to the new accounting system.[18]

Therefore, in countries most affected by this transition, labor productivity growth may be artificially low in the early part of our sample, a result that may bias our estimates toward showing an acceleration in labor productivity. Thus, the switchovers to new national accounting methods do not help to account for the absence of an upswing in recorded foreign productivity growth.

## *Structural Considerations*

If the failure of foreign productivity growth to pick up in a manner commensurate with the recent rise in U.S. productivity growth cannot be wholly attributed to either measurement or cyclical factors, then part of the divergence in performance may be structural in origin. Accordingly, this divergence may have its roots in more fundamental economic forces. Two important structural factors affecting movements in U.S. and foreign productivity growth rates are changes in the quality of the labor force—as reflected in the skills, educational attainment, and demographic characteristics of workers—and the sluggishness of the rest of the world, relative to the United States, in adopting recent innovations in information technology.

## Labor Quality

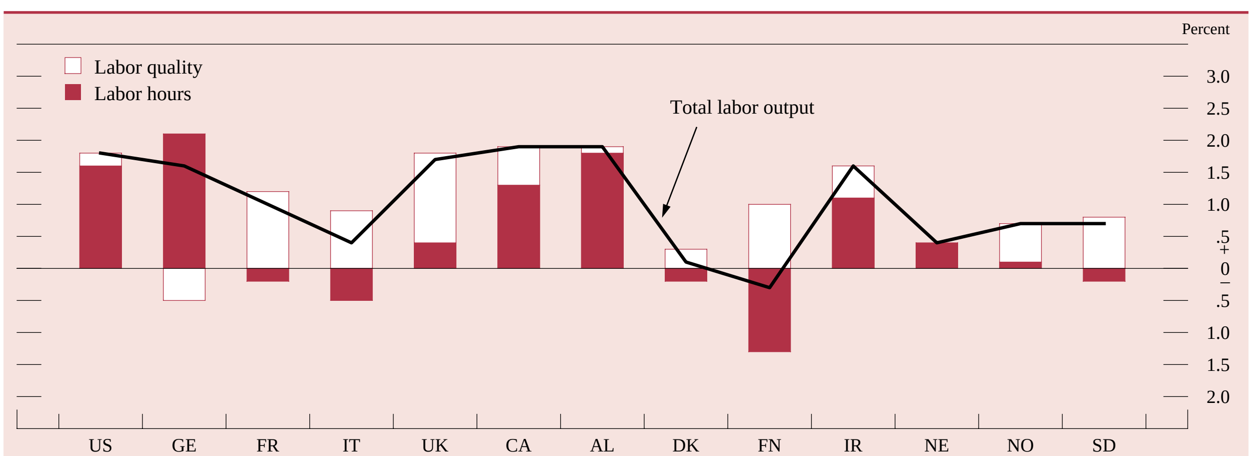
To examine the role played by changes in the quality of the labor force in the United States and abroad, we examined data from a study undertaken at the OECD by Scarpetta, Bassinini, Pilat, and Schreyer, who allow for change in average worker quality by using data on wages and employment for laborers with different educational levels.[19] Chart 2 shows the growth rate of their labor input measure for thirteen of the countries in this study for the 1986–98 period, including a breakdown of growth in labor input into hours growth and the change in quality of labor. As shown in the chart, changes in labor quality have generally been a much more important component of labor productivity growth abroad than in the United States.

In fact, although the data in chart 2 do not distinguish between changes in labor quality in different periods, the OECD study reports that growth of U.S. labor quality remained relatively stable throughout the 1981–98 period.[20] The results suggest that a pickup in labor quality growth was not an important

18. The bias to our multifactor productivity estimates for these countries is less clear because their capital stock growth as well as their output growth in the 1980s will be understated.

19. See "Economic Growth in the OECD Area."
20. Ibid.

2. Change in labor hours, labor quality, and total labor input, selected countries, 1986–98




NOTE. The data for Germany include both the pre- and post-unification periods.

The country abbreviations are the following:

US = United States
GE = Germany
FR = France
IT = Italy
UK = United Kingdom
CA = Canada
AL = Australia
DK = Denmark
FN = Finland
IR = Ireland
NE = Netherlands
NO = Norway
SD = Sweden

SOURCE. Stefano Scarpetta, Andrea Bassanini, Dirk Pilat, and Paul Schreyer, "Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level," OECD Economics Department Working Paper, no. 248.

factor in explaining the acceleration in U.S. productivity. This finding is consistent with the evidence based on BLS data from table 2 that show little change in the growth rate of labor quality during the past two decades.

However, in some European countries, such as France and Italy, a slowdown in the growth of labor skills does appear to partially explain the slowdown in productivity growth.[21] In particular, the OECD study reports that, once an adjustment has been made for labor quality, trend multifactor productivity growth in France and Italy picks up in the latter half of the 1990s relative to the first half of the 1990s. However, even after one adjusts for labor quality, the estimates of trend multifactor productivity growth in France and Italy in the latter half of the 1990s are still lower than the estimates of multifactor productivity growth in the 1980s. In sum, unmeasured changes in labor quality do not appear to account for most of the divergences in U.S. and foreign productivity performance in recent years.

## Diffusion of Technology

A second hypothesis explaining why foreign productivity growth has not risen as much as U.S. productivity growth is the slower pace with which foreign countries have adopted recent innovations in information technology (IT). Researchers have focused on three channels by which those innovations may increase productivity growth. The first channel is the contribution that IT industries make toward productivity growth through heightened productivity performance in the production of IT goods, such as computers, software, and other high-tech equipment. Even though these industries generally contribute only a small fraction of total production, they may make a large contribution to overall productivity growth if there are strong productivity gains in these industries. For example, Oliner and Sichel estimate that, although the computer and semiconductor sectors' share of total output in the nonfarm business sector is only about 2½ percent in the United States for 1996–99, these sectors accounted for about half of their estimate of multifactor productivity growth from 1996 to 1999.[22]

Comparable data on the computer and semiconductor industries do not exist for many foreign industrial countries. Instead, we examine production of IT goods, which include data processing equipment, telecommunications equipment, and consumer electronics, relative to total output for the seventeen countries in this study. In 1997, Ireland, Japan, Finland, and Sweden were the only countries with IT production shares that were greater than that of the United States (chart 3). High IT production shares in Finland and Ireland are consistent with their relatively fast multifactor productivity growth and may partially explain it, although neither Finland nor Ireland has experienced a sizable acceleration in multifactor productivity in recent years. Low multifactor productivity growth in Denmark and Spain is consistent with these countries' relatively low level of IT production.

The other two channels relate to the use of information technology in other sectors of the economy. Investment in IT goods can boost the capital–labor ratio and therefore raise labor productivity. In recent years, with the price of IT goods falling rapidly as a result of technological improvements, investment in IT equipment has been increasing rapidly relative to investment in other types of capital. Finally, information technologies, such as Internet-ready computers, may create network effects that spur the dissemination of information, resulting in disembodied technical change.

Investment in information technology abroad does not appear to have translated into higher productivity growth through these two channels as much as in the United States. One reason is that, compared with the United States, foreign investment in information technology has been a smaller share of foreign economies than of the U.S. economy, so that the payoffs to information technology in terms of improved productivity growth have yet to show up.

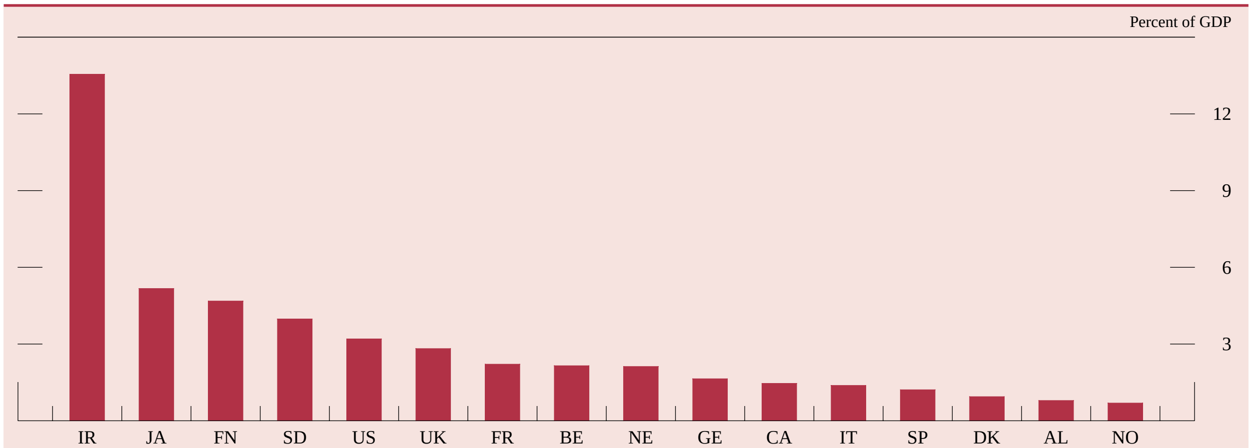
As evidence of this possibility, table 4 displays data from Schreyer on several measures of the IT sector in the G-7 economies.[23] From this table, one

21. One possible explanation for this slowdown in labor quality in some European countries is that in the 1980s and the 1990s, declines in hours worked in these countries (see table 1) fell particularly hard on low-skilled workers. This trend tended to boost the average quality of a worker in those years. In more recent years, with labor market conditions improving, the utilization of low-skilled workers has increased, thereby slowing labor quality growth.

22. Oliner and Sichel also estimate that these sectors contributed 0.35 percentage point to an acceleration of roughly 1 percentage point in the annual growth rate of labor productivity from 1991–95 to 1996–99. See Oliner and Sichel, "The Resurgence of Growth in the 1990s." Other studies that have also found a significant contribution to the acceleration in labor productivity growth from the production of computer hardware include Gordon, "Does the 'New Economy' Measure Up to the Great Inventions of the Past?"; Jorgenson and Stiroh, "Raising the Speed Limit: U.S. Economic Growth in the Information Age;" Karl Whelan, "Computers, Obsolescence, and Productivity," Finance and Economics Discussion Series 2000-06 (Board of Governors of the Federal Reserve System, January 2000); and Council of Economic Advisers, *Economic Report of the President* (February 2000).

23. See Schreyer, "The Contribution of Information and Communication Technology to Output Growth."

3. Production of information technology goods, selected countries, 1997




NOTE. IT goods include data processing equipment, telecommunications equipment, and consumer electronics.

The country abbreviations are the following:

IR = Ireland
JA = Japan
FN = Finland
SD = Sweden
US = United States
UK = United Kingdom
FR = France
BE = Belgium
NE = Netherlands
GE = Germany
CA = Canada
IT = Italy
SP = Spain
DK = Denmark
AL = Australia
NO = Norway

can see that information technology's share of nonresidential gross fixed capital formation has been increasing in all of the G-7 countries as producers substitute IT equipment for other types of investment goods. As a result, information technology's share of the total nominal capital stock has increased in all of these countries, with the United States, at 7.4 percent, having the highest share of IT capital in 1996 and Italy, at 2.1 percent, the lowest. With IT equipment making up a larger share of total capital, it is not surprising that information technology's share of total income in the United States is also higher than in the other G-7 countries. As a result, IT equipment makes a larger contribution to output growth in the United States than in the other G-7 countries.[24] Finally, Schreyer's study also reports that the contribution of IT capital to output growth is somewhat higher in the United Kingdom and Canada than it is

24. Schreyer's analysis probably understates the contribution of information technology to growth in all countries because his definition of IT equipment does not include software.

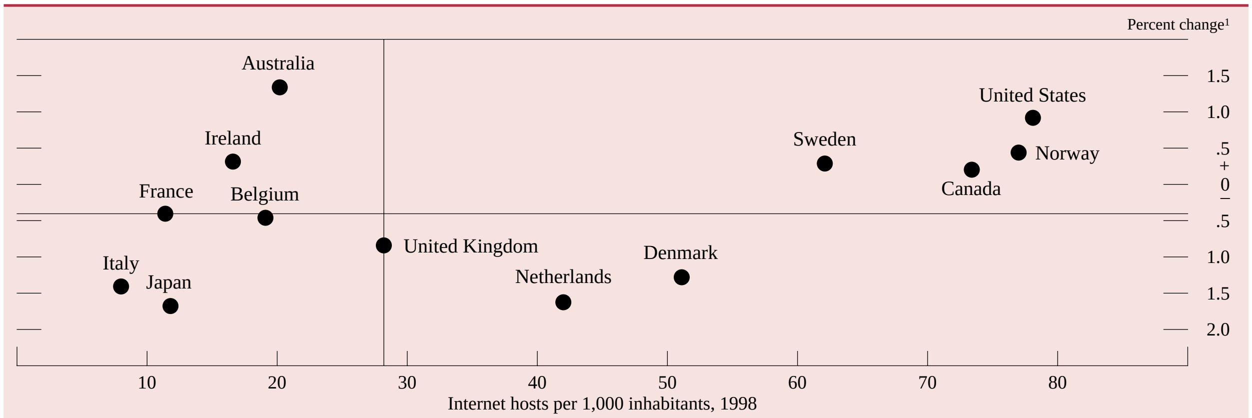
4. Share and contribution of information technology in the Group of Seven countries, 1985, 1990, and 1996

Percent except as noted

| IT measures | United States | Canada | France | Western Germany | Italy | Japan | United Kingdom |
|---|---|---|---|---|---|---|---|
| *Share of IT* | | | | | | | |
| In nonresidential gross fixed capital formation | | | | | | | |
| 1985 | 12.1 | 11.1 | 10.1 | 7.1 | 5.8 | 4.2 | 10.4 |
| 1990 | 15.7 | 12.6 | 8.8 | 7.2 | 7.7 | 5.3 | 13.3 |
| 1996 | 19.9 | 16.2 | 10.9 | 10.9 | 9.6 | 8.1 | 18.3 |
| In nominal productive capital stock | | | | | | | |
| 1985 | 6.2 | 4.3 | 2.4 | 2.9 | 1.3 | 1.2 | 3.6 |
| 1996 | 7.4 | 5.0 | 3.2 | 3.0 | 2.1 | 2.3 | 5.2 |
| In total income | | | | | | | |
| 1985 | .8 | .7 | .3 | .3 | .5 | .5 | .4 |
| 1990 | 1.3 | 1.4 | .9 | .7 | .8 | .7 | 1.0 |
| 1996 | 1.7 | 1.5 | .9 | .8 | .9 | .8 | 1.5 |
| *Contributions to output growth (percentage points) from IT equipment* | | | | | | | |
| 1980–85 | .28 | .25 | .17 | .12 | .13 | .11 | .16 |
| 1985–90 | .34 | .31 | .23 | .17 | .18 | .17 | .27 |
| 1990–96 | .42 | .28 | .17 | .19 | .21 | .19. | .29 |

SOURCE. Paul Schreyer, "The Contribution of Information and Communication Technology to Output Growth: A Study of the G-7 Countries," OECD Science, Technology, and Industry Working Paper, 2000/2 (OECD, 2000).

4. Acceleration in multifactor productivity in relation to the number of Internet hosts, selected countries




1. Change in growth rates of multifactor productivity between 1981–95 and 1996–98.

Source. Number of Internet hosts from *OECD Information Outlook 2000*, figure 2, p. 79.

in France, Germany, Italy, and Japan. This finding also reflects information technology's relatively low share of total income in those countries.[25]

Unfortunately, Schreyer's analysis does not extend beyond 1996. It therefore does not include the latter half of the 1990s, for which researchers such as Oliner and Sichel have found that the use of information technology as a capital input played a significant role in the pickup in labor productivity growth in the United States.[26] To present more recent evidence, we examine the change in multifactor productivity growth for selected OECD countries during 1981–95 and 1996–98 plotted against the number of Internet hosts (chart 4) and also against the number of secure servers (chart 5), which is a more relevant measure of the extent of electronic commerce than the number of Internet hosts.[27] Using the median of the corresponding variables as critical values, we can group the observations into four quadrants. The countries that are in the northeast quadrant in both charts are Canada, Norway, Sweden, and the United States—countries in which a relatively large improvement in multifactor productivity growth has been accompanied by a substantial proliferation of information technology. The countries in the southwest quadrant include Japan, France, and Italy; in these countries the declines in multifactor productivity growth have been accompanied by a more limited diffusion of information technology.

## *Sustained versus Transitory Growth Differentials*

An important question raised by the estimated differential between U.S. and foreign productivity growth rates is how long it will be sustained. Even if the higher measured productivity growth experienced in

25. Although the data on both IT production and investment are consistent with a slower rate of innovation and adoption of information technology abroad than in the United States, the reasons for this development are not clear. One explanation is that, relative to foreign countries, several institutional features of the United States are more hospitable to innovation and adoption of these technologies. Such features include the regulatory environment, the flexibility of the labor force, and the breadth and depth of financial markets. For a more detailed discussion of these features, see Roger Ferguson, ''Is Information Technology the Key to Higher Productivity Growth in the United States and Abroad?'' (remarks before the 2000 Global Economic and Investment Outlook Conference, Carnegie Bosch Institute, Pittsburgh, Pa., September 21, 1999), available on line at http://www.federalreserve.gov/boarddocs/speeches/1999/19990921.htm.

26. See Oliner and Sichel, ''The Resurgence of Growth in the Late 1990s.''

27. We used the following definitions of an Internet host and a server:

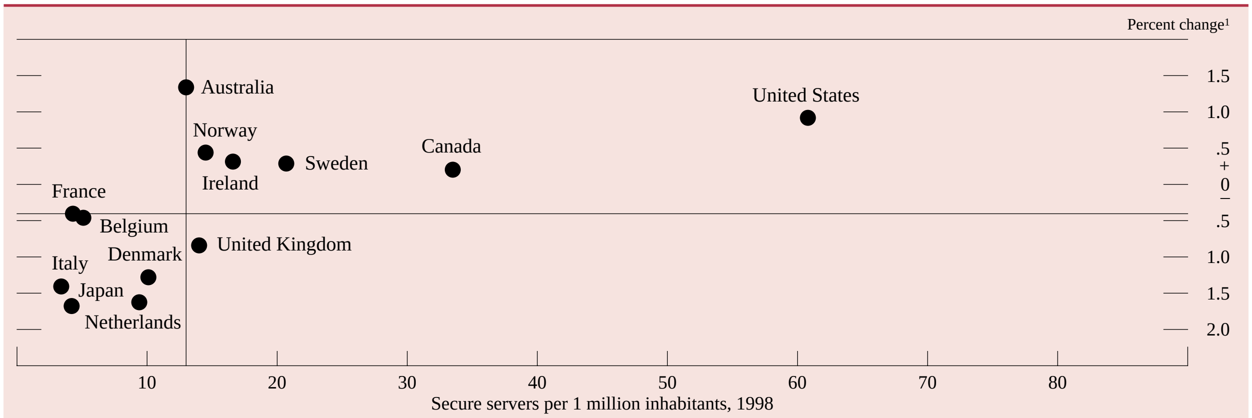
> On the Internet, the term ''host'' means any computer that has full two-way access to other computers on the Internet. A host has a specific ''local or host number'' that, together with the network number, forms its unique IP address. If you use Point-to-Point Protocol to get access to your access provider, you have a unique IP address for the duration of any connection you make to the Internet and your computer is a host for that period. In this context, a ''host'' is a node in a network.

See *whatis.com*. On line. TechTarget.com, Inc. Available: http://whatis.techtarget.com/WhatIs_Definition_Page/0,4152,212254,00.html Oct. 21, 1999 [last update]

> Specific to the Web, a Web *server* is the computer program (housed in a computer) that serves requested HTML pages or files. A Web *client* is the requesting program associated with the user. The Web browser in your computer is a client that requests HTML files from Web servers.

See *whatis.com*. On line. TechTarget.com, Inc. Available: http://whatis.techtarget.com/WhatIs_Definition_Page/0,4152,212964,00.html Nov. 29, 1999 [last update].

5. Acceleration in multifactor productivity in relation to the number of secure Internet servers, selected countries




1. Change in growth rates of multifactor productivity between 1981–95 and 1996–98.

SOURCE. Number of Internet servers from *OECD Information Outlook 2000*, figure 3, p. 80.

the United States in recent years is attributable to structural factors, rather than cyclical or methodological considerations, this does not mean that U.S. productivity growth will indefinitely remain higher than that in the rest of the world. In fact, there are reasons to believe that the differential is likely to erode over time.

First, to the extent that past experience is a useful guide, these countries will likely exhibit a phenomenon known as convergence: Countries that are behind in terms of their implementation of technologies can learn from countries that are more advanced and increase their productivity more rapidly. As these countries take advantage of new technologies and the availability of unexploited returns to scale, productivity growth rates first rise and then diminish over time.

Second, the U.S. experience and that of some other countries suggests that the increasing use of information technology has been an important part of a pickup in multifactor productivity growth. For example, Sweden, Norway, and Canada all tend to be relatively intensive users of information technology, and they seem to be starting to reap the benefits of this investment. Because investment in and use of information technology is becoming increasingly important, even in countries where structural impediments such as inflexible labor markets and a burdensome regulatory environment are thought to inhibit the adoption of new technologies, it is not unreasonable to expect that IT investments will help boost productivity growth abroad in the future.

## CONCLUSION

We have documented that a pickup in productivity growth such as occurred in the United States in the second half of the 1990s, measured as either labor or multifactor productivity growth, does not appear to have occurred in most foreign industrial countries. In fact, in many foreign industrialized economies, measured growth rates of labor and multifactor productivity actually declined during this period.

In the absence of more definitive answers, the following explanations may be relevant as to why foreign economies have not experienced the acceleration in productivity witnessed in the United States. First, to some extent, recent U.S. productivity performance may contain a cyclical element related to the strength of the economy, compared with more muted growth abroad, although this factor does not seem to explain all the divergence in U.S. and foreign productivity performance. Second, although it is difficult to determine the overall quantitative effect of differences in measurement across countries, the evidence suggests that measurement bias has, at most, only a small role in accounting for the failure of measured productivity growth to pick up abroad. Finally, some of the upswing in U.S. productivity growth compared with that abroad is likely due to more fundamental changes in the U.S. economy, reflecting more advanced diffusion of technological improvements, especially in the IT sector, than has occurred in most foreign industrialized countries.

Nevertheless, there are reasons to expect that the differential will not be sustained indefinitely. First, the historical record suggests that productivity growth has tended to converge among industrial countries. Second, there is evidence that, although the diffusion of information technology has not occurred as rapidly abroad as in the United States, the proliferation of these technologies is occurring there as well. □