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Revisiting recent productivity developments across OECD countries

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Abstract

This paper compares productivity developments across industrial countries based on official OECD data in the business sector. It discusses the uncertainties surrounding the measurement of both productivity levels and productivity growth, and then focuses on changes in productivity growth. The paper analyses labour productivity patterns and trends of total factor productivity (TFP) across countries. The recent performance of the United States clearly stands out. In particular, the level of US labour productivity appears to be the highest among the major industrial countries and has been rising the fastest in the recent past. Despite substantial uncertainties surrounding these international comparisons, there is little doubt that the US performance has improved sharply in relative terms. Productivity has accelerated in the United States but decelerated in most other industrial economies. Indeed, only a few countries have experienced a structural improvement in their productivity performance over recent years. Moreover, rather than just reflecting stronger capital accumulation, the US performance has been associated with a higher rate of technological progress that was maintained during the latest recession. In contrast, the accumulation of capital has been quite strong in most other major industrial economies. This might be a source of concern in some places, given the observed trend decline in the rate of technical progress.

JEL classification: O50, O47, Q30, N10, F01, E32, C20, C82

Keywords: productivity, international comparisons, industrial countries, statistical uncertainty, technological progress, labour force, capital stock, time trend, business cycle

Contents

Revisiting recent productivity developments across OECD countries

Les Skoczylas and Bruno Tissot[1]

Introduction

There is a growing interest in comparing productivity developments across industrial countries. The objective of this paper is to revisit these developments in a systematic way. The analysis is based on official OECD data in the business sector that appear more internationally comparable than national sources. The paper discusses the uncertainties surrounding the measurement of both productivity levels and productivity growth. It then focuses on changes in productivity growth (ie the second derivative) when judging relative performance across countries. Comparisons also have to take into consideration the state of the business cycle, as suggested by empirical evidence. Finally, the paper complements the analysis of labour productivity patterns by estimating and comparing trends of total factor productivity (TFP) across countries - not least because of the implications this may have for future prospects.

The paper then briefly discusses the cross-country differences emerging from these analyses. A main feature is that the recent performance of the United States clearly stands out. In particular, the level of US labour productivity appears to be the highest among the major industrial countries and has been rising the fastest in the recent past. While there are certainly substantial uncertainties surrounding these international comparisons, there is little doubt that the US performance has improved sharply in relative terms, as productivity has accelerated (ie productivity growth rates have increased) in the United States but decelerated in most other industrial economies. Indeed, only a few countries (mainly some Nordic countries) have experienced a structural improvement in their productivity performance over recent years. Moreover, rather than just reflecting stronger capital accumulation, the US performance has been associated with a higher rate of technological progress that was maintained during the latest recession. In contrast, the accumulation of capital has been quite strong in most of other major industrial economies. This might be a source of concern in some places, given the observed trend decline in the rate of technical progress.

The structure of the paper is the following. The reasons why productivity is a key issue are briefly summarised in Section I. The various difficulties encountered in conducting international comparisons are described in Section II. A framework for determining trend productivity growth and searching for time breaks is presented in Section III. Section IV shows that productivity developments are significantly influenced by the state of the business cycle. Section V presents estimates of trend labour productivity growth rates in the main industrial economies. Section VI deals with the impact of capital accumulation on labour productivity and provides a cross-country analysis of long-term developments in TFP. The policy implications are considered in Section VII.

I. A growing interest in productivity developments

Productivity and differences in productivity growth between the main industrial countries have raised considerable interest in recent public debate (see, for instance, BIS (2004)). Productivity is indeed a key issue for economic analysis and policy, though its definition is not entirely clear for some observers.

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[1] The authors are members of the staff of Bank for International Settlements, Basel, Switzerland. They have greatly benefited from the help of Philippe Hainaut and extensive comments by Palle Andersen, David Archer, Claudio Borio, Andy Filardo, Gabriele Galati, Stefan Gerlach, Marjorie Santos, Philip Turner and Bill White. This paper is a revised version of the one published in the Irving Fisher Committee Bulletin No 20, April 2005. The usual disclaimer nonetheless applies: views expressed in this paper are those of the authors, and remaining errors theirs alone.

Some definitions

Broadly, the generic term "productivity" refers to labour productivity, defined as real output per unit of labour. There are, however, important definition issues:

- The definition of productivity can be much wider, since labour is not the sole input used when producing one unit of GDP; Section VI below emphasises the usefulness of considering the productivity of capital and therefore total factor productivity (TFP).
- Even if restricted to the input of labour, productivity can have different meanings, depending, for instance, on the data available or the country considered. Labour productivity is traditionally calculated by dividing the level of output (in volume) by the number of people employed ("output per person"). But the exact definition of the numerator may vary, and can be GDP, value added in the business sector, or manufacturing output. Moreover, the denominator can be expressed as the number of hours worked ("output per hour") in the sector considered.
- These definitions matter. If average hours worked per person change, following, for instance, the introduction of new legislation or a shift in the share of part-time workers in the labour force, reasoning in terms of GDP per person employed or per hour worked is important. An additional complication is that any productivity effect from a change in working hours might depend on its cause.[2]
- While productivity is constructed as a ratio, comparisons across countries only rarely deal with its levels. In fact, when they refer to "productivity", most observers focus on its growth, ie on the changes in labour productivity arising from movements in real output, labour input or both.

In the present paper, we use the most common definitions and define *productivity* (resp *productivity per hour*) as the level of output per person (resp per hour worked) and *productivity growth* (resp *productivity growth per hour*) as the change in this ratio. *Total factor productivity* (*TFP*, resp *TFP per hour*) refers to the combined productivity of capital and labour, the latter being expressed in terms of number of people employed (resp of hours worked). Finally, for reasons detailed below, we mainly consider the *output of the business sector.* The exception is Section II on international comparisons, which looks at productivity (in levels) for the whole economy.

Productivity is a key issue at the country level …

Productivity is important as it shapes potential supply and plays a major role in determining living standards (see, for instance, OeNB (2004)). Simply put, higher rates of productivity growth will sustain larger real changes in profits and wages in the long run - GDP will double in around 25 years if productivity rises by 3% per year, while it takes 70 years if the annual rate is only 1%.

For policymakers, estimates of productivity growth and thus potential output are a key element in ascertaining the state of the output gap. The derived prospects for capacity and inflationary pressures have large implications for interest rates. In the longer run, in theory, the potential growth rate is also a key variable driving real equilibrium interest rates (see Burda and Wyplosz (2001) for an overview).[3] Turning to the fiscal side, the level of potential output is of particular importance in judging the stance of fiscal policy as well as the sustainability of budget positions. In particular, a key issue regarding the fiscal consequences of ageing is long-term developments in potential growth, because they determine the resources from which future social benefits will be paid.

Developments in productivity are also important for financial markets. For instance, if trend productivity is driving potential growth higher, this should sustain investors' expectations of earnings and in turn support share prices. By contrast, if a country is experiencing a steady but undetected productivity

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[2] By construction, total output per person tends to fall if the share of part-time workers rises while output per hour should remain unchanged. But output per hour can also be negatively affected if the share of low-skilled workers (often the case in part-time jobs) in employment increases.

[3] ECB (2004a) also discusses the relationship between productivity and the natural real interest rate.

slowdown, expectations of future earnings growth are likely to decline, which may lead to a fall in equity prices.

… as well as at the global level

Differences in productivity growth explain differences in economic performance between countries. They appear to have been a key factor behind the diverging GDP growth rates observed in the main industrial countries in the past few decades, though other structural factors, such as the evolution of the labour force, have also been at play.

The implications of productivity for relative expected returns are also a powerful driver of international capital flows. For instance, the reported improvement in US productivity growth rates during 1995-2000 raised the expected rate of return of capital in the United States relative to other countries. As a result, the United States became more attractive for foreign investors, allowing the financing of a large current account deficit without apparent pressure on exchange rates and interest rates - in fact, the dollar appreciated sharply over this period (see Bailey et al (2001)).

Finally, the degree to which higher productivity levels or growth rates in some countries can be replicated in others influences global growth prospects, with important policy implications. For instance, there has been a growing belief that investment in information technology has positively affected the acceleration of US productivity growth, prompting several countries to promote the acquisition of IT equipment.[4] Such policies might, however, not yield the expected results if the US performance is mainly due to structural factors (such as a rise in the rate of technological progress) rather than to IT capital deepening.

Productivity levels seem to be the highest in the United States

The first point to note is the large differences in *GDP per capita* across industrial countries (PPP-adjusted; Table 1). The *United States* is first, with a lead of around 30% over the other main industrial economies. The *euro area* is better placed in terms of *output per worker*, with the gap with the United States being significantly reduced. The main reason is that employment rates are lower, reflecting various factors (eg early retirement and higher unemployment). When output is measured per hour worked, the difference narrows to around 10%, and some European countries even appear to have a better performance than the United States. A key factor is that euro area employees work less (Blanchard (2004)). The relative position of *Japan* is still less favourable in terms of labour productivity.

Another important feature is that the steady convergence of productivity levels in Europe and Japan towards the US level, observed for most of the postwar period, seems to have halted in the early 1990s and, subsequently, might even have reversed (for an assessment of recent developments in Europe, see Denis et al (2004)). As a result, the US productivity performance has recently improved in relative terms: the US lead over the euro area as a whole (though substantial differences exist among countries within the area) and Japan has increased slightly since 1995, in terms of both GDP per person employed and GDP per hour worked. These differences have been particularly evident since the latest downturn, with US productivity rebounding markedly after the 2001 recession.

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[4] For a cross-country overview of productivity developments during the IT accumulation period of the 1990s, see, for instance, Gust and Marquez (2000).

Table 1

Productivity levels[1]

United States = 100

	GDP per capita		Labour productivity			
			Per person employed		Per hour worked	
	1995	2003	1995	2003	1995	2003
United States	100	100	100	100	100	100
Euro area	72	70	84	77	95	89
Germany	77	70	81	73	97	90
France	75	74	93	88	108	107
Italy	75	70	93	80	104	88
Spain	57	62	78	73	83	75
Netherlands	78	78	80	73	107	98
Belgium	78	76	98	92	111	106
Austria	84	79	81	74	96	87
Greece	47	52	64	70	61	64
Portugal	47	49	47	49	47	51
Finland	69	72	81	76	87	80
Ireland	64	87	86	92	86	99
Japan	81	74	72	69	71	69
United Kingdom	72	77	76	79	81	83
Canada	80	87	89	86	92	86
Sweden	77	75	79	74	89	85
Denmark	81	80	76	75	92	89
Norway	86	96	84	92	110	123
Iceland	81	76	83	74	84	73

[1] Whole economy; calculations made using purchasing power parities (PPP); Eurostat's precise denomination is PPS (purchasing power standards).

Source: European Commission, Eurostat (2004a and 2004b).

II. Comparisons across countries

Comparisons of productivity levels are notoriously imprecise

A widely shared view is that levels of productivity are not internationally comparable because of measurement problems related to both the numerator (output) and the denominator (the labour factor); see Maddison and van Ark (1994) as well as OECD (2001a). International comparisons of the level of output are also sensitive to the exchange rates used (Magnien et al (2002)). If current exchange rates are considered, then a country with a depreciating exchange rate will see its productivity decline, all other things being equal. One solution, adopted in Table 1 above, is to use purchasing power parity indices (Schreyer and Koechlin (2002)); but significant difficulties also surround these calculations (Richardson (2001)).

A second difficulty is that economic concepts differ across countries, despite ongoing progress in harmonising local practices. Informal activity is not taken into consideration in the same way in all countries and total GDP numbers might include a larger part of it in one country than in another

(Blades and Roberts (2002)). Similar difficulties exist with respect to employment, which can be defined in different ways, depending on country or sector. Furthermore, data on hours worked are notoriously more difficult to obtain and to compare than data on persons employed (OECD (2004a)).

A third problem is that statistical measures of key economic concepts differ. In addition, measurements change, because of the introduction of new techniques (hedonic prices), changes in the economy (declining importance of the mining sector in total output), or the limited availability of some data (leading to the continuous implementation/improvement of statistical surveys). In recent years, it has become more difficult to collect information and to accurately measure economic activity within and outside national boundaries due to the growth of multinational companies, increased trade and financial integration, etc (see for instance in the US case Hatzius (2004)).

Some studies have tried to resolve this issue by confining comparisons to specific sectors[5] that are considered to be easy to measure and thus less prone to cross-country discrepancies. A widely held view is that data in manufacturing are fairly reliable while measuring output in the service sector is more difficult: the real value of legal services, for instance, is hard to determine while steel production is easier to measure. Nonetheless, sectoral comparisons also have shortcomings. For instance, the focus on manufacturing is misleading since this sector differs in size across countries. It also represents only a minor and declining part of modern economies. In fact, the share in GDP of "reasonably measurable" sectors (agriculture and manufacturing activities) tends to decline over time as services expand (Griliches (1994)). In addition, empirical evidence suggests that even in the manufacturing sector alone, productivity levels might not be comparable and depend on the base year (Sorensen and Schjerning (2003)). Finally, measurement problems could be more serious at the sectoral level than at the macro level since some measurement errors at the sectoral levels "wash out" through aggregation, when output from some sectors is used elsewhere as inputs.[6]

Table 2 illustrates the size of these uncertainties and how alternative estimates could change the respective ranking of industrial countries. For instance, GDP per hour would be lower (by around 4%) in France than in the United States according to one estimate, and significantly higher (by 6%) according to another.

Table 2

Levels of labour productivity, total economy, 1999
(United Kingdom = 100): ranges for alternative estimates

	GDP per worker	GDP per hour
United States	141-145	118-126
Japan	93-107	88-93
France	114-119	113-133
Germany	105-107	107-116
Italy	117-130	123-132
United Kingdom	100	100
Canada	113-118	99-114

Source: Drew et al (2001). The alternative estimates presented for 1999 by Drew et al relate to the use of different methodologies when computing international comparisons of productivity levels. These different methodologies are: the UK Department of Trade and Industry approach; a study conducted by Crafts and O'Mahony in 2001; the OECD methodology; and the EU methodology. These alternative estimates differ for several reasons: the degree of harmonisation when measuring output; the way data are converted to a single currency basis; the choice of the base year for these conversions; the choice of the data sources for the employment series (household data versus establishment data) and their degree of standardisation; and the assessment of the number of hours worked.

[5] By using industry-specific conversion factors to calculate productivity levels. See Pilat (1996) and the work conducted at the Groningen Growth and Development Centre, in particular van Ark (1993). Denis et al (2004) have, in addition, pinpointed the industrial sectors that appear to have driven the EU-US productivity differentials over recent decades. Some research is also conducted on firm-specific data (O'Mahony and van Ark (2003)).

[6] Schreyer (2001) observes that the impact of using a different set of ICT deflators is likely to be small when looking at aggregate measures of GDP volume growth but much higher when looking at disaggregated measures of outputs, inputs and productivity.

Comparing productivity changes is also misleading

For these reasons, most international comparisons have focused on productivity changes. The basic argument is that even if the measured levels of total output and/or of labour inputs differ between two countries, changes in these levels are likely to be more comparable. In addition, comparing growth rates (in volumes) does not require a common exchange rate.

However, even productivity changes are not free of measurement problems (see O'Mahony and van Ark (2003)):

- Substantial uncertainty surrounds the measurement of employment growth because of difficulties in tracking new forms of jobs or newly created firms. In several countries (United States, Canada and Switzerland) concurrent surveys (payroll survey versus household survey) present clearly diverging pictures of job creation. Similar difficulties may surround measures of hours worked.[7] A recent example of the uncertainty in measuring employment is the expansion in "mini-jobs" (subsidised low-paid jobs free of some social security charges and taxes) in Germany over the past few years.
- A second difficulty is linked to the estimation of output levels. Different methods of calculating value added in certain sectors can influence their weight in GDP and thus their contribution to output growth (see Wölfl (2003)). The fact that the wholesale trade and retail trade, where value added is hard to measure, have been a major contributor to the rise in US productivity gains in recent years is one example of this.[8] A related issue is the measurement of spending on software, which has grown rapidly in the past few years (Ahmad et al (2003)). In the United States, such expenditure is treated as investment (thus positively contributing to GDP growth) to a much larger extent than in the other main industrial countries, where it is more likely to be treated as intermediate consumption (hence with no impact on value added growth).
- A third set of problems is related to the measurement of output deflators. It is well known that correctly measuring the price of public services is difficult. But finding sound measures of real output or reliable deflators in several large sectors of the economy is also hard. Another widely noted problem is the use of hedonic price indices, which allow better account to be taken of quality improvements, especially, but not only, in IT products (see Schreyer (2001) for the issue of ICT deflators). Roughly speaking, real volume growth is much lower when using traditional deflators. For instance, the price of a laptop can be estimated to have risen by 10% using traditional statistical techniques (ie by measuring the price of the "average" laptop sold in a store) but to have declined by 10% if its quality (speed, memory, etc) has improved by 20%.[9] The consequence is that moving to quality-adjusted deflators can affect aggregate GDP growth and lead to higher productivity growth rates than previously assumed.[10]
- A final issue is whether to use chained or fixed indices, as recently highlighted in Japan. The adoption in 2004 of a chain-type index for calculating output meant that real GDP growth was revised downwards by more than one percentage point for the 2003 fiscal year.

All in all, measured GDP growth (and thus productivity growth) in Europe could be higher by up to half a percentage point annually if statistical methods were more similar to those used in the United States.[11] Alternative estimates of employment growth could influence labour productivity growth by up

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[7] See Eldridge et al (2004) for an analysis of different estimates of average hours worked in the United States.

[8] The average annual rate of US productivity growth (defined here by real value added per hours worked by full-time and part-time employees in private industries) has increased by 1.3 percentage points (pp) from 1988-95 to 1996-2004. This acceleration has been more marked in the durable goods industry (+3.9 pp) but also, and perhaps more surprisingly, in the retail trade sector (+2.0 pp) and in the wholesale trade sector (+2.1 pp).

[9] See Congressional Budget Office (2002) for a short presentation of these techniques and the surrounding issues in measuring US productivity.

[10] These problems are compounded by the fact that measurements of productivity in IT-producing and in IT-using industries differ across countries (Pilat and Wölfl (2004)).

[11] See Ahmad et al (2003) for a detailed discussion. Other estimates give the same order of magnitude. For instance, Sakellaris and Vijselaar (2004) find that quality-adjusted output would grow almost 0.5 percentage points faster in the euro

to another half a percentage point annually in some countries (Ahmad et al (2003)). These measurement issues should not be ignored. Cross-country differences in measured yearly productivity growth are well comparable with the range of uncertainty reported above, and sometimes even lower. Indeed, the standard deviation of yearly rates of productivity growth across the main OECD countries (cf data presented in Table 3) has been stable at around 0.8 over the past three decades. Hence, apparent divergences in productivity growth would narrow sharply or might even reverse should the same statistical methodologies be applied across national borders.[12]

III. The issue of interest: have trend productivity growth rates changed?

Changes in productivity growth rates …

If statistical measurements do not vary over time, distortions in estimated productivity growth would disappear when looking at changes in productivity growth rates (ie the acceleration of productivity), which would thus be more comparable across countries. To illustrate these issues, we used the OECD *Economic Outlook* database (OECD (2004b)) so as to work on a relatively homogeneous statistical source (compared to using national data for each country). We also restricted comparisons to the business sector in order to avoid the special difficulties involved in measuring output in the public sector and non-market production.[13]

The data presented in Table 3 show that business labour productivity growth rates in the *OECD area* have decreased over the past four decades, in terms of both output per employee and output per hour worked. This decline was shared by almost all economies, though some countries (especially the *United States*) reversed this trend around the mid-1990s. Turning to the productivity of capital, a global feature is that it has declined over the past four decades. However, the rate of decline has progressively stabilised on average in the OECD area, and some countries (especially the United States) have seen an increase in capital productivity in recent decades.

… should be more comparable across countries

There are two caveats when comparing changes in productivity growth rates across countries.

First, methodological innovations can lead to sudden changes in measured productivity growth: for instance, if the size of a rapidly growing sector is suddenly revised upwards. However, such revisions are usually neutral, the general practice being to recalculate the past data when sufficient information is available.

Second, and more importantly, discrepancies in measured productivity growth might widen over time, due to sector-related biases. Assume, for instance, that GDP is equally divided between a sector with high productivity growth rates (say 10% per year) and one where productivity is flat. Suppose, in addition, that the relative share of the first sector rises in country A by 1 percentage point of GDP per year but remains stable in country B, solely because of measurement differences. Then economy-wide productivity growth would be stable at 5% (= ½*10% + ½*0%) per year in country B while it would increase by 0.1 percentage points per year in country A. Hence measurement differences would lead

area. Research at the Deutsche Bundesbank (2001) and by Scheuer (2001) leads to the same estimates. The difference in growth between Germany and the United States due to measurement issues was around 0.4 percentage points annually in the second half of the 1990s, close to the bias calculated for the United Kingdom at the Bank of England (Wadhwani (2000)) and for France at the statistical office (Lequiller (2001)).

[12] It might be noted that observers do not appear to be very concerned about measurement problems - especially in financial markets; see for instance Levy (2003); from the same community, an opposite and less widely shared view is Daly (2004).

[13] Nordhaus (2002) found that the rebound in US productivity growth from the 1978-95 period to the 1996-2000 period was between 1.04 and 1.61 percentage points depending on the definitions of output used (ie an uncertainty of roughly ½ percentage point).

to a constant widening in the difference between productivity growth rates in the two countries.[14] In this regard, attention has mainly focused on the development of the IT sector over the past decade.

Table 3

Productivity in the business sector

Average annual percentage changes

	Output per person				**Output per hour worked**				**Output per unit of capital**			
	1966-1975[1]	**1976-1985**	**1986-1995**	**1996-2004**	**1966-1975**[1]	**1976-1985**	**1986-1995**	**1996-2004**	**1966-1975**[1]	**1976-1985**	**1986-1995**	**1996-2004**
Australia	2.6	2.0	1.1	2.1	1.6	2.4	1.0	2.3	–1.0	–1.1	–0.1	0.2
Austria	5.0	2.8	2.5	1.8	–	–	–	–	–2.2	–2.3	–1.3	–1.7
Belgium	3.7	2.9	1.8	1.3	4.8	3.4	2.3	2.0	–0.0	–0.8	–0.5	–0.6
Canada	2.1	1.0	1.0	1.5	2.9	1.4	1.1	1.4	–0.2	–0.5	0.1	1.0
Denmark	2.2	1.7	1.8	2.0	3.5	3.0	2.1	2.3	–3.2	–1.1	–1.3	–1.3
Finland	4.7	3.0	3.6	2.3	5.8	3.5	3.7	2.6	–	–0.3	–0.9	2.9
France	4.4	2.7	2.1	1.2	4.5	3.7	2.6	2.0	–0.8	–3.1	–1.8	–0.5
Germany	3.8	2.0	2.0	1.0	5.1	2.6	2.7	1.6	–1.7	–0.6	0.1	–0.2
Iceland	3.7	2.4	1.2	2.6	5.2	3.2	1.3	2.6	–0.4	0.4	0.1	0.0
Ireland	5.5	3.8	3.7	3.6	6.1	4.6	4.1	4.7	3.4	0.4	3.2	3.2
Italy	5.2	2.7	2.4	0.5	5.9	3.4	2.6	0.8	–0.0	–0.2	–0.7	–1.4
Japan	7.1	2.7	2.2	1.7	5.4	2.8	3.2	2.1	–3.6	–2.2	–2.4	–2.0
Netherlands	4.0	2.1	1.4	0.9	4.1	2.8	3.3	1.4	0.6	–0.0	0.6	–0.4
New Zealand	1.0	0.7	0.9	1.3	1.8	0.9	0.9	1.5	–1.9	–0.8	–0.4	0.1
Norway	3.7	2.1	1.8	2.4	5.1	3.4	2.2	2.9	1.6	–0.2	0.8	1.4
Spain	5.4	3.3	1.6	0.7	5.2	4.3	1.8	0.7	–0.6	–2.6	–1.3	–0.5
Sweden	3.2	1.5	2.7	2.2	4.6	1.9	2.1	2.7	–1.3	–1.7	–0.7	0.2
Switzerland	2.2	0.8	–0.1	0.7	1.9	1.6	0.2	1.0	–2.4	–0.9	–1.4	–1.1
United Kingdom	3.3	2.4	1.6	1.6	3.3	3.1	1.7	1.8	–0.4	0.5	–0.0	–1.0
United States	1.6	1.2	1.3	2.6	2.5	1.3	1.2	2.8	–1.0	0.2	0.8	0.8
Euro area[2]	3.4	2.5	2.0	0.9	4.5	3.3	2.6	1.4	–2.1	–1.2	–0.7	–0.6
OECD ex US[3]	3.3	2.4	1.9	1.3	4.4	2.9	2.5	1.7	–2.2	–1.1	–0.9	–0.9
OECD[4]	2.8	2.0	1.7	1.9	3.7	2.3	2.0	2.1	–1.5	–0.5	–0.2	–0.2

–: data not available.

[1] For some countries, data were not available for the entire period (see Annex A). [2] Weighted average of Belgium, France, Germany, Italy, Netherlands and Spain, based on 2000 GDP and PPP exchange rates. [3] Weighted average of Australia, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, United Kingdom. [4] Weighted average of the group defined in footnote 3 plus the United States.

Sources: OECD; national data; BIS calculations.

However, this difficulty should not be overstated. In particular, anecdotal evidence suggests that the ongoing specialisation of some countries in the highly productive IT sector largely exceeds what could be attributed to measurement differences.[15] Second, the example presented above shows that large

[14] A similar development would occur if productivity growth rates were constantly rising in a specific sector in one country, but were stable in the other country solely because of measurement issues.

[15] For instance, it has been estimated that the labour productivity gap between the Canadian and US economies has widened over the last two decades mainly because of "real" differences, ie differences in industrial structure (IMF (2004)). Looking at US sectoral data, Comin (2003) finds that output price measurement "is not a key element (…) in the time series evolution of productivity growth". The ECB (2004b) stated that the continued decline in euro area productivity growth over the past

statistical biases would be required, since sectors' relative shares would have to change rapidly in order to have a sufficient influence on changes in relative productivity growth rates between two countries. Indeed, even if annual GDP growth rates in Europe and the United States might differ by up to half a percentage point because of statistical biases, as reported above, the difference between these growth rates is likely to have changed only slightly over time - by construction, by less than half a percentage point; several estimates suggest, in fact, that the contribution of statistical discrepancies has been significantly lower than that.[16] This is well below the relative changes in trend productivity growth rates observed across the main industrial economies over the past few decades. For instance, our estimations presented below show that the US yearly rate of trend labour productivity growth (with input of labour expressed as hours worked) was around 3 percentage points below the trend rate of the rest of OECD countries in the early 1970s, and is now higher by almost 1.5 pp. Hence, the relative change in these trend productivity annual growth rates has represented around 4.5 pp over the past few decades - far above the uncertainty of a few tenths of a percentage point suggested above.

Measuring structural changes in productivity growth rates

All in all, the degree of uncertainty surrounding the measurement of cross-country differences in productivity growth rates appears, in relative terms, much higher than that affecting comparisons of changes in trend productivity growth rates. This suggests that international comparisons should focus on whether productivity growth in a specific economy has improved over time or not. This can be done using various statistical techniques. Several studies have recently tried to determine whether trend productivity growth rose in the United States in the mid-1990s - see, for instance, Filardo and Cooper (1999) for the use of various methods to correct for cyclical influences in the United States, and Maury and Pluyaud (2004) for the application of the Bai-Perron method to several industrial countries.

The approach retained in this paper is described in Box 1 and is relatively simple. It tries to draw one or several lines through the actual productivity series, thereby producing a stylised representation of the trend, which is taken to be structural productivity (see Bodier et al (2001), as well as Doisy (2001) for measuring potential GDP growth in France). The main advantage is that country estimates are produced in a transparent and homogeneous way, allowing a direct comparison of trend productivity growth. Moreover, it allows measuring the influence of the business cycle and yields results that are broadly comparable with other studies using different techniques (at least for the main economies, see below).

Box 1

A general framework for testing for time breaks in productivity growth

Measuring trend productivity

The formal approach is relatively straightforward, as it retains a simple and deterministic trend for productivity growth (see Carnot et al (2005)). Let P denote productivity in levels, GDP total output in real terms and L labour input (being either total hours worked or the number of persons employed):

(1) $P = GDP / L$

Regress $log(P)$ on a linear time trend (T):

decades, compared to the United States, is "a feature that results independently of the measure of labour input used (…) and of the economic aggregate chosen".

16 For instance, the bias regarding the quality adjustment of capital estimated by Sakellaris and Vijselaar (2004) for euro area GDP growth was roughly the same in the period 1982-90 and in 1991-2000, implying that this had no effect on changes in productivity growth. Wadhwani (2000), in contrast, estimates that the understatement of actual output growth in the United Kingdom (compared to the United States) has been rising over time, from 0.10 percentage points (pp) in 1979-89 to almost 0.4 pp in 1994-98, ie an acceleration of around 0.3 pp.

Box 1 (cont)

A general framework for testing for time breaks in productivity growth

(2) $log\ P = a\ T + b + u$

where a and b are parameters and u a residual.

Trend productivity P^* is then defined by:

(3) $log\ P^* = a^*\ T + b^*$

where a^* and b^* are the estimated parameters of (2).

Differentiating (3) yields $p^* = a^*$ (since $\Delta T = 1$) which is the yearly rate of trend (or structural) productivity growth.

Allowing for temporal breaks

(2) can be re-estimated by allowing for different time trends over the sample period:

(4) $log\ P = \Sigma_{i=1}^{i=I}\ a^i\ T^i + b + u$

where I is the number of time trends in the estimation and (I –1) the number of breaks, T^i is the i^{th} time trend (equal to 0 before the year y_i, 1 for y_i and growing by 1 each year following y_i), $(a^i)_{i=1}^{i=I}$ and b are the parameters and u the residual.

This estimation leads to a new set of trend productivity growth rates:

(5) $p^* = \Sigma_{i=1}^{i=I}\ a^{*i}\ I_{y \geq yi}$

If, for instance, I =1, then equation (4) is the same as (2): there is only one time trend and no breaks. If I=2, then there is one time break, with $p^* = a^{*1}$ for all the years preceding y_2 and $p^* = a^{*1} + a^{*2}$ for the year y_2 and all the following years.

The break years y_i are estimated imposing three conditions:

(i) all the parameters of equation (4) have to be statistically significant;

(ii) for a given value of the number of time trends, the quality of the estimation (as summarised by the F^I statistic of equation (4)) is the highest among all the possible combinations of any other break years;

(iii) a minimum period of six years must separate two adjacent break years, the implicit idea being to keep trend productivity growth constant during a sufficient period of time (roughly comparable to the length of the business cycle in industrial countries).[1]

In practice, a step-by-step approach has been adopted. Equation (4) was first estimated for I =1; for I >1 and an existing combination of (I–1) break years (y_2 … y_I), (4) was re-estimated for I+1, leading to I break years (y'_2 … y'_i … y'_{I+1}) and this new estimation was kept if:

(i) all the new parameters were significant;

(ii) $F^{I+1} > F^I$.

Correcting for cyclicality

In order to correct for the cyclical component of productivity growth, a first solution is to add to (4) a variable that can capture the cycle.

(6) $log\ P = \Sigma_{i=1}^{i=I}\ a^i\ T^i + b + c\ CY + u$

where CY is the indicator of the cycle and c another parameter. The proxy retained for CY in this paper is capacity utilisation in industry.

CY has to display no temporal trend (in practice its mean was normalised to zero so that trend productivity continues to be given by (5)). The specification of (6) implies that it is the change in CY, and not its level, that influences productivity growth.

1 The basic aim is to try to obtain a sequence of waves in labour productivity, echoing recent views on the US situation (see, for instance, Meyer (2001)). Interestingly, we were not able to find a single break over the past 40 years or so in some countries. Estimates with a shorter minimum period between break years (for instance two years) gave somewhat more breaks for some countries but produced relatively similar results in terms of trend productivity growth rates.

IV. The influence of the business cycle

Cyclical influences may distort cross-country comparisons

The approach detailed above might not be sufficient for determining underlying trends in productivity growth. Because of the lags with which labour adjusts to changes in output, it is well known that measured labour productivity moves procyclically, and this might distort international comparisons.

Strictly speaking, productivity growth rates are not synchronised with the business cycle, since they tend to be the highest during periods when output is accelerating - ie when the change in output is the largest, not when the economy is peaking. For instance, firms that have hoarded labour during a recession can raise output without much increase in measured employment once demand picks up: productivity growth therefore surges in the upswing phase before slowing as the labour market begins to recover. These cyclical influences are particularly important in certain years, implying that they have to be taken into consideration when searching for temporal breaks in productivity growth. For instance, US capacity utilisation fell sharply in 2001, contributing to a decline in labour productivity growth rates of around 1 percentage point. But the underlying trend remained strong and measured productivity actually recovered sharply in 2002 and 2003.[17]

The extent to which changes in productivity are cyclically influenced is of particular importance when making cross-country comparisons. This is because national business cycles are far from being synchronised. In the early 1990s, for instance, the output decline in the major English-speaking countries preceded that in continental Europe and Japan by two years. This lag was mainly attributable to country-specific events, notably German reunification and the end of the asset price bubble in Japan. The latter also led to protracted balance sheet problems which weighed on activity in Japan throughout the 1990s. The resulting decoupling of Japan from the global business cycle was reinforced by the Asian crisis in 1997-98. The latest downturn in 2001-02 was somewhat more synchronised, but not entirely. In particular, the US economy started to recover earlier than both the euro area and Japan.

Nevertheless, international comparisons are often made without taking proper account of the influence of business cycles. For instance, observers have focused on comparing national developments since the mid-1990s - in reference to the reported improvement in US productivity during this period. However, cyclical developments might have significantly biased these comparisons: according to the OECD, the output gap in Japan in 2000 was almost the same as in 1995, compared to an improvement of almost 3 percentage points in the United States. Another example is the global recovery since 2002. The United States has experienced a faster growth in demand and this may have raised the “cyclical component” of US productivity growth relative to other countries. Indeed, from 2002 to 2005, the negative US output gap has been reduced by around 2 percentage points while it has actually widened by around 2 pp in the euro area.

Dealing with cyclical fluctuations

We disentangle cyclical fluctuations from trend in several ways, though a wider range of methods exist (see, for instance, Gordon (2003)).[18] The first and preferred approach directly corrects productivity levels by using an indicator of the cycle (cf Box 1). There are several variables that can be used for this purpose and they do not necessarily move in tandem (see Steindel (2004) for a discussion on the divergence between manufacturing production and goods output in the United States). Duval (2000)

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17 See Oliner and Sichel (2002) for an assessment of whether the 2001 IT-led economic downturn changed the underlying US productivity performance; and Greenspan (2002) for the implications of the latest US cyclical downturn.

18 An alternative and simple method would be to compare productivity during complete cycles. Trend productivity growth rates would be measured as the rate of actual productivity growth between comparable points in the cycle. A similar approach is to compare productivity growth around business cycle peaks (Council of Economic Advisers (2002)). However, the choice of “extreme” points of the cycle is arbitrary and estimations for the current cycle are by nature difficult. Nor are these methods well suited for international comparisons, given that business cycles are not synchronised. Finally, and perhaps most importantly, these approaches basically assume that no structural change in productivity can occur during a business cycle, an assumption that seems too restrictive. For instance, a general view is that US trend productivity accelerated in the mid-1990s, ie about in the middle of the 1991-2001 cycle.

looked at the degree of slack in the labour market, retaining the job vacancies ratio to characterise the cyclical position of the US economy. In the present study we use capacity utilisation in manufacturing (or industry), which measures how much productive capacity is in use. These data appear to be relatively homogeneous among OECD countries and are available over a long period of time.[19] In addition, the shape of the business cycle in manufacturing seems to reflect developments in the whole economy - despite the limited size of manufacturing, its contribution to the variance of total output is important.[20] Finally, there seem to be no other cyclical indicators available with a similar degree of homogeneity across countries.

We therefore adopted a second approach and smoothed the original productivity data by using the HP filter proposed by Hodrick and Prescott (1980).[21] We thus applied the technique described in Box 1 (eg equation (4)) and estimated an alternative set of both trend productivity growth and break years. This second approach has several advantages, including: the ability to obtain cyclically adjusted series in a direct way and without having to make any particular economic assumption; a better comparability of country estimates; and a larger set of data.[22]

However, this statistical method has limitations (see O'Mahony and van Ark (2003)). It rests on somewhat arbitrary assumptions especially regarding its degree of smoothness (the choice of λ). The filtered series may also retain some undetected procyclicality, and one cannot be sure that the correction reflects cyclical developments rather then other unknown factors. Finally, the impact of the cycle on productivity growth cannot be directly estimated. Yet the key problem is the "end-of-sample bias", ie the fact that the estimations of the recent HP trends tend to be overly influenced by the latest observations. This is a major handicap since our purpose is precisely to look at recent developments in trend productivity growth.

Against this background, the present study favours the first approach of directly correcting for cyclical developments, but we checked the results by comparing them to the other estimates.[23] The results, presented in Annex C, are broadly similar regarding both relative trends in productivity growth and estimates of break years. For some smaller countries, however, these alternative methods produced rather different results, arguing for cautious interpretation.

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19 Needless to say, this approach has drawbacks. First, capacity utilisation is confined to industry, which is only a small part of the economy. Furthermore, the way these data are elaborated (type of question, period under review) differ. In addition, the series are not available for all industrial economies during the same period and are missing in some. For instance, we could estimate the cyclical component of productivity for the whole 1960-2003 period in the United States but only from 1968 onwards in Italy. Hence, estimations had to be conducted on different periods, which may affect the comparability of the results. Finally, the degree of capacity utilisation is not free of measurement problems. Different surveys can lead to different estimates, as observed by Wadhwani (2001) - though these differences are more notable in levels than in changes. In particular, the data we used for Australia displayed a significant degree of uncertainty that may have affected the validity of the results presented in this paper.

20 This is the reason why OECD estimates of leading indicators rely on industrial production as the "reference series" for the business cycle.

21 Hence we directly estimated trend productivity by running the HP filter so as to satisfy:

$$\underset{P_t^*}{Min} \sum (\log P_t - \log P_t^*)^2 + \lambda \sum (\Delta \log P_t^* - \Delta \log P_{t-1}^*)^2$$

where log P is the logarithm of productivity and log P^* the logarithm of trend productivity. A general feature of this filter is that it takes into account both closeness to actual productivity (the first term of the minimisation) and the variability of the trend (second term). The relative weight of these two criteria is set by the choice of the parameter λ, typically 100 for annual data. For an application of this technique to productivity data in the United States and France, see Gilles and L'Horty (2003).

22 This also allows the possibility to incorporate expected developments in productivity in the analysis, since productivity was forecast by the OECD up to 2005 (though significant uncertainty surrounds these projections). In contrast, the latest capacity utilisation data were only available up to 2004 and no projections of capacity utilisation are available. Hence, the correction of the cycle presented in Box 1 was not possible for 2005.

23 Applying the HP filter to productivity levels appears to yield less smoothing as well as a somewhat higher occurrence of break points. We also estimated a third set of trend productivity growth rates by running the HP filter directly on productivity growth. In this case, the end-of-sample bias appeared to be even more significant. In addition, this method does not allow us to determine break years, since the trend is equal to the filtered data.

V. Recent trends in labour productivity

The business cycle and productivity: some empirical evidence

Productivity displays significant cyclical movement, with capacity utilisation having a positive impact on both labour and capital productivity growth in almost all countries (Table 4).

First, if breaks in productivity trends are not considered, the estimated impact of the cycle is often insignificant, or the estimate has a negative sign. However, when allowing for breaks, the impact of the cycle is highly significant and, as expected, positive in almost all countries, the main exceptions being Australia, for which the data we used look uncertain (cf footnote 19), Denmark and Ireland.

Second, the estimated impact of the business cycle on labour productivity depends on how labour input is measured. In general, it is higher when labour productivity is measured as the ratio of GDP to the number of persons employed (though there are some exceptions). A possible explanation is that in response to cyclical developments firms are better able to adjust the number of hours worked per employee than the number of their employees.

Table 4

Impact of the cycle on labour and capital productivity[1]

	Output per person		Output per hour worked		Output per unit of capital	
	Observed[2]	**Corrected[3]**	**Observed[2]**	**Corrected[3]**	**Observed[2]**	**Corrected[3]**
Australia	...	–0.7**	...	–0.6**	3.4***	1.1**
Austria	...	0.9***	–	–	2.3***	1.6***
Belgium	–2.4***	1.3***	–3.2***	1.0**	...	2.4***
Canada	1.1***	1.0***	...	0.7***	...	2.5***
Denmark	...	–0.8***	...	–0.9***	–2.0***	–2.0***
Finland	2.3***	1.6***	3.0***	1.1***	...	5.5***
France	...	0.4***	...	0.8***	...	0.8***
Germany	–2.9***	0.8***	–3.5***	0.8***	3.0***	1.9***
Ireland	...	1.5**	...	...	–5.5***	–2.5**
Italy	–2.1***	2.3***	–3.4***	1.7***	0.9**	2.2***
Japan	...	2.0***	...	2.1***	5.2***	4.4***
Netherlands	...	1.4***	...	0.8***	1.0**	1.8***
New Zealand	1.3***	1.3***	0.9*	1.8***	4.8***	2.1***
Norway	...	0.9**	–1.8**	0.8**	2.9*	2.3***
Spain	...	0.4**	–4.6***	0.8**	4.2***	1.5***
Sweden	2.2***	2.0***	...	1.4***	4.6***	2.2***
Switzerland	...	1.2***	...	1.2***	3.1***	2.8***
United Kingdom	...	0.7***	...	–0.8**	3.0***	2.1***
United States	1.0*	0.8***	...	0.8***	3.1***	2.5***
Euro area	...	1.2***	...	0.5***	2.2***	1.9***
OECD ex US	...	1.2***	...	1.0***	2.6***	2.2***
OECD	0.5*	1.1***	...	0.5***	2.6***	2.3***

–: data not available; ...: not statistically significant.

[1] See footnotes to Table 3 for the exact composition of country groups and footnote 19 for Australia. ***, ** and * represent the significance level of 1%, 5% and 10% respectively. [2] Elasticity c when regressing productivity on a time trend and *CY* with no time-break, ie: $\log P = a\,T + b + c\,CY$). *CY* is the capacity utilisation in manufacturing (or industry), normalised in order to allow cross-country comparisons. [3] Same elasticity, but measured when trend breaks are allowed.

Sources: OECD; national data; BIS calculations.

Third, for almost all countries the impact of the cycle is much more important for capital productivity than for labour productivity. This is not surprising, given that firms have only limited ways to adjust their stock of capital in the near term. If, for instance, the economy is picking up, they might invest more or slow the rate of capital depreciation, but this will have only a modest impact on the stock of capital.

Turning to individual countries, it might be thought that the cyclical impact on labour productivity (defined as output per person employed) should be the lower, the more flexible labour markets are. Indeed, the influence is relatively low in the *United States* and high in *Japan* and *Italy*. In most of the other euro area countries, the impact is between these two extremes, although the cyclical effects in *France* and *Germany* (often considered as having inflexible labour markets) do not appear particularly large.

Cross-country differences look less significant when considering the productivity of capital, although the impact of the cycle looks rather low in *France*. By contrast, the cyclical influence appears quite high in *Japan.*

Trend labour productivity growth rates in OECD countries

Labour productivity growth rates have on average declined since the 1960s. Trend productivity (with input of labour defined as the number of hours worked) was growing by around 3½% per year in the *OECD area* as a whole in the late 1960s and early 1970s, but this growth rate then fell by around 1½ percentage points and has since been stable at rather low levels. These developments have been shared by most countries, though there are differences (Table 5 and Graph 1).

- A striking case is the *United States*, where output per hour worked has accelerated significantly since the late 1990s and now appears to be growing at the same pace as before the 1970s.
- A significant acceleration in trend productivity also appears to have taken place in some of the *Nordic countries* since the 1980s, especially in *Sweden*, *Denmark* and *Norway*. But, in contrast to the United States, productivity growth rates are still well below the levels recorded three decades ago.
- The performance of the other main industrial countries has been, on average, weaker. The *non-US OECD area (ie the main OECD countries excluding the United States)* has experienced a steady deceleration in trend labour productivity. Productivity appears to have grown by almost 2% per year since the mid-1990s, around half of the rate registered in the early 1970s.
- The slowdown in productivity growth has been significant in the *euro area*, particularly in *Italy* and, perhaps more surprisingly - though some explanation can be raised, as suggested in Section VII - in *Spain*. In other euro area countries (eg *Germany* and the *Netherlands*) as well as in *Japan*, the slowdown has been more uneven. Productivity accelerated somewhat in the course of the 1980s but appears to have resumed its decline in the 1990s in both Germany and Japan.
- In *France*, the *United Kingdom* and *Canada*, trend growth in output per hour dropped sharply after the 1960s but has stabilised or even began to increase somewhat in more recent years. Yet the situation in the *United Kingdom* is surprising: several reforms have been implemented in order to improve the functioning of various markets, as in the United States, but productivity has failed to strengthen - though the HP method points to a minor acceleration in recent years. In *France*, recent data suggest that productivity growth has risen a little, but this still looks relatively uncertain.
- Trend productivity growth has barely changed since the 1970s in *Australia*, *Ireland* and *New Zealand*. The *Australian* situation appears to have improved in the 1990s but then deteriorated somewhat in the most recent years (productivity decelerated significantly during 2000-05 compared to the late 1990s). Also in *Ireland*, productivity growth rates dropped significantly in 2003-04. Yet it is premature to draw firm conclusions at this stage.

Table 5

Most recent trends in labour productivity growth rates[1]

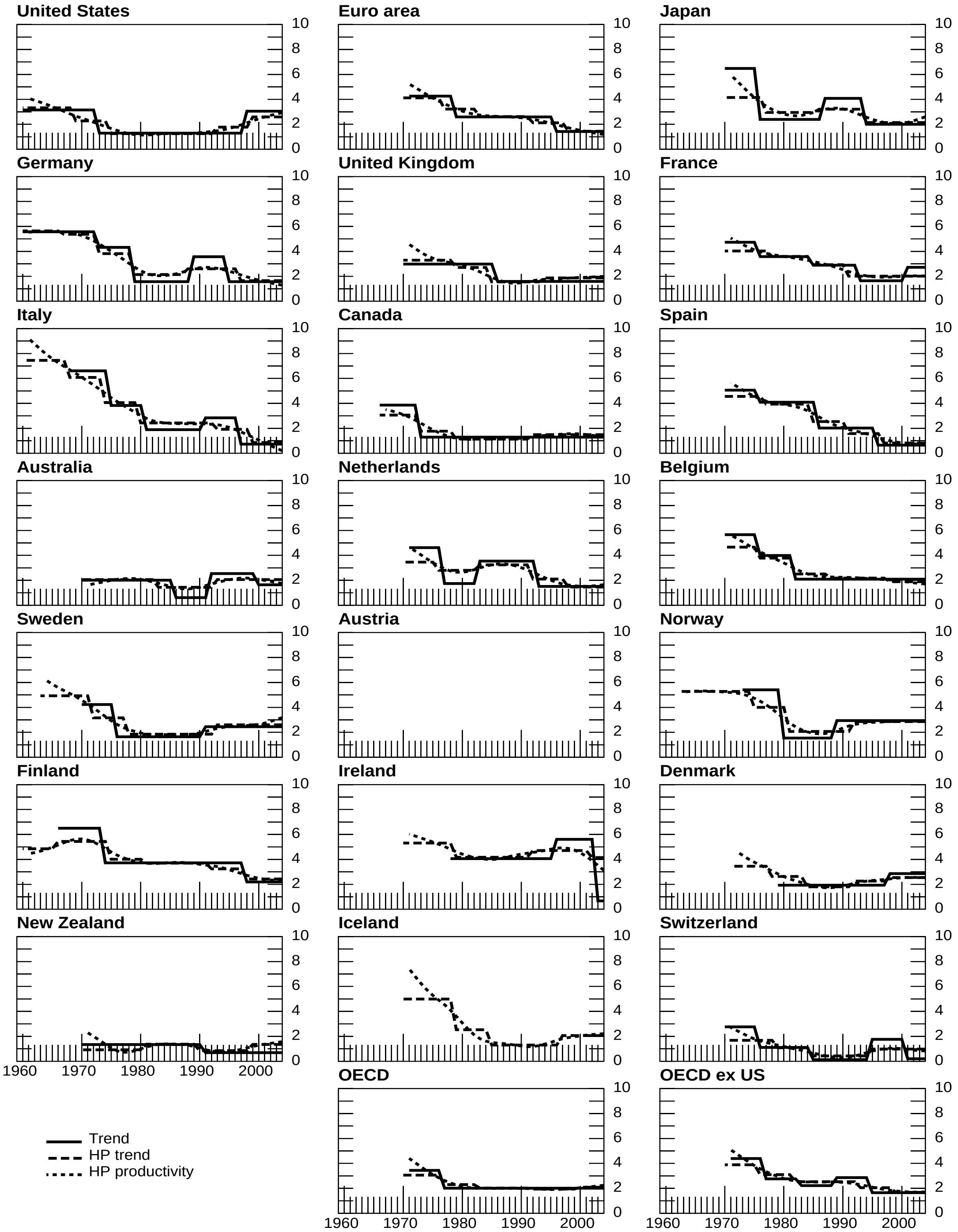
	Previous trend		Current trend		Acceleration (change in trend growth rates)	Confirmation by other methods (ie statistical smoothing)?
	Start year	Average	Start year	Average		
Australia	Early 90s	2½	Early 00s	1½	–1	*Not confirmed*
Austria	Mid-70s	2½	Early 00s	1	–1½	Yes, but smaller decline
Belgium	Mid-70s	4	Early 80s	2	–2	Yes
Canada	Mid-60s	4	Mid-70s	1¼	–2¾	Yes
Denmark	Late 70s	2	Late 90s	3	+1	Yes, but smaller increase
Finland	Mid-70s	3¾	Late 90s	2¼	–1½	Yes
France	Mid-90s	1½	Early 00s	2¾	+1¼	*Not confirmed*
Germany	Late 80s	3½	Mid-90s	1½	–2	Yes, but smaller decline
Iceland	Mid-80s	1¼	Late 90s	2	+¾	–
Ireland[2]	Mid-90s	5½	Early 00s	¾	–4¾	*Not confirmed*
Italy	Early 90s	2¾	Late 90s	¾	–2	Yes
Japan	Mid-80s	4	Mid-90s	2	–2	Yes, but smaller decline
Netherlands	Mid-80s	3½	Mid-90s	1½	–2	Yes
New Zealand	Early 70s	1¼	Early 90s	¾	–½	*Not confirmed*
Norway	Early 80s	1½	Late 80s	3	+1½	Yes
Spain	Mid-80s	2	Mid-90s	¾	–1¼	Yes
Sweden	Mid-70s	1½	Early 90s	2½	+1	Yes
Switzerland	Mid-90s	1¾	Early 00s	¼	–1½	*Not confirmed*
United Kingdom	Early 70s	3	Mid-80s	1½	–1½	Yes, but perhaps slight increase recently
United States	Mid-70s	1¼	Late 90s	3	+1¾	Yes
Euro area	Late 70s	2½	Mid-90s	1½	–1	Yes
OECD ex US	Late 80s	3	Mid-90s	1¾	–1¼	Yes, but smaller decline
OECD	Early 70s	3½	Late 70s	2	–1½	Yes, but perhaps slight increase recently

[1] Calculated using input of labour, expressed as hours worked (number of employees for Austria, HP filtered data for Iceland); business sector; annual rates in per cent. See footnotes to Table 3 for the exact composition of country groups, footnote 19 for Australia, and Table 4 for the methodology applied. [2] Results not significant.

Graph 1

Labour (hours) productivity

Annual growth rates, in per cent



Note: Results of the econometric estimation are not significant for Ireland.

Sources: OECD; BIS calculations.

These results appear consistent with widely held views regarding the current performance of industrial economies and, for instance, with Nicoletti and Scarpetta (2003), who investigate trend productivity developments in OECD countries in the 1980s and 1990s.[24] In a nutshell, their estimates show that trend labour productivity accelerated in the United States and some Nordic countries in the course of the 1990s, while it decelerated sharply in Japan, Germany, Italy and the Netherlands. They also point to a possible stabilisation in labour productivity growth in the United Kingdom and France in the late 1990s and to some improvement in Canada. In contrast with the results presented here, however, they found that productivity growth strengthened in New Zealand and even more so in Australia in the late 1990s (as already noted, the divergence with the results presented here may be attributed to less favourable developments observed in these countries since 2000 as well as to the uncertainty surrounding the data used in the present paper - cf for instance footnote 19).

VI. Developments in total factor productivity

The general framework

Another important issue is the influence of capital accumulation and technological progress on labour productivity. Higher growth in labour productivity can result from an increase in output using the same units of labour and capital inputs (so-called "technological progress"), or from using more capital for a given labour input ("capital deepening"), or from a combination of these effects.

From this perspective, to what extent did the developments discussed in Section V reflect differences in accumulating capital, especially IT equipment, or in rates of technological progress? As detailed in Box 2, growth theory is the obvious framework to deal with these issues, as it puts emphasis on supply side factors when looking at long trends in economic growth. TFP can be estimated using a simple production function approach on OECD annual data for GDP, employment, average hours worked and the capital stock in the business sector since 1960. The data are, however, not available for all industrial countries and over the whole sample (see Annex A and results in Table 6).

Box 2

Total factor productivity - the general framework

Estimating TFP

The starting point is the Solow model (1956): GDP is obtained from a simple production function that captures the relationship between output and the two substitutable production factors, capital and labour:

(7) $GDP = F(K, L, TFP)$

where *GDP*, *K*, *L* and *TFP* respectively stand for output, the capital stock, labour input and a residual. *L* can be measured as the number of persons employed or as the number of hours of work (defined as L^h). *K* is the capital stock that is in place. *TFP* is called total factor productivity, which captures the contribution of all the factors not incorporated in the labour and capital. Hence, TFP reflects the influence of, for instance, technical and organisational progress, and it is referred to as "technological progress".

While *Y*, *K* and *L* (or L^h) are statistically observed, *TFP* is estimated as a residual. One common way is to retain for (7) a Cobb-Douglas production function:

(8) $GDP = TFP\, L^{\alpha} K^{1-\alpha}$

[24] In contrast with the vast majority of other studies, their work (rightly) considers input of labour as the number of hours worked and deal with data in the business sector that are cyclically adjusted. From this point of view, the approach is relatively similar to the one presented here. But they look at average developments for predetermined periods (1980-90, 1990-2000 and 1996-2000 - with data missing for 1997-2000 for several countries); the end-of-sample bias using statistical smoothing techniques could be significant for the final years of the sample; and observations after 2000 have not been taken into consideration. More updated information on labour and capital productivity is provided in the statistical annex of the OECD *Economic Outlook* (2004b).

Box 2 (cont)

Total factor productivity - the general framework

where α is the elasticity of output with respect to labour and $(1-\alpha)$ that of capital. On the assumption that production factors are remunerated at their marginal productivity and that α is stable over the sample period,[1] one can derive *TFP* from:

(9) $Log\ (TFP) = log\ (GDP) - \alpha\ log\ (L) - (1-\alpha)\ log\ (K)$

Decomposing labour productivity growth

The relation between labour productivity and total factor productivity is also straightforward. Indeed, combining (1) and (8) gives:

$P = GDP\ /\ L = TFP\ L^{\alpha}\ K^{1-\alpha}\ /\ L = TFP\ (K/L)^{1-\alpha} = TFP\ R^{1-\alpha}$

where *R* is the ratio of capital per unit of labour (called “capital depth”).

The differentiation of (9) yields directly the relationship between yearly changes in labour productivity (*p*) and in total factor productivity (*tfp*):

(10) $p = tfp + (1-\alpha)\ r$

where $r = \Delta(log\ R)$ is the yearly variation in capital per unit of labour, called “capital deepening” (the impact of which on labour productivity growth is obtained by multiplying by $(1-\alpha)$).

The decomposition of (9) can also be made for labour productivity defined as GDP per hour worked (P_h).

Finally, TFP growth rates can be decomposed in the changes in labour and capital productivity (resp *P* and P_k), as:

(11) $tfp = \alpha\ p + (1-\alpha)\ p_k$, since $p = tfp + (1-\alpha)\ r$ and $p_k = tfp - \alpha\ r$:

In other words, TFP growth rates are a weighted average of labour (*p*) and capital (p_k) productivity growth rates.

The long-run view

When using a Cobb-Douglas production function as in (8), the marginal productivity of capital, *mpc*, is:

$mpc = \partial GDP\ /\ \partial K = (1-\alpha)\ TFP\ L^{\alpha}\ K^{-\alpha} = (1-\alpha)\ GDP/K$

If production factors are remunerated at their marginal productivity, the income of capital is:

(12) $income\ of\ capital = mpc\ K = (1-\alpha)\ GDP$

If the share $(1-\alpha)$ of total income going to capital is constant, the situation is compatible with a steady capital-to-output ratio (K/GDP) and a steady rate of return of capital.[2] In this steady-state case, the relation (10) between TFP and labour productivity can be simplified to:

(13) $p = (g - l) = tfp\ /\ \alpha$

since $R = K\ /\ L$, $\Delta K\ /\ K = \Delta GDP\ /\ GDP = g$ and $r = \Delta R\ /\ R = k - l = p$

In sum, along the steady-state growth path, labour productivity growth rates are equal to TFP growth rates divided by the income share of labour (which is by construction lower than 1 so that labour productivity growth rates are higher than TFP growth rates).

One implication of the decomposition presented above is that long-run labour productivity growth is driven by the rate of technological progress (TFP growth), while the impact of capital deepening is proportional. This is important when assessing the sustainability of changes in labour productivity growth. From (10) we have:

(14) $\Delta p = \Delta tfp + \Delta\ ((1-\alpha)\ r)$

With α constant and the sustainability conditions (13) we get:

(15) $\Delta tfp = \alpha \Delta p$ and

(16) $\Delta\ ((1-\alpha)\ r) = (1-\alpha)\ \Delta p$

Box 2 (cont)

Total factor productivity - the general framework

If, for instance, α=⅔, then an acceleration in (steady-state) labour productivity of say 1 percentage point will be considered “sustainable” if it is matched by an increase in TFP growth rates of ⅔ pp and by an increase in the contribution of capital deepening of ⅓ pp. If, in contrast, TFP growth has not changed, then the contribution of capital deepening would amount to 1 percentage point and would look too high.

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[1] In reality, α fluctuates over the cycle. We therefore took the average of *α* over the sample period when calculating TFP. [2] The assumption here is that the distribution of value added between labour and capital is stable in advanced economies in the long run (and that capital per worker grows over time and its rate of return is broadly constant). These stylised facts were already reported by Kaldor (1961). However, they only apply to a closed economy and require both the rate of depreciation of capital and the saving- (or investment-) to-GDP ratio to be stable. Yet, the capital/output ratio may change over the long run in response to changes in relative prices (witness the ongoing fall in IT prices) or in labour resources and technology.

Table 6

Total factor productivity in the business sector

Average annual percentage changes

	Total factor productivity				**Total factor productivity (hours worked)**			
	1966-1975[1]	**1976-1985**	**1986-1995**	**1996-2004**	**1966-1975[1]**	**1976-1985**	**1986-1995**	**1996-2004**
Australia	1.0	0.7	0.6	1.2	–0.1	0.8	0.6	1.4
Austria	2.2	0.8	1.1	0.4	–	–	–	–
Belgium	2.2	1.4	0.9	0.5	2.8	1.7	1.2	0.9
Canada	1.2	0.4	0.7	1.3	1.7	0.7	0.7	1.2
Denmark	0.2	0.6	0.6	0.8	1.0	1.5	0.8	1.0
Finland	–	1.7	1.8	2.6	–	2.0	1.9	2.7
France	2.4	0.4	0.6	0.5	0.9	1.0	0.9	1.0
Germany	1.7	1.0	1.3	0.6	2.5	1.4	1.7	0.9
Iceland	2.1	1.6	0.8	1.6	3.1	2.1	0.9	1.6
Ireland	4.6	2.2	3.5	3.4	4.7	2.7	3.7	4.0
Italy	2.6	1.3	0.9	–0.4	2.9	1.6	1.0	–0.3
Japan	2.3	0.5	0.1	0.1	0.4	0.6	0.7	0.3
Netherlands	2.6	1.2	1.1	0.4	2.5	1.7	2.2	0.6
New Zealand	–0.0	–0.0	0.3	0.7	0.1	0.1	0.3	0.8
Norway	2.7	1.1	1.4	1.9	3.5	1.8	1.6	2.2
Spain	2.7	0.6	0.3	0.2	1.9	1.1	0.4	0.2
Sweden	1.6	0.4	1.6	1.5	2.6	0.6	1.2	1.8
Switzerland	0.5	0.2	–0.6	0.1	–0.3	0.7	–0.4	0.2
United Kingdom	2.0	1.7	1.0	0.7	1.9	2.1	1.1	0.8
United States	0.7	0.9	1.1	1.9	1.2	0.9	1.0	2.0
Euro area	1.1	1.0	0.9	0.3	1.7	1.4	1.2	0.6
OECD ex US	1.0	1.0	0.8	0.4	1.7	1.3	1.1	0.6
OECD	1.1	1.0	0.9	1.1	1.6	1.2	1.1	1.2

–: data not available.

[1] Data for some countries were not available for the entire period. See footnotes to Table 3 for the exact composition of country groups.

Sources: OECD; national data; BIS calculations.

Disentangling these factors[25] is essential when comparing developments in productivity across countries and, in particular, when judging the sustainability of any acceleration in labour productivity. For instance, if the increase in labour productivity growth is solely the result of the accumulation of equipment, then maintaining this trend would require that capital spending would have to continue to grow at a high rate. This would, however, not be sustainable in the longer run if capital-output ratios as well as the shares of labour and capital in national income are expected to be constant.

Certainly, there are severe difficulties in measuring the input of capital. For instance, separating what reflects technological change and what is due to the evolution of the capital stock is challenging (see van Ark (2001)). Disentangling the contribution of IT and non-IT capital might be important, as argued by Khan and Santos (2002) using a growth-accounting exercise similar to the one presented in Box 2 on Canadian data. Or different ways of aggregating capital stock items or estimating the depreciation profile can reverse estimated growth contributions of capital, as observed by Wadhwani (2001) and estimated by Oulton and Srinivasan (2003). The valuation of existing fixed assets is also uncertain. In principle, it should be carried out at replacement costs. In practice, however, firms record assets at historic acquisition costs in their balance sheet and replacement costs are often derived from bankruptcy procedures and therefore likely to be biased downwards. Hence, statisticians have to use an indirect method (called the "perpetual inventory method") to estimate the market value of assets, based on the application of adequate price indices to cumulated flows of gross fixed capital formation net of depreciation.

In turn, uncertainty in measuring the contribution of capital to economic growth affects estimates of TFP growth, as noted by Schreyer (2001) when dealing with different sets of ICT deflators. Moreover, the share of physical capital in real output (hence the choice of α) is important for measuring the contribution of TFP to output growth (Senhadji (2000)). Artus and Cette (2004) emphasise that the measurement of the capital stock differs markedly across countries; their own calculations, based on more homogeneous assumptions, lead to different estimates of capital productivity compared to the OECD. These limitations reinforce the view that one should focus on the evolution of TFP growth over time rather then on simply comparing levels of TFP growth rates across countries.

Finally, developments in TFP growth are likely to be more procyclical than labour productivity because the adjustment of the capital stock to the state of the business cycle is less rapid than in the case of labour.

Given all these elements, the methods described in Box 1 have been applied to TFP estimates, either by directly correcting for cyclical developments, or by using the HP filter for smoothing purposes. The impact of the cycle on TFP growth appears significant for almost all industrial countries and, when changes in trend TFP growth are taken into consideration, positive (Table 7). This is not surprising given that both labour and capital productivity move procyclically and that TFP growth rates are a weighted average of labour and capital productivity growth rates. The influence of the state of the business cycle is relatively small in the *United States* and the *United Kingdom* but also in *France* and *Germany*. It is rather important in *Italy* and *Japan*.

[25] This is a simple way of measuring TFP. Dean and Harper (1998) provide an overview of the measurement of multifactor productivity, benefiting from the expertise of the US Bureau of Labor Statistics. For the specific issues surrounding the measurement of multifactor productivity and quality-adjusted measures of factor inputs (in particular of capital services or human capital), see Groth et al (2004) and Schreyer (2003). Alternative measures of the capital stock can also yield different results, as argued by Wadhwani (2001). In addition, the productivity of public capital might be an important factor that is not taken into account in calculations limited to the business sector (see Kamps (2004)).

Table 7

Impact of the cycle on total factor productivity

	Total factor productivity[1]		Total factor productivity (hours worked)[2]	
	Observed	**Corrected**	**Observed**	**Corrected**
Australia	1.7 ***	–0.7 **	1.7 ***	1.7 ***
Austria	...	1.3 ***	–	–
Belgium	–1.3 ***	1.7 ***	–1.7 ***	1.5 ***
Canada	2.0 ***	1.6 ***	1.4 ***	1.5 ***
Denmark	...	–0.9 ***	–1.1 ***	–1.1 ***
Finland	...	3.4 ***	1.6 ***	3.0 ***
France	...	0.7 ***	0.6 ***	0.7 ***
Germany	...	1.3 ***	...	1.2 ***
Ireland	–2.1 *	…	–3.0 **	–3.0 **
Italy	...	2.2 ***	...	2.2 ***
Japan	...	2.7 ***	1.8 ***	2.7 ***
Netherlands	...	1.7 ***	...	1.1 ***
New Zealand	2.9 ***	2.9 ***	2.8 ***	2.8 ***
Norway	...	1.4 ***	...	1.5 ***
Spain	...	0.7 ***	...	1.0 ***
Sweden	3.0 ***	2.1 ***	1.7 ***	2.1 ***
Switzerland	0.9 **	1.7 ***	1.3 ***	1.4 ***
United Kingdom	...	1.4 ***	1.3 **	1.0 ***
United States	1.8 ***	1.4 ***	1.2 **	1.1 ***
Euro area	...	1.5 ***	...	1.3 ***
OECD ex US	1.1 ***	1.7 ***	0.8 *	1.4 ***
OECD	1.4 ***	1.6 ***	0.9 ***	1.3 ***

–: data not available; ...: not statistically significant.

[1] Estimated with labour input as the number of people employed. [2] Estimated with labour input as the number of hours worked. ***, ** and * represent the significance level of 1%, 5%, and 10% respectively. See footnotes to Table 3 for the exact composition of country groups, footnote 19 for Australia, and Table 4 for the way the impact of the cycle is estimated.

Sources: OECD; national data; BIS calculations.

Cross-country developments in TFP

Long-term developments in total factor productivity reflect the trends in labour productivity described above but also more specific elements. For the OECD area as a whole, TFP growth rates appear to have been relatively stable over the past few decades (Table 8 and Graph 2). They declined slightly from 1976-85 to 1986-95 but have improved marginally in the past decade. Turning to individual countries:

- The *US* performance looks quite strong: trend TFP (per hour) accelerated in the 1980s and again in the 1990s and is now estimated to be growing by more than 2% per year, ie almost as rapidly as in the 1960s. From this perspective, the US improvement appears more deeply rooted than when just looking at labour productivity (which accelerated in the course of the 1990s): TFP strengthened earlier, and in a more continuous way.
- The acceleration observed in some of the *Nordic countries* in terms of labour productivity appears confirmed by developments in TFP growth.
- Another result is that the discrepancy between the United States and the *other major OECD countries* (in aggregate) has steadily widened (Graph 3). The performance of non-US OECD countries is weaker in relative terms, since trend TFP growth rates have declined significantly over the past few decades, to as low as ½% per year currently.

- Reflecting developments in labour productivity, the slowdown in TFP has been marked in the *euro area* as a whole, but particularly in *Italy* and *Belgium*. The situation has also deteriorated, but less markedly, in *Germany* and *Spain*. In *Japan*, the weakening in trend TFP growth over the past few decades has been somewhat more moderate and less continuous than the decline in labour productivity growth; nevertheless, TFP appears to be flat or even decreasing, as output growth is mainly attributable to higher inputs of labour and capital. The *UK* performance deteriorated after the 1970s and failed to improve subsequently, a picture quite similar to the development observed in labour productivity.
- Compared to trend labour productivity, the outlook looks more favourable for TFP growth in Canada and France. In *Canada*, trend TFP accelerated in the late 1990s though this improvement has still to be confirmed (recent data have not been that strong). TFP growth rates have been almost stable in *France* since the 1970s, with apparently a very slight improvement after the mid-1990s. Though substantial uncertainty remains, the situation of *Australia* and *New Zealand* appears to have been stable or even improving in the course of the 1990s.

Table 8

Most recent trends in total factor productivity growth rates[1]

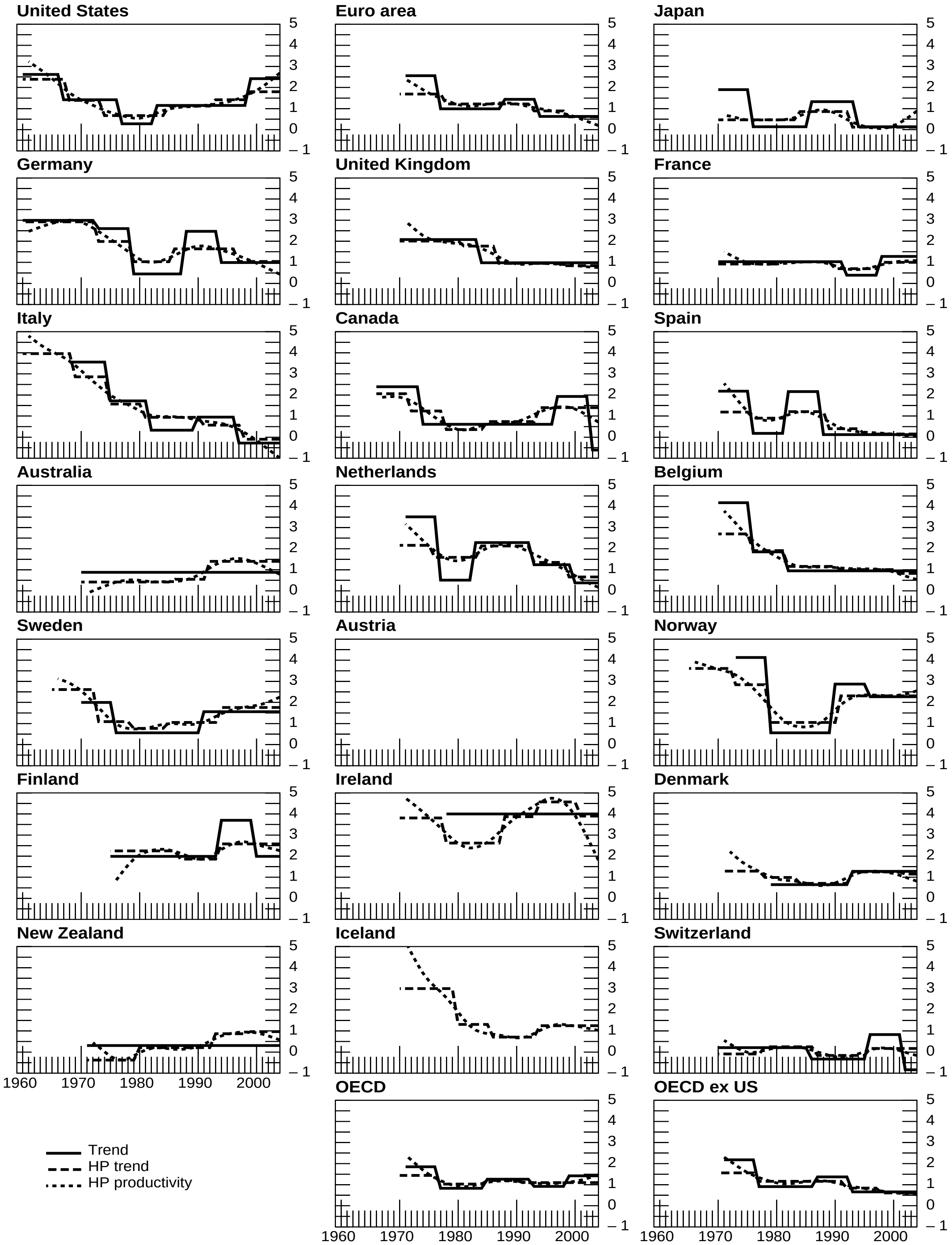
	Previous trend		**Current trend**		**Acceleration (change in trend growth rates)**	**Confirmation by other methods (ie statistical smoothing)?**
	Start year	**Average**	**Start year**	**Average**		
Australia	–	–	Early 70s	1	0	*No, TFP might have accelerated in the 1990s*
Austria	Late 80s	1¼	Early 00s	–¾	–2	Yes, but smaller decline
Belgium	Mid-70s	2	Early 80s	1	–1	Yes
Canada	Late 90s	2	Mid-00s	–½	–2½	*No, the 1990s improvement remains*
Denmark	Late 70s	¾	Mid-90s	1¼	+½	Yes
Finland	Mid-90s	3¾	Early 00s	2	–1¾	*No, the 1990s improvement remains*
France	Early 90s	½	Late 90s	1¼	+¾	Yes, but smaller increase
Germany	Late 80s	2½	Mid-90s	1	–1½	Yes, but smaller decline
Iceland	Mid-80s	¾	Mid-90s	1¼	+½	–
Ireland	–	–	Late 70s	4	0	*No, TFP might have decelerated in the 2000s*
Italy	Early 90s	1	Late 90s	–¼	–1¼	Yes
Japan	Mid-80s	1¼	Mid-90s	0	–1¼	Yes
Netherlands	Mid-90s	1¼	Early 00s	½	–¾	Yes
New Zealand	–	–	Early 70s	¼	0	*No, TFP might have accelerated in the 1990s*
Norway	Early 90s	3	Mid-90s	2¼	–¾	*No, the 1990s improvement remains*
Spain	Early 80s	2¼	Late 80s	0	–2¼	Yes, but smaller decline
Sweden	Mid-70s	½	Early 90s	1½	+1	Yes
Switzerland	Mid-90s	¾	Early 00s	–¾	–1½	*Not confirmed*
United Kingdom	Early 70s	2	Mid-80s	1	–1	Yes
United States	Mid-80s	1¼	Late 90s	2½	+1¼	Yes
Euro area	Late 80s	1½	Mid-90s	½	–1	Yes
OECD ex US	Late 80s	1½	Mid-90s	¾	–¾	Yes
OECD	Mid-90s	1	Late 90s	1½	+½	Stability instead of a slight improvement

[1] Calculated using input of labour, expressed as hours worked (number of employees for Austria); business sector; annual rates in per cent. See footnotes to Table 3 for the exact composition of country groups, footnote 19 for Australia, and Table 4 for the methodology applied.

Graph 2

Total factor productivity (hours)

Annual growth rates, in per cent

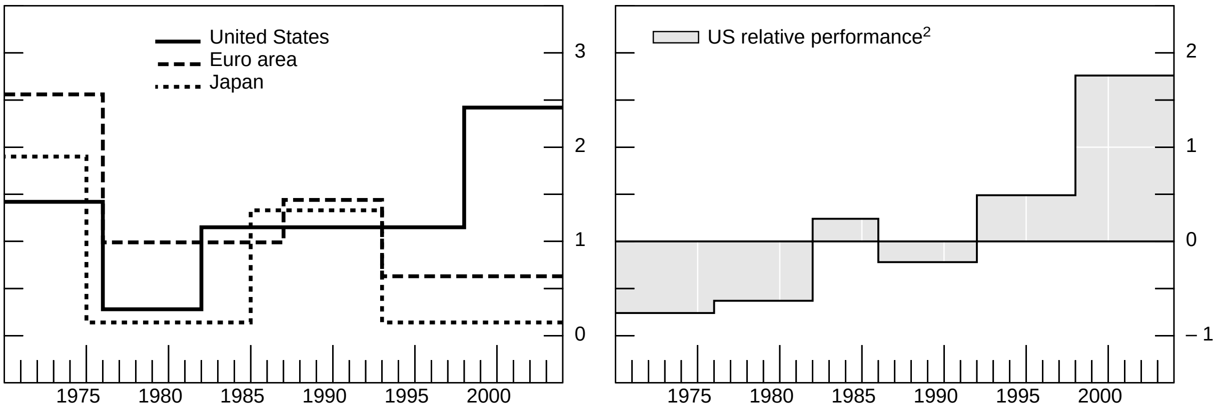


Sources: OECD; BIS calculations.

Graph 3

Trends in total factor productivity (TFP)[1]

Annual changes, in per cent



[1] TFP is calculated using input of labour, expressed as hours worked; business sector; for an explanation, see Box 2. [2] Trend TFP gains in the United States minus those in the group composed of Australia, Canada, euro area countries (see footnote 2 to Table 3), Japan, Sweden and the United Kingdom.

Sources: OECD; BIS calculations.

Similarly to the results presented above for trends in labour productivity, estimates by Nicoletti and Scarpetta (2003) yield similar conclusions: in the 1990s, trend TFP accelerated in the United States, some Nordic countries, Canada and (slightly) France; meanwhile, TFP growth declined sharply in Japan, Italy and Spain (by respectively 1.5 pp, 0.8 pp and 1.6 pp from the 1980s to 1996-2000). However, their results point more clearly to an improvement in both Australia and New Zealand in the late 1990s (but, as already mentioned, without considering developments since 2000) and, though only modestly, in the United Kingdom.

TFP growth and capital accumulation

The results presented above show that there have been substantial differences between developments in trend labour productivity growth and in trend TFP growth. For instance, some countries have experienced a steady deceleration in labour productivity but a stabilisation or even an acceleration in TFP. This has reflected different patterns of capital accumulation across countries, as summarised in Table 9.

- The main feature behind the recent increase in labour productivity growth in the *United States* has been the acceleration in technological progress. The contribution of capital deepening has been also positive, especially since the mid-1990s, but not out of line with developments in labour productivity: trend TFP increased by 2% annually in the 1996-2004 period while the contribution of capital deepening to annual labour productivity growth was of 0.7 percentage points. Indeed, a major factor behind the US acceleration in TFP over the past few decades has been the sharp improvement in the productivity of capital (see Annex B2).
- In the main *OECD countries excluding the United States*, by contrast, the deceleration in TFP over the past few decades has been accompanied by a relatively strong contribution of capital deepening to labour productivity growth. Indeed, the contribution has been higher than the contribution from TFP growth, while it should be significantly lower in the longer run, as argued in Box 2. Since the productivity of capital has fallen, there is a risk that some correction in the capital/output ratio might occur at some point. This risk looks significant in the *euro area* as a whole, and particularly in *Spain* and even more so in *Italy*. For instance, Italian trend TFP growth rates turned negative in the 1996-2004 period but labour productivity growth remained relatively resilient, supported by capital deepening. The situation looks even less favourable in *Japan*: TFP growth rates have declined over the past few decades, to almost zero, while capital deepening contributed almost 2 percentage points to trend labour productivity growth in the 1996-2004 period.

- The outlook looks more favourable for some other countries. As noted above, TFP growth rates have stopped declining or even started to increase in *Canada* and some of the *Nordic countries*, while the contribution of capital deepening has been very limited. This possibly suggests further support for higher labour productivity growth looking ahead.

Table 9

Trend-productivity growth rates and changes over the past three decades[1]

	Trend growth rates 1996-2004, annual rates in per cent					**Changes in trend growth rates from 1986-95 to 1996-2004**		**Changes in trend growth rates from 1976-85 to 1986-95**	
	Output per person	**Contribution of average hours worked**[2]	**Output per hour worked**	**Contribution of capital deepening**[3]	**TFP (per hour worked)**	**Output per hour**	**TFP (per hour worked)**	**Output per hour**	**TFP (per hour worked)**
Australia	1.8	–0.2	2.0	1.2	0.9	0.7	–0.0	–0.6	0.0
Austria[4]	1.8	–	–	1.4	0.4	–0.7	–0.8	0.0	0.6
Belgium	1.2	–0.9	2.1	1.1	1.0	0.0	0.0	–1.1	–0.5
Canada	1.4	0.1	1.3	0.1	1.2	0.0	0.6	0.0	0.0
Denmark	2.3	–0.4	2.7	1.4	1.3	0.7	0.4	0.0	0.2
Finland	2.3	–0.2	2.5	–0.2	2.7	–1.2	0.4	0.0	0.3
France	1.1	–1.0	2.1	1.0	1.1	–0.4	0.3	–1.0	–0.3
Germany	1.0	–0.6	1.6	0.6	1.0	–1.2	–0.8	0.4	0.7
Iceland[5]	2.0	0.0	2.0	0.7	1.3	0.7	0.4	–1.8	–1.2
Ireland[6]	3.7	–0.8	4.5	0.5	4.0	0.5	0.0	0.0	0.0
Italy	0.7	–0.3	1.0	1.1	–0.1	–1.4	–0.8	–0.5	–0.5
Japan	1.5	–0.5	2.0	1.9	0.1	–1.5	–1.0	1.1	1.0
Netherlands	1.3	–0.2	1.5	0.7	0.8	–1.4	–1.2	0.4	0.6
New Zealand	1.0	0.3	0.7	0.4	0.3	–0.3	0.0	–0.3	0.0
Norway	2.5	–0.4	2.9	0.7	2.3	0.4	0.3	–0.6	0.3
Spain	0.7	0.1	0.6	0.5	0.1	–1.4	–0.4	–2.1	–0.4
Sweden	2.0	–0.5	2.5	0.9	1.6	0.4	0.5	0.4	0.5
Switzerland	0.7	–0.4	1.1	0.8	0.3	0.8	0.6	–0.7	–0.5
United Kingdom	1.6	0.0	1.6	0.6	1.0	0.0	0.0	–1.4	–0.9
United States	2.5	–0.1	2.7	0.7	2.0	1.4	0.8	–0.0	0.5
Euro area	0.9	–0.5	1.4	0.8	0.6	–1.2	–0.6	–0.5	0.0
OECD ex US	1.3	–0.4	1.7	1.0	0.7	–0.9	–0.5	–0.2	0.1
OECD	1.9	–0.1	2.0	0.8	1.2	0.0	0.1	–0.1	0.2

–: data not available.

[1] See footnotes to Tables 3 and 4 for the exact composition of country groups and the methodology applied and footnote 19 for Australia. [2] Contribution to annual growth rates in trend output per worker. [3] Contribution to annual growth rates in trend output per hour. [4] Number of employees instead of hours worked. [5] HP filtered data. [6] Econometric estimates are not significant.

VII. Conclusions

The US performance stands out

The level of US labour productivity appears to be the highest among the major industrial countries and has been rising the fastest in the recent past. There are, however, substantial uncertainties surrounding these international comparisons.

But there is little doubt that the US performance has sharply improved in relative terms, as productivity growth has accelerated in the United States but decelerated in most other industrial economies. Indeed, only a few countries (mainly some Nordic countries) have also experienced a structural improvement in their productivity performance over recent years.

Moreover, rather than just reflecting stronger capital accumulation, the US performance has been associated with a higher rate of technological progress that was maintained during the latest recession. In contrast, the accumulation of capital has been quite strong in most other major industrial economies, and this might be a source of concern in some places where a trend decline in the rate of technical progress has been observed.

All in all, this suggests that trend GDP growth rates have diverged significantly among major industrial economies.[26] In terms of growth rates, and according to the OECD, potential output might currently be growing by around 3-3¼% per year in the United States, compared to around 2½% in the United Kingdom, 2% in the euro area and 1% in Japan. In terms of changes in growth rates, the United States has seen a clear improvement in its relative position: potential growth is still running at roughly the same pace as in the 1980s, while it has decelerated sharply in the euro area and even more so in Japan.

What has happened versus why

Whether the growing gap between TFP in the United States and that in other countries will narrow is difficult to judge (see OeNB (2004)). Certainly, information and communication technologies have contributed positively to economic growth in many industrial countries over the past few decades and this effect has been particularly felt in the United States.[27] But observing what happened in the United States is different from explaining why it happened, as pointed out by Stiroh (2001).

Analysing the factors behind the better US performance is well beyond the aim of this paper.[28] But some striking elements have emerged.

First, the improvement in US productivity does not appear to be the sole result of the reported greater use of IT equipment in the United States compared to other countries since the mid-1990s. The bulk of the US accumulation in IT equipment occurred in the 1990s, ie well after US TFP started to accelerate according to estimates presented in this paper. Moreover, IT use has also expanded in other countries over the past decade; but, despite this, trend productivity growth rates have not increased in these economies and have in fact declined. This suggests two things: (1) other factors than the use of IT should have been at play in driving the relative performance of the United States compared to the other main industrial economies; (2) IT investment might be a necessary (perhaps) but not a sufficient factor in order to achieve a meaningful improvement in aggregate productivity (for this kind of analysis, see Greenan et al (2002)).[29]

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[26] For a recent discussion surrounding these interactions, see Daly (2004). For a long-term view of potential growth rates and estimations, see OECD (2000, 2004b).

[27] For an overview of the impact of IT investment in industrial countries, see Colecchia and Schreyer (2002). For the specific case of the United States see, among others, the seminal paper from Oliner and Sichel (2000).

[28] For a recent overview of the factors that can influence long-run growth in TFP, see Arnold (2003) as well as de Serres (2003). For an estimation of long-run effects of labour productivity determinants in Europe, see Denis et al (2004) as well as Belorgey et al (2004). For the policy implications, see OECD (2001b).

[29] This is not to say that this factor did not play a role. But other elements could also have been at play. For instance, lower IT equipment in non-US countries was often associated with insufficient investment into the more general determinants of long-run growth and technical progress, such as research, education and the diffusion of new technologies

Second, there has been an acceleration in trend TFP in the United States since the 1970s, a period over which substantial structural reforms have been implemented. The more recent improvement in some Nordic countries has also taken place during a period when significant reforms were implemented. The link between these developments is, however, a source of debate as there are two opposing views:

- For some observers, the deregulation of markets for goods and services has been a key factor driving productivity performance. They argue that the resulting increase in competition has spurred innovation by creating strong incentives to reduce production and distribution costs.[30] Certainly, the United States has seen the emergence of large producers in the IT sector, a sector characterised by both fierce competition and a very high rate of technological progress. Sizeable productivity improvements have also been recorded in retail trade, where competition has again been intense. In addition, the degree of flexibility of the US labour market has been emphasised, in particular the long-term fall in structural unemployment since the early 1980s (by around 1.5 percentage points so far according to the OECD) as well as the ease with which workers move from declining to growing sectors.
- An opposite view, however, is that the simultaneity of these developments and of the improvement in the US productivity performance might have been a coincidence. This second group of observers highlight that other countries (eg the United Kingdom) have also implemented substantial reforms in order to improve the functioning of their labour and goods markets, but with no obvious results on productivity growth.[31]

Third, industrial countries have experienced substantial changes in trend productivity growth over the past few decades. If history is any guide, this suggests that the recent divergences could well not be maintained in the future. On the one hand, one view is that the recent improvement in US productivity growth may not last indefinitely. In particular, companies' willingness to cut costs, as well as the lagged impact of past large investments in IT equipment, may have raised the level of productivity, and thus its measured growth for a time (see Gordon (2003)). Eventually, however, such effects could well fade away (Dudley (2004)). On the other hand, the tendency for structural reforms, implemented in the past two decades, to increase the demand for less skilled labour could have held down measured overall productivity growth in a significant way in the United States and some European countries (eg Ireland, the Netherlands and the United Kingdom). A related and positive consequence is that structural unemployment has come down in these regions.[32] At some point, such transitory effects might begin to dissipate, possibly revealing higher underlying productivity growth in the coming years.

(Aiginger (2004)). Moreover, Ferguson and Wascher (2004) argue that factors pertaining to private sector initiatives play a key role in shaping periods of strong productivity growth that are characterised by technology innovations. Furthermore, Basu et al (2003) emphasise the role played by investment in intangible organisational capital.

30 For a review of the interactions between institutional reforms in markets and macroeconomic performance, see Pichelmann and Roeger (2004). Gust and Marquez (2002) found that regulatory environments played a role in explaining differences in IT adoption and thus productivity developments in industrial countries in the 1990s. Looking at the impact of trade, Hung et al (2003) estimate that competition effects stemming from import prices have been particularly powerful in fostering US productivity. The policy implication of these observations is that the implementation of structural reforms might be one key prerequisite for creating stronger market incentives and duplicating the US innovation process.

31 Moreover, and even if one assumes a link between structural reforms and productivity performance, this does not necessarily imply that those reforms actually have to be implemented (Turner (2003)). Indeed, individual and social choices might well point to opposite preferences (eg appetite for leisure; planning restrictions for retailers and the use of land; etc).

32 These countries have introduced incentives to hire young or unskilled workers. For example, some have cut social security taxes or income taxes for low-skilled workers, while others have encouraged their recruitment through increased labour market flexibility. Such measures can adversely affect measured aggregate labour productivity for a time even though they increase potential growth in the longer run.

Annex A

Data availability

	Average labour share, in %, 1970-2002	Business sector			Manufacturing
		Output per person	Output per hour worked	Output per unit of capital	Capacity utilisation
Australia	56	1966	1970	1966	1965
Austria	62	1965	–	1960	1963
Belgium	60	1970	1970	1970	1962
Canada	62	1966	1966	1966	1961
Denmark	64	1971	1971	1971	1979
Finland	60	1960	1960	1975	1966
France	62	1963	1970	1963	1962
Germany	63	1960	1960	1960	1960
Iceland	62	1970	1970	1970	–
Ireland	55	1961	1970	1961	1978
Italy	51	1960	1960	1960	1968
Japan	56	1962	1970	1965	1966
Netherlands	59	1969	1970	1969	1971
New Zealand	54	1963	1970	1971	1961
Norway	56	1962	1962	1965	1973
Spain	55	1964	1970	1964	1965
Sweden	66	1963	1963	1965	1970
Switzerland	63	1961	1970	1961	1967
United Kingdom	65	1963	1970	1963	1960
United States	63	1960	1960	1960	1948
Euro area	59	1970	1970	1970	1971
OECD ex US	59	1970	1970	1970	1971
OECD	61	1970	1970	1970	1971

–: data not available.

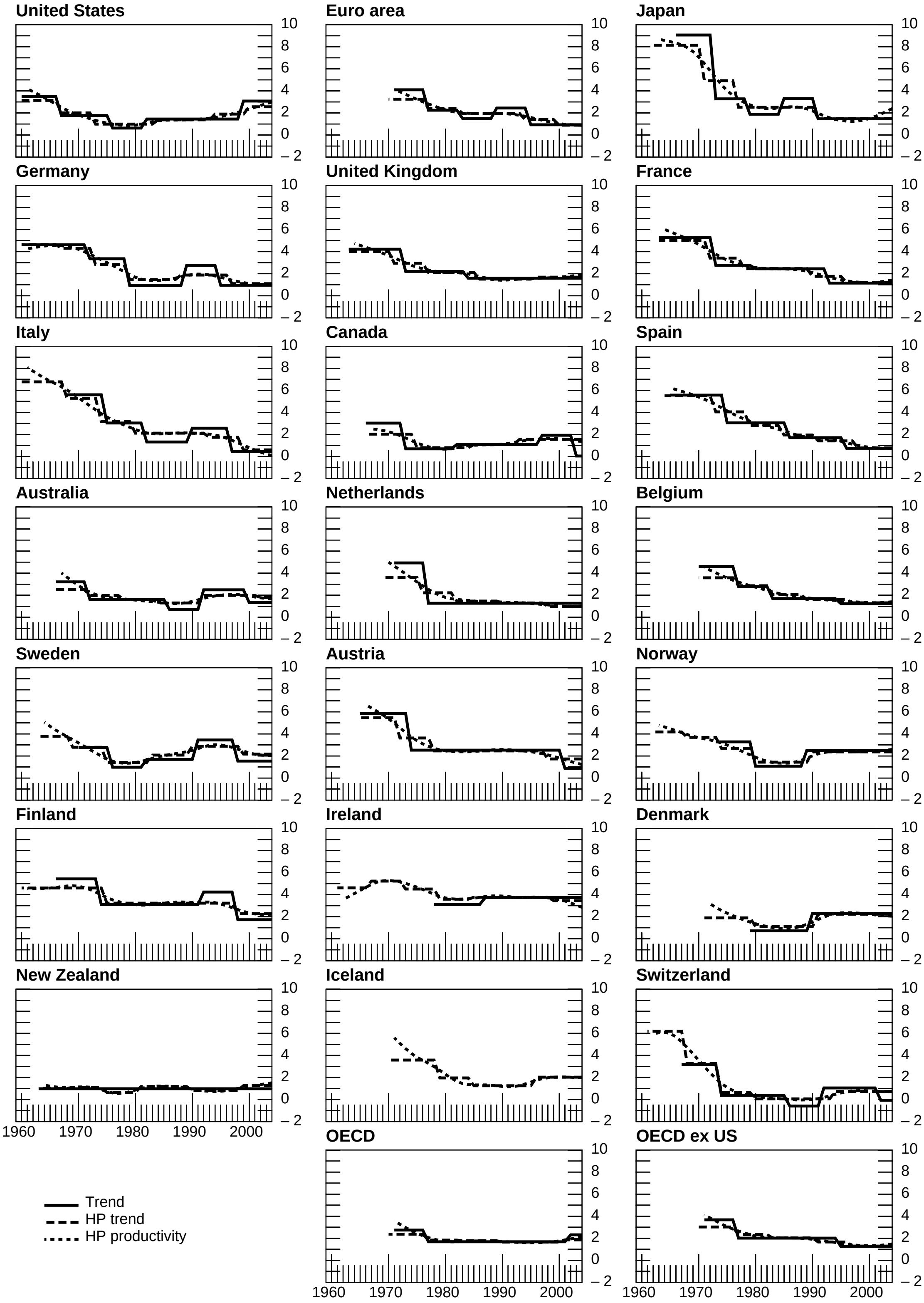
See footnotes to Table 3 for the exact composition of country groups.

Sources: OECD (2004b); national data; BIS calculations.

Annex B1

Labour productivity

Annual growth rates, in per cent

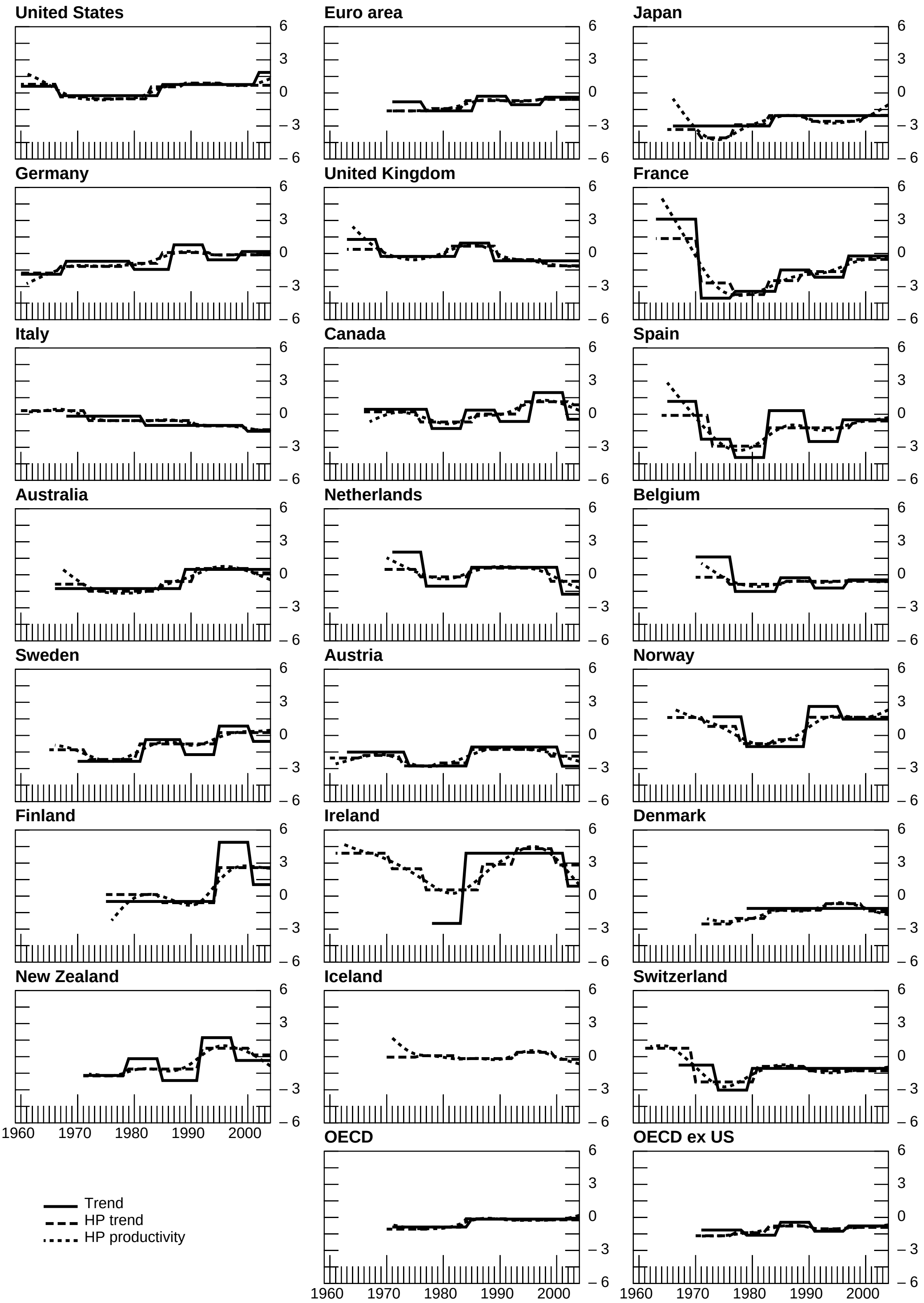


Sources: OECD; BIS calculations.

Annex B2

Capital productivity

Annual growth rates, in per cent

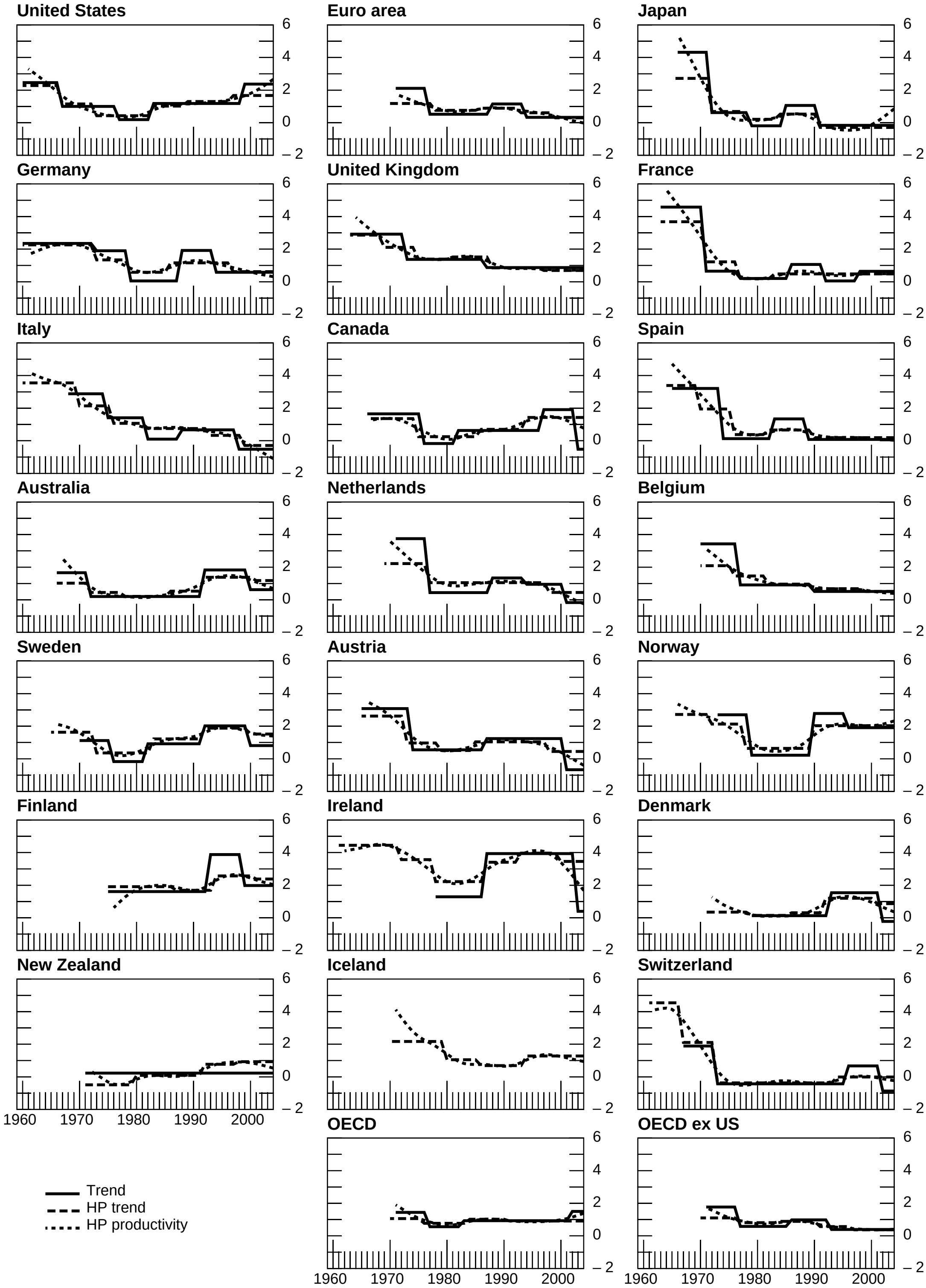


Sources: OECD; BIS calculations.

Annex B3

Total factor productivity

Annual growth rates, in per cent



Note: Results of the econometric estimation are not significant for Ireland.

Sources: OECD; BIS calculations.

Annex C:
Estimation results for the main industrial countries[33]

Table C1

Capital productivity, HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years						F-stat
Australia	–0.1497	(–40.9)	–0.0085	(–24.5)	–0.0064 (–15.4) 1972	0.0088 (29.5) 1985	0.0118 (35) 1991	–0.0039 (–8.4) 2001			15973
Austria	–0.3444	(–184.9)	–0.0205	(–48.4)	0.0024 (3.9) 1966	–0.0095 (–19.4) 1973	0.0026 (5.3) 1979	0.0123 (36.9) 1985	–0.0061 (–18.9) 1999		111734
Belgium	–0.9974	(–307.6)	–0.0022	(–9.9)	–0.0064 (–22.9) 1976	0.0027 (25.1) 1986					39381
Canada	–0.5766	(–252.3)	0.0021	(11.8)	–0.0092 (–32.1) 1976	0.0072 (25.5) 1986	0.0112 (35.4) 1994	–0.0028 (–3.4) 2003			2597
Denmark	–0.6806	(–144)	–0.0253	(–80.7)	0.005 (10.7) 1977	0.0075 (25.7) 1983	0.0059 (23) 1993	–0.0066 (–17.6) 2000			57586
Finland	–1.4018	(–169.3)	0.0014	(3.7)	–0.0074 (–12.2) 1985	0.0318 (60.6) 1995					3240
France	–0.2779	(–43.6)	0.0136	(17.8)	–0.0403 (–28.9) 1971	–0.0105 (–7.4) 1977	0.0126 (9) 1983	0.0082 (6.9) 1989	0.0111 (11.5) 1997		14553
Germany	–0.6004	(–596.5)	–0.0177	(–93.9)	0.006 (24.7) 1967	0.0028 (13.5) 1979	0.0098 (42.6) 1985	–0.0021 (–12.8) 1994			47756
Iceland	–0.7345	(–277.2)	–0.0004	(–2.2)	0.0013 (4.8) 1976	–0.0026 (–16.2) 1983	0.0057 (36.9) 1993	–0.0064 (–28) 2000			335
Ireland	–1.8636	(–599.1)	0.0389	(95.9)	–0.0141 (–17) 1971	–0.0192 (–25.5) 1977	0.0233 (30.4) 1987	0.0141 (15.2) 1993	–0.0148 (–14.2) 2000		43257
Italy	–0.9222	(–1264.3)	0.0032	(38.8)	–0.009 (–82) 1972	–0.0049 (–40.6) 1991	–0.0034 (–13) 2000				49963

[33] See Box 1 for the methodology used.

Table C1 (cont)

Capital productivity, HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years						F-stat
Japan	0.2901	(79.9)	–0.0332	(–83.5)	–0.0076 (–12.4) 1971	0.0119 (24) 1977	0.0083 (19.2) 1983	–0.0052 (–16.1) 1990	0.0054 (13.5) 2000		188189
Netherlands	–1.023	(–220.9)	0.0049	(14.8)	–0.0068 (–14.8) 1976	0.008 (32.5) 1985	–0.012 (–36.4) 1999				1672
New Zealand	–0.2103	(–42.9)	–0.0174	(–59.1)	0.0062 (16.1) 1979	0.0189 (65) 1992	–0.0061 (–10) 2001				7415
Norway	–0.8035	(–153.6)	0.0163	(30.1)	–0.0081 (–9) 1972	–0.0156 (–18.6) 1978	0.0036 (4.6) 1984	0.0203 (40.3) 1990			5054
Spain	–0.3267	(–62.5)	–0.0011	(–2.1)	–0.0279 (–37.4) 1973	0.0166 (35.4) 1983	0.0062 (9.9) 1998				16479
Sweden	–0.6052	(–183.5)	–0.013	(–39.1)	–0.0088 (–19.5) 1972	0.0141 (59.1) 1981	0.0103 (47.4) 1995				33244
Switzerland	–0.8051	(–217.7)	0.0077	(15.5)	–0.0306 (–42.9) 1970	0.0141 (24.8) 1981	–0.004 (–8.3) 1990				14243
UK	–0.7579	(–323.8)	0.0038	(13.3)	–0.0066 (–17.7) 1970	0.0095 (38.4) 1981	–0.0122 (–41.5) 1990	–0.0056 (–15.9) 1998			1934
United States	–0.2563	(–174.1)	0.0078	(26.4)	–0.0114 (–23.6) 1967	–0.0018 (–5.3) 1973	0.0109 (32.7) 1983	0.0034 (8.7) 1989	–0.002 (–6.4) 1996		4404
Euro area	0.4739	(241)	–0.0163	(–126.2)	0.0021 (9.4) 1978	0.0072 (46.3) 1984	0.0011 (8.7) 1997				94444
OECD ex US	0.5184	(289)	–0.0167	(–136.4)	0.0027 (13.2) 1977	0.0061 (38.2) 1983	–0.0025 (–16.1) 1991	0.0013 (8.5) 1997			155999
OECD	0.2704	(151.2)	–0.0107	(–91.3)	0.0018 (8.4) 1978	0.0076 (43.3) 1984	–0.001 (–9) 1992				27242

Table C2

Labour productivity (persons employed), HP filtered data

T-stat in brackets	**Constant**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**												**F-stat**
Australia	10.3018	(4535.3)	0.0252	(111.9)	–0.0055	(–15.9)	–0.0038	(–13.6)	–0.0029	(–13)	0.0068	(40.2)	–0.0019	(–5.7)			215637
						1972		1978		1984		1992		2002			
Austria	9.2303	(1921.5)	0.0547	(110.8)	–0.0184	(–23.7)	–0.0117	(–27.9)	–0.0073	(–20.7)							119847
						1972		1978		1998							
Belgium	9.8448	(2818.3)	0.0358	(149.7)	–0.0072	(–18)	–0.0081	(–22.1)	–0.0045	(–14.9)	–0.0029	(–11.8)					159339
						1977		1983		1989		1997					
Canada	10.4438	(3909.7)	0.0203	(92.6)	–0.0123	(–37.3)	0.0029	(10.1)	0.0046	(17.4)							46871
						1975		1985		1993							
Denmark	12.1749	(3226.3)	0.019	(86.5)	–0.0079	(–25.4)	0.0112	(56)									76278
						1980		1991									
Finland	9.3882	(6938.8)	0.0461	(376.2)	–0.0138	(–81.9)	–0.0095	(–32.9)									454145
						1975		1998									
France	9.5869	(3674.1)	0.0503	(172.7)	–0.0161	(–29.3)	–0.0096	(–22.5)	–0.007	(–16.8)	–0.0057	(–12)					136712
						1972		1978		1990		1996					
Germany	9.65	(5034.6)	0.0465	(120.1)	–0.0034	(–5.3)	–0.0147	(–25.1)	–0.0138	(–30.1)	0.0042	(12.3)	–0.0078	(–21.4)			133301
						1967		1973		1979		1988		1997			
Iceland	13.7081	(2807.6)	0.0358	(115.6)	–0.0162	(–27.7)	–0.0071	(–15.3)	0.0078	(22.1)							47050
						1979		1985		1996							
Ireland	8.9673	(4528.6)	0.0462	(122.9)	0.0061	(10.5)	–0.0072	(–15.1)	–0.0092	(–20.9)	0.0018	(6.4)	–0.0031	(–10.9)			614259
						1967		1973		1979		1985		1999			
Italy	9.1302	(3666.7)	0.0677	(150.9)	–0.0149	(–18.3)	–0.0211	(–26.6)	–0.0105	(–19.3)	–0.0038	(–7.1)	–0.0114	(–14.7)			111210
						1968		1974		1980		1993		1999			
Japan	14.1662	(3070.1)	0.0814	(141.4)	–0.0321	(–30.1)	–0.0241	(–31.6)	–0.0102	(–24.9)							74295
						1971		1977		1991							
Netherlands	9.8378	(2166.1)	0.0359	(107.9)	–0.0137	(–25)	–0.0075	(–17.4)	–0.0017	(–4.8)	–0.0033	(–8.9)					58550
						1976		1982		1990		1998					

Table C2 (cont)

Labour productivity (persons employed), HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years											F-stat
New Zealand	10.4531	(9198.3)	0.0102	(64.4)	0.0008	(3.1)	–0.0046	(–23.6)	0.0054	(36)	–0.0037	(–32.2)	0.0045	(30.9)		174402
						1969		1975		1981		1990		1999		
Norway	11.991	(4772.4)	0.0418	(103.3)	–0.0049	(–7.8)	–0.0099	(–20.2)	–0.0126	(–35.5)	0.0093	(47.5)				205642
						1968		1974		1980		1990				
Spain	9.0047	(3005.1)	0.0551	(181.7)	–0.0146	(–24.4)	–0.0125	(–18.7)	–0.0085	(–12.8)	–0.0053	(–8.7)	–0.0064	(–11.8)		108078
						1973		1979		1985		1991		1998		
Sweden	12.0315	(3302.9)	0.0378	(74.6)	–0.0099	(–12.8)	–0.0137	(–25.8)	0.0066	(14.4)	0.008	(18.7)	–0.0071	(–15.1)		93573
						1969		1975		1983		1990		1999		
Switzerland	10.6038	(2474.5)	0.0619	(84.8)	–0.0293	(–24)	–0.0262	(–24.4)	–0.0058	(–8.4)	0.0067	(15.8)				12785
						1968		1974		1980		1994				
UK	9.3786	(4715.2)	0.0401	(168.5)	–0.0106	(–25.2)	–0.0084	(–24.9)	–0.006	(–25.2)	0.0018	(7.5)				195725
						1971		1977		1986		1996				
United States	10.3633	(6622.3)	0.0314	(99.7)	–0.0113	(–22.1)	–0.0102	(–30)	0.0039	(16.7)	0.0052	(14.6)	0.0066	(12.8)		88234
						1967		1973		1984		1994		2000		
Euro area	–1.0108	(–252.2)	0.0325	(118.7)	–0.0084	(–18.8)	–0.0045	(–15)	–0.0056	(–18.5)	–0.0051	(–11.5)				107078
						1977		1983		1994		2000				
OECD ex US	–0.974	(–338.2)	0.0302	(153.6)	–0.0069	(–21.1)	–0.003	(–11.6)	–0.0037	(–14.7)	–0.0037	(–15.3)				208875
						1977		1983		1991		1997				
OECD	–0.8216	(–437.6)	0.0237	(184.8)	–0.0054	(–25.2)	–0.0006	(–3.6)	–0.0012	(–9.7)	0.002	(10.7)				402023
						1977		1983		1990		2001				

Table C3

Labour productivity (hours worked), HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years						F-stat
Australia	2.7904	(1634.8)	0.0206	(222.6)	–0.0062 (–37.1) 1983	0.0062 (38.7) 1993					193148
Belgium	2.1809	(388.5)	0.0466	(116.7)	–0.0088 (–14.4) 1976	–0.0127 (–26.2) 1982	–0.0033 (–9.2) 1988	–0.0029 (–9.2) 1998			145891
Canada	2.7687	(774.8)	0.0306	(91.6)	–0.0129 (–24) 1973	–0.0064 (–19.5) 1979	0.0036 (19.8) 1992				69441
Denmark	4.4576	(1113.6)	0.0345	(134.6)	–0.0082 (–19.4) 1978	–0.0083 (–24.7) 1984	0.0046 (14) 1992	0.0028 (8.2) 1998			156679
Finland	1.747	(1007.1)	0.0485	(126.7)	0.0059 1966	–0.0143 (–37.9) 1975	–0.0031 (–9.1) 1981	–0.0046 (–13.3) 1992	–0.0081 (–19) 1998		539979
France	2.1497	(636.1)	0.0403	(182)	–0.0044 (–11.7) 1978	–0.0066 (–18.4) 985	–0.0092 (–35.4) 1991				283807
Germany	1.9995	(870)	0.0564	(121.5)	–0.0027 (–3.4) 1967	–0.0155 –22) 1973	–0.0168 (–30.5) 1979	0.0046 (11.3) 1988	–0.0095 (–21.7) 1997		166807
Iceland	5.8841	(813.9)	0.0499	(108.8)	–0.0246 (–28.6) 1979	–0.0123 (–18.4) 1985	0.0076 (14.2) 1997				30674
Ireland	1.2656	(350.6)	0.0531	(239.8)	–0.0114 (–37.8) 1979	0.0054 (22.5) 1992	–0.0056 (–8.7) 2002				411633
Italy	1.5272	(579)	0.0745	(156.8)	–0.0137 (–15.8) 1968	–0.0202 (–24) 1974	–0.0163 (–28.2) 1980	–0.0051 (–8.9) 1993	–0.0106 (–12.9) 1999		134923
Japan	6.9637	(1263.9)	0.0415	(111.9)	–0.012 (–23.1) 1977	0.0026 (7.1) 1986	–0.0107 (–32.5) 1994				142047
Netherlands	2.3822	(455.2)	0.0346	(93.6)	–0.0066 (–12.5) 1976	0.0044 (13.2) 1983	–0.0114 (–31.7) 1992	–0.0064 (–16) 1998			161750
New Zealand	2.9243	(1146.8)	0.0092	(61.9)	0.0045 1981	–0.0052 (–19.8) 1990	0.005 (14.5) 1999				34954

Table C3 (cont)

Labour productivity (hours worked), HP filtered data

T-stat in brackets	Constant	Time trend	Time breaks: additional change in trend productivity growth rates and respective break years						F-stat
Norway	4.3675 (2143.9)	0.0528 (268.6)	–0.0128 (–26.3) 1975	–0.0193 (–40.8) 1981	0.0079 (26.6) 1992				222159
Spain	1.4961 (252.3)	0.0456 (113.6)	–0.0062 (–10.4) 1977	–0.014 (–25.7) 1985	–0.0096 (–15.5) 1991	–0.0076 (–14.3) 1997			84351
Sweden	4.4564 (1450.1)	0.0493 (143.9)	–0.0177 (–27.9) 1972	–0.0131 (–29.4) 1978	0.0075 (28.7) 1993				119652
Switzerland	3.5426 (1246.6)	0.0168 (93.1)	–0.006 (–17.5) 1979	–0.0065 (–23) 1985	0.0055 (27) 1995				30140
UK	1.9097 (642.6)	0.0329 (174.7)	–0.0058 (–16.2) 1979	–0.0116 (–36.9) 1985	0.0032 (14.7) 1994				161930
United States	2.7579 (1758.3)	0.0332 (131.1)	–0.0105 –22.6) 1969	–0.0102 (–32.8) 1975	0.0052 (16.5) 1993	0.0082 (16) 1999			100460
Euro area	–5.9088 (–1355.2)	0.0412 (138.3)	–0.009 (–18.3) 1977	–0.006 (–16.5) 1983	–0.005 (–13.9) 1992	–0.0068 (–17) 1998			158592
OECD ex US	–5.85 (–1349.7)	0.0389 (126.3)	–0.0079 (–17.2) 1976	–0.0057 (–20.9) 1982	–0.0048 (–17.9) 1993	–0.0037 (–10.3) 1999			216660
OECD	–5.6207 (–2194.9)	0.0306 (174.6)	–0.0076 (–26.4) 1977	–0.0028 (–13.2) 1983	–0.0008 (–4.8) 1992	0.0015 (6.2) 2000			308183

Table C4

Total factor productivity (persons employed), HP filtered data

T-stat in brackets	**Constant**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**												**F-stat**
Australia	5.6963	(2326.2)	0.0102	(42.3)	–0.0057	(–15.5) 1972	–0.0024	(–9.4) 1978	0.0032	(13.1) 1986	0.0085	(36.4) 1992	–0.002	(–5.3) 2001			29322
Austria	5.5498	(1640.3)	0.0262	(79.6)	–0.0165	(–27.6) 1973	–0.0046	(–7.9) 1979	0.0053	(13.4) 1985	–0.0059	(–15.2) 1998					18696
Belgium	5.4962	(1844.7)	0.0209	(98.6)	–0.0063	(–19.7) 1976	–0.005	(–23) 1982	–0.0028	(–16.5) 1990	–0.0017	(–7.8) 1999					67619
Canada	6.2047	(2509)	0.0136	(67.4)	–0.0111	(–37.9) 1975	0.0045	(17.3) 1986	0.0073	(26.5) 1994							20158
Denmark	7.4954	(3013.2)	0.0035	(23)	–0.002	(–7.9) 1979	0.0016	(6.3) 1986	0.0089	(38.3) 1992	–0.0033	(–9) 2001					17578
Finland	5.167	(3471.7)	0.0191	(287.8)	–0.0022	(–14.7) 1987	0.0088	(47.6) 1994	–0.0019	(–6.2) 2001							289650
France	5.7855	(1405.5)	0.0368	(74.8)	–0.0246	(–27.5) 1971	–0.0103	(–12.1) 1977	0.0029	(5.9) 1983							9525
Germany	5.842	(6308.6)	0.0226	(208.4)	–0.0092	(–32.6) 1973	–0.0076	(–22.3) 1979	0.0058	(23.1) 1986	–0.0054	(–21.8) 1997					89561
Iceland	8.2342	(2996.8)	0.0217	(128.6)	–0.0112	(–32) 1980	–0.0036	(–10.6) 1986	0.0059	(22.9) 1994							42865
Ireland	4.0741	(2336)	0.0445	(210.7)	–0.0088	(–18.7) 1972	–0.0135	(–28.6) 1978	0.0119	(24.5) 1987	0.0056	(10) 1993	–0.0051	(–7.1) 2000			210440
Italy	4.2135	(2861.4)	0.0355	(162.6)	–0.0141	(–30.5) 1970	–0.0107	(–20.2) 1976	–0.0032	(–8) 1982	–0.0042	(–10.5) 1993	–0.0062	(–10.5) 1999			46342
Japan	8.1279	(1885.5)	0.0272	(61.2)	–0.0203	(–27.3) 1972	–0.0048	(–7) 1978	0.0032	(5.3) 1984	–0.0082	(–21.1) 1991					3932
Netherlands	5.415	(1539.6)	0.0222	(95.2)	–0.0117	(–43.3) 1977	–0.006	(–22.1) 1998									37746

Table C4 (cont)

Total factor productivity (persons employed), HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years												F-stat
New Zealand	5.5577	(3102.2)	–0.0049	(–46.8)	0.0058	(39.1) 1980	0.0068	(40.2) 1992	0.0016	(6.6) 1998							10090
Norway	6.3779	(1531.2)	0.0272	(63.5)	–0.0059	(–8.6) 1972	–0.0149	(–34.1) 1978	0.0139	(58.5) 1990							43389
Spain	4.7966	(1018.6)	0.0339	(58.6)	–0.0144	(–16.2) 1970	–0.0157	(–22) 1976	0.0028	(4.9) 1982	–0.0047	(–13.6) 1990					10746
Sweden	7.7821	(2997.8)	0.0163	(66.6)	–0.0127	(–36.5) 1973	0.0086	(32.4) 1983	0.0066	(21.2) 1992	–0.0036	(–7) 2000					37462
Switzerland	6.392	(1308.5)	0.0454	(49.2)	–0.0243	(–18.2) 1967	–0.0248	(–39.8) 1973	0.0036	(9.6) 1994							2908
UK	5.8325	(2643)	0.0286	(92.9)	–0.0075	(–15.9) 1969	–0.0072	(–18.7) 1975	0.0013	(4) 1981	–0.0067	(–25.6) 1988	–0.0016	(–6.3) 1997			88624
United States	6.4664	(4844.4)	0.0228	(84.6)	–0.0113	(–25.8) 1967	–0.0072	(–23.1) 1973	0.0059	(19.8) 1983	0.0028	(8.3) 1989	0.0037	(12.1) 1997			51228
Euro area	–0.3908	(–240.2)	0.0118	(111.7)	–0.0042	(–25.4) 1978	0.0013	(8.3) 1986	–0.0028	(–14.9) 1993	–0.0031	(–13.9) 1999					64792
OECD ex US	–0.3612	(–246.3)	0.011	(109.9)	–0.0029	(–18.6) 1977	0.0008	(6) 1984	–0.0032	(–23.1) 1991	–0.002	(–14.8) 1997					100399
OECD	–0.3989	(–303.1)	0.0106	(114.6)	–0.0029	(–23.1) 1976	0.0025	(29.2) 1984	–0.0011	(–16.7) 1991							331652

Table C5

Total factor productivity (hours worked), HP filtered data

T-stat in brackets	Constant		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years						F-stat
Australia	1.5419	(1024.5)	0.0042	(55)	0.0013 (5.7) 1986	0.0085 (35.7) 1992					32497
Belgium	0.9075	(241.3)	0.027	(101.1)	–0.0079 (–19.5) 1976	–0.0075 (–29.1) 1982	–0.0015 (–8) 1991	–0.0018 (–4.6) 2001			76846
Canada	1.4749	(356.6)	0.0206	(50.3)	–0.0082 (–13.2) 1972	–0.0088 (–19.3) 1978	0.0038 (11) 1985	0.0066 (24.5) 1994			21501
Denmark	2.5892	(1302.8)	0.0129	(101.3)	–0.003 (–14.3) 1978	–0.0028 (–18.5) 1984	0.0054 (45) 1993	–0.001 (–3.2) 2002			103702
Finland	0.6187	(379.5)	0.0225	(310.4)	–0.0039 (–25.5) 1987	0.0072 (46.5) 1994					378932
France	1.4671	(2193.1)	0.0092	(236.9)	0.001 (15) 1981	–0.0032 (–43.2) 1990	0.003 (31.5) 1998				313554
Germany	1.0326	(978)	0.0292	(235.3)	–0.0093 (–29.1) 1973	–0.0096 (–24.8) 1979	0.0061 (21.1) 1986	–0.006 (–21.3) 1997			137132
Iceland	3.3831	(828.6)	0.0301	(120.2)	–0.017 (–32.7) 1980	–0.006 (–11.8) 1986	0.0054 (14.1) 1994				27990
Ireland	–0.042	(–9.3)	0.0381	(130.1)	–0.0119 (–28.2) 1978	0.0125 (29.2) 1988	0.007 (13.2) 1994	–0.0067 (–8.3) 2001			163580
Italy	0.3286	(206.9)	0.0396	(153.2)	–0.011 (–21.5) 1969	–0.0129 (–23.6) 1975	–0.0063 (–14.9) 1981	–0.0037 (–9.9) 1991	–0.0067 (–13.6) 1998		63574
Japan	4.0891	(3223.3)	0.0047	(69.8)	0.0039 (28.7) 1984	–0.0074 (–51.9) 1993					23834
Netherlands	1.005	(252.4)	0.0216	(77.2)	–0.0057 (–15) 1976	0.0054 (23.2) 1984	–0.0078 (–27.6) 1993	–0.0069 (–18.1) 1999			101231
New Zealand	1.4869	(835.6)	–0.0038	(–36.4)	0.0059 (41.3) 1980	0.0066 (39.7) 1993	0.001 (3.7) 1999				12797

Table C5 (cont)

Total factor productivity (hours worked), HP filtered data

T-stat in brackets	**Constant**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**												**F-stat**
Norway	2.0948	(526.5)	0.0361	(93.4)	–0.0077	(–11.4)	–0.0179	(–37.9)	0.0126	(46.2)							63505
						1973		1979		1991							
Spain	0.846	(237)	0.0119	(46.8)	–0.0029	(–7.5)	0.0031	(10.6)	–0.0081	(–29.2)	–0.0025	(–10.5)					26158
						1976		1982		1989		1995					
Sweden	2.7597	(869.1)	0.0261	(84.5)	–0.0152	(–27.1)	–0.0032	(–5.7)	0.0028	(6.3)	0.0071	(22.7)					33638
						1973		1979		1985		1994					
Switzerland	2.1025	(1421.4)	–0.0009	(–9.6)	0.0034	(24)	–0.0041	(–38.1)	0.0033	(28.6)							653
						1978		1987		1996							
UK	1.0062	(644.8)	0.0201	(217.1)	–0.0024	(–11.7)	–0.0082	(–44.4)	–0.0011	(–5.8)							143487
						1981		1987		1998							
United States	1.6517	(1332.7)	0.0239	(107.4)	–0.01	(–25.6)	–0.0072	(–25.1)	0.0045	(19.1)	0.003	(8.8)	0.0038	(8.5)			63887
						1968		1974		1985		1993		1999			
Euro area	–3.263	(–1842.4)	0.0169	(150.5)	–0.0047	(–33.1)	–0.0033	(–22.4)	–0.0028	(–11.5)							132514
						1978		1993		1999							
OECD ex US	–3.2301	(–1894.2)	0.0156	(138.9)	–0.004	(–29.7)	–0.0032	(–26.4)	–0.0023	(–12.7)							163858
						1977		1992		1998							
OECD	–3.3131	(–2290.2)	0.0144	(146.7)	–0.0041	(–28.4)	0.0017	(13.4)	–0.001	(–9.9)							291274
						1977		1985		1991							

Table C6

Capital productivity, adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Australia	–0.1224	(–7.7)	0.0106	(2.2)	–0.0125	(–16.5)	0.0174	(12.3) 1989									204
Austria	–0.4037	(–38.8)	0.0161	(6.1)	–0.0151	(–16.5)	–0.0126	(–8.9) 1974	0.0172	(16.9) 1985	–0.0174	(–5.9) 2001					3348
Belgium	–1.2653	(–46.9)	0.0238	(10.2)	0.0162	(8.9)	–0.0313	(–13.4) 1977	0.0124	(7.4) 1985	–0.0093	(–4.9) 1991	0.0074	(4.2) 1997			467
Canada	–0.6093	(–54.5)	0.0248	(12)	0.0044	(5.4)	–0.0174	(–8.3) 1978	0.0167	(5.9) 1984	–0.0103	(–3.7) 1990	0.0262	(9) 1996	–0.0242	(–4.6) 2002	99
Denmark	–0.9748	(–49.4)	–0.0202	(–4.5)	–0.0112	(–18.9)											180
Finland	–1.2743	(–53.6)	0.0555	(8.6)	–0.0049	(–5.5)	0.0537	(13.5) 1995	–0.0384	(–4.3) 2001							89
France	–0.4121	(–40.2)	0.0083	(5.3)	0.0312	(24.8)	–0.0717	(–31) 1971	0.0062	(3.2) 1977	0.0194	(10.2) 1985	–0.0066	(–3) 1991	0.0193	(9.4) 1997	4957
Germany	–0.608	(–97.2)	0.0193	(12.8)	–0.0188	(–18.4)	0.0118	(8.5) 1968	–0.0074	(–5.6) 1980	0.0223	(12.1) 1987	–0.0136	(–6.5) 1993	0.0075	(3.3) 1999	826
Ireland	–0.7678	(–4.5)	–0.025	(–2.1)	–0.0248	(–3.4)	0.0637	(8.4) 1984	–0.0299	(–2.3) 2002							276
Italy	–0.8725	(–99.6)	0.0216	(12.3)	–0.0018	(–3.5)	–0.0084	(–10.4) 1982	–0.0053	(–3.4) 2000							1137
Japan	0.1979	(16.7)	0.0439	(13.6)	–0.03	(–49.8)	0.0094	(11.4) 1984									6517
Netherlands	–1.2439	(–51.3)	0.0185	(11.3)	0.0206	(12.6)	–0.0309	(–14.3) 1977	0.0171	(22.8) 1985	–0.0244	(–15.5) 2001					267
New Zealand	–0.2258	(–4.8)	0.021	(4.9)	–0.017	(–5.9)	0.0152	(3.1) 1979	–0.0198	(–4.5) 1985	0.0389	(8.6) 1992	–0.0207	(–4.7) 1998			114

Table C6 (cont)

Capital productivity, adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Norway	–0.8698	(–13.2)	0.0227	(4.6)	0.0169	(4.7)	–0.027	(–6.7) 1979	0.0364	(15.1) 1990	–0.0115	(–4) 1996					189
Spain	–0.4358	(–22.1)	0.0152	(6)	0.0116	(5.3)	–0.0343	(–10.1) 1971	–0.0166	(–6.1) 1977	0.0425	(17.2) 1983	–0.028	(–11.8) 1990	0.0197	(8.7) 1996	1940
Sweden	–0.4506	(–27.2)	0.0217	(6.2)	–0.0235	(–22.8)	0.0197	(7.3) 1982	–0.0136	(–4.2) 1989	0.0259	(7.7) 1995	–0.0139	(–3) 2001			445
Switzerland	–0.6802	(–21.9)	0.0277	(10)	–0.0076	(–2.9)	–0.0227	(–5.7) 1974	0.0197	(9.7) 1980							1015
UK	–0.8237	(–53.1)	0.0211	(8.8)	0.0128	(6.3)	–0.0154	(–6.4) 1969	0.0121	(5.8) 1983	–0.0161	(–7.8) 1989					94
United States	–0.2618	(–39.3)	0.0253	(15.1)	0.006	(4.8)	–0.0085	(–5.7) 1967	0.0101	(17.5) 1985	0.011	(3.5) 2002					286
Euro area	0.3542	(20.7)	0.0194	(14.7)	–0.0081	(–7.2)	–0.0082	(–5.7) 1977	0.0133	(13.2) 1986	–0.0077	(–6.2) 1992	0.0068	(5.6) 1998			1990
OECD ex US	0.4413	(48.1)	0.0219	(18.5)	–0.0115	(–20.1)	–0.0047	(–4.8) 1979	0.0117	(11.9) 1985	–0.0081	(–7.9) 1991	0.0048	(5.4) 1997			4228
OECD	0.2438	(39.5)	0.0233	(15.8)	–0.0088	(–29.1)	0.0072	(16.7) 1985									807

Table C7

Labour productivity (persons employed), adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Australia	10.2395	(463.5)	–0.0065	(–2.3)	0.0321	(14.8)	–0.0159	(–6) 1972	–0.0092	(–5.2) 1986	0.0179	(7.7) 1992	–0.0116	(–3.8) 2000			1857
Austria	9.1788	(793.1)	0.0085	(3.8)	0.0584	(63.4)	–0.0331	(–32.4) 1974	–0.0167	(–7.5) 2001							11213
Belgium	9.6918	(365.1)	0.0133	(5.9)	0.0461	(25.5)	–0.0181	(–7.3) 1977	–0.011	(–8.5) 1983	–0.0047	(–5.1) 1995					5574
Canada	10.3434	(695.1)	0.01	(6.2)	0.0303	(22.3)	–0.0233	(–12.4) 1973	0.0039	(3.8) 1982	0.0084	(5.7) 1997	–0.0188	(–3.1) 2003			1587
Denmark	12.4317	(490.7)	–0.0077	(–3)	0.0072	(7.5)	0.0158	(11.4) 1990									1005
Finland	9.2905	(578)	0.0157	(5.6)	0.0543	(40.8)	–0.0232	(–14.5) 1974	0.0113	(6.4) 1992	–0.0251	(–9.3) 1998					8067
France	9.5631	(2123.3)	0.0043	(5.2)	0.0527	(111.2)	–0.025	(–28) 1973	–0.0032	(–4.7) 1980	–0.013	(–26.7) 1993					36608
Germany	9.6417	(2302.2)	0.0079	(6)	0.0462	(90.9)	–0.0126	(–10.9) 1972	–0.0244	(–18.8) 1979	0.0183	(14.2) 1989	–0.018	(–14) 1995			15238
Ireland	9.3229	(128.8)	0.0152	(2.1)	0.031	(10.9)	0.0064	(2.1) 1987									1909
Italy	9.206	(617.9)	0.0227	(14.1)	0.056	(49.1)	–0.0256	(–17.3) 1975	–0.0172	(–13.8) 1982	0.0125	(10.5) 1990	–0.0212	(–18.6) 1997			11488
Japan	14.0378	(637.2)	0.0199	(6.3)	0.0907	(48.2)	–0.0579	(–19.4) 1973	–0.0139	(–4.6) 1979	0.0142	(5.4) 1985	–0.0184	(–10.3) 1991			5548
Netherlands	9.6498	(309)	0.0142	(6.2)	0.0493	(24.6)	–0.0366	(–16.7) 1977									2839

Table C7 (cont)

Labour productivity (persons employed), adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
New Zealand	10.4547	(1172.8)	0.0129	(3.3)	0.0098	(30)											451
Norway	12.0704	(235.2)	0.009	(2.1)	0.0328	(12)	–0.0221	(–6.6) 1980	0.0144	(9.8) 1989							1575
Spain	8.9917	(907.4)	0.0045	(2.1)	0.0557	(66.4)	–0.025	(–18.8) 1975	–0.0134	(–12.1) 1986	–0.0096	(–7) 1996					9064
Sweden	12.1451	(490.2)	0.0201	(9.5)	0.0278	(15.6)	–0.018	(–6.9) 1976	0.0071	(4.1) 1982	0.0176	(11.7) 1991	–0.0191	(–10.6) 1998			4192
Switzerland	10.8579	(726.8)	0.0122	(8.3)	0.0318	(25.8)	–0.0281	(–18.1) 1974	–0.0096	(–7.7) 1986	0.0164	(11.5) 1992	–0.0111	(–3.6) 2002			459
UK	9.3567	(746.4)	0.0071	(3.2)	0.0422	(33.4)	–0.0201	(–10.9) 1973	–0.0062	(–5.9) 1984							3911
United States	10.3434	(1246.1)	0.0083	(3.6)	0.035	(19.7)	–0.0173	(–6.7) 1967	–0.0114	(–6.2) 1976	0.0082	(5.7) 1982	0.0163	(8.5) 1999			3070
Euro area	–1.1333	(–73.9)	0.0124	(9.7)	0.041	(40.2)	–0.0185	(–12.8) 1977	–0.0075	(–6.2) 1983	0.0095	(7.8) 1989	–0.0152	(–16.9) 1995			10874
OECD ex US	–1.0645	(–71.2)	0.0116	(8)	0.0367	(38.1)	–0.0166	(–15.4) 1977	–0.0076	(–15.5) 1995							13231
OECD	–0.8707	(–57.5)	0.0111	(7.3)	0.0274	(28.4)	–0.0106	(–10.1) 1977	0.0063	(3.5) 2002							8717

Table C8

Labour productivity (hours worked), adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Australia	2.8027	(194.1)	–0.0059	(–2)	0.0201	(28.8)	–0.014	(–8.3) 1986	0.0193	(8.6) 1992	–0.009	(–3) 2000					1940
Belgium	2.034	(38.3)	0.0098	(2.5)	0.0566	(15.2)	–0.0167	(–3.6) 1976	–0.019	(–10.2) 1982							3633
Canada	2.6858	(147.5)	0.0071	(3.6)	0.0386	(24.7)	–0.0257	(–15.3) 1973									2657
Denmark	4.768	(268.9)	–0.0088	(–2.9)	0.0193	(32.8)	0.0093	(4.4) 1998									1059
Finland	1.5894	(105.8)	0.0108	(4.3)	0.065	(52.6)	–0.0278	(–19.6) 1974	–0.0153	(–10.9) 1998							14180
France	2.0483	(98)	0.0075	(5.9)	0.0473	(32.6)	–0.0115	(–6.2) 1976	–0.0069	(–6.5) 1985	–0.0125	(–10.8) 1993	0.0108	(4.9) 2001			11719
Germany	1.9934	(608)	0.0079	(7.4)	0.0557	(149.2)	–0.0125	(–12.7) 1973	–0.0275	(–24.1) 1979	0.02	(19.1) 1989	–0.02	(–19.2) 1995			41999
Ireland	1.6476	(23.1)	0.0075	(1)	0.035	(12.8)	0.0125	(4.1) 1988									2228
Italy	1.5645	(99.2)	0.0172	(10.7)	0.0661	(54.4)	–0.0278	(–16.6) 1975	–0.0194	(–15.5) 1981	0.0095	(8) 1991	–0.0211	(–16.1) 1997			14545
Japan	6.635	(193.4)	0.0214	(6.9)	0.0648	(27.5)	–0.0409	(–14.3) 1976	0.0169	(10.7) 1987	–0.0208	(–14.1) 1994					7040
Netherlands	2.2214	(56.8)	0.0077	(2.9)	0.0462	(17.6)	–0.0288	(–7.9) 1977	0.018	(10.1) 1983	–0.0203	(–15.7) 1993					5165
New Zealand	2.8521	(136.1)	0.0183	(3.4)	0.0134	(14.1)	–0.0065	(–2.8) 1991									222
Norway	4.3216	(105.6)	0.0081	(2.4)	0.0541	(24.8)	–0.0387	(–14.5) 1980	0.014	(11.9) 1989							4287

Table C8 (cont)

Labour productivity (hours worked), adjusted for the cycle

T-stat in brackets	**Constant**		**Cycle**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**										**F-stat**
Spain	1.4162	(38.6)	0.0078	(2.4)	0.0506	(20.3)	–0.0097	(–3.2)	–0.0207	(–12.6)	–0.0137	(–7.2)					3289
								1976		1986		1996					
Sweden	4.544	(142.1)	0.014	(5)	0.0423	(18.7)	–0.0259	(–9.6)	0.0081	(8.6)							3353
								1976		1991							
Switzerland	3.3917	(106.1)	0.0122	(5.9)	0.0276	(12.2)	–0.0165	(–5.6)	–0.0098	(–7)	0.0163	(8.9)	–0.0156	(–4.5)			540
								1976		1985		1995		2001			
UK	1.9508	(98.8)	–0.0082	(–2.2)	0.0298	(31.5)	–0.0139	(–9.5)									1287
								1986									
United States	2.7587	(466)	0.0077	(4.1)	0.0315	(53)	–0.0186	(–24.8)	0.0176	(13.2)							5252
								1973		1998							
Euro area	–5.9302	(–447.5)	0.005	(3.3)	0.0426	(53.3)	–0.0167	(–17.1)	–0.0117	(–17)							14483
								1979		1996							
OECD ex US	–5.9212	(–316.7)	0.0099	(5.2)	0.0439	(35.4)	–0.0163	(–9.2)	–0.0054	(–3.6)	0.0064	(4.1)	–0.0121	(–10.8)			11672
								1977		1983		1989		1995			
OECD	–5.6718	(–328.8)	0.0048	(2.8)	0.0344	(31.6)	–0.0143	(–12.3)									12128
								1977									

Table C9

Total factor productivity (persons employed), adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Australia	5.6252	(216.5)	–0.0074	(–2.1)	0.0183	(7.1)	–0.0176	(–5.4) 1972	0.0034	(2.2) 1984	0.0181	(6.8) 1994	–0.0176	(–4.2) 2000			243
Austria	5.4882	(477.2)	0.0134	(6.3)	0.0308	(32)	–0.0253	(–20) 1974	0.0069	(8.7) 1987	–0.0191	(–7.8) 2001					1347
Belgium	5.2997	(211.2)	0.0167	(7.7)	0.0343	(20.3)	–0.0252	(–12.7) 1977	–0.004	(–6.4) 1990							1734
Canada	6.1687	(641.7)	0.016	(11)	0.0165	(21.3)	–0.0182	(–11.6) 1976	0.008	(6.4) 1982	0.0128	(9.5) 1997	–0.0243	(–4.5) 2003			841
Denmark	7.544	(463)	–0.0094	(–4.4)	0.0013	(2.2)	0.0141	(10.8) 1993	–0.0176	(–4.2) 2002							225
Finland	5.2277	(425.7)	0.0341	(10.5)	0.0161	(33.4)	0.0227	(11.5) 1993	–0.019	(–6.2) 1999							1856
France	5.7144	(855.4)	0.0072	(7.2)	0.0458	(56)	–0.0393	(–26.2) 1971	–0.0045	(–3.7) 1977	0.0086	(7.4) 1986	–0.0101	(–7) 1992	0.0059	(4.1) 1998	2273
Germany	5.828	(1602.6)	0.0127	(10.9)	0.0235	(56.7)	–0.0045	(–4) 1973	–0.0185	(–14) 1979	0.0187	(15.7) 1988	–0.0134	(–12.2) 1994			5210
Ireland	4.6486	(62.5)	0.0116	(1.6)	0.0129	(4.4)	0.0259	(8.2) 1987									1320
Italy	4.2616	(285.9)	0.0221	(14)	0.0288	(25.2)	–0.0147	(–9.7) 1975	–0.0131	(–9.1) 1982	0.0057	(5) 1988	–0.0119	(–11.4) 1998			1458
Japan	7.9403	(353.9)	0.0274	(9.4)	0.0432	(21)	–0.037	(–12.8) 1972	–0.0081	(–3.1) 1979	0.0125	(5.2) 1985	–0.0122	(–7.4) 1991			200
Netherlands	5.2018	(220.9)	0.0171	(10.3)	0.0375	(23.6)	–0.0331	(–16.2) 1977	0.009	(8.5) 1988	–0.0039	(–3.2) 1994	–0.0112	(–5.8) 2001			2102
New Zealand	5.4305	(508.3)	0.0295	(8.9)	0.0023	(6.6)											66

Table C9 (cont)

Total factor productivity (persons employed), adjusted for the cycle

T-stat in brackets	**Constant**		**Cycle**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**									**F-stat**
Norway	6.3471	(124)	0.0137	(3.6)	0.027	(9.6)	–0.0248	(–8) 1979	0.0256	(13.7) 1990	–0.0087	(–3.9) 1996				930
Spain	4.7993	(514.3)	0.0068	(3.7)	0.0321	(36.9)	–0.0308	(–20.8) 1974	0.0121	(8.4) 1983	–0.0126	(–11) 1989				1141
Sweden	7.8633	(331.5)	0.0212	(10.8)	0.0112	(6.6)	–0.0129	(–5.2) 1976	0.0109	(7.1) 1982	0.011	(9) 1992	–0.0121	(–5.8) 2000		1375
Switzerland	6.5959	(349)	0.0171	(10.6)	0.0189	(11.8)	–0.0232	(–13.4) 1973	0.011	(8.5) 1996	–0.0154	(–3.8) 2002				93
UK	5.8173	(609.3)	0.0141	(8.1)	0.0292	(30.7)	–0.0155	(–11.9) 1973	–0.005	(–6.6) 1987						2806
United States	6.4511	(908)	0.0138	(7)	0.0246	(16.5)	–0.0146	(–7) 1967	–0.0081	(–5.5) 1977	0.0099	(7.9) 1983	0.0119	(7) 1999		1926
Euro area	–0.5235	(–43.8)	0.0145	(15.7)	0.0211	(26.7)	–0.0159	(–16.2) 1977	0.0063	(10.4) 1988	–0.0082	(–13.4) 1994				3205
OECD ex US	–0.4574	(–36.8)	0.0171	(15.3)	0.0177	(21.5)	–0.0119	(–11.2) 1977	0.004	(6.4) 1986	–0.0059	(–10.6) 1993				2583
OECD	–0.4515	(–33.3)	0.0159	(13.2)	0.0144	(16.1)	–0.0088	(–6.8) 1977	0.0037	(6) 1983	0.0057	(3.8) 2002				2958

Table C10

Total factor productivity (hours worked), adjusted for the cycle

T-stat in brackets	Constant		Cycle		Time trend		Time breaks: additional change in trend productivity growth rates and respective break years										F-stat
Australia	1.4449	(94.7)	0.0167	(3.1)	0.0088	(16.4)											170
Belgium	0.6955	(17.1)	0.0148	(5)	0.0418	(14.6)	–0.0233	(–6.5) 1976	–0.009	(–6.3) 1982							1565
Canada	1.4332	(135.9)	0.0147	(11.1)	0.0239	(27.6)	–0.0178	(–18.1) 1974	0.0132	(11.5) 1997	–0.0254	(–4.9) 2003					1494
Denmark	2.7257	(157.3)	–0.0112	(–5)	0.0065	(10.4)	0.0063	(5.5) 1993									398
Finland	0.6729	(57.9)	0.0301	(9.7)	0.0199	(44.7)	0.0171	(9) 1994	–0.0171	(–4.9) 2000							2151
France	1.4465	(277.2)	0.0066	(5.6)	0.0103	(45.8)	–0.0064	(–6.8) 1992	0.0089	(5.6) 1998							1512
Germany	1.0193	(298.1)	0.0125	(11.4)	0.0299	(76.6)	–0.0039	(–3.8) 1973	–0.0215	(–17.4) 1979	0.0202	(18) 1988	–0.0148	(–14.3) 1994			11674
Ireland	–0.183	(–3.5)	–0.0304	(–2.4)	0.04	(24.8)											584
Italy	0.3383	(25.5)	0.022	(15.4)	0.0356	(35)	–0.0184	(–13.9) 1975	–0.0139	(–12.5) 1982	0.0062	(5.9) 1990	–0.0123	(–12.1) 1997			3058
Japan	3.8794	(120.6)	0.0269	(9.3)	0.019	(8.6)	–0.0176	(–6.4) 1976	0.0119	(8.5) 1986	–0.0119	(–9.5) 1994					281
Netherlands	0.8161	(35)	0.0105	(6.6)	0.0351	(22.4)	–0.03	(–13.8) 1977	0.0178	(16.5) 1983	–0.0105	(–10.5) 1993	–0.0086	(–5.4) 2000			4870
New Zealand	1.3667	(130.3)	0.0277	(8.5)	0.0031	(8.9)											82
Norway	1.9742	(43.6)	0.0154	(4.6)	0.0413	(16.7)	–0.0357	(–13) 1979	0.0231	(14) 1990	–0.006	(–3.1) 1996					1820

Table C10 (cont)

Total factor productivity (hours worked), adjusted for the cycle

T-stat in brackets	**Constant**		**Cycle**		**Time trend**		**Time breaks: additional change in trend productivity growth rates and respective break years**									**F-stat**
Spain	0.7026	(30.6)	0.0102	(5.5)	0.0218	(13.7)	–0.02	(–8.3) 1976	0.0198	(10.6) 1982	–0.0204	(–17.4) 1988				718
Sweden	2.8496	(112.6)	0.0213	(9.7)	0.02	(11.2)	–0.0144	(–6.8) 1976	0.01	(13.4) 1991						1538
Switzerland	2.0581	(201.6)	0.0144	(7.6)	0.0021	(4)	–0.0054	(–4.8) 1986	0.0116	(5.6) 1996	–0.0167	(–3.3) 2002				17
UK	0.9983	(76.3)	0.0098	(4.5)	0.0208	(31.5)	–0.011	(–11.8) 1984								1429
United States	1.6369	(257.2)	0.0108	(6.2)	0.0262	(19.6)	–0.012	(–6.5) 1967	–0.0114	(–8.6) 1977	0.0087	(7.8) 1983	0.0127	(8.3) 1999		2997
Euro area	–3.3865	(–239.4)	0.0134	(12.3)	0.0256	(27.3)	–0.0157	(–13.5) 1977	0.0045	(6.3) 1988	–0.0081	(–11.1) 1994				5010
OECD ex US	–3.3184	(–230)	0.0143	(10.9)	0.0218	(22.9)	–0.0127	(–10.5) 1977	0.0046	(5.9) 1987	–0.0071	(–9.9) 1993				3955
OECD	–3.3695	(–281.9)	0.0129	(11.6)	0.0185	(23.5)	–0.0102	(–9.7) 1977	0.0043	(6.3) 1985	–0.0034	(–4.2) 1993	0.005	(4.8) 1999		4641

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