KARL AIGINGER

# CAN INNOVATION EXPLAIN THE INCREASING GROWTH DIFFERENCES IN THE 1990S?

Differences between macroeconomic growth rates increased across countries during the 1990s. This paper investigates the influence of innovation on growth. As a first step, we analyse differences in macroeconomic growth of output and productivity, then we focus on manufacturing, first at the aggregate level, then for sectors and industries. That innovation, knowledge and ICT are drivers of growth is clearly supported by the data. Nevertheless, policies to combat unemployment and strategies to maintain the competitiveness of more slowly growing industries are also important. While the growth differential increased across countries, industries of accelerating growth and industries with modest growth have grown to be more similar. Technology-driven and ICT industries which had rapidly grown in the USA at the start of the 1990s now increase their business share and productivity in Europe as well.

Karl Aiginger is an economist at WIFO. The author is grateful to the group of advisors of the Competitiveness Report 2001 for useful and constructive comments. The study is part of a background report provided by WIFO for the European Commission, Enterprise Directorate-General, for the Competitiveness Report 2001. The data were processed and analysed with the assistance of Dagmar Guttmann • E-mail addresses: Karl.Aiginger@wifo.ac.at, Dagmar.Guttmann@wifo.ac.at

In the first chapter, we report on differences in output and productivity across countries on the aggregate level and, in the second chapter, we relate them to the forces expected to determine long-term growth such as knowledge, ICT and capabilities. Then we identify those industries which increased productivity fastest, look into the issue of how closely productivity growth is related to research intensity, and how similar the sectoral pattern of growth is. The concluding section investigates which countries are leading with respect to the growth drivers, whether countries lagging behind are catching up, and how the EU is performing relative to the USA.

**Productivity gap between the EU and the USA increased in the 1990s**

The USA is again forging ahead in productivity growth. Following a longer period of more rapid productivity growth in the EU, it accelerated in the USA over the past decade and is now higher than in Europe and Japan. This is true not only for labour productivity, but also for multi-factor productivity; the trend holds for the total economy and not just for manufacturing. We combine evidence reported in the literature[1] with our own evidence, specifically extending the analysis up to the year 2000.

**Growth boosts productivity in the USA**

Macroeconomic growth was strong enough in the USA to boost productivity. Real output increased by 3.3 percent in the 1990s, implying a growth in labour productivity of 2 percent p.a. Productivity growth in the second half of the 1990s exceeded the rate for the first half by 1.3 percent, driven by an acceleration of growth from 2.4 percent to 4.3 percent (Table 1). In the EU, productivity growth in the 1990s was only 1.5 percent and *decelerated* from 1.9 to 1.0 percent between the first and the second half of the decade. This decline in productivity growth happened despite an acceleration in output growth by 1 percentage point (to 2.4 percent) in the second half of the 1990s (Figures 1 and 2).

The highest macro productivity growth was achieved by Ireland, Finland, Denmark, Portugal and Sweden (Table 2). The Nordic countries managed this on top of above-average productivity levels at the start of the 1990s. Ireland made a considerable jump upward during this decade and Portugal managed to close the gap. In the majority of EU countries, productivity growth decelerated during the second half of the 1990s (most strongly in Spain and Italy)[2]. In Greece and Belgium, on the other hand, productivity

[1] *Scarpetta et al.* (2000), *Bassanini - Scarpetta – Visco* (2000), *OECD* (2001A/B), *European Economy* (2000), *McMorrow – Roeger* (2001).

[2] Productivity also decelerated substantially in Sweden during the second half of the 1990s, but this happened on top of an extreme boost during the first half of the decade.

growth was greater in the second half compared to the first half. Cyclical factors and changes in labour policy seem to have shifted production (and thus measured productivity) between the first and second half of the 1990s, in addition to innovation and productivity[3].

*Recent studies on growth performance and its underlying forces*

| Author/Institution | Title | Scope | Additional features |
|---|---|---|---|
| *European Commission* (1998) | The Competitiveness of European Industry 1998 | Competitiveness in the triad | Taxonomies, small firms, multinationals |
| *European Commission* (1999) | The Competitiveness of European Industry 1999 | Adaptability and change | Intangible investment, Asian crisis |
| *European Commission* (2000A) | European Competitiveness Report 2000 | Competition in quality | Service inputs, pharmaceuticals |
| *European Commission* (2001A) | European Competitiveness Report 2001 | Impact of innovation an manufacturing performance | Communication technologies, innovation |
| *Eurostat* (1999) | Panorama of European Business | Main trends for industries | Overview of structure and performance |
| *Aiginger et al.* (1999) | Specialisation and (Geographic) Concentration of European Manufacturing | Degree and change in specialisation and geographic concentration | Survey on trade theory, growth differences |
| *Peneder* (2001) | Entrepreneurial Competition and Industrial Location | Theoretical and empirical overview | Background for three taxonomies |
| *Davies – Lyons* (1990) | Industrial Organisation in the EU | Strategies of leading firms | Matrix of 300 leading firms |
| *Ilzkovitz – Dierx* (2000)<br>*European Economy* (2000) | European Integration and the Location of Industries | Overview on studies concerning specialisation | Survey of liberalisation, growth differences |
| *Aiginger*(2000A) | Europe's Position in Quality Competition | Country shares in price or quality sensitive industries and in high- and low-price segments | Importance of quality competition for Europe |
| *Braunerhjelm et al.* (2000) | Integration and the Regions of Europe | Concentration and specialisation of regions | Policy impact on income differences, agglomeration, catching up |
| *OECD* (2001A) | The New Economy: Beyond the Hype. Final Report on the OECD Growth Project | Explaining differences in growth performance of OECD countries | Policy conclusions |
| *OECD* (2001B) | Growth Project, Draft Ministerial Paper | Explaining growth pattern | ICT, diffusion of technologies, human capital, firm creation |
| *McMorrow – Roeger* (2001) | Potential Output: Measurement Methods, "New" Economy Influences and Scenarios for 2001-2010 | New Economy effect on potential growth | Growth scenarios for the EU and the USA |
| *European Commission – ECFIN* (2000) | The EU Economy 2000 Review | Is there a new pattern of growth emerging? | Prospects and challenges for Europe |

### Continued productivity growth in European manufacturing

Labour productivity in EU manufacturing increased rather smoothly, at 3 percent p.a. (Table 2). In contrast to macro productivity, a slight acceleration was evident between the first and the second halves of the 1990s. However, European levels of acceleration and labour productivity growth were lower than in the USA. The highest levels of productivity growth in the EU during the 1990s were achieved by Ireland, Finland, Austria and Sweden; in these four countries, productivity in manufacturing rose faster than in the USA. The lowest growth rates were for Portugal, Spain and France (less than 2 percent p.a.). Taking productivity growth in the second half of the 1990s separately, three countries managed to increase productivity faster than the USA. Eleven countries were not able to match US levels of productivity growth during the last five years; in Italy, productivity growth was near zero, in Spain productivity was even decreasing[4].

### Larger divergence of growth rates across countries

The divergence of growth rates increased for the overall economy as well as for manufacturing[5]. Slow-growing countries managed barely more than 1 percent for the whole decade; high-growth countries achieved about or above 4 percent. The standard deviation increased by more than 50 percent for macro growth as well as for manufacturing[6]. Surprisingly, the standard deviation of labour productivity growth did not increase. This is due to the fact that several low-growth countries, like Germany, the UK and Greece, decreased employment by heavy restructuring to maintain or regain competitiveness, specifically in capital-intensive industries and firms .

[3] This is reflected in a higher standard deviation of the growth rates for the two halves as compared to the whole 1990s.

[4] If ranked by acceleration between the second and the first halves of the 1990s, Finland, France, Ireland and Germany spurred productivity fastest; Denmark, Austria and Portugal came in next.

[5] *Scarpetta et al.* (2000) show this for the actual growth rate, trend growth and growth per capita for a wider set of countries, using data up to 1998.

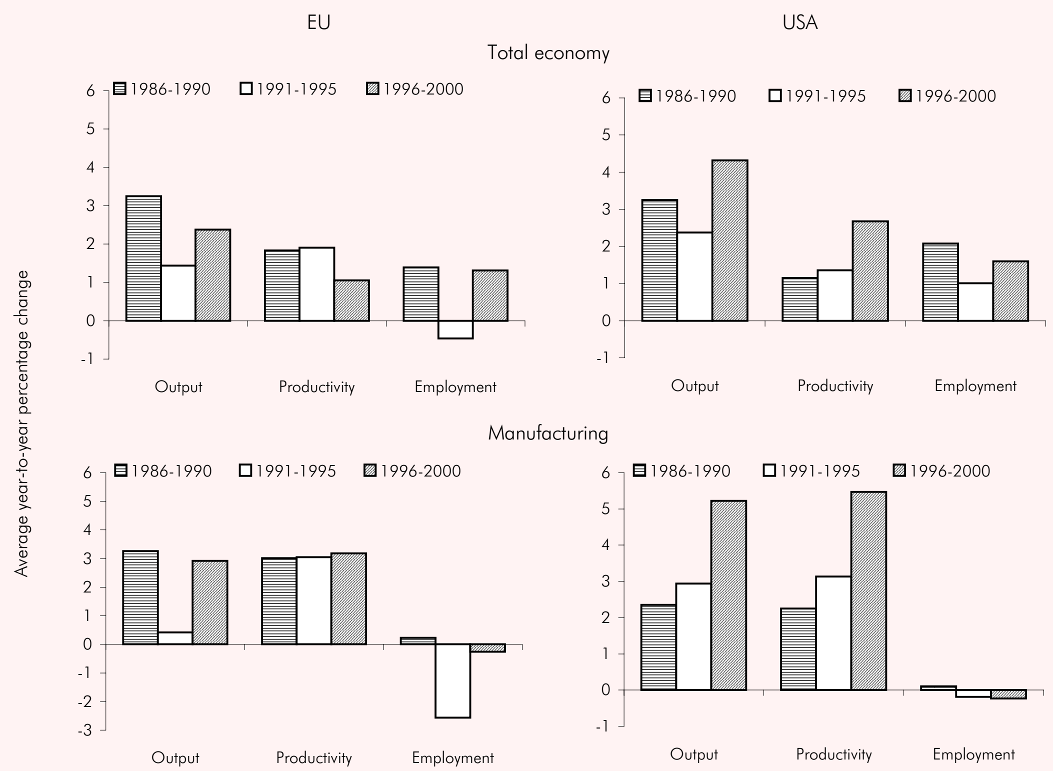
[6] The growth variance increases also if we calculate the coefficient of variation instead of the sta ndard deviation and if we exclude Ireland as an "outlier".

*Table 1: Productivity growth acceleration in the USA but not in the EU*

| | | Total economy | | Manufacturing | |
|---|---|---|---|---|---|
| | | EU | USA | EU | USA |
| | | Year-to-year percentage change | | | |
| Output | | | | | |
| 1986-1990 | | + 3.2 | + 3.2 | + 3.3 | + 2.4 |
| 1991-1995 | | + 1.4 | + 2.4 | + 0.4 | + 2.9 |
| 1996-2000 | | + 2.4 | + 4.3 | + 2.9 | + 5.2 |
| 1991-2000 | | + 1.9 | + 3.3 | + 1.7 | + 4.1 |
| *Acceleration second versus first half* | *percentage points* | + *0.9* | + *1.9* | + *2.5* | + *2.3* |
| Labour productivity | | | | | |
| 1986-1990 | | + 1.8 | + 1.1 | + 3.0 | + 2.3 |
| 1991-1995 | | + 1.9 | + 1.4 | + 3.0 | + 3.1 |
| 1996-2000 | | + 1.0 | + 2.7 | + 3.2 | + 5.5 |
| 1991-2000 | | + 1.5 | + 2.0 | + 3.1 | + 4.3 |
| *Acceleration second versus first half* | *percentage points* | − *0.9* | + *1.3* | + *0.1* | + *2.3* |
| Trend growth of GDP per capita | | | | | |
| 1981-1990 | | + 2.0 | + 2.0 | | |
| 1991-1998 | | + 1.4 | + 2.2 | | |
| Multi-factor productivity | | | | | |
| 1981-1990 | | + 1.7 | + 1.0 | | |
| 1991-1998 | | + 1.3 | + 1.4 | | |

Source: WIFO calculations using Eurostat (New Cronos); 1999-2000: EC, Economic Forecasts 2000-2002; *Bassanini – Scarpetta – Visco* (2000). Labour productivity . . . output per employment; output . . . GDP for total economy, production index for manufacturing. Trend growth and multi-factor productivity estimated by *Bassanini – Scarpetta – Visco* (2000).

*Figure 1: Macro productivity decelerates in the EU but remains stable for manufacturing*




Source: WIFO calculations using Eurostat (New Cronos); 1999-2000: EC, Economic Forecasts 2000-2002. Productivity . . . real GDP per employment for total economy, production index per employment for manufacturing.

*Table 2: Growth performance becomes more diverse*

| | Output | | | | | Productivity | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1986-1990 | 1991-1995 | 1996-2000 | 1991-2000 | Second versus first half | 1986-1990 | 1991-1995 | 1996-2000 | 1991-2000 | Second versus first half |
| | Year-to-year percentage change | | | Acceleration in percentage points | | Year-to-year percentage change | | | Acceleration in percentage points | |
| *Total economy* | | | | | | | | | | |
| EU | + 3.2 | + 1.4 | + 2.6 | + 2.0 | + 1.2 | + 1.8 | + 1.9 | + 1.0 | + 1.5 | – 0.9 |
| Belgium | + 3.0 | + 1.3 | + 2.3 | + 1.8 | + 1.0 | + 1.9 | + 1.3 | + 1.8 | + 1.5 | + 0.5 |
| Denmark | + 2.1 | + 2.5 | + 2.6 | + 2.5 | + 0.1 | + 1.3 | + 3.3 | + 1.8 | + 2.5 | – 1.5 |
| Germany | + 3.4 | + 2.0 | + 2.1 | + 2.0 | + 0.1 | + 1.9 | + 2.1 | + 1.4 | + 1.7 | – 0.6 |
| Greece | + 1.9 | + 1.2 | + 3.2 | + 2.2 | + 2.0 | + 1.3 | + 0.7 | + 2.7 | + 1.7 | + 2.0 |
| Spain | + 4.9 | + 1.3 | + 3.3 | + 2.3 | + 1.9 | + 1.8 | + 2.5 | – 0.3 | + 1.1 | – 2.7 |
| France | + 3.0 | + 1.0 | + 2.4 | + 1.7 | + 1.4 | + 2.2 | + 1.2 | + 1.1 | + 1.1 | 0.0 |
| Ireland | + 5.5 | + 6.1 | + 9.7 | + 7.9 | + 3.6 | + 3.7 | + 4.4 | + 4.0 | + 4.2 | – 0.4 |
| Italy | + 3.0 | + 1.1 | + 1.5 | + 1.3 | + 0.4 | + 2.6 | + 2.2 | + 0.7 | + 1.5 | – 1.5 |
| The Netherlands | + 3.0 | + 2.1 | + 3.1 | + 2.6 | + 1.0 | + 0.7 | + 0.4 | + 0.3 | + 0.3 | – 0.1 |
| Austria | + 3.2 | + 2.0 | + 2.5 | + 2.2 | + 0.5 | + 2.6 | + 1.4 | + 1.5 | + 1.5 | 0.0 |
| Portugal | + 5.5 | + 1.7 | + 3.4 | + 2.6 | + 1.8 | + 3.5 | + 3.0 | + 1.6 | + 2.3 | – 1.4 |
| Finland | + 3.4 | – 0.5 | + 4.5 | + 1.9 | + 5.0 | + 2.6 | + 3.0 | + 2.6 | + 2.8 | – 0.4 |
| Sweden | + 2.3 | + 0.5 | + 2.2 | + 1.3 | + 1.7 | + 0.9 | + 2.9 | + 1.2 | + 2.0 | – 1.7 |
| UK | + 3.2 | + 1.3 | + 2.3 | + 1.8 | + 1.0 | + 1.3 | + 2.0 | + 0.9 | + 1.5 | – 1.1 |
| Japan | + 5.2 | + 1.5 | + 1.2 | + 1.4 | – 0.4 | + 3.7 | + 0.9 | + 1.2 | + 1.0 | + 0.3 |
| USA | + 3.2 | + 2.4 | + 4.1 | + 3.2 | + 1.7 | + 1.1 | + 1.4 | + 2.7 | + 2.0 | + 1.3 |
| Standard deviation | | | | | | | | | | |
| EU countries | 1.15 | 1.48 | 2.02 | 1.63 | | 0.90 | 1.11 | 1.07 | 0.92 | |
| Triad | 1.12 | 0.52 | 1.47 | 0.96 | | 1.30 | 0.52 | 0.91 | 0.50 | |
| *Manufacturing* | | | | | | | | | | |
| EU | + 3.3 | + 0.4 | + 2.9 | + 1.7 | + 2.5 | + 3.0 | + 3.0 | + 3.2 | + 3.1 | + 0.1 |
| Belgium | + 3.5 | + 1.3 | + 3.4 | + 2.3 | + 2.1 | + 3.4 | + 3.9 | + 3.9 | + 3.9 | + 0.0 |
| Denmark | + 1.6 | + 3.0 | + 3.6 | + 3.3 | + 0.6 | + 2.6 | + 1.5 | + 3.3 | + 2.4 | + 1.8 |
| Germany | + 3.5 | – 0.8 | + 3.6 | + 1.4 | + 4.4 | + 2.0 | + 2.6 | + 4.9 | + 3.8 | + 2.3 |
| Greece | + 0.2 | – 0.7 | + 3.2 | + 1.3 | + 3.9 | + 0.5 | + 3.6 | + 4.2 | + 3.9 | + 0.6 |
| Spain | + 3.4 | + 0.9 | + 2.4 | + 1.6 | + 1.5 | + 2.1 | + 4.2 | – 1.4 | + 1.3 | – 5.6 |
| France | + 2.2 | – 0.4 | + 3.7 | + 1.6 | + 4.1 | + 3.8 | + 0.7 | + 3.2 | + 1.9 | + 2.5 |
| Ireland | + 8.3 | + 10.2 | + 12.2 | + 11.2 | + 2.0 | + 7.7 | + 6.8 | + 9.2 | + 8.0 | + 2.3 |
| Italy | + 3.2 | + 1.4 | + 1.8 | + 1.6 | + 0.4 | + 3.8 | + 3.1 | + 1.2 | + 2.2 | – 2.0 |
| The Netherlands | + 1.8 | + 1.4 | + 3.6 | + 2.5 | + 2.2 | + 0.0 | + 2.7 | + 2.9 | + 2.8 | + 0.3 |
| Austria | + 4.5 | + 2.4 | + 5.6 | + 4.0 | + 3.2 | + 5.8 | + 4.8 | + 6.1 | + 5.4 | + 1.3 |
| Portugal | + 4.9 | – 0.8 | + 2.8 | + 1.0 | + 3.7 | + 5.0 | + 0.5 | + 1.8 | + 1.2 | + 1.3 |
| Finland | + 2.7 | + 2.8 | + 9.8 | + 6.2 | + 7.0 | + 4.6 | + 4.9 | + 8.8 | + 6.8 | + 3.9 |
| Sweden | + 2.1 | + 3.2 | + 5.1 | + 4.2 | + 1.9 | + 2.1 | + 7.2 | + 3.4 | + 5.3 | – 3.8 |
| UK | + 3.4 | + 0.6 | + 1.1 | + 0.8 | + 0.5 | + 3.5 | + 4.3 | + 3.0 | + 3.7 | – 1.3 |
| Japan | + 4.5 | – 0.6 | + 1.1 | + 0.2 | + 1.7 | + 4.0 | + 1.0 | + 3.0 | + 2.0 | + 2.1 |
| USA | + 2.4 | + 2.9 | + 5.2 | + 4.1 | + 2.3 | + 2.3 | + 3.1 | + 5.5 | + 4.3 | + 2.3 |
| Standard deviation | | | | | | | | | | |
| EU countries | 1.91 | 2.80 | 3.05 | 2.78 | | 2.05 | 2.00 | 2.78 | 2.04 | |
| Triad | 1.08 | 1.84 | 2.09 | 1.95 | | 0.86 | 1.22 | 1.37 | 1.15 | |

Source: WIFO calculations using Eurostat (New Cronos); 1999-2000: estimate, EC, Economic Forecasts 2000-2002. Output . . . GDP for total economy, production index for manufacturing, productivity . . . real GDP per employment for total economy, production index per employment for manufacturing.

**Multi-factor productivity growth accelerated in the USA**

During the 1990s, labour productivity (output per person) rose more strongly in the USA than in the EU (2.0 percent versus 1.5 percent). Part of this productivity increase may be due to capital deepening, and, in fact, the USA did increase its historically low investment ratio. This was partly driven by ICT (information and communication technologies). The business cycle also has an impact, since productivity rises pro-cyclically[7]. Measures of multi-factor productivity try to correct for capital deepening and for deviation of actual from potential output, by relating the "trend output" to all inputs.

The OECD estimates that multi-factor productivity growth increased in the USA from 1.0 percent in the 1980s to 1.4 percent in the 1990s (Table 3)[8]. For the EU, this study reports an increase of 1.7 percent in the 1980s, declining to 1.3 percent between 1991 and 1998. The difference in growth dynamics of multi-factor productivity is small, but becomes important since the data indicate a deceleration for the EU during a period of

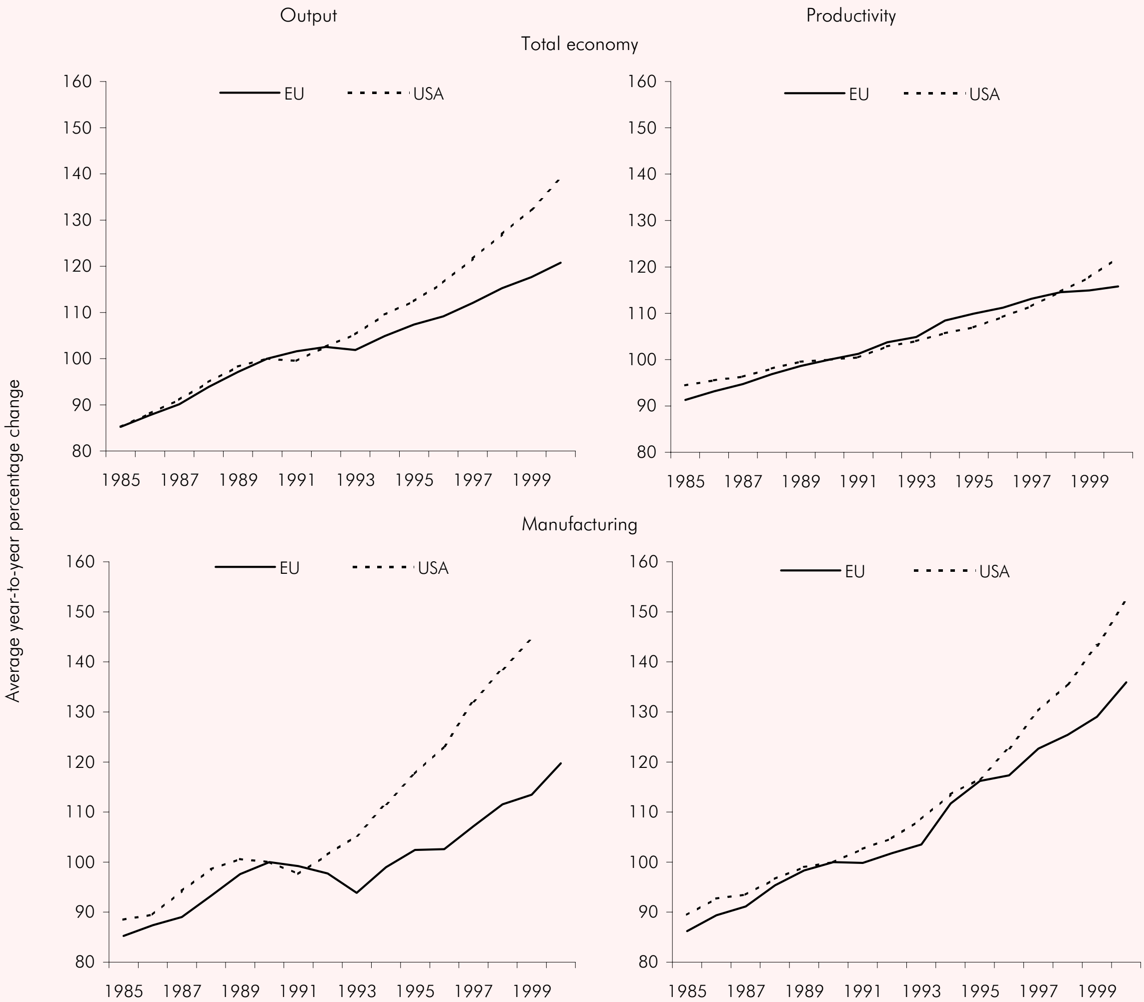
[7] The EU countries had to increase budgetary discipline (Maastricht criteria) and the central banks had to build up credibility to combat inflation; both had been done earlier in the USA; this enabled it to institute less restrictive fiscal and monetary policies in the 1990s.

[8] Other non-EU countries with increasing multi-factor productivity are Australia, New Zealand, Canada and Norway (*Bassanini – Scarpetta – Visco,* 2000, p. 23, Table 3, hours-adjusted version).

acceleration in the USA. Experience differs according to countries. Within the European Union, four countries, namely Denmark, Finland, Portugal and Sweden, enjoyed an acceleration during the 1990s relative to the 1980s. Ireland, Denmark, Finland, the Netherlands and Portugal achieved higher growth in multi-factor productivity than the USA.

*Figure 2: Higher growth of output and productivity in the USA*

*1990 = 100*




Source: WIFO calculations using Eurostat (New Cronos); 1999-2000: EC, Economic Forecasts 2000-2002. Output . . . GDP for total economy, production index for manufacturing, productivity . . . real GDP per employment for total economy, production index per employment for manufacturing.

*McMorrow – Roeger* (2001) provide an estimate up to 2000, with trends similar to the OECD findings. For the USA, multi-factor productivity growth is reported to accelerate from 0.9 percent in the 1980s to 1.1 percent in the first half of the 1990s and to 1.4 percent in the second half of the 1990s. For the EU, productivity change amounted to 1.1 percent in the 1980s and in the first half of the 1990s, and 1.0 percent in the second half of the 1990s[9]. All these calculations use trend growth rates, which intend to eliminate cyclical factors, but such concepts may be late in detecting fundamental change.

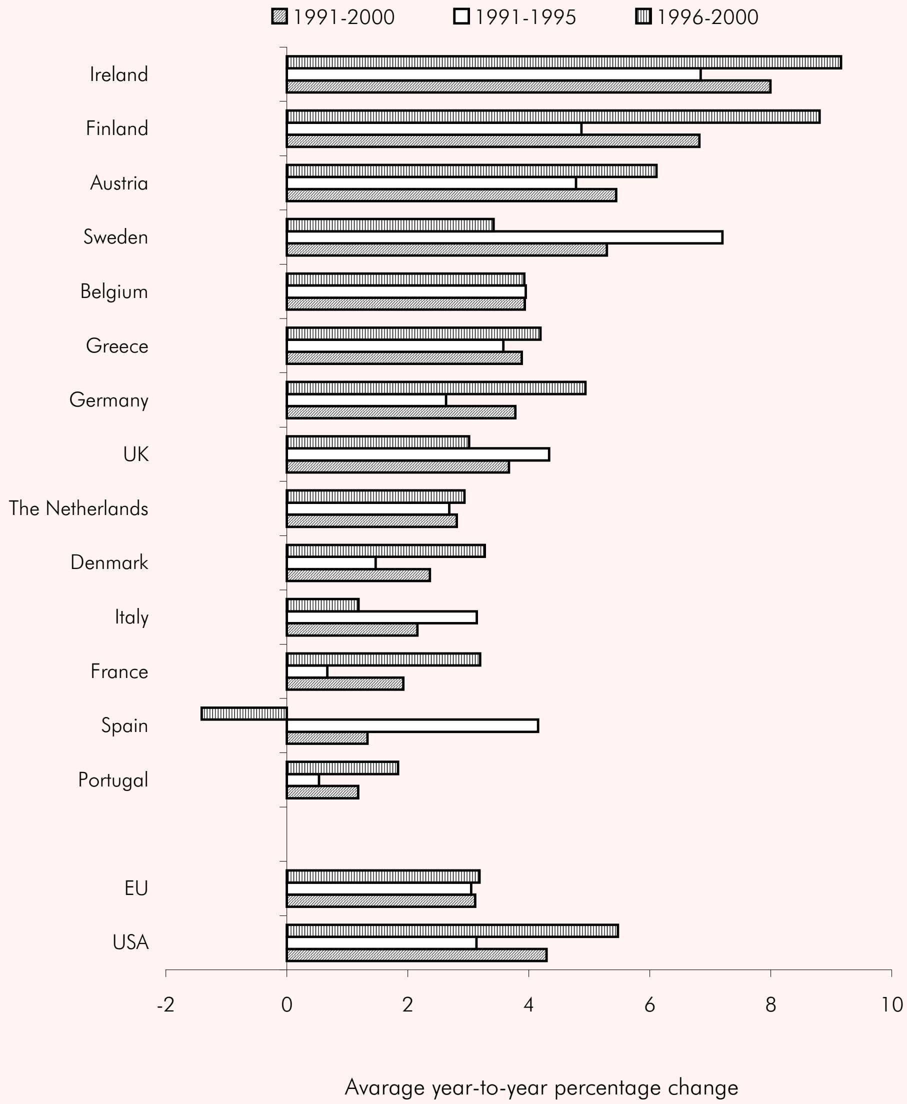
In summary, the evidence of higher growth in multi-factor productivity is not strong enough to assuage all doubts which could arise due to issues of measurement or from assessments of the cyclical component. If the slowdown, which started in late 2000, proves stronger and lasts longer in the USA than in the EU, the estimate for "trend growth" will be revised down later, perhaps eliminating the currently reported differences

[9] *McMorrow – Roeger* (2001) apply several methods to eliminate trends and to measure inputs; we report results based on the HP filtered trend.

in multi-factor productivity growth. Nevertheless, the overall performance of the US economy in the 1990s was exceptional by many criteria. The USA forged ahead in growth, labour productivity, and multi-factor productivity; at the same time it was successful in capital deepening and in increasing employment at a high rate. This combination is sometimes seen in countries catching up, after they have reached a take-off point (see, e.g., *Scarpetta et al.,* 2000), but it is unusual for a country already leading in productivity. On the other hand, four EU countries have managed to increase multi-factor productivity as rapidly as the USA.

*Figure 3: Four countries match US productivity growth in manufacturing during the 1990s*

*EU countries ranked according to growth of productivity in the 1990s, largest increase first*




Source: WIFO calculations using Eurostat (New Cronos), OECD. Productivity . . . production index per employment.

**Proxies for theoretical determinants of growth (growth drivers)**

The factors proposed by growth theories emphasising the causality between innovation and long-term growth, are indeed related to growth performance. Indicators on research, on the knowledge base, on ICT, on capabilities (growth drivers) are all positively related to growth of output and productivity. Each indicator is subject to measurement problems and can explain only some part of the growth differences, but together they establish a system of growth drivers which explains a significant part of the performance differences across EU countries in the 1990s.

*Table 3: Estimates of multi-factor productivity change*

| | 1981-1990 | 1991-1998 | 1996-1998 |
|---|---|---|---|
| | | Average year-to-year percentage change | |
| EU[1] | + 1.7 | + 1.3 | + 1.3 |
| Belgium | + 1.4 | + 1.0 | + 0.8 |
| Denmark | + 1.0 | + 1.8 | + 1.7 |
| Germany | + 1.6 | + 1.4 | + 1.5 |
| Greece | + 0.6 | + 0.3 | + 0.6 |
| Spain | + 2.2 | + 0.6 | + 0.4 |
| France | + 2.1 | + 1.1 | + 1.1 |
| Ireland | + 3.9 | + 3.9 | + 3.6 |
| Italy | + 1.5 | + 1.2 | + 1.0 |
| The Netherlands | + 2.2 | + 1.7 | + 1.2 |
| Austria | + 1.2 | + 1.1 | + 1.4 |
| Portugal | + 1.9 | + 2.2 | . |
| Finland | + 2.4 | + 3.2 | + 3.5 |
| Sweden | + 0.8 | + 1.3 | + 1.3 |
| UK | . | + 1.3 | + 1.4 |
| Japan | + 2.0 | + 1.6 | + 1.6 |
| USA | + 1.0 | + 1.4 | + 1.5 |

Source: WIFO calculations; *Bassanini – Scarpetta – Visco* (2000). – [1] Average weighted with real GDP shares as of 1990.

### Looking for indicators which proxy growth determinants

We will focus now on EU member countries and on the manufacturing sector in the 1990s, for two reasons[10]: First, there is evidence that it is the manufacturing sector[11] rather than the services sector which drives productivity growth and creates differentials. Secondly, it is for manufacturing that we can gradually add additional information by means of disaggregation to sectors and industries. Here, research intensity can be measured and firm data are available. We refer to labour productivity if we do not specify otherwise. We use indicators related to knowledge, innovation, and ICT and we use information contained in the Community Innovation Survey to verify the importance of capabilities. A measure of the speed of structural change may indirectly add information regarding the need, as well as the potential, for change, building a bridge to the country profiles which follow[12].

### Research indicators (weakly) related to productivity in manufacturing

Growth of production and productivity is positively related to research input, patents and publications. The relationship is not very close, significance is given to the relation between growth and publications and to productivity growth and patents (Table 4)[13]. Figure 4 shows that Sweden and Finland have top positions according to all indicators; Germany ranks high in patents and research input, but has only a moderate position in output growth and productivity; the UK, which is among the leading countries with respect to research indicators, has slow growth. The southern EU countries – Greece, Spain, Portugal and Italy – rank low in R&D, although some achieve above-average growth in output (Spain) and high growth in productivity (catching up – Greece). Ireland, the fastest growing economy, has increased its research input and output, and is provided with a high share of technology-driven industries, but still lags behind in research intensity. Austria is far better ranked in growth than in research indicators.

### Knowledge base and ICT drive country growth

As indicators of the knowledge base, we combine indicators of secondary and tertiary education with indicators of the production and use of ICT. Sweden ranks highest for human capital; Denmark and Belgium are ranked better due to high outlays as well as greater shares for higher education. The UK falls back with respect to this category; Austria and Ireland rank better according to human capital than according to research and ICT (Figure 4). For ICT, Ireland ranks first in the production and consumption share of ICT industries in manufacturing, but only middling with respect to diffusion (Internet hosts and computers per resident). Germany and Belgium lose ranks for production structure and computers per resident. The countries ranked lower are the same as for

[10] Results for macroeconomic growth are available in the OECD Growth Project (*OECD*, 2001B).

[11] See, for example, *Scarpetta et al.* (2000).

[12] A certain ambiguity remains as to which indicators should be used, firstly because some indicators are poor proxies for the processes considered important; secondly, because we have to choose from a multiplicity of indicators, of which each single one is flawed by measurement problems. We overcome these obstacles by using ranks (which are more robust than quantitative indicators) and by looking at the combined rankings of several indicators.

[13] However, most correlations are not significant by the usual standards. Production growth relates significantly to patents, expenditure on education, working population with tertiary education, computers and Internet hosts per resident, innovation expenditures, co-operations and share of firms with continuous research.

R&D. Again, all correlations with production and productivity growth are positive; significance is signalled for the share of the work force with tertiary education. Computers per resident and Internet hosts are weakly significant in correlation with production growth.

*Table 4: Closeness of fit between growth and growth drivers in manufacturing*

*Rank correlation coefficients*

| | Production growth 1991-2000 | Productivity growth 1991-2000 |
|---|---|---|
| R&D expenditures as a percentage of GDP | 0.3319<br>*(0.2464)* | 0.3187<br>*(0.2668)* |
| R&D personnel as a percentage of the labour force | 0.4374<br>*(0.1178)* | 0.3626<br>*(0.2026)* |
| Patents per resident | 0.3670<br>*(0.1967)* | 0.5253*<br>*(0.0537)* |
| Publications per resident | 0.4593*<br>*(0.0985)* | 0.3363<br>*(0.2398)* |
| Public expenditure on education as a percentage of GDP | 0.4813<br>*(0.0814)* | 0.1736<br>*(0.5528)* |
| Percentage of the population that has attained at least upper secondary education, by age group (1998) | 0.3758*<br>*(0.1854)* | 0.4110<br>*(0.1443)* |
| Percentage of the population that has attained at least tertiary education, by age group (1998) | 0.4316<br>*(0.1234)* | 0.4094<br>*(0.1460)* |
| Employees in science and technology sectors as a percentage of total employment | 0.3451<br>*(0.2269)* | 0.2703<br>*(0.3499)* |
| Persons with tertiary education as a percentage of total working population | 0.4681*<br>*(0.0914)* | 0.3670<br>*(0.1967)* |
| ICT expenditure as a percentage of GDP | 0.3011<br>(0.2955) | 0.2440<br>(0.4006) |
| ICT production as a percentage of total manufacturing | 0.4559<br>(0.1022) | 0.2967<br>(0.3030) |
| PCs per resident | 0.6484**<br>*(0.0121)* | 0.4681*<br>*(0.0914)* |
| Internet users as a percentage of total population | 0.6088**<br>*(0.0209)* | 0.5341*<br>*(0.0492)* |
| Cellular phone subscribers per 100 residents | 0.4286<br>*(0.1263)* | 0.2396<br>*(0.4094)* |
| Innovation expenditures as a percentage of sales | 0.5431**<br>*(0.0447)* | 0.3444<br>*(0.2278)* |
| Share of new or improved products as a percentage of sales | 0.4462<br>*(0.1098)* | 0.3495<br>*(0.2207)* |
| Firms with co-operations as a percentage of all firms | 0.6084**<br>*(0.0210)* | 0.4596*<br>*(0.0983)* |
| Firms with continuous research as a percentage of all firms | 0.7582**<br>*(0.0017)* | 0.6396**<br>*(0.0138)* |
| Structural change indicator ("speed of change")[1] | 0.4154<br>*(0.1397)* | 0.4637*<br>*(0.0949)* |
| Combined indicator[2] | 0.6264**<br>*(0.0165)* | 0.4593*<br>*(0.0985)* |

Growth drivers: average of the 1990s (usually up to 1998). * . . . significant at the 10-percent level, ** . . . significant at the 5-percent level, italic numbers in parentheses . . . *p* values. – [1] *Aiginger* (2001). – [2] Combined information on the growth drivers.

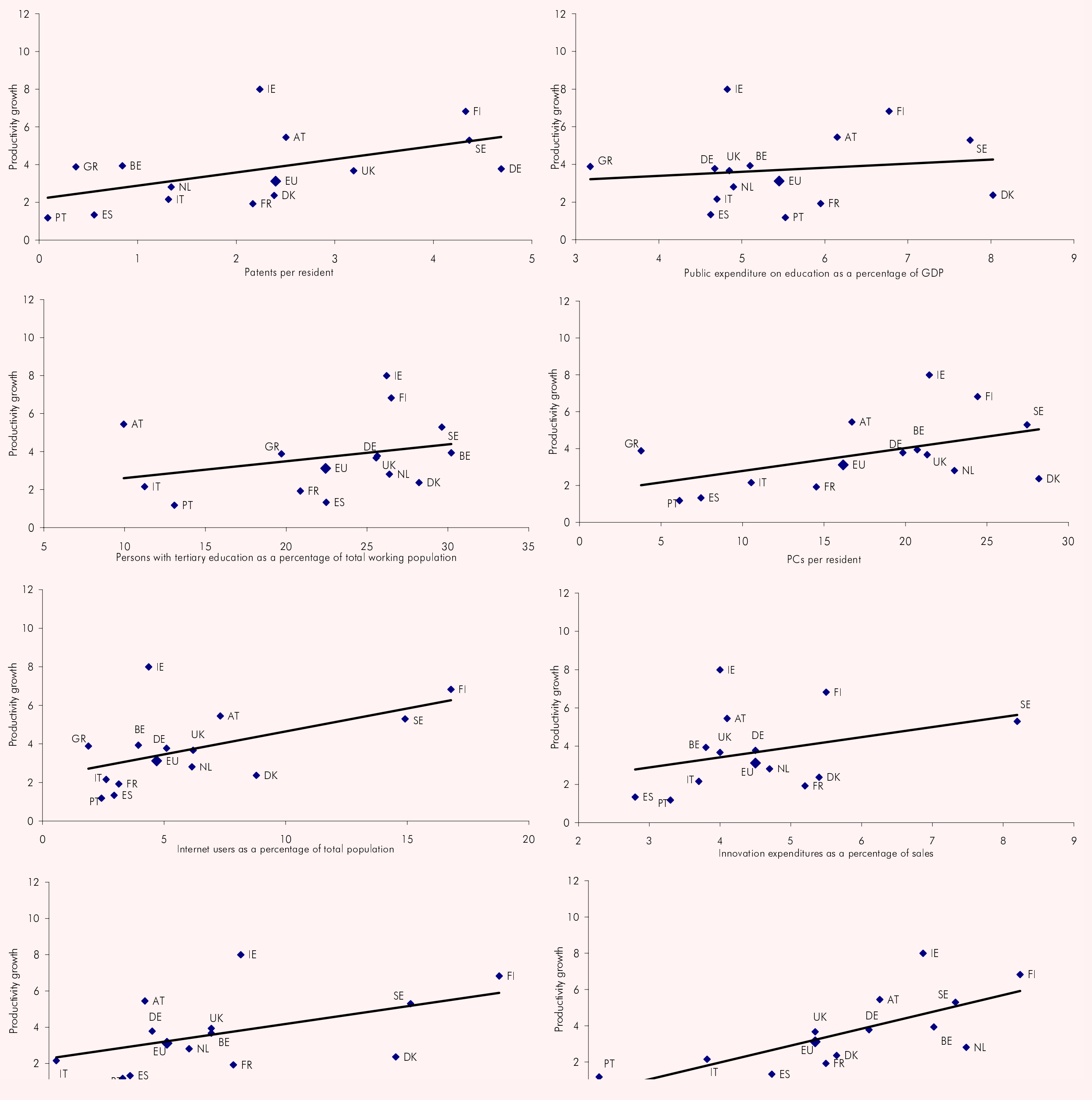
**Capabilities are important**

Indicators which try to give a notion of capabilities are closely related to growth. There is a consensus that capabilities are decisive for the performance of firms, but that they are difficult to measure. We chose four indicators from the CIS innovation survey which could proxy some aspects of capabilities: Innovation expenses relative to sales[14], and the

[14] Innovation expenditures include software, acquisition of patents, know-how, trademarks, training, industrial design, etc. Some of these positions reflect activities which allow to build up a competitive advantage and make use of knowledge which is available in principle, but with regard to which firms need specific abilities to get hold of. Thus innovative expenditures do signal elements addressed by the capability approach but not contained in research expenditures.

share of firms which report co-operative and continuous research are significantly related to production growth; the last two are also related to productivity growth. The share of new products in sales relates closely, but is just barely not significant.

*Figure 4: The underlying forces (growth drivers) for productivity growth*




[1] Combined information on the growth drivers.

The Netherlands, Denmark and Austria are ranked higher according to the capability indicators than according to the measures for research. Austria ranks third according to the share of new and improved products, and is above average in the share of firms with continuous research and innovation expenditures. Belgium ranks high in the share of firms reporting co-operative activities and in marketing-intensive industries. The Netherlands ranks high with respect to the share of firms with continuous research and marketing-driven industries.

**Growth and "speed of change" interrelated**

The "speed of change" of the industrial structure[15] is significantly related to productivity growth. It is highest in Ireland, as is productivity growth. Finland has a high productivity growth and is ranked fourth in speed of change. At the lower end, Germany, Italy and the UK have a slow speed of change and slow productivity growth. Austria's and Sweden's productivity has increased at a lower speed of change, probably due to laws restricting firm exits. In Portugal and Greece (and to some extent Spain), relatively high speed of change was not sufficient to raise productivity. High unemployment did lower the pressure to upscale productivity, as policy efforts to foster employment did in Denmark and the Netherlands.

**What we have learned**

First we have to remind ourselves that correlations indicate the closeness of relations, but prove no causality. Second, given the complexity of the relationship between the innovation system and productivity growth, no close statistical correlation between any single indicator and growth of productivity should be expected. If we combine the information on the suspected drivers of growth in a single indicator ("combined indicator"), we eliminate measurement errors in the individual series and attain a significant relation. It is interesting that, in general, the indicators are more closely related to output growth than to productivity growth[16], indicating that productivity is not only related to its active "drivers", but also reflects employment strategies and restructuring efforts of firms, which attempt to regain competitiveness in contested positions[17]. The close relation to indicators of capabilities supports the complementary importance of evolutionary theories and of approaches emphasising the absorptive capacity of firms. The significance of the speed of change variable shifts attention to factors that foster, or prevent, as the case may be, adaptation of supply to demand forces[18].

**Relationship between research intensity and productivity at the sectoral level**

Productivity increased fastest in two groups of sectors: In the second half of the decade, it was technology-driven industries; and in the first half of the 1990s, productivity rose especially rapidly in capital-intensive industries. The first tendency contributes to a close connection between research intensity and productivity growth across sectors. The second tendency reduces the match, since own research input is low in capital-intensive industries. For an indicator of productivity growth we use real value added per employment; for an indicator of research intensity, we use research outlays in relation to nominal production[19].

**Technology and restructuring drives productivity**

High-tech industries with strong productivity growth in the EU include electronic and medical equipment (Figure 5). On the other hand, productivity increased very fast in capital-intensive sectors like basic metals and pulp and paper, and chemicals. In the last two sectors, the passive character of productivity growth is revealed by an overproportionate reduction in employment[20].

The smallest increases were reported in the apparel, leather and food sector. Textiles were inbetween combining an average growth of productivity with a steep decline in employment. According to various measures, printing and publishing was a special case

[15] This indicator measures the sum of absolute changes in the shares of sectors or industries in total manufacturing between a base year and the final year. It is a proxy reflecting changes in demand, but also indirectly measures rigidities. It was developed in *Aiginger* (2000A) and in *European Commission* (2000A). For the computation of correlations, a comprehensive indicator was used which combines changes in value added, exports and employment at the NACE 2-digit and 3-digit levels (*Aiginger,* 2001).

[16] The significance is given at the 2-percent level for production growth, and at the 10-percent level for productivity growth (for the combined indicator).

[17] Evidence for this is the high productivity increase – relative to output – in slow-growing countries and in capital-intensive industries.

[18] The indicators also offer a partial explanation for the acceleration of production growth in the 1990s, as compared to the 1980s. Best again are indicators from the category including capabilities (innovation-to-sales ratio, co-operations, firms with continuous research), as well as human capital, ICT share in value added and speed of change. On the other hand, if we want to explain the acceleration of growth in the second half of the 1990s, as compared to the first, we attain no satisfactory correlations. The reason is that the distribution of growth between the two halves of the 1990s is determined by the business cycle, by shocks and measurement problems.

[19] We use the production index for measuring productivity of total manufacturing. For sectors and industries we switch to value added or production data, since these are the only data available on a more disaggregated level. Real value added had to be estimated by WIFO, using nominal value added by SBS and real value added for some industries in SBS. For research and development, we used ANBERD, for production STAN (both provided by the OECD). For the correlations, we used a combined indicator of productivity (with nominal and real value added and production value as the numerator), which should help to eliminate noise and measurement errors in each of the series. We report results which are robust for all indicators.

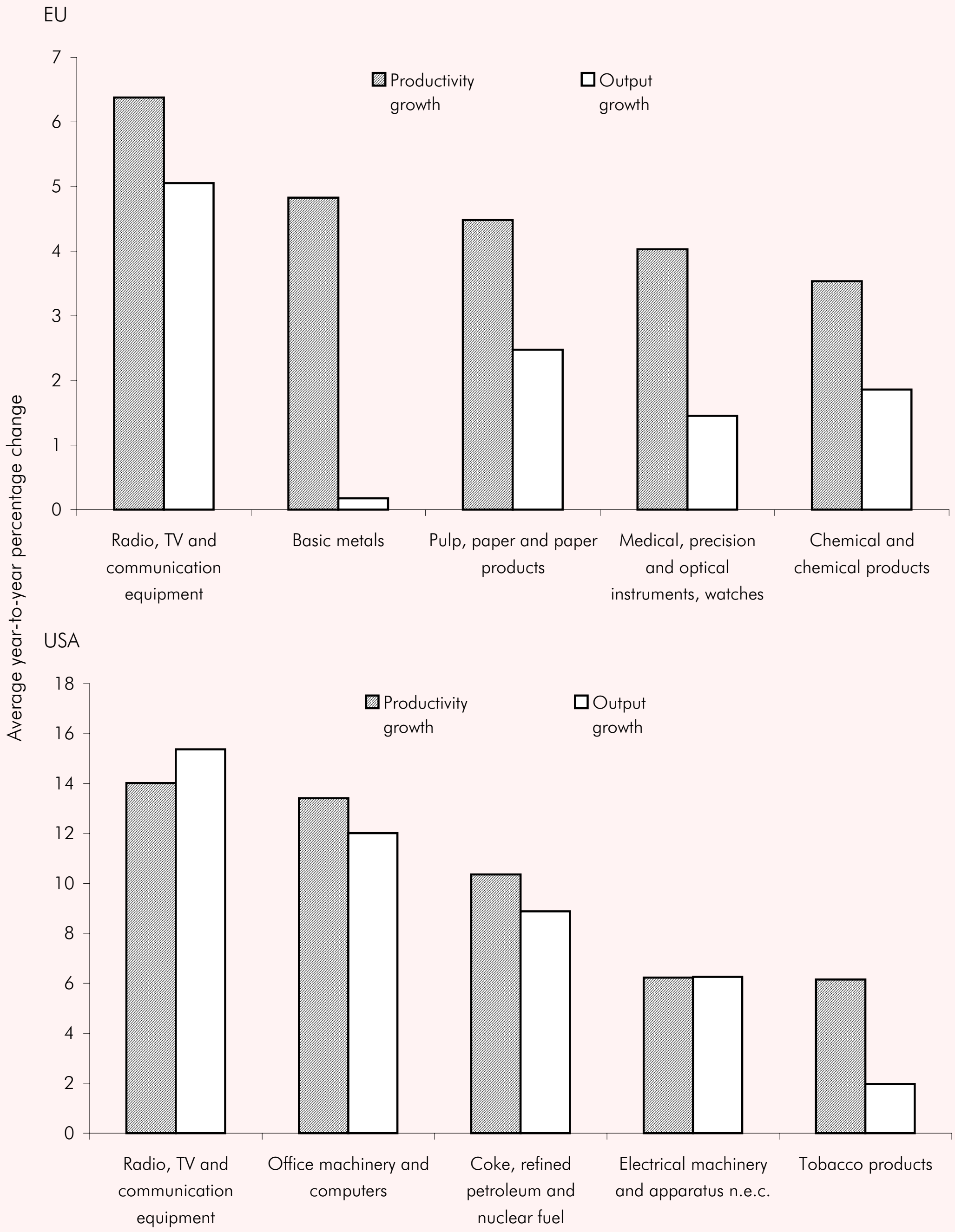
[20] At the industry level, telecom industries, production of electronic valves and motor parts are among the top ten, as are production of man-made fibres, pulp and paper and tubes.

with rather low productivity improvements, but at the same time it was the only sector in which employment increased.

If we look at the second half of the 1990s, the impact of the technology-driven industries on the productivity growth became stronger. Neither of the capital-intensive sectors mentioned increased productivity growth between the first and second halves of the 1990s[21].

*Figure 5: Sectors with the highest increase in productivity in the EU and in the USA*

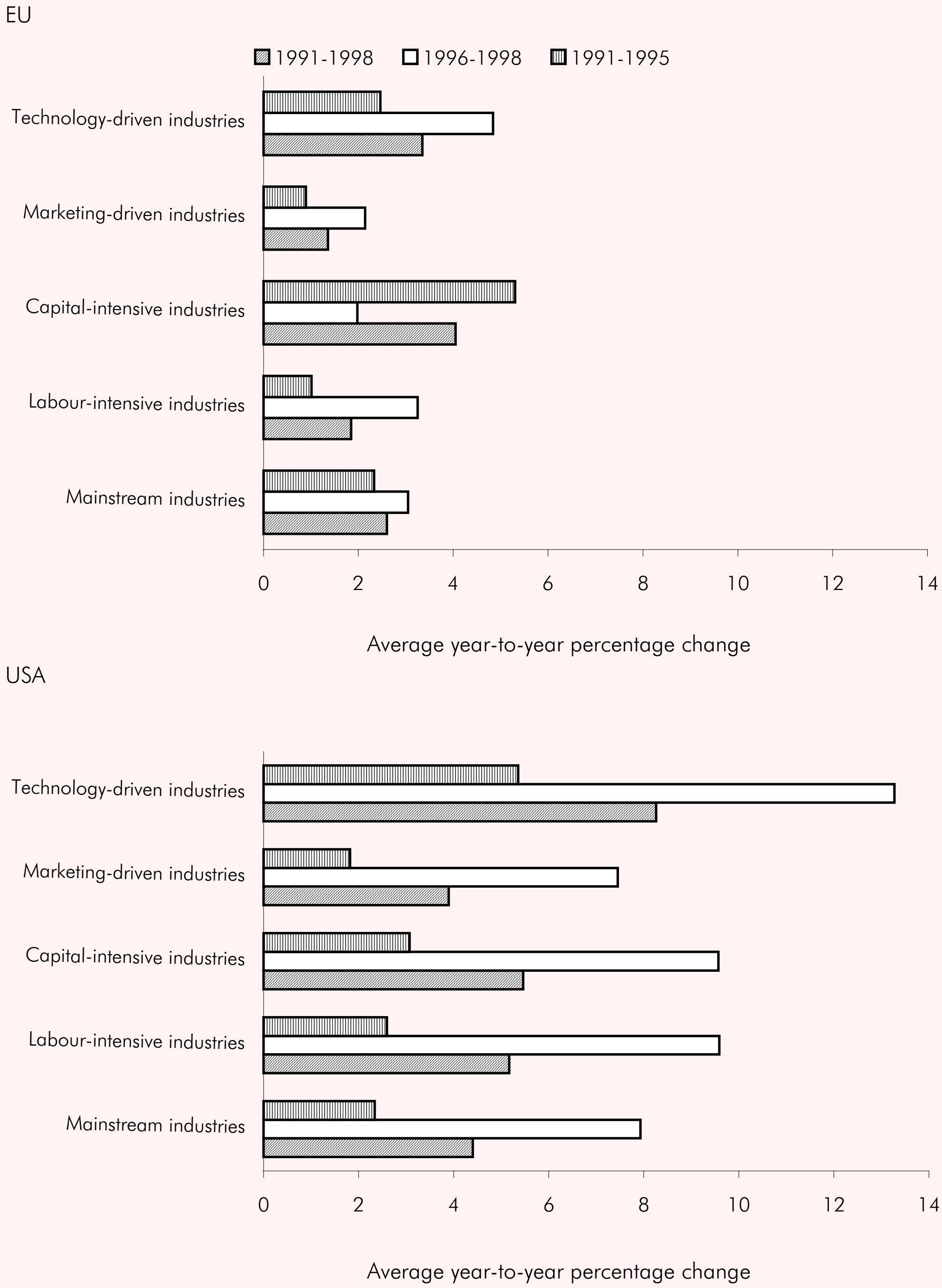
*Real value added per employment, 1991-1998*




Source: WIFO calculations using Eurostat (New Cronos).

[21] Taking productivity growth acceleration as a criterion reveals several industry-specific and cyclical effects not driven by innovation: for example, the petroleum industry is accelerating productivity growth, while pulp and paper is falling back.

*Figure 6: Technology-driven and capital-intensive industries boost productivity in the EU*




Source: WIFO calculations using Eurostat (New Cronos). Productivity . . . real value added per employment.

We can see this shift if we classify industries according to their main inputs. In the 1990s, the greatest productivity increase took place in capital-intensive industries (4.1 percent), followed by the technology-driven industries (3.4 percent), with labour and marketing-intensive industries trailing in productivity performance. If we focus on the later years, technology-driven industries increased productivity most strongly (4.8 percent), implying that this sector also leads in acceleration. Capital-intensive industries fell back to a level of 2 percent growth in productivity (Figure 6)[22].

[22] All these tendencies are replicated if we use nominal data or a combined productivity indicator.

In the USA, the role of high-tech industries is even more pronounced. First, the share of technology-driven industries is larger. Secondly, the technology-driven industries increased productivity by 8.3 percent in the 1990s – a much higher level than was achieved by the capital-intensive industries. Productivity growth accelerated from 5.4 percent in the first half of the 1990s to 13.3 percent in the second. The USA had 14 industries in which productivity increased at double-digit rates in the period 1996 to 1998; most of them are of the technology-driven kind. In the EU, only four industries enjoyed double-digit increases[23].

**Impact of technology even more visible in the USA**

*Table 5: Productivity and research intensity correlations for the EU and the USA*

*Rank correlation coefficients*

| | Production | | Productivity | |
|---|---|---|---|---|
| | Contemporaneous | Lagged | Contemporaneous | Lagged |
| Average over EU countries | 0.2535<br>*(0.2549)* | 0.2343<br>*(0.2939)* | 0.6894***<br>*(0.0004)* | 0.6996***<br>*(0.0003)* |
| Belgium | 0.4681**<br>*(0.0280)* | 0.5031**<br>*(0.0170)* | 0.5042**<br>*(0.0167)* | 0.5076**<br>*(0.0159)* |
| Denmark | 0.2410<br>*(0.2799)* | 0.1851<br>*(0.4097)* | 0.1508<br>*(0.5030)* | 0.1154<br>*(0.6092)* |
| Germany | – 0.0390<br>*(0.8633)* | 0.0412<br>*(0.8555)* | 0.1191<br>*(0.5974)* | 0.0977<br>*(0.6654)* |
| Spain | 0.1530<br>*(0.4966)* | 0.2095<br>*(0.3494)* | 0.0548<br>*(0.8087)* | 0.0457<br>*(0.8398)* |
| France | 0.3698*<br>*(0.0902)* | 0.3902*<br>*(0.0726)* | 0.5483***<br>*(0.0082)* | 0.5731***<br>*(0.0053)* |
| Italy | 0.0186<br>*(0.9344)* | 0.0186<br>*(0.9344)* | 0.0457<br>*(0.8398)* | 0.0887<br>*(0.6948)* |
| The Netherlands | 0.0954<br>*(0.6727)* | 0.0751<br>*(0.7398)* | 0.3642*<br>*(0.0956)* | 0.3134<br>*(0.1556)* |
| Finland | 0.4421**<br>*(0.0394)* | 0.4071*<br>*(0.0600)* | 0.0830<br>*(0.7134)* | 0.0491<br>*(0.8281)* |
| Sweden | 0.5370***<br>*(0.0100)* | 0.5618***<br>*(0.0065)* | 0.3145<br>*(0.1540)* | 0.3710*<br>*(0.0892)* |
| UK | 0.2784<br>*(0.2097)* | 0.2998<br>*(0.1752)* | 0.3123<br>*(0.1571)* | 0.3439<br>*(0.1171)* |
| Japan | – 0.0536<br>*(0.8126)* | – 0.0243<br>*(0.9146)* | 0.3947*<br>*(0.0691)* | 0.3913*<br>*(0.0717)* |
| USA | 0.3066<br>*(0.1652)* | 0.3427<br>*(0.1184)* | 0.4771**<br>*(0.0247)* | 0.4579**<br>*(0.0321)* |

Source: WIFO calculations using Eurostat (New Cronos) and OECD (STAN). Production . . . three indicators combined: nominal production (STAN), nominal value added (New Cronos), real value added (New Cronos, WIFO estimate), productivity . . . production per employment, contemporaneous . . . production and productivity growth 1991-1998 versus research intensity 1991-1998, lagged . . . production and productivity growth 1991-1998 versus research intensity 1985-1995, * . . . significant at the 10-percent level, ** . . . significant at the 5-percent level, *** . . . significant at the 1-percent level, italic numbers in parentheses . . . *p* values.

Telecom equipment has the highest research intensity of the European sectors, followed by other transport and instruments (Figure 7). In the leading sectors, research relative to sales declined in the late 1990s, while on the other hand productivity growth increased.

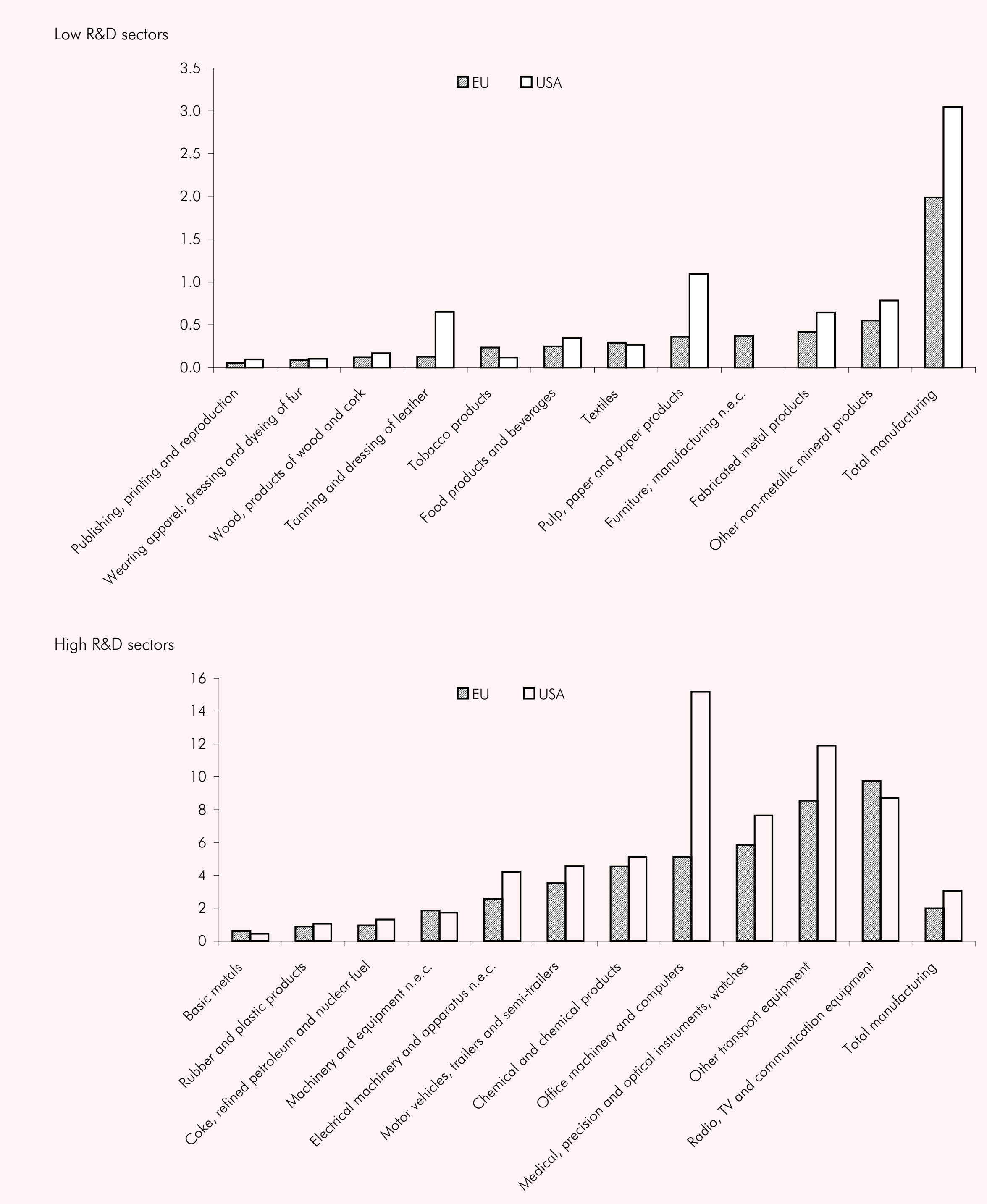
**Research intensity similar across sectors, but higher in the USA**

In the USA, office machinery, other transport, and telecom equipment are the most research-intensive industries, with rising trends for the first two, and a decrease in the computer industry. Productivity – notoriously difficult to measure in these industries – increased during the 1990s, partly in the second half (office machinery, aerospace), and partly in the first. The hierarchy of research intensity is otherwise very similar in the USA and the EU, but the research intensity is higher in the USA in 16 of the 22 sectors. Three industries with rather low shares of research are leading in productivity improvements: leather, textiles and printing. The reason could be that research is outsourced, e.g., in textiles production, while knowledge-intensive functions are concentrated at headquarters level.

[23] Telecom equipment, motor vehicle bodies, weapons and ammunition, aircraft and spacecraft.

*Figure 7: Research intensity in sectors is similar in the EU and in the USA*

*R&D expenditures as a percentage of sales, 1990-1998*



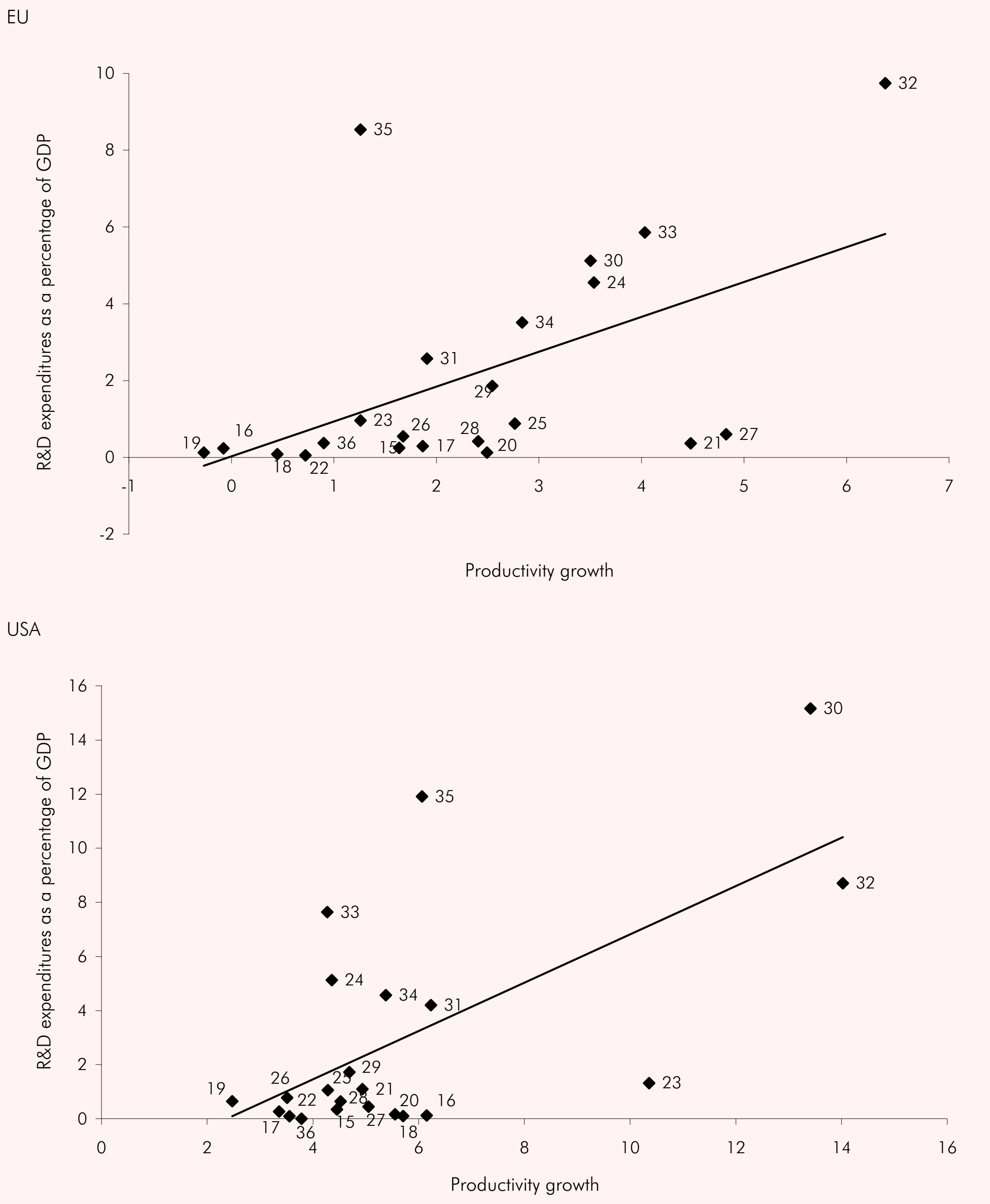

Source: WIFO calculations using Eurostat (New Cronos), OECD (STAN).

**Research-intensive sectors enjoy higher productivity growth**

Productivity growth in the 1990s and research intensity are significantly related across sectors (Table 5). This holds for the European Union as a whole, as well as for the USA, but not for the majority of the EU countries. International spill-overs of research could be one reason for the lack of correlation at the country level. Research does not relate closely to production growth – with the notable exceptions of Finland and Sweden. Lags do not change the closeness of the match.

*Figure 8: Productivity growth and research intensity across sectors for the EU and the USA*

*Real value added per employment, 1991-1998*




| | | | |
|---|---|---|---|
| 15 | Food products and beverages | 26 | Other non-metallic mineral products |
| 16 | Tobacco products | 27 | Basic metals |
| 17 | Textiles | 28 | Fabricated metal products |
| 18 | Wearing apparel; dressing and dyeing of fur | 29 | Machinery and equipment n.e.c. |
| 19 | Tanning and dressing of leather | 30 | Office machinery and computers |
| 20 | Wood, products of wood and cork | 31 | Electrical machinery and apparatus n.e.c. |
| 21 | Pulp, paper and paper products | 32 | Radio, TV and communication equipment |
| 22 | Publishing, printing and reproduction | 33 | Medical, precision and optical instruments, watches |
| 23 | Coke, refined petroleum and nuclear fuel | 34 | Motor vehicles, trailers and semi-trailers |
| 24 | Chemical and chemical products | 35 | Other transport equipment |
| 25 | Rubber and plastic products | 36 | Furniture; manufacturing n.e.c. |

Source: WIFO calculations using OECD (STAN).

*Table 6: Innovation intensity and productivity growth: sectoral evidence*

| | Low productivity growth | High productivity growth |
|---|---|---|
| *EU* | | |
| Low research intensity | Food products and beverages<br>Tanning and dressing of leather<br>Wearing apparel; dressing and dyeing of fur<br>Publishing, printing and reproduction | |
| High research intensity | | Radio, TV and communication equipment<br>Medical, precision and optical instruments, watches<br>Office machinery and computers<br>Chemical and chemical products<br>Motor vehicles, trailers and semi-trailers |
| *USA* | | |
| Low research intensity | Food products and beverages<br>Textiles<br>Publishing, printing and reproduction<br>Furniture; manufacturing n.e.c. | Tobacco products<br>Wearing apparel, dressing and dyeing of fur |
| High research intensity | | Office machinery and computers<br>Other transport equipment<br>Radio, TV and communication equipment<br>Motor vehicles, trailers and semi-trailers<br>Electrical machinery and apparatus n.e.c. |

Source: WIFO calculations using Eurostat (New Cronos) and OECD (STAN). The criterion for classification was whether research intensity was in the upper or lower tercile (top or low seven) of the sectors and productivity growth (value added at 1995 prices per employ ment) was in the upper or lower tercile in the 1990s.

Electronic equipment, instruments and computers are sectors with high research intensity and productivity growth[24]. Additionally, chemicals and motor vehicles are in the top third of the sectors for both indicators (Figure 8). On the other side, leather and apparel and the food industry have low research intensities and low productivity growth. Textiles combines low research and low production growth.

Other transport is the sector with the second highest research input, while production and productivity increases are reported to be low. However, data sets differ as to the extent, and this sector is very diverse (from aircraft and spacecraft to railways). In addition, the locations of research and production for this sector are not the same throughout the EU, and are sometimes even outside Europe. Electrical machinery is within the top three in research intensity, and has a moderate position in productivity growth.

Publishing and printing is a sector with low direct research intensity, but it is implementing new forms of technology at a very fast speed, via technology investments embodied in machines and inputs. It is a high-growth sector and it is also increasing employment, so that productivity performance is below average (actually the fourth lowest, as measured by real value added per employment).

Table 6 classifies the sectors according to productivity and research intensity for the EU and the USA. Electronic equipment assumes a position of high research intensity and high productivity growth in 10 of 11 EU countries. This favourable position is attained five times for instruments and three times for other transport. For motor vehicles, chemicals and office machinery, this "box" contains two entries. On the other hand, in at least three countries food, wood products, and pulp and paper combine low research intensity and low productivity growth. Publishing and printing is an exception insofar as in six countries research intensity and productivity growth are low, but production growth is rather high.

It is interesting to see which sectors are not placed in the expected boxes where low productivity growth and low research intensity or high productivity growth and high research intensity come together. Office machinery and other transport have high levels of research intensity and low production (and productivity) growth for several countries. This combination indicates a different specialisation pattern for research and production. Low research and high production and productivity growth is seen for several countries in

[24] The position varies depending on the indicator. For the combined indicator (production value, nominal plus real value added) it attains ranks of 1, 3, and 7 among 22 sectors. Office machinery falls back due to its weak position in nominal value added.

wood products and apparel, showing how traditional industries succeed in staying competitive without direct research input.

### Similarity of productivity growth across countries

The same industries are contributing to productivity growth in the EU and the USA. The similarity increased during the 1990s and became even more pronounced over the last several years. Technology-driven industries are partly behind this trend, but the improvement in their performance was greater in the USA, while capital-intensive industries increased their productivity more strongly in Europe. This extends the picture representative of sectors to the industry level.

### Productivity growth pattern becomes more similar

Productivity growth[25] across industries in the EU and in the USA differed significantly in the 1980s, but it was positive and significantly correlated in the 1990s[26]. The similarity increased between the first and the second halves of the 1990s, and the correlation reached its highest value in the very last years of this decade. Even the acceleration in productivity growth is significantly related, at least at the sectoral level (Table 7). Several factors are behind this picture. First technology-driven industries, which showed a disappointing productivity performance in the 1980s (see Solow paradox), started to increase productivity in the early 1990s. In the EU productivity in this sectors was rather weak in this phase, perhaps due to a lag in technology or the result of the cyclical downturn and the currency crisis. Competitive pressure, on the other hand, boosted productivity in the capital-intensive sector. In the second half the productivity increased strongest in the technology-driven sector in the EU as well as in the USA (albeit at a higher rate in the USA). The lower similarity in the early 1990s was probably driven by the currency crisis at the European level, perhaps in addition to German unification and the competitive pressure from the Single Market programme. In the late 1990s, technological forces seem to have determined the pattern.

### US performance driven by technology

The impact of technology-driven industries is greater in the USA. Productivity increased more strongly and accelerated faster in these industries. Secondly, at the beginning of the 1990s, the share of technology-driven industries was 22 percent in the EU and 26 percent in the USA. Thirdly, the productivity lead of the USA – however difficult absolute productivity may be to measure – was specifically large in these industries, so that the dynamics of this sector took place on top of a strong starting position.

Of the industries which are among the top 25 in both regions, three are electronic industries (equipment, computers, valves and tubes), two are motor vehicles industries. Weapons and ammunition and instruments are other high-tech industries in which productivity increased faster in the EU than in the USA (Table 8). Most of the others are capital-intensive industries, ranging from man-made fibres to steel industries, and pulp and wood. High-tech industries with high productivity increases in the EU, which are not among the industries with high productivity growth in the USA, are pharmaceuticals, electronic apparatus, and recorded media. In general, of the 25 industries with the highest productivity increases in the EU in the 1990s, 14 are also among the first 25 in the USA[27]. The concordance at the lower end of the spectrum is less impressive. Of the 25 industries with the lowest productivity increases in the EU, only 10 are in the same group in the USA; among these are five textile industries, oils and fats and motorcycles.

### Similarity in productivity growth for individual countries

If we compare individual European countries with the EU total, we see that productivity growth is rather similar: in 11 countries during the 1990s, the ranks are significantly related between a country and the EU[28]. The only countries without significant relationships are Denmark, Ireland and Finland. For France, Spain, the Netherlands and Austria, the correlation is significant for sectors as well as for industries. Three small countries (Belgium, Portugal and Sweden) have, together with two large countries (France and Spain), the closest conformity to EU productivity growth[29].

---

[25] Remember that we use the average performance according to three variables to define productivity growth in these correlations and to smooth out measurement errors in each of the following: production per employment, nominal and real value added per employment.

[26] The rank correlation is 0.51 for sectors and 0.22 for industries (significant at the 1-percent and 3-percent levels, respectively).

[27] Of the 25 industries with the highest productivity increases in the EU between 1996 and 1998, 12 are in the same groups as those in the USA.

[28] As a criterion, we use the rank correlation for productivity growth (combined indicator), and significance of 90 percent at a minimum of one level of aggregation (sectors or industries).

[29] The relationship between country and EU performances in increasing productivity remains close when we focus on the shorter period of 1996 to 1998, and is better when we focus on the acceleration of productivity growth during this period versus the first half of the 1990s. Only four countries exhibit no significant relation-

**Structure matters, but not too much**

If there is a strong pattern of variation in productivity growth across industries, countries with a higher share of industries which boost productivity could have higher growth. This is partly the case. For example, if the USA would have had the EU production structure, its increase in productivity would have been slower by ½ percentage point during the 1990s. The reason is that the high productivity growth in the technology-driven industries would have had less weight. On the other hand, if the EU would have had the US production structure, it would not have had a higher productivity increase, as several of the capital-intensive industries, in which productivity increases were specifically strong, would have had less weight. Of the EU countries, Greece (due to its high share of capital-intensive industries) and Ireland (due to its high share of technology-driven industries) would have lost most, and the highest gains in productivity would have been realised by the Netherlands and Belgium.

*Table 7: Productivity growth in the EU and the USA becomes more similar*

*Coefficients of rank correlation between productivity growth in the EU and the USA across sectors and industries*

| | Sector level | Industry level |
|---|---|---|
| *Periods* | | |
| 1986-1990 | – 0.3416 | 0.0826 |
| | (0.1197) | (0.4165) |
| 1991-1995 | 0.5234** | 0.0418 |
| | 0.0124) | (0.6813) |
| 1996-1998 | 0.5539*** | 0.2429** |
| | *(0.0075)* | *(0.0154)* |
| 1991-1998 | 0.5088** | 0.2170** |
| | *(0.0156)* | *(0.0310)* |
| 1986-1998 | 0.4749** | 0.2712*** |
| | *(0.0255)* | *(0.0066)* |
| Acceleration second versus first half | 0.4241** | 0.0824 |
| | *(0.0492)* | *(0.4175)* |
| *Individual years*[1] | | |
| 1987 | 0.3645* | 0.2512** |
| | *(0.0953)* | *(0.0121)* |
| 1988 | 0.1226 | 0.1400 |
| | *(0.5866)* | *(0.1669)* |
| 1989 | 0.0493 | 0.1045 |
| | *(0.8274)* | *(0.3032)* |
| 1990 | 0.6900*** | 0.2739*** |
| | *(0.0004)* | *(0.0061)* |
| 1991 | 0.6499*** | 0.1490 |
| | *(0.0011)* | *(0.1410)* |
| 1992 | – 0.0731 | 0.1082 |
| | *(0.7446)* | *(0.2862)* |
| 1993 | 0.1795 | 0.0532 |
| | *(0.4242)* | *(0.6008)* |
| 1994 | 0.1454 | 0.2127** |
| | *(0.5185)* | *(0.0345)* |
| 1995 | 0.0419 | 0.0868 |
| | *(0.8531)* | *(0.3928)* |
| 1996 | 0.5336** | 0.2646*** |
| | *(0.0105)* | *(0.0081)* |
| 1997 | 0.7672*** | 0.4908*** |
| | *(0.0000)* | *(0.0000)* |

Source: WIFO calculations using Eurostat (New Cronos). The calculations were done by first calculating a 3-year moving average and then correlating the vectors of growth rates in productivity (production per employment, nominal and real value added per employment) in the EU and the USA. 1997 therefore refers to growth during the period 1996 to 1998 in the EU versus growth during the period 1996 to 1998 in the USA. * . . . significant at the 10-percent level, ** . . . significant at the 5-percent level, *** . . . significant at the 1-percent level, italic numbers in parentheses . . . *p* values. – [1] 3-year moving average.

ship between their own acceleration of productivity growth and that of the EU: Belgium, Ireland, the Netherlands and Greece.

*Table 8: Industries with high productivity growth (top 25)*

| | | EU Productivity growth | | | | Share of value added | USA Productivity growth | | | | Share of value added | Top 25 in EU and USA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1991-1998 | | 1996-1998 | | 1990 | 1991-1998 | | 1996-1998 | | 1990 | 1991-1998 | 1996-1998 |
| | | Percent p.a. | Rank | Percent p.a. | Rank | Percent | Percent p.a. | Rank | Percent p.a. | Rank | Percent | | |
| 272 | Tubes | + 8.0 | 1 | + 8.8 | 6 | 0.5 | + 4.9 | 37 | +10.1 | 24 | 0.3 | | ✓ |
| 247 | Man-made fibres | + 7.0 | 2 | + 1.0 | 64 | 0.3 | + 6.4 | 17 | +12.3 | 10 | 0.6 | ✓ | ✓ |
| 322 | TV, and radio transmitters, apparatus for line telephony | + 7.0 | 3 | +16.4 | 1 | 1.5 | +11.0 | 3 | +13.8 | 9 | 1.7 | ✓ | ✓ |
| 342 | Bodies for motor vehicles, trailers | + 6.4 | 4 | +13.5 | 2 | 0.5 | + 8.5 | 6 | +17.0 | 4 | 0.7 | ✓ | ✓ |
| 211 | Pulp, paper and paperboard | + 6.1 | 5 | + 4.1 | 31 | 1.6 | + 5.6 | 23 | +10.7 | 21 | 2.4 | ✓ | ✓ |
| 323 | TV, radio and recording apparatus | + 6.0 | 6 | + 6.2 | 16 | 0.8 | + 1.5 | 91 | – 0.2 | 96 | 0.1 | | |
| 284 | Forging, pressing, stamping and roll forming of metal | + 5.4 | 7 | + 7.7 | 8 | 0.7 | + 4.7 | 43 | + 8.3 | 47 | 0.6 | | |
| 343 | Parts and accessories for motor vehicles | + 5.4 | 8 | + 4.7 | 28 | 1.8 | + 5.4 | 25 | + 9.7 | 28 | 1.8 | ✓ | |
| 271 | Basic iron and steel, ferro-alloys (ECSC) | + 5.3 | 9 | + 1.2 | 63 | 2.5 | + 7.5 | 9 | +10.7 | 20 | 1.0 | ✓ | ✓ |
| 321 | Electronic valves and tubes, other electronic comp. | + 5.1 | 10 | + 5.5 | 20 | 0.7 | +16.0 | 1 | +23.3 | 2 | 2.6 | ✓ | ✓ |
| 273 | Other first processing of iron and steel | + 5.1 | 11 | + 5.5 | 21 | 0.4 | + 6.9 | 14 | +11.7 | 14 | 0.5 | ✓ | ✓ |
| 223 | Reproduction of recorded media | + 4.9 | 12 | + 6.5 | 14 | 0.1 | – 2.8 | 99 | – 3.3 | 98 | 0.0 | | |
| 296 | Weapons and ammunition | + 4.8 | 13 | +10.7 | 3 | 0.2 | + 6.9 | 15 | + 9.3 | 34 | 0.4 | ✓ | |
| 241 | Basic chemicals | + 4.7 | 14 | + 0.4 | 73 | 4.7 | + 4.6 | 45 | + 8.9 | 40 | 4.6 | | |
| 202 | Panels and boards of wood | + 4.7 | 15 | + 7.9 | 7 | 0.3 | + 7.1 | 12 | + 7.7 | 55 | 0.4 | ✓ | |
| 176 | Knitted and crocheted fabrics | + 4.5 | 16 | + 6.2 | 17 | 0.1 | + 4.8 | 39 | + 9.5 | 32 | 0.1 | | |
| 332 | Instruments for measuring, checking, testing, navigating | + 4.4 | 17 | + 6.1 | 18 | 1.3 | + 6.3 | 18 | + 9.1 | 36 | 2.9 | ✓ | |
| 201 | Sawmilling, planing and impregnation of wood | + 4.3 | 18 | + 9.5 | 5 | 0.4 | + 8.4 | 7 | +15.1 | 7 | 0.5 | ✓ | ✓ |
| 244 | Pharmaceuticals | + 4.2 | 19 | + 3.6 | 36 | 2.6 | + 4.2 | 58 | + 9.1 | 38 | 2.9 | | |
| 275 | Casting of metals | + 4.1 | 20 | + 5.1 | 24 | 0.8 | + 4.6 | 44 | + 6.4 | 66 | 0.7 | | |
| 274 | Basic precious and non-ferrous metals | + 3.9 | 21 | + 2.3 | 51 | 1.1 | + 3.5 | 70 | + 3.2 | 90 | 1.2 | | |
| 297 | Domestic appliances n.e.c. | + 3.9 | 22 | + 3.0 | 43 | 0.9 | + 4.7 | 41 | + 9.0 | 39 | 0.6 | | |
| 156 | Grain mill products and starches | + 3.8 | 23 | + 3.6 | 38 | 0.4 | + 8.6 | 5 | +12.0 | 13 | 1.1 | ✓ | ✓ |
| 335 | Watches and clocks | + 3.7 | 24 | + 2.9 | 45 | 0.1 | + 0.8 | 94 | +11.6 | 16 | 0.1 | | ✓ |
| 300 | Office machinery and computers | + 3.5 | 25 | + 7.0 | 10 | 2.1 | +13.4 | 2 | +25.1 | 1 | 2.4 | ✓ | ✓ |
| | Total manufacturing | + 2.6 | | + 3.0 | | 100.0 | + 5.5 | | + 9.9 | | 100.0 | | |

Source: WIFO calculations using Eurostat (New Cronos). Productivity . . . nominal value added per employment.

**Convergence within the EU, but not between large European countries and the USA**

European countries are converging with respect to the main drivers of growth – albeit very slowly. Whether Europe is catching up with the USA is less clear. The top EU countries are improving their positions with respect to the USA, leading in about one third of the indicators. For the total EU, this is definitely the case for mobile phone users and telecom expenditures. For the other indicators, the USA is maintaining its lead, while the gap is declining for some indicators, and expanding for others. A final judgement on the issue of convergence is especially difficult for some indicators, since the faster US growth in the 1990s may not only be a consequence of the "drivers" of growth, but higher revenues may have been reinvested into the growth drivers. This cumulative nature seems to apply to research intensity in manufacturing.

We apply 20 indicators to assess convergence within the EU (Table 9); 16 indicators enable us to compare the position of Europe relative to the USA. The indicators are those which are related to the growth performance in manufacturing and they are used for the country profiles[30]. We defined as the top five those countries leading in the EU at the beginning of the 1990s; the low five are those countries which ranked lowest at that time. Therefore, the individual countries within the upper and lower groups change according to the indicator. Sweden's excellence is reflected insofar as it is within the top five for all but one indicator, and is first in seven. It is followed by the Netherlands, the

[30] We had to exclude those which are not available for the beginning of the 1990s (specifically the capability indicators). For the others, we compare performance at the beginning of the 1990s (usually a year between 1990 and 1992) to the most recent available information (a year between 1997 and 2000). The exact years are shown in Table 9.

UK, Finland, and Germany, as far as the number of ratings among the first five are concerned. The southern EU countries tend to be among the low five (Table 10).

*Table 9: Convergence of countries within the EU according to 20 drivers of growth*

| | Top 5 EU countries | | Low 5 EU countries | |
|---|---|---|---|---|
| | First year | Last year | First year | Last year |
| Total expenditure on R&D as a percentage of GDP | 1.481 | 1.474 | 0.511 | 0.508 |
| Business enterprise expenditure on R&D (BERD) as a percentage of GDP | 1.622 | 1.613 | 0.418 | 0.420 |
| R&D personnel as a percentage of the labour force | 1.393 | 1.158 | 0.481 | 0.665 |
| Research intensity in manufacturing | 1.090 | 1.112 | 0.486 | 0.528 |
| Publications per resident | 1.594 | 1.504 | 0.458 | 0.542 |
| Patents per resident | 1.668 | 1.776 | 0.331 | 0.308 |
| Public expenditure on education as a percentage of GDP | 1.237 | 1.263 | 0.807 | 0.801 |
| Percentage of the population that has attained at least upper secondary education, by age group (1998) | 1.390 | 1.219 | 0.568 | 0.769 |
| Percentage of the population that has attained at least tertiary education, by age group (1998) | 1.395 | 1.144 | 0.649 | 0.848 |
| Human resources in science and technology by country | 1.368 | 1.318 | 0.703 | 0.768 |
| Working population with tertiary education (ISCED 5 to 7) | 1.279 | 1.170 | 0.674 | 0.645 |
| ICT expenditure as a percentage of GDP | 1.175 | 1.068 | 0.777 | 0.978 |
| Information technology expenditure as a percentage of GDP | 1.299 | 1.340 | 0.621 | 0.618 |
| Telecommunication expenditure as a percentage of GDP | 1.166 | 1.132 | 0.885 | 0.881 |
| PCs per resident | 1.874 | 1.400 | 0.617 | 0.642 |
| Internet users as a percentage of total population | 2.143 | 1.581 | 0.223 | 0.707 |
| Cellular phone subscribers per 100 residents | 2.147 | 1.190 | 0.202 | 0.851 |
| Share of technology-driven industries in nominal value added | 1.335 | 1.404 | 0.635 | 0.663 |
| Share of skill-intensive industries in nominal value added | 1.332 | 1.301 | 0.655 | 0.646 |
| Share of ICT industries in nominal value added | 1.423 | 1.426 | 0.615 | 0.545 |

For the percentage of population that has attained secondary and tertiary education, a comparison is made between the older (45 to 54) and the younger (25 to 34) age groups. First year, last year . . . that year in the 1990s for which earliest or latest data, respectively, are available, top 5, low 5 countries . . . determined for each indicator according to ranks at the beginning (usually an average 1992-1994).

**EU countries converge – successful catching-up process**

The low five countries improved their positions in 14 of 20 indicators (Table 9). The speed of catching up is rapid for the information technology indicators; catching up is evident in secondary education and for four of the six research indicators. Expenditures on telecommunication equipment in countries lagging at the beginning of the 1990s are now partly above average, reflecting heavy investment in infrastructure. Catching up is not visible in the share of jobs demanding the highest qualifications, in skill-intensive industries, and in patents.

The top five countries are increasing their leads in patents, education, the research intensity of manufacturing, as well as in technology-driven industries and in information technology expenditures. This reflects to a large extent the strong positions of Finland and Sweden in research and ICT. In PC and Internet use and in secondary education, the relative lead decreased, reflecting increasing market saturation in the foremost EU countries and the catching up of the followers. Nevertheless, the countries which are ahead are noticeably persistent. Sweden, which was among the leading five countries for 16 indicators at the beginning of the 1990s, is now among the top five in all but one; for the Netherlands the corresponding figures are 11 in the early 1990s and 8 in the late 1990s. Finland increased its number of leading positions from 12 to 15, Denmark from 10 to 11. The large countries in general lost ranks, Germany lost five of 15 positions among the top five , the UK seven out of 15, France did not loose leading positions, but lost in the combined ranking (Table 10).

The coefficient of variation increases in about half of the indicators. However, decreases are much stronger than increases, underlining the dominant trend of convergence[31]. For example, for research and development indicators the coefficient increases when we relate the difference in country performance to the unweighted average of countries, but decreases when we compare the variance to the weighted average. The economic force behind this is the reduction of the research expenditures relative to GDP in the large EU countries (France, Germany, the UK and Italy), while the small countries are increasing research expenditures sharply. The share of the working population with tertiary education also increased slightly, due to upward jumps by Ireland and Finland[32]. Structural indicators also reveal a slight divergence, as technology-driven industries and ICT indus-

[31] Seven of ten increases are less than 10 percent, eight of ten increases in the coefficient of variation are larger than 10 percent.

[32] The variance of education expenditures has grown since the low five did not increase their positions.

tries become more concentrated (dominated by the higher shares of Ireland, Finland and Sweden). The strongest convergence is evident for the indicators of secondary education[33] and of the use of mobile phones and Internet.

*Table 10: Leaders in the EU according to 20 drivers of growth*

| | Number of rank 1 | | Number of rank 1 to 5 | | Average rank | |
|---|---|---|---|---|---|---|
| | First year | Last year | First year | Last year | First year | Last year |
| Belgium | 0 | 0 | 4 | 3 | 7.50 | 7.95 |
| Denmark | 3 | 2 | 10 | 11 | 5.10 | 5.20 |
| Germany | 3 | 2 | 13 | 8 | 4.65 | 7.10 |
| Greece | 0 | 0 | 1 | 2 | 11.90 | 11.20 |
| Spain | 1 | 1 | 1 | 4 | 10.90 | 9.60 |
| France | 1 | 0 | 7 | 9 | 6.35 | 6.75 |
| Ireland | 2 | 0 | 5 | 6 | 7.20 | 7.25 |
| Italy | 0 | 0 | 2 | 3 | 10.55 | 9.80 |
| The Netherlands | 2 | 0 | 11 | 8 | 5.35 | 6.35 |
| Austria | 0 | 0 | 6 | 5 | 8.35 | 8.10 |
| Portugal | 0 | 1 | 2 | 3 | 11.20 | 10.75 |
| Finland | 1 | 6 | 12 | 15 | 5.40 | 3.75 |
| Sweden | 7 | 8 | 16 | 19 | 3.00 | 2.00 |
| UK | 0 | 0 | 15 | 8 | 4.60 | 6.20 |

Ranking based on the 20 variables in Table 9; first year, last year . . . that year in the 1990s for which earliest or latest data, respectively, are available (see Table 9).

**Europe closing the gap to the USA with respect to a few growth drivers**

A comparison with the USA is possible for 16 indicators. The EU has taken the lead in mobile phones per capita and for expenditures on telecommunications (TLC)[34] relative to GDP. In both cases, Europe has a considerable lead today, while it was lagging behind in the early 1990s. In the other 14 indicators, the USA has maintained its lead, and in none of them is its margin less than 10 percent.

*Table 11: Position of the EU versus the USA according to 16 drivers of growth*

| | EU relative to USA | | Top 5 EU countries relative to USA | |
|---|---|---|---|---|
| | First year | Last year | First year | Last year |
| Total expenditure on R&D as a percentage of GDP | 0.693 | 0.661 | 0.897 | 0.942 |
| Business enterprise expenditure on R&D (BERD) as a percentage of GDP | 0.606 | 0.564 | 0.812 | 0.866 |
| R&D personnel as a percentage of the labour force | . | . | . | . |
| Research intensity in manufacturing | 0.652 | 0.623 | 0.797 | 0.823 |
| Publications per resident | 0.646 | 0.878 | 1.099 | 1.456 |
| Patents per resident | 0.617 | 0.554 | 1.040 | 0.905 |
| Public expenditure on education | . | . | . | . |
| Percentage of the population that has attained at least upper secondary education, by age group (1998) | 0.609 | 0.795 | 0.839 | 0.973 |
| Percentage of the population that has attained at least tertiary education, by age group (1998) | 0.514 | 0.694 | 0.708 | 0.794 |
| Human resources in science and technology by country | . | . | . | . |
| Working population with tertiary education (ISCED 5 to 7) | . | . | . | . |
| ICT expenditure as a percentage of GDP | 0.654 | 0.731 | 0.768 | 0.781 |
| Information technology expenditure as a percentage of GDP | 0.568 | 0.493 | 0.738 | 0.660 |
| Telecommunication expenditure as a percentage of GDP | 0.749 | 1.135 | 0.873 | 1.284 |
| PCs per resident | 0.369 | 0.481 | 0.723 | 0.744 |
| Internet users per resident | 0.178 | 0.584 | 0.596 | 1.123 |
| Cellular phone subscribers per 100 residents | 0.356 | 1.271 | 1.103 | 1.694 |
| Share of technology-driven industries in nominal value added | 0.826 | 0.757 | 0.870 | 0.907 |
| Share of skill-intensive industries in nominal value added | 0.920 | 0.895 | 1.034 | 1.015 |
| Share of ICT industries in nominal value added | 0.723 | 0.475 | 0.932 | 0.722 |

For the percentage of population that has attained secondary and tertiary education, a comparison is made between the older (45 to 54) and the younger (25 to 34) age groups. First year, last year . . . that year in the 1990s for which earliest or latest data, respectively, are available, top 5 countries . . . determined for each indicator according to ranks at the beginning (usually an average 1992-1994).

[33] This indicator measures the share of secondary education attained by the older-age group versus that in the younger.

[34] This indicator shares with some others the problem that it measures input but not output.

The EU is catching up with the USA significantly in publications, in secondary and tertiary education and in Internet and PC use (Table 11). The gap with respect to US figures widened in IT expenditures, in the share of ICT industries, technology-driven industries, and skill-intensive industries. Europe is not catching up in patents. The gap widened for research if we measure total expenditures relative to GDP. This is because the large countries (Germany, France, the UK, and Italy) had lower research ratios in 1998 than in 1992. The smaller countries have increased their expenditures, so that a comparison of the unweighted means of EU countries with the USA would indicate that they are catching up. For the research intensity of manufacturing, the EU did catch up at first, but according to the latest information, the difference later widened, which would not be unusual during a period of higher growth in the USA.

**Leading countries improve positions for 12 indicators**

The picture is definitely better for the leading EU countries[35]. The top five countries improved their positions relative to the USA for 12 of 16 indicators. The leading EU countries surpassed the USA in publications, Internet use and the share of skill-intensive sectors (in addition to mobile phones and telecom expenditures, where the EU was already ahead). The only areas where the top five EU countries were not improving their relative positions are patents, the share of IT expenditures and the share of ICT industries in production (Table 11)[36]. A similar result is given if we relate the performance of the best three countries to that of the USA, this time taking the performance of Sweden, Finland, and Denmark for all indicators.

## References


Ahn, S., Hemmings, P., "Policy Influences on Economic Growth in OECD Countries", OECD, Economics Department Working Papers, 2000, (246).

Aiginger, K. (2000A), Europe's Position in Quality Competition. Background Paper for the Competitiveness Report 2000, European Commission, Enterprise Directorate-General, Brussels, 2000.

Aiginger, K. (2000B), Special Feature on Countries Profile in Manufacturing, Eurostat, Luxembourg, 2000.

Aiginger, K., "Speed of Change and Growth of Manufacturing", in *Peneder et al.* (2001).

Aiginger, K, Böheim, M., Gugler, K., Peneder, M., Pfaffermayr, M., "Specialisation and (Geographic) Concentration of European Manufacturing", European Commission, Enterprise Directorate-General, Working Paper, 1999, (1).

Aiginger, K., Landesmann M., Competitive Economic Performance: The European View, Conference on Transatlantic Perspectives on US-EU Economic Relations: Convergence, Conflict and Cooperation, Harvard University, 2002.

Bassanini, A., Scarpetta, S., Visco, I., "Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries", OECD, Economics Department Working Papers, 2000, (259).

Braunerhjelm, P., Faini, R., Norman, V., Ruane, F., Seabright, P., "Integration and the Regions of Europe: How the Right Policies Can Prevent Polarization", CEPR, Monitoring European Integration, 2000, (10).

Davies, S., Lyons, B., Industrial Organisation in the EU, Oxford University Press, 1996.

Davies, S., Rondi, L., Sembenelli, A., "SEM and the Changing Structure of EU Manufacturing, 1987-1993", University of East Anglia, The Economics Research Centre, Discussion Paper, 1998, (9815).

European Commission, The Competitiveness of European Industry 1998, Brussels, 1998.

European Commission, The Competitiveness of European Industry 1999, Brussels, 1999.

European Commission (2000A), European Competitiveness Report 2000, Brussels, 2000.

European Commission (2000B), Innovation in a Knowledge Driven Economy. Annex: European Innovation Scoreboard, Brussels, 2000.

European Commission (2001A), European Competitiveness Report 2001, Brussels, 2001.

European Commission (2001B), Realising the European Union's Potential. Appendix 2 to the Stockholm Report, Brussels, 2001.

European Commission, ECFIN, "The EU Economy 2000 Review", European Economy, 2000, (71).

Eurostat, Panorama of European Business, Luxembourg, 1999.

Ilzkovitz, F., Dierx, A., "European Integration and the Location of Industries. Recent Empirical Evidence and Main Policy Issues", European Commission DG for Economic and Financial Affairs, European Economy, 2000.


[35] Remember that the top five were determined at the beginning of the 1990s and that they vary according to the indicators.

[36] The top five EU countries are falling back marginally in their shares of skill-intensive industries.

*Can Innovation Explain the Increasing Growth Differences in the 1990s? – Summary*

During the 1990s, the growth performance varied not only between the EU and the USA, but also across EU countries. The variance in growth increased for the total economy, but grew even larger for manufacturing, which plays a central role in determining performance differences. The growth in EU manufacturing is indeed related to the factors which economic theory suggests: research, human capital, knowledge, capabilities and the use of ICT technology. However, the competitive pressure was strong in the 1990s for low-growth countries, as well as for mature, capital-intensive industries. This implies that the variance of productivity differences did not increase in parallel to that of the growth differences, and that productivity increases were driven not only by innovation but also by needs for restructuring (passive change). Furthermore, the 1990s spanned a period of severe external shocks, including the currency crisis in the first half, and the Asian crisis in the second. European integration made an important step forward, evolving from the Single Market to the Monetary Union. Individual countries pursued various strategies to combat high unemployment and to cut budget deficits. These factors make it difficult to carve out the exact impact of innovation on growth in output and productivity.

The strongest increase in productivity occurred in technology-driven industries, where not only the research intensity, but also innovation outlays in general are very high, thus establishing a correlation between innovation and growth across sectors and industries. However, specifically in the EU, and during the first half of the 1990s, productivity also increased quickly in capital-intensive industries. Some labour-intensive industries managed to remain competitive by increasing productivity and quality, as did mainstream industries in which Europe is specifically strong. The acceleration of productivity growth between the first and the second halves of the 1990s was, nevertheless, mainly driven by the technology-intensive sector.

Manufacturing in the USA excelled in several respects during the 1990s. Growth was higher, productivity increased more strongly and accelerated faster than in the EU during the second half of the decade. The impact of technology seems to have been stronger, or at least more direct, than in the EU: the share of technology-driven industries has been historically higher, and the productivity lead – however difficult to measure – is highest in these industries. In the USA, many high-tech industries, and the group of technology-driven industries as such, enjoyed double-digit annual growth rates in labour productivity during the second half of the 1990s.

The industry pattern of growth is therefore related between the USA and the EU, but not completely. This is also true for individual EU countries. We have drawn country profiles, showing in which industries countries are specialised, how they perform according to drivers of future growth, which contribution is made by innovative activities and how policies are aimed at increasing growth and competitiveness. Having illustrated all the differences across countries, we can venture to draw the tentative conclusion that policies and performance do seem to be converging a little within EU countries, however at a very slow speed and with fits and starts, experiments and errors. For most drivers of growth, the USA was leading during the 1990s, and, due to the cumulative nature of causes and effects, the gap will not close without specific policy efforts in Europe. However, the top countries in Europe are managing to close the gap on an individual basis and are successfully contesting the USA in an increasing number of fields.

While we have focussed on innovation in this study, we have to acknowledge that other factors are also relevant. Many countries, specifically the large EU countries, tried to reduce unemployment, to achieve balanced budgets or to reduce the share of government in relation to GDP, some countries reformed labour market policy and attempted to reform the welfare state. Monetary policy was more supportive to demand in the USA, rather restrictive in the EU, specifically in Germany (for a fuller evaluation of these determinants see the "OECD Growth Project").



Marterbauer, M., "The Loss of the Positive Growth Margin. Macroeconomic Performance of Austria from 1970 to 1999", in *Peneder et al.* (2001).

McMorrow, K., Roeger, W., "Potential Output: Measurement Methods, 'New' Economy Influences and Scenarios for 2001-2010", European Commission, Economic Papers, 2001, (150).

OECD (2001A), The New Economy: Beyond the Hype. Final Report on the OECD Growth Project, Paris, 2001.

OECD (2001B), Growth Project. Draft Ministerial Paper, Paris, 2001.

Peneder, M., "Intangible Investment and Human Resources. The New WIFO Taxonomy of Manufacturing Industries", WIFO Working Papers, 1999, (114).

Peneder, M., "Intangible Assets and the Competitiveness of European Industries", in Buigues, P., Jacquemin, A., Marchipont, J.-F. (Eds.), Competitiveness and the Value Of Intangible Assets, Edward Elgar, Cheltenham, 2000.

Peneder, M., Entrepreneurial Competition and Industrial Location, Edward Elgar, Cheltenham, 2001.

Peneder, M., Aiginger, K., Hutschenreiter, G., Marterbauer, M., Structural Change and Economic Growth, WIFO, Vienna, 2001.

Scarpetta, S., Bassanini, A., Pilat, D., Schreyer, P., "Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level", OECD, Economics Department Working Papers, 2000, (248).

Schulmeister, S., "Globalization Without Global Money: The Double Role of the Dollar as National Currency and World Currency", Journal of Post Keynesian Economics, 2000, 22(3).

Wolfmayr-Schnitzer, Y., "Economic Integration, Specialisation and the Location of Industries. A Survey of the Theoretical Literature", WIFO Working Papers, 1999, (120).

Wykoff, A., "Differences in Economic Growth Across the OECD in the 1990s: The Role of Innovation and Information Technologies", DSTI Preliminary Findings and Contribution to the Growth Project, OECD, Paris, 1999.