# *Focus*

# II. Euro-area productivity trends – An industry-level perspective

*Over the last decade, the euro area has experienced a slowdown in labour productivity relative both to previous time periods and to the US. This focus section exploits a new sectoral database to shed some light on the possible causes of this disappointing performance. The analysis shows that the relative weakness of productivity in the euro area can be traced back to developments in total factor productivity (TFP) rather than developments in capital formation patterns and can be attributed to a small group of industries, including electrical and optical equipment; wholesale and retail trade; financial services; and other business services. On a more encouraging note, there is one area of the economy where the euro area has managed to consistently outperform the US in TFP terms over the recent years, namely the 'network' industries.*

*An econometric analysis of the determinants of TFP growth shows that, whilst there is a convergence trend across countries in terms of TFP, the catching-up process has weakened over time, especially in the post-1995 period. In fact, TFP growth now appears to be increasingly associated with innovation and technological spillovers from countries positioned at the 'technology frontier'. Technological spillovers are likely to be stronger in countries making more intensive use of R&D and human capital.*

*The analysis suggests that the TFP trends in those specific industries where euro-area-US differences are concentrated are influenced by a relatively wide spectrum of factors. Whereas the relative under-performance of the euro area's ICT-producing manufacturing industry (mainly semiconductors) is linked to R&D intensity factors, the divergences in the retail and wholesale trade industries relate to cyclical factors and the better exploitation of scale economies. Finally, the euro-area's out-performance of the US in the network industries seems to be mainly linked to one-off static efficiency gains associated with the sustained deregulation drive which occurred in these industries over the last two decades.*

Despite the recent upturn in growth, the euro area's overall growth performance since the mid-1990s has been relatively disappointing. While many Member States have managed to improve their labour market positions, this has unfortunately been accompanied by a slowdown on the productivity side in a significant number of countries, in sharp contrast to many other developed economies, in particular the US where the long-term downward movement in productivity growth rates experienced since the 1970s was reversed around the mid-1990s.

Whilst there have been a number of analyses of the possible causes of the euro area's disappointing performance at the macro level, it has until recently been difficult to conduct a detailed cross-country examination at the industry level due to lack of adequate data. This situation has significantly improved with the March 2007 release of the EU KLEMS datasets. EU KLEMS provides data on economic growth, productivity, employment, capital formation and technological change for a large range of manufacturing and service industries. This focus section exploits this dataset to shed new light on the likely causes of the productivity slowdown in the euro area.[41] Section 1 presents the broad stylised facts concerning productivity trends at the economy-wide and industry levels for the euro area and the US. Section 2 examines in more detail the possible determinants of total factor productivity (TFP) performance at the industry level, assessing in particular the role played by the regulatory environment and by knowledge production (R&D and education). Section 3 discusses some policy implications.

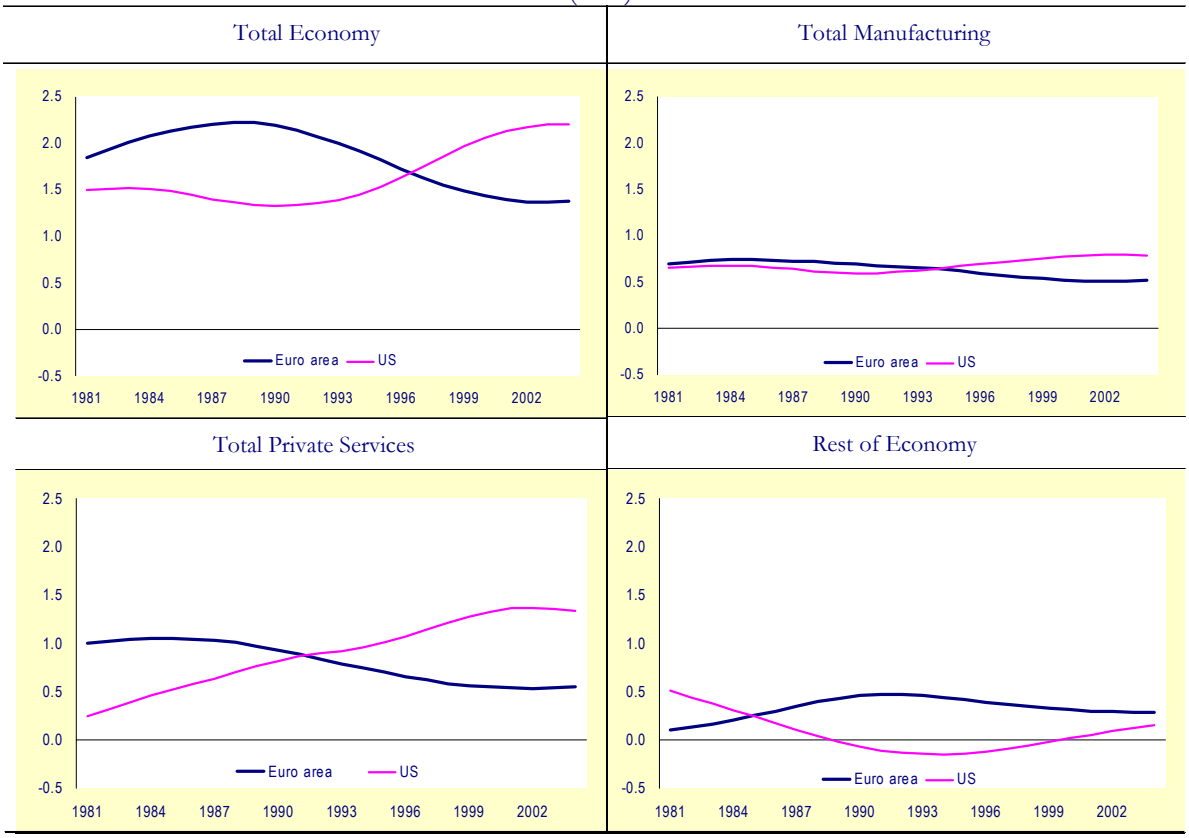
## *1. Euro-area productivity trends at the aggregate and sectoral level*

### A productivity slowdown mostly attributable to the private services sector

As shown in Graph 20, productivity growth in the euro area fell below the US rate in the late 1990s, bringing its post World War II convergence with US productivity levels to an end. Graph 20 also shows a decomposition of productivity growth in the euro area and the US into three broad sectors, namely manufacturing, private services and the rest of the economy (i.e.

[41] The analysis presented here is a shortened version of Chapter II in European Commission (2007), 'EU Economy 2007 Review', European Economy No 8.

Graph 20: **Trend contributions to the total change in labour productivity per hour: euro area and US**
(in %)




***Sources:*** EU KLEMS, Commission services.

primary industries plus public services). The graph shows the contributions of each of these sectors to the change in labour productivity of the total economy. The four panels of the graph have the same scale and are additive (i.e. manufacturing + services + rest of economy = total economy).[42] This data shows that the US's out-performance of the euro area in terms of labour productivity has applied right across the various sectors of industry, with both the manufacturing and private services sectors showing contrasting fortunes for the two areas. It also indicates that most of the deterioration in the relative productivity performance of the euro area can be attributed to the private services sector. For the most recent years, there has been a gap between the trend productivity of the US and the euro area of the order of 0.8 pp., with roughly 95% of the gap emanating from private services and 33% from manufacturing (with an offsetting -28% contribution for the rest of the economy where the productivity performance was actually stronger in the euro area than in the US).

## Some insights from growth accounting

A wide variety of methods can be used to decompose real GDP growth into its main determinants, one of which is applied by the EU KLEMS research consortium.[43] This variant essentially uses a production function which includes productive capital (a volume index of capital services); human capital (a skills-based indicator of the average qualifications of the labour force); employment levels adjusted for hours worked; and a residual term which, amongst other things, includes an estimate of the level of efficiency associated with the use of the various factors of production.

[42] The trends have been calculated using a Hodrick-Prescott (HP) filter.

[43] See European Commission, op. cit., for more details.

Table 10: **Growth accounting analysis – Gross value added growth and contributions**
(Annual average volume growth rates in %)

| | Euro area (1) | | | US | | |
|---|---|---|---|---|---|---|
| | 1981-1995 | 1996-2000 | 2001-2004 | 1981-1995 | 1996-2000 | 2001-2004 |
| **Total Industries** | | | | | | |
| **1. Labour Services** | 0.2 | 0.8 | 0.4 | 0.9 | 1.3 | -0.5 |
| **2. Capital Services** | 1.0 | 1.3 | 0.9 | 1.7 | 2.0 | 0.9 |
| **Of which** | | | | | | |
| **ICT** | 0.3 | 0.5 | 0.3 | 0.7 | 1.4 | 0.6 |
| **Non-ICT** | 0.8 | 0.8 | 0.7 | 1 | 0.6 | 0.3 |
| **3. TFP** | 0.6 | 0.4 | -0.1 | 0.3 | 0.8 | 1.7 |
| ***Total Industries*** | *1.9* | *2.4* | *1.3* | *2.8* | *4.1* | *2.1* |
| **Manufacturing** | | | | | | |
| **1. Labour Services** | -1.1 | 0.0 | -0.5 | -0.2 | 0.3 | -3.4 |
| **2. Capital Services** | 0.8 | 0.9 | 0.5 | 1.0 | 1.8 | 0.2 |
| **Of which** | | | | | | |
| **ICT** | 0.2 | 0.3 | 0.2 | 0.5 | 1.1 | 0.3 |
| **Non-ICT** | 0.7 | 0.5 | 0.3 | 0.4 | 0.7 | -0.1 |
| **3. TFP** | 1.6 | 1.3 | 0.5 | 2.2 | 2.8 | 4.0 |
| ***Total Manufacturing*** | *1.4* | *2.2* | *0.4* | *3.0* | *4.9* | *0.8* |
| **Private Services** | | | | | | |
| **1. Labour Services** | 0.7 | 1.2 | 0.6 | 1.4 | 2.1 | -0.1 |
| **2. Capital Services** | 1.4 | 1.7 | 1.3 | 2.4 | 2.5 | 1.2 |
| **Of which** | | | | | | |
| **ICT** | 0.4 | 0.7 | 0.4 | 0.9 | 1.9 | 0.9 |
| **Non-ICT** | 1.0 | 1.1 | 0.9 | 1.5 | 0.6 | 0.3 |
| **3. TFP** | 0.6 | 0.0 | -0.3 | -0.5 | 0.5 | 1.6 |
| ***Total Private Services*** | *2.7* | *2.9* | *1.6* | *3.2* | *5.1* | *2.6* |
| **Rest of Economy** | | | | | | |
| **1. Labour Services** | 0.5 | 0.7 | 0.5 | 1.5 | 1.3 | 1.4 |
| **2. Capital Services** | 0.6 | 0.6 | 0.6 | 0.7 | 1.1 | 0.8 |
| **Of which** | | | | | | |
| **ICT** | 0.2 | 0.3 | 0.2 | 0.3 | 0.7 | 0.3 |
| **Non-ICT** | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
| **3. TFP** | -0.1 | 0.3 | 0.1 | -0.4 | -0.7 | -0.2 |
| ***Total Rest of Economy*** | *0.9* | *1.6* | *1.2* | *1.8* | *1.7* | *2.0* |

(1) Euro area excluding EL, IE, LU and PT.
***Source:*** EU KLEMS, Commission services

Table 10 gives the results for the euro area and the US using the EU KLEMS growth accounting approach, with value added being decomposed into labour services, capital services and TFP.[44] The table shows that the big labour productivity gap between the euro area and the US over the period since 1995 has been mainly driven by TFP developments although differences in the value added contribution of ICT capital services was a significant additional explanatory factor over the period 1996-2000. Over the most recent period, 2001-2004, it is clearly TFP which has driven the euro-area-US productivity differences. For 'total industries', the TFP growth rate differential since 2000 is an alarming 1.8 pp, compared with a TFP gap of only 0.4 pp over 1996-2000.

This gap in TFP growth rates is widespread at the sectoral level, with very large and rising euro-area-US TFP growth rate differentials for both the manufacturing and private services sectors. In the manufacturing sector, capital services trends in both areas appear to be broadly converging over time, with this pattern being a feature of both ICT and non-ICT capital deepening. In contrast, it is interesting to note that in the services sector there is a clear compositional shift in the US towards greater

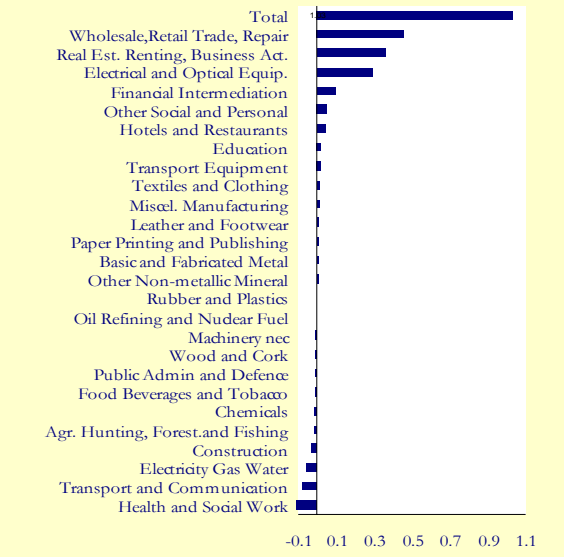
[44] Due to the lack of capital stock data for some Member States, a detailed growth accounting analysis at the industry level is only possible for 8 euro-area countries. The euro-area aggregates computed below therefore exclude Greece, Ireland, Luxembourg and Portugal.

levels of ICT capital deepening. While the gap between the two areas with regard to total capital services is small, there is evidence that the US's capital spending is increasingly being focused on ICT rather than on the more traditional forms of capital expenditure. Furthermore, it should be noted that the bulk of the overall economy-wide differences in ICT capital spending between the euro area and the US since the mid-1990s is due to higher ICT investment spending in the private services sector.

### TFP differentials with the US can be traced back to a small number of sectors

Due to the availability of capital stock data for a large number of individual industries in EU KLEMS, it is possible to do a more detailed productivity breakdown of the manufacturing, private services and 'rest of economy' sectors by examining those industries in the databank where capital stock data exists and which are therefore amenable to growth accounting analysis (28 in total – 14 manufacturing, 7 private services and 7 'other industries').

Graph 21: **28 Industry breakdown of total TFP Contribution to value added growth US minus euro area (**1996-2004**)** (1)




(1) Euro area excluding EL, IE, LU and PT.
***Source:*** EU KLEMS, Commission services

Graph 21 decomposes the total TFP growth gap between the US and the euro area over the 1996-2004 period into the respective contributions of the 28 industries. The graph shows the highly industry-specific nature of the TFP differences, with only a handful of industries explaining the diverging euro-area-US trends, namely wholesale and retail trade; real estate and other business services; electrical and optical equipment (which includes semiconductors, the main ICT-producing industry); and to a lesser extent financial services. On a more positive note, the graph also shows some industries where the euro area has done better, with a number of the so-called 'network' industries doing particularly well.

## *2. The determinants of TFP growth*

The analysis in this section aims to isolate the critical factors behind differences in the evolution of TFP, which, as shown earlier, accounts for the most important share of the gap in productivity growth between the euro area and the US over the last decade.

### Conceptual framework: innovation as the key driver of growth

A better understanding of the key determinants of TFP growth has been high on the research agenda of international organisations and the academic community over the past decade. There is a growing consensus in the literature that recent growth theories, based on 'Schumpeterian' creative destruction mechanisms, can help interpret recent developments.[45] These theories focus on innovation as the key driver of growth in economies at, or close to, the 'technology frontier'. Innovators, by introducing superior product varieties and technologies, have the effect of both displacing existing firms and of inducing the adoption of new products and techniques at the wider industry level. At the aggregate level, the innovation rate depends on the resources devoted to the innovation effort (i.e. R&D and human capital) and on the stock of existing knowledge (knowledge spillovers). The growth rate of the economy will depend not only on the rate of innovation but also on the rate at which 'state-of-the-art' technologies are adopted / diffused throughout the wider economy. Countries that are close to the

[45] See for instance Aghion, P. and P. Howitt (2006), 'Joseph Schumpeter Lecture: Appropriate Growth Policy: A Unifying Framework', *Journal of the European Economic Association*, 4(2-3), pp. 269-314.

technology frontier will mainly grow thanks to the development of new technologies, whilst the 'follower' grouping of countries will derive the largest share of their TFP growth from the adoption of already existing, technologies which are available at the frontier.

In this 'Schumpeterian' world, institutions and policies play a key role in determining the relative position of countries in the global innovation race. These framework conditions directly impact on the relative ability of countries to innovate at the frontier or to adopt existing leading-edge technologies. Follower countries would gain from institutions and policies favouring the cost-efficient adoption of existing technologies, while countries operating at the frontier would profit from policies that promote excellence in higher education and R&D; financial markets that reward risky projects; and regulations that do not put an excessively heavy burden on either incumbent firms or on potential entrants.

### A review of existing empirical work

A number of papers in the literature have already analysed the determinants of TFP in a Schumpeterian framework. Most of the existing analyses use panel data information, pooling data on TFP levels and growth rates over several years and countries. Some papers also use information at the sectoral / industry levels, with the datasets usually obtained from the OECD's STAN database. The available empirical specifications normally reflect a reduced form of the basic innovation-imitation model, with most of them regressing TFP growth on two essential variables:

- a measure of the technology gap (i.e. the distance between the TFP of the country analysed and that of the country with the highest level of efficiency); and
- an estimate of the growth rate of TFP at the frontier (i.e. the TFP growth rate of the most efficient country).

The first variable captures the extent to which TFP growth in a specific country can be explained by the adoption of more efficient existing technologies. The assumption here is simply that the larger the technology gap, the higher the potential gains from adopting more efficient, internationally available, technologies and consequently the faster the rate of TFP growth. The second variable aims to capture the link between TFP growth in the 'catching-up' country and the extent of innovation and knowledge spillovers which are occurring in the technologically most advanced country. In addition to these two basic explanatory variables, most papers also control for a series of policy and institutional factors that may affect the rate of TFP growth independently or may interact with the 'technology gap' and 'technology spillovers' variables to have an impact on TFP.

The choice of explanatory factors which we use in our analysis of the factors driving technological change and efficiency gains is strongly driven by the work of Aghion and Howitt (2006) as well as the Sapir report.[46] Both studies suggest that the failure of the EU's economic system to deliver a satisfactory growth performance from the mid-1990s onwards was due to outdated economic institutions (which were supportive of growth in the past but have now become an obstacle to growth) and the failure of the EU to transform its industrial structure to achieve an innovation-based economy. High growth in the post-WWII era was driven by high levels of industrial production, economies of scale and imitation of US technological advances. As the EU approached the technological frontier, growth became increasingly dependent on innovation.

Both studies suggest that economies based on innovation are the key to higher employment and growth. The studies stress that innovation stems from entrepreneurial activities but that these activities can only develop if Europe focuses on reforming its education systems; promoting higher levels of better targeted R&D; ensuring better regulation to facilitate entry and exit of firms; providing more adequate infrastructure to facilitate the free movement of people, goods and ideas; stimulating innovation via financial and tax incentives; and promoting more labour market flexibility.

[46] Aghion and Howitt (2006), op. cit.

Sapir, A. et al. (2003), 'An agenda for a growing Europe: Making the EU system deliver', report by an Independent High Level Group established on the initiative of the President of the European Commission'.

The growth-policy recommendations included in the above studies also find support in the empirical literature where innovation and imitation (i.e. adoption of available technologies) are assessed as to their respective roles in determining the overall technological gains of an economy. Within this overarching endogenous growth framework, the importance of the high / low skill composition of a country's human capital and the economy's distance from the technological frontier are both assessed.

Vandenbussche, Aghion and Méghir (2006) show that if one holds the level of human capital constant, its growth-enhancing effects depend both on its composition and on distance to the technology frontier.[47] More specifically, Vandenbussche et al. contend that the TFP growth-enhancing impact of skilled labour increases with a country's proximity to the frontier under the reasonable assumption that innovation is a more skill-intensive activity than imitation.

In keeping with this theme, Acemoglu, Aghion and Zilibotti (2002) emphasise the distinction between innovation and imitation as two alternative sources of productivity growth and the importance of growth-maximising institutions or policies evolving as a country or industry catches up with the technology frontier.[48] This line of reasoning is also supported by Aghion, Bloom, Blundell, Griffith and Howitt (2003) who show that when most firms in an industry are close to the national technological frontier, product market competition is positive for innovation.[49] This is also suggested in the paper by Aghion, Blundell, Griffith, Howitt and Prantl (2006), which presents evidence that the closer industries in an economy are to the world technology frontier, the more growth-enhancing is the threat of entry.[50] Finally, Nicoletti and Scarpetta (2003) also show that lowering barriers to entry has a positive effect in terms of stimulating TFP growth.[51]

## Empirical strategy and basic regression results

The aim of the panel regression analysis presented hereafter is to build on existing work in this area by capitalising on the recent release of the EU KLEMS datasets and specifically on the increased availability of TFP data series and of substantially enhanced industry-level detail. The analysis concerns 9 EU countries plus the US over the 1980-2004 period and covers a total of 28 industries. The empirical approach is similar to that in Nicoletti and Scarpetta (2003). In the baseline specification, TFP growth rates are regressed over a measure of innovation / technology spillovers (i.e. the TFP growth rate of the leader country) and of a technology gap term (i.e. the lagged logarithm of the difference between TFP in a specific country and TFP at the frontier, with the frontier being determined by the country exhibiting the highest TFP level in that particular industry, in that particular year). Country, sector and year fixed effects control for factors that may independently affect TFP growth rates.

The basic regression results support the expectation that TFP growth is higher in a country when:[52]

- there is stronger TFP growth in the frontier economy (which reflects the impact of innovation and technology spillovers); and
- when the technology gap is larger, with the gap measured by the difference in TFP levels for the country in question relative to the global leader (which reflects the impact of adopting existing superior technologies).

[47] Vandenbussche, J., P. Aghion and C. Meghir (2006), 'Growth, Distance to the Frontier and Composition of Human Capital', *Journal of Economic Growth*, 11, pp. 97-127.

[48] Acemoglu, D., P. Aghion, and F. Zilibotti, (2002), 'Distance to Frontier, Selection and Economic Growth', NBER working paper 9066.

[49] Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2003), 'Competition and Innovation, an inverted U Relationship', NBER working paper 9269.

[50] Aghion, P., N. Bloom, R. Blundell., R. Griffith and P. Howitt (2003), 'Competition and Innovation, an inverted U Relationship', NBER working paper 9269.

[51] Nicoletti, G. and S. Scarpetta (2003), 'Regulation, Productivity and Growth: OECD Evidence', Economic Policy, 36, pp. 9-72, April.

[52] The basic regressions are not shown here due to lack of space but can be found in European Commission (2007), op. cit.

Table 11: **The role of human capital and R&D**

| | All Industries | All Industries | All Industries | All Industries | Only manufacturing sector | Only private services sector | Only ICT-related sectors |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| TFP growth at the frontier | 0.177* | 0.176* | 0.187* | 0.174** | 0.173** | 0.438*** | 0.141** |
| | (2.02) | (2.02) | (2.19) | (2.66) | (2.40) | (3.90) | (3.16) |
| Technological gap | 0.083** | -0.082** | -0.079** | -0.080*** | -0.105** | -0.036 | -0.013 |
| | (3.16) | (3.14) | (3.06) | (3.21) | (2.80) | (1.32) | (1.41) |
| Human capital | -0.009 | 0.005 | 0.001 | -0.006 | -0.017 | 0.004 | -0.007 |
| | (1.40) | (1.23) | (0.17) | (0.55) | (0.69) | (0.86) | (1.01) |
| R&D | 0.001 | 0.005 | 0.005*** | -0.000 | 0.008 | 0.023 | 0.000 |
| | (0.33) | (1.33) | (4.96) | (0.02) | (0.56) | (0.86) | (0.02) |
| Interaction TFP growth at the frontier with human capital | | | | 0.169 | 0.216 | 0.198*** | 0.128 |
| | | | | (1.32) | (1.40) | (5.39) | (1.32) |
| Interaction TFP growth at the frontier with R&D | | | | 0.019 | 0.013 | 0.459 | 0.064 |
| | | | | (0.54) | (0.36) | (1.71) | (1.38) |
| Interaction technological gap with human capital | | | | 0.018 | 0.015 | 0.002 | 0.014 |
| | | | | (0.89) | (0.41) | (0.35) | (0.99) |
| Interaction technological gap with R&D | | | | 0.004 | 0.019 | -0.033 | -0.005 |
| | | | | (0.21) | (0.64) | (0.64) | (0.46) |
| Country fixed effects | Yes | No | Yes | Yes | Yes | Yes | Yes |
| Sector fixed effects | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N. obs. | 2385 | 2385 | 2385 | 2385 | 1535 | 674 | 892 |
| $R^2$ | 0.19 | 0.18 | 0.19 | 0.20 | 0.23 | 0.20 | 0.31 |

***Notes –*** Estimation method: panel OLS regressions; standard errors robust with respect to heteroschedasticity and possible correlation within countries. Absolute value of t tests reported in parentheses. ***, **, * denote, respectively, statistical significance at 1, 5, and 10% level.
TFP growth at the frontier: TFP growth of the country with the highest TFP level in sector *s*, year *t* (leader country). Source EUKLEMS
Technological gap: lagged log (TFP level –log(TFP level of the leader country). Source: EUKLEMS
Human capital: share of high skill labour compensation in total labour compensation. Standardised variable. Source: EUKLEMS
R&D: R&D expenditure/gross output. Standardised variable. Source: OECD STAN

These results do not seem to be sector-specific; they also hold when the sample is restricted to the manufacturing, private services or ICT-related sectors. They do, however, appear to be sensitive to the period chosen: in the decade from 1995-2004, TFP growth was mostly driven by growth at the frontier, with a non-significant impact from the technology gap variable. This finding is consistent with the view that across Europe, growth is increasingly being driven by innovation activity and less by the adoption of existing up-to-date technologies.

In addition to the two main explanatory variables, the baseline specification was subsequently augmented to control for the impact of framework conditions. A long list of country-level variables were tested to capture the possible effect of, amongst other things, overall macroeconomic conditions; the presence of those economy-wide infrastructures which are most closely associated with the development of new technologies; the importance of ICT use; and the age structure of the population.

Confounding our prior expectations, such economy-wide variables produced results which were generally insignificant in terms of their TFP effects. In addition, there is little evidence from the regressions that ICT use has had a large role to play in determining cross-country TFP trends. The overall contribution of ICT would appear to be adequately reflected in the growth accounting results presented earlier, with the regression

analysis finding little support for additional TFP-enhancing spillover effects from an intensive use of ICT capital at the macro level.

### Human capital and R&D play a role at the technology frontier

In recent years, there has been considerable interest in analysing the effects of investments in knowledge and human capital formation on the overall TFP performance of countries. With Europe lagging behind not only in terms of ICT penetration rates but also with regard to other indicators of knowledge production (such as R&D investments and the share of high-tech industries), the creation of knowledge capital has emerged as a central policy concern, with the Lisbon process being a concrete example of an ongoing policy programme aimed at boosting the pace of innovation.

Against this background, Table 11 reports the results for the basic specification augmented to take into account the role of human capital and R&D in affecting TFP growth.[53] The main message to be retained from the table is that both human capital and R&D do have a positive effect on TFP growth. R&D has a direct impact,[54] while the effect of human capital is indirect, emanating from a stronger positive impact of TFP growth at the frontier. The influence of human capital, however, is highly sector-specific, and appears to be most effective in determining the TFP performance of the private services sector.[55] However, for countries at or close to the technology frontier, policies aimed at improving the overall framework conditions for maximising the TFP benefits of human capital and R&D would be directly beneficial in facilitating the transition of their growth models to one based more on their own internal innovation capacity.

### Effects of anti-competitive regulation seem to be highly industry-specific

Recent studies report that levels of regulation are potentially crucial driving forces for efficiency gains. For instance, European Commission (2007) concludes that competition is crucial for both the level and growth rate of productivity.[56]

To assess the importance of this specific determinant, Table 12 presents the results for the impact of several regulation indicators in the product, labour and financial markets on TFP performance.[57] The results suggest that, across 'all industries', the different regulatory indicators do not play a very important direct role in determining TFP growth, with non-significant results for most of the alternative specifications tested. In addition, there are some counter-intuitive effects when the analysis is restricted solely to the manufacturing, private services or ICT-related sectors, with tighter product market and financial market regulations predicted to be positive for TFP growth in some specific sectors.

With regard to the indirect interaction effects of the different forms of regulation, tighter financial market regulation appears to have consistently negative effects on TFP growth taking place at the frontier, both when all the sectors are pooled and when only individual sectors are considered in the regressions (i.e. manufacturing, private services and ICT-related sectors). In contrast, the results for product market regulations do not appear to be as robust since many of the coefficient estimates are insignificant and shift from positive to negative depending on the sector considered. As far as labour market regulations are concerned, they

[53] To facilitate the interpretation of the results, the human capital and R&D variables have been standardised in such a way as to have a zero mean and a unit standard deviation. When, for example, the human capital variable is interacted with variable *x*, the coefficient indicates the change in the coefficient of variable *x* which is associated with a one-standard-deviation increase in the human capital variable (while the coefficient of variable x indicates its impact in keeping human capital at its mean value).

[54] Column (1) shows that the direct impact of R&D is not significant. A significant impact is recovered only by eliminating sector fixed effects (as shown in columns (2) and (3)).

[55] This effect is captured by the significant coefficient on the human capital variable when interacted with the variable for TFP growth at the frontier in column (6).

[56] European Commission (2007), 'Policies in the pursuit of higher productivity: another look', Chapter 4 in 'EU Economy 2007 Review', European Economy No 8.

See also OECD (2003), 'The Sources of economic growth in OECD countries'.

[57] To facilitate the interpretation of the results, the indicators are standardised. The indicators increase with the intensity of the regulatory burden.

Table 12: **The role of regulations**

| | All Industries | All Industries | Only manufacturing sector | Only private services sector | Only ICT-related sectors |
|---|---|---|---|---|---|
| | (1) | (3) | (4) | (5) | (6) |
| TFP growth at the frontier | 0.171*** | 0.175*** | 0.398*** | 0.138*** | 0.153*** |
| | (3.39) | (5.82) | (4.02) | (3.97) | (7.07) |
| Technological gap | -0.049*** | -0.047*** | -0.042* | -0.026*** | -0.030*** |
| | (5.09) | (5.20) | (2.26) | (5.13) | (6.95) |
| Product market regulation | -0.002 | -0.000 | 0.126*** | -0.008 | 0.008** |
| | (0.96) | (0.01) | (3.41) | (1.65) | (2.81) |
| Labour market regulation | 0.008 | -0.004 | -0.009 | 0.002 | 0.006 |
| | (1.45) | (0.79) | (1.46) | (0.36) | (0.95) |
| Financial market regulation | 0.005 | -0.007 | -0.004 | 0.009 | 0.009* |
| | (1.31) | (1.43) | (0.36) | (1.73) | (2.01) |
| Interaction TFP growth at the frontier with product market regulation | | 0.016 | 0.416** | -0.005 | -0.040 |
| | | (0.41) | (2.73) | (0.23) | (0.98) |
| Interaction TFP growth at the frontier with labour market regulation | | 0.090** | 0.080** | 0.069* | 0.014 |
| | | (2.43) | (2.12) | (1.85) | (0.35) |
| Interaction TFP growth at the frontier with financial market regulation | | -0.078 | -0.127** | -0.063** | -0.081** |
| | | (1.62) | (2.80) | (2.55) | (2.57) |
| Interaction technological gap with product market regulation | | -0.007 | 0.064 | -0.013* | 0.002 |
| | | (0.90) | (1.17) | (2.07) | (0.38) |
| Interaction technological gap with labour market regulation | | -0.004 | -0.007 | -0.005 | 0.001 |
| | | (0.48) | (0.47) | (0.81) | (0.16) |
| Interaction technological gap with financial market regulation | | -0.003 | -0.014 | 0.016** | 0.007* |
| | | (0.34) | (0.97) | (2.34) | (1.89) |
| N. obs. | 6340 | 6340 | 2929 | 2043 | 2271 |
| $R^2$ | 0.13 | 0.14 | 0.18 | 0.11 | 0.22 |

Notes – Estimation method: panel OLS regressions; fixed effects included for countries, sectors, and years; standard errors robust with respect to heteroschedasticity and possible correlation within countries. Absolute value of t tests reported in parentheses. ***, **, * denote, respectively, statistical significance at 1, 5, and 10 per cent level.
TFP growth at the frontier: TFP growth of the country with the highest TFP level in sector *s*, year *t* (leader country). Source: EUKLEMS
Technological gap: lagged log(TFP level )–log(TFP level of the leader country). Source: EUKLEMS
Product market regulation: indicator of the "knock on" sectoral impact of regulations in non-manufacturing sectors. Standardised variable. Source: OECD "Regimpact" indicator
Labour market regulation: indicator of anti-competitive regulations in the labour market. Standardised variable. Source: Fraser institute freedom indicators (taken with negative sign).
Financial market regulation: indicator of anti-competitive regulations in the financial markets. Standardised variable. Source: Fraser institute freedom indicators (taken with negative sign).

appear to increase TFP growth at the frontier, irrespective of the sectoral breakdown used in the sample. Since the theoretical literature does not provide a clear-cut answer regarding the link between labour market regulation, innovation and TFP, a note of caution is required in interpreting the positive relationship between stricter labour market regulation and TFP growth. In particular, the limited time variation of the sample used in the regressions makes it difficult to disentangle the short-term transitional effects of labour market reforms, introduced by many EU countries since the early 1990s, from the long-run impact of those reforms on TFP growth rates.[58]

In overall terms, given the lack of any evidence of a direct impact from the regulatory indicators at the level of 'total industries' and the

[58] On the one hand, stricter labour market regulation, notably employment protection legislation, may, by limiting the room for re-adjustment of the labour force in the event of redundancies, hinder the incentives for firms to engage in risky innovation projects, thus reducing TFP growth at the frontier. On the other hand, stronger protection of employment may increase training and investment in skills, which are generally complementary to innovation and TFP growth.

Table 13: **Industry-specific models**

| | ICT-producing manufacturing | | Retail and affiliated industries | | Utilities | |
|---|---|---|---|---|---|---|
| | Only ICT-producing manufacturing | Only remaining industries | Only retail and affiliated industries | Only remaining industries | Only utilities | Only remaining industries |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| TFP growth at the frontier | 0.007 | 0.168** | 0.152** | 0.194** | 0.086 | 0.190*** |
| | (0.05) | (2.34) | (2.61) | (2.37) | (0.47) | (4.08) |
| Technological gap | 0.010 | -0.082** | -0.034*** | -0.0544*** | -0.022 | -0.048*** |
| | (0.67) | (3.28) | (4.26) | (4.03) | (0.84) | (4.92) |
| Interaction TFP growth at the frontier with R&D | 0.130*** | 0.016 | | | | |
| | (3.50) | (0.38) | | | | |
| Relative contribution of private consumption to GDP growth | | | 0.004*** | 0.001 | | |
| | | | (5.08) | (1.80) | | |
| Product market regulation | | | | | -0.010* | 0.004 |
| | | | | | (2.00) | (0.063) |
| Interaction TFP growth at the frontier with product market regulation | | | | | 0.032 | 0.043 |
| | | | | | (0.33) | (1.32) |
| Interaction technological gap with product market regulation | | | | | -0.115 | 0.005 |
| | | | | | (1.06) | (0.90) |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Sector fixed effects | No | Yes | Yes | Yes | Yes | Yes |
| Year fixed effects | No | Yes | Yes | Yes | Yes | Yes |
| N. obs. | 141 | 2497 | 836 | 5030 | 684 | 5656 |
| $R^2$ | 0.56 | 0.18 | 0.17 | 0.14 | 0.22 | 0.13 |

Notes – Estimation method: panel OLS regressions; fixed effects included for countries, sectors, and years; standard errors robust with respect to heteroschedasticity and possible correlation within countries. Absolute value of t tests reported in parentheses. ***, **, * denote, respectively, statistical significance at 1, 5, and 10 per cent level.
TFP growth at the frontier : TFP growth of the country with the highest TFP level in sector *s*, year *t* (leader country). Source: EUKLEMS
Technological gap : lagged log (TFP level )–log(TFP level of the leader country). Source: EUKLEMS
R&D : R&D expenditure/gross output. Standardised variable. Source: OECD STAN
Human capital: share of high skill labour compensation in total labour compensation. Standardised variable. Source: EUKLEMS
Relative contribution of private consumption to GDP growth: GDP growth due to private consumption/GDP growth. Source AMECO.
Product market regulation: indicator of the "knock on" sectoral impact of regulations in non-manufacturing sectors. Standardised variable. Source: OECD "Regimpact" indicator.

robustness issues / counter-intuitive results for some of the indirect interaction effects, it is clear that more research is needed to get a better understanding of the role of the regulatory environment in explaining cross-country TFP growth differentials. In particular, more industry-specific regulatory indicators may be needed to better understand the effects of a more competition-friendly regulatory environment on TFP trends.

Part of the problems experienced with the regulatory regressions may be linked to the need to use a lower level of disaggregation than the broad sectoral aggregates which were used for the analysis in Table 12. This is attempted in Table 13 which presents results for sectors defined at a finer level of industry disaggregation. The aim is to identify the key TFP growth determinants in those broad industry groupings that explain the bulk of the euro-area-US TFP differences over the past decade.

Column (1) shows that for the ICT-producing industry (i.e. electrical and optical equipment) the basic variables behave somewhat differently from prior expectations. The frontier and technology gap variables are non-significant. This result is consistent with the existing evidence which suggests that labour productivity in the 'high tech' sectors is not converging across

countries, in contrast with what is observed for most other sectors. Interestingly, the results change drastically when the same specification is tested on 'total industries' excluding the ICT-producing manufacturing industry (column (2)).

Regarding retail and wholesale trade services (column (3)), the results indicate a significant role for cyclical factors in providing a direct explanation for observed differences in TFP growth between the US and the EU Member States (as suggested by the strongly significant positive coefficient for the relative contribution of private consumption to GDP growth). Due to its construction as a residual term, TFP growth also captures productivity improvements associated with the better exploitation of scale economies, which are likely to be a relevant factor in explaining productivity dynamics in this group of service industries. It is worth noting that a similar positive impact of cyclical factors is not observed in the other sectors (column (4)).

Finally, regarding the 'network' industries, product market regulations are shown to have a significant negative impact on this grouping of industries but not on the rest of the economy. This could be related to the deregulation drive which has been a feature of those industries over the last two decades, with the more pro-competitive environment created yielding significant benefits in terms of overall TFP trends. However, these latter benefits are likely to be skewed more towards one-off static efficiency gains than permanent dynamic effects.

## *3. Summary and policy implications*

Over the last decade many euro-area Member States have experienced a slowdown in their productivity performances relative both to previous time periods and to other developed OECD economies, most notably the US. Our analysis has shown that most of the euro-area-US differences are not to be found in investment patterns but are mainly driven by developments in TFP. At the sectoral level, the deterioration in the euro-area's relative performance mostly reflects the insufficient contribution to TFP growth of the high technology part of the manufacturing sector and of the private services sector. The analysis actually shows that a small group of industries is responsible for most of the euro area's productivity weakness, namely electrical and optical equipment; wholesale and retail trade; financial services; and other business services. On a more encouraging note, there is one area of the economy where the euro area has managed to consistently outperform the US in TFP terms over the recent years, namely the 'network' industries.

Analysing econometrically the determinants of TFP growth, a relatively clear finding is that, whilst there is a generalised tendency toward catching up across countries in terms of TFP level, it seems to be weakening over time, especially in the post-1995 period. For the ICT-producing manufacturing sector this process of catching-up is particularly weak. In contrast, TFP growth appears increasingly associated with innovation and technological spillovers from countries positioned at the 'technology frontier'. TFP growth is also likely to benefit more from innovation at the technology frontier if there is more intensive use of R&D and human capital.

The regression analysis suggests that the TFP trends in those specific industries where euro-area-US differences are concentrated can be attributed to a relatively wide spectrum of factors. Whereas the relative under-performance of the euro-area's ICT producing manufacturing industry (mainly semiconductors) is linked to issues of R&D intensity, the divergences in the retail and wholesale trade industries relate to cyclical factors and the better exploitation of scale economies. Finally, with regard to the euro-area out-performance in the network industries, there is evidence to suggest that these are mainly linked to one-off static efficiency gains associated with the sustained deregulation drive which occurred in these industries over the last two decades.

Regarding the policy implications that can be derived from the analysis, two tentative points can be made:

Firstly, the TFP patterns which have emerged over recent decades, especially since the mid-1990s, indicate a growing need for a more intensive use of R&D and high-skilled human capital in frontier economies. Rather than an increase in the resources devoted to R&D and higher education (in itself necessary, provided

that their efficiency and effectiveness is secured) what seems to matter most is the provision of adequate framework conditions to facilitate the reallocation of these scarce knowledge-intensive resources towards those industries which can deploy them most productively.

Secondly, the highly diverse range of factors which the present analysis has highlighted as potential contributors to the ongoing euro-area-US TFP differences, may suggest a need to adopt a more targeted, industry-level approach to structural reform efforts. In this context, the present focus section should be seen more as an attempt to raise questions and to indicate avenues for further research than as providing clear policy recommendations.