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EU Productivity and Competitiveness: An Industry Perspective

Can Europe Resume the Catching-up Process?

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Editors

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Table of Contents

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Executive Summary

Background

- Since the mid 1990s the average growth rates of real GDP, labour productivity and total factor productivity in the European Union have fallen behind those in the United States. What makes this remarkable is that this is the first time since World War II that these performance measures have shown lower growth rates for the EU for several years in a row.

- This represented a reduction in labour productivity levels in the EU relative to the US in recent years, down from a position of near parity in the mid 1990s. Estimates of the average GDP per hour worked gap range from EU levels between 87% and 92% of US levels in 2002 and early indications are that the gap has widened further in 2003.

- There is a wide variation across the European Union in productivity performance, both in terms of growth rates as well as levels. A limited number of countries show productivity levels near to that of the US (Germany, Netherlands) or even above it (Belgium, France), whereas others are substantially behind. However, nearly all countries show a recent erosion of their average productivity levels relative to the US.

- Weighting growth rates by each country's shares of EU employment highlights the importance of two countries (Germany and Italy) in accounting for the EU slowdown in the second half of the 1990s. Thus of the countries that experienced a slowdown, about 75% of the total decline was due to these two, with Germany about twice as important as Italy.

- The contrasting experience of the US and the EU in the 1990s could in theory be due to cyclical influences. A range of tests in this report show no significant effect on the productivity growth measures due to different timings of the business cycle.

- This report argues that these findings can be better understood by employing an industry perspective. This approach can answer the following questions, which aggregate economy wide estimates cannot deal with.

  — To what extent are the aggregate trends in output and productivity common across industries?

- — Are there differences in industry specialisations across the two regions?
- — How are industry output and productivity affected by investment in physical and human capital?
- — How is productivity related to competitiveness in manufacturing?
- — Is productivity affected by the market environment in which firms operate?

- In addition an industry perspective can help to inform industrial policy in the EU.

Industry databases

- For the purpose of this study, a unique database, the *Industry Labour Productivity Database*, has been developed for this report.

- The database provides industry detail for 1979 to 2001 on output, hours worked and labour productivity for all 15 EU countries and the US.

- The database covers 56 individual industries covering the total aggregate economy.

- In addition, data series for capital inputs and labour force skills were constructed for the US and four of the larger EU countries, namely France, Germany, the Netherlands and the UK, for 26 individual industries.

- To achieve international consistency, US deflators were employed to obtain real output series in manufacturing sectors producing information and communications technology (ICT) equipment. A common (Törnqvist) weighting system was employed to obtain more consistent aggregate series across countries.

- Finally, to study relative competitiveness, the database includes estimates of relative productivity levels and unit labour costs in manufacturing. These again cover all EU countries.

Results: Labour productivity

Industry variation

- The data show a wide variation in performance across industries, countries and time periods. Double-digit annual average growth rates in labour productivity are common in ICT producing sectors such as office machinery and electronic components. Strongly negative rates occur frequently in services such as transport or business services industries. About half the industries show higher growth in the EU, but the locus of these industries has changed through time.

- Comparing the period since 1995 to the early 1990s, the acceleration in US growth is by no means ubiquitous, occurring in about half of the 56 individual industries. But in contrast less than 20% of industries in the total EU show accelerating growth across these two periods.

- Weighting each industry's performance by employment shares gives an indication of their contribution to aggregate economy labour productivity growth. In the US, the post 1995 acceleration is dominated by a few industries, namely ICT producing sectors, wholesale and retail trade and banking and auxiliary financial services. This confirms findings elsewhere in the literature, stressing the importance of services in explaining the US growth advantage over the EU. In the EU, the aggregate deceleration in the same period is spread more widely across industries.

Industry taxonomies

- In order to make sense of this wide variation in performance, industries were grouped according to common features. Thus taxonomies were created based on whether industries are producers or users of ICT (and within the latter their intensity of use), whether industries mainly employ skilled or unskilled labour, and on the channels through which innovation occurs.

- In both the US and the EU, the ICT producing group experienced very high and accelerating productivity growth rates, although double-digit rates are confined to manufacturing. ICT producing services (communications, computer software, etc.) is the only group that shows the reverse pattern of accelerating growth in the EU and decelerating in the US, but this group has a small employment share.

- In intensive ICT using sectors, productivity growth in the EU is relatively stable across time in contrast to a very large acceleration in the US, mostly in the services part. This is a clear indication that the US is ahead of Europe in terms of productive application of ICT outside the ICT producing sector itself.

- Non-ICT industries (those neither producing nor intensively using the new technology), show decelerating growth in both regions. The rate of decline in the final period is greater in the EU but from higher growth rates in the 1980s and early 1990s. Non-ICT service industries show a marginal improvement in the US post 1995 which is not matched in the EU.

- Dividing industries according to their use of skilled labour shows accelerating US growth in industries which are intensive in their use of university graduates. In this group no productivity change across time occurs in the EU.

- Productivity growth rates in sectors characterised by higher intermediate skills (higher level but below degree) were relatively high and increasing across time in the EU. This group includes most of the non-ICT producing engineering industries, which are traditionally seen as areas of EU strength, relying on the large endowments of skilled craft workers in many EU countries.

- Of more concern for the EU is declining productivity growth in sectors that intensively use lower intermediate skills, particularly since this group shows pronounced acceleration in the US from the mid 1990s. This group includes some of the larger ICT using sectors in services, notably wholesale and retail distribution. This raises the possibility that traditional lower intermediate skills in the EU may not be appropriate for the needs of the information economy.

- Finally in both the EU and the US productivity growth has been declining in low skill intensive industries. These include many mature manufacturing sectors subject to product cycle influences arising from strong competition with low wage economies in the developing world and Central and Eastern Europe.

- The innovation taxonomy considered the source of innovations, distinguishing between those where innovations were external (supplier based) or internal to the industry (scale intensive, science based, based on organisational innovations or instigated through the demands of clients).

- The US outperformed the EU in specialised suppliers manufacturing (which are mainly ICT producing industries). In services both supplier based services (dominated by retail trade) and client led groups (dominated by wholesale trade) showed the familiar pattern of accelerating US labour productivity growth simultaneously with unchanged or declining EU growth. Innovation in these service industries will become an increasingly important source of productivity growth in future.

- The EU outperformed the US in all periods in all (manufacturing) goods industry groups, except in specialised suppliers manufacturing. This indicates Europe's relative strength in traditional manufacturing and in industries where (mainly process) innovations arose from in-house R&D. The latter is strongly tied to the EU advantage in industries characteristics of higher intermediate skills. However, the productivity growth rates in all these manufacturing industry groups are slowing down, which – in combination with the declining shares of these industries – raises the question whether manufacturing will remain the 'power house' of the European economy as it used to be before.

- In summary the taxonomies point to industry features that can explain some of the varying performance when industries are grouped on the basis of key characteristics that matter for growth differentials. More importantly, they also provide explanations for the diverging EU-US productivity performance which are not apparent from examination of the aggregate economy figures. Thus industries can be loosely divided into the following groups, based on their labour productivity performance, sharing one or more of the listed features:
    - *US productivity growth acceleration, EU unchanged or declining.* Industries that are ICT producing manufacturers or intensive users of ICT, employ graduates or lower intermediate skilled labour, and where innovations arise through specialised suppliers, supplier based innovation and are provided through demands of clients.

— *EU productivity growth relatively high, little or no US acceleration.* Industries that are ICT producing services, employ highly skilled craftsmen (higher intermediate skilled labour) and/or where innovations are largely process changes arising from in-house R&D.

— *Relatively low and declining productivity growth in both the US and EU.* Industries that neither produce nor intensively use ICT and employ mostly unskilled labour.

Results: Input use and Total Factor Productivity

- This section of the report compares performance in the US with an EU-4 aggregate employing data for France, Germany, the Netherlands and the UK.

Physical capital and labour quality

- Investment in ICT equipment has been proceeding rapidly in both the EU-4 and the US. The contribution of ICT capital per hour worked (capital deepening) to labour productivity growth has been increasing across time and this is widespread across industries. Its impact is proportionally greater in ICT producing and ICT using industries than in more traditional sectors but nevertheless remains significant in the latter.

- Whereas the contribution of non-ICT capital deepening has been relatively stable in the US, in the EU-4 the importance of non-ICT capital has been declining through time in most sectors. There is a clear reduction in the rate of substitution of capital for labour in most industry groups in the EU-4. Although this report cannot unambiguously relate this to the moderation in wage growth in the EU-4 during the second half of the 1990s, it is very likely that this traditional explanation has a role to play but is very dependent on country-specific institutional arrangements in their labour markets.

- Industries in both the EU and US have increased their skill base, and hence the quality of their labour force. However, the rate of increase has slowed in the US in the ICT producing sectors, that are the most intensive users of university graduates. In the EU-4, the slowdown in labour quality growth has occurred primarily in non-ICT industries. This may be influenced by active labour market policies to reduce unemployment and increase the employment rate, inducing relatively low skilled workers back into the labour force.

Total Factor Productivity

- Total factor productivity is defined as the change in output after taking account of growth in physical capital and changes in the quantity and quality of labour input. In many respects the TFP estimates mirror the results for labour productivity with accelerated growth in recent years confined to the US.

- The estimates confirm the now widely accepted proposition that the US TFP growth acceleration occurred in ICT using as well as ICT producing sectors. But the results also suggest an acceleration in TFP growth in ICT using sectors in the EU-4 although at much lower rates than in the US. Thus the labour productivity slowdown among ICT users in these four EU countries combined was largely due to a reduction in ICT capital deepening.

- These observations raise the possibility that, at least in the US, ICT has an impact on TFP above that due to ICT capital deepening.

Firm Level Analysis

- In addition to presenting results by industry, one chapter of this report is devoted to an analysis of productivity change at the company level providing complementary evidence to the industry results discussed above.

- An econometric analysis suggests that returns to R&D are positive and significant in the US, and in the three largest EU countries combined (France, Germany and the UK) but not in the EU as a whole.

- The analysis also suggests positive returns to R&D in firms located in service industries post 1995 in both the US and the EU.

- The results indicate that small and intermediate size companies, employing less than 250 and between 250-1000 employees, respectively, enjoyed higher productivity growth than the larger ones. However, returns to R&D investment in both the EU and the US were highest in the largest companies, especially in the manufacturing sector.

- This chapter in addition reviews the literature on firm dynamics and concludes that, compared to the EU, entry of new firms is easier in the US and there is stronger growth of surviving firms after entry.

Results: Manufacturing productivity levels and unit labour costs

- The report also compares labour productivity levels in manufacturing in the EU relative to the US. This shows considerably lower EU levels in ICT producing sectors. Similarly calculations of unit labour costs show the EU at a competitive disadvantage relative to the US in these sectors.

- In contrast EU unit labour costs, averaged across the years 1999 to 2001, were lower than in the US across a wide range of traditional manufacturing industries.

- But comparisons with the US are less relevant here, since both the EU and US are likely to have high unit labour costs relative to their main competitors in developing countries and Central and Eastern Europe.

Policy Implications

- Chapter VI of the report outlines the main forces driving EU productivity growth and their policy implications. In general it stresses that public policy interventions are likely to involve costs as well as benefits in productivity terms, and that there is no easy cure to correct the EU's productivity problem.

- On balance the report suggests that policies to strengthen product market competition may be worthwhile in some industries, in particular in services. While recognising that intensification of product market competition may sometimes also have a negative impact on incentives to innovate, the weight of empirical evidence appears to favour an emphasis on continued deregulation.

- In contrast to product markets, there is less consensus on the productivity growth impact of deregulating labour markets. Here the trade off is between static gains in efficiency and the more dynamic implications for investment in human capital. If labour market deregulation undermines incentives for individuals to accumulate human capital or for firms to engage in on the job training, then this could have a negative impact on long run growth.

- Raising employment has long been on the agenda of EU policy. But increased employment of low-skilled labour may have negative consequences for labour productivity growth at least in the short run. The potential conflict between employment and productivity objectives can be ameliorated if simultaneous efforts are made to upgrade the skills of new entrants and re-entrants to the labour force, in particular in the light of new opportunities for innovation in technology using industries.

- Finally there are strong arguments in favour of providing general support to build up the EU knowledge base, for example, through programmes which promote two-way knowledge transfer between enterprises and academic 'science base' institutions and encourage enterprises to build up collaborative R&D networks in conjunction with supply-chain partners and with universities and research institutes. There should also be stronger emphasis on activities that support innovation in service industries. But the high degree of institutional variation among EU member-states suggests that policies aimed at promoting knowledge transfer and fostering innovation should also try to build on accumulated institutional strengths within individual EU countries.

Report overview

This report consists of a summary chapter, five chapters making up the main body of the analysis and a chapter describing sources and methods for the underlying industry results. *Chapter I, Productivity Performance Overview*, begins with a discussion of the overall productivity picture comparing the EU with the US. Following a brief overview of the important features of the databases and a discussion of some additional measurement issues, the chapter summarises the main findings from the study and the policy implications.

Detailed analyses are presented in chapters II-V, which together form the main analytical part of this report. *Chapter II, Industry Structure and Taxonomies,* describes industry structure in the EU and US. Industry structure is first described in terms of the size distribution of firms and levels of capital per hour worked, followed by industry clustering procedures. Industry taxonomies are created based on common structural features of industries, such as their intensity of use of information technology inputs or skilled workers and on the channels through which innovations occur. *Chapter III, Productivity and Competitiveness in the EU and the US,* presents the main results on industry productivity performance. It starts with estimates of output per hour worked, extends to measures that additionally take account of capital inputs and labour quality and finally to an examination of relative productivity levels and unit labour costs in manufacturing. *Chapter IV, Structural and Cyclical Performance,* examines the argument that cyclical developments affect the comparability of EU-US comparisons, by decomposing labour productivity growth into trend and cyclical components in order to separate the short run impacts from long run trends in productivity growth rates. This chapter also considers the link between inventories and information technology. The industry analyses in Chapters II-IV are supplemented by additional analysis at a more micro level in *Chapter V, Productivity Performance at the Company Level.* This chapter employs company accounts data which allows estimation of the direct effect of R&D on performance at the firm level. For completeness, Chapter V also includes a summary of the literature on firm dynamics, i.e. the process by which entry, exit and growth increases productivity growth.

Chapter VI, The Policy Framework: Does the EU need a Productivity Agenda, begins with a discussion of theoretical perspectives that can be employed to understand the policy implications of the results in the analytical chapters. This is followed by a discussion of the main policy recommendations that are frequently put forward to cure the EU's productivity problem. Finally, *Chapter VII: Data Sources and Methodology,* describes in greater detail the construction of the industry databases.

Chapter I:

Productivity Performance Overview

Mary O'Mahony and Bart van Ark

I.1 Introduction

Since the mid 1990s the average growth rates of real GDP, labour productivity and total factor productivity in the European Union have fallen behind those in the United States. What makes this remarkable is that this is the first time since World War II that these performance measures have shown lower growth rates for the EU for several years in a row. The recent economic slowdown in the US and the EU has not changed this development. As a result the labour productivity gap in the EU relative to the US has widened by 2 percentage points, from 96 per cent of the US level in 1995 to 94 per cent in 2000, and by another 2 percentage points to 92 of the US level in 2002 (GGDC/TCB estimates).[1]

At the same time there is considerable diversity both in terms of growth performance as well as comparative levels between European countries. Comparative growth rates of labour productivity between 1995 and 2002 differ between –0.3 per cent (for Spain) and 5.0 per cent (for Ireland). And there is a variation of plus 17 percentage points (for Belgium) and minus 38 per cent (for Portugal) around the average EU labour productivity level relative to the US in 2002.

The main aim of this report is to show that the growth slowdown in the EU and the widening of the productivity gaps relative to the US since the mid 1990s cannot be fully understood without adopting an industry perspective to output, input and productivity performance. Thus there is a need to go beneath these aggregate numbers to ascertain to what extent variations across countries are largely explained by industry structure. In addition it considers whether these features are common to all or just a subset of EU countries.

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1 Estimates produced by the Groningen Growth and Development Centre/The Conference Board – available from *http://www.eco.rug.nl/ggdc/homeggdc.html* – see McGuckin and van Ark (2003) for details. Note an alternative estimate of relative levels of output per hour worked, produced by Eurostat, shows a wider gap with the EU reaching only 87% of US levels in 2002, *http://europa.eu.int/comm/eurostat*. Differences between these sources largely reflect methodological differences in measuring US labour input – see European Commission (2003) for details.

This report argues that the European slowdown in growth is a reflection of an adjustment process towards a new industrial structure, which has developed more slowly in the EU than in the US. Rapid diffusion of new technology will facilitate the adjustment process in the future. However, an institutional environment that slows down change may hold up the structural adjustment process in Europe and inhibit the reallocation of resources to their most productive uses.

This chapter begins with an overview of the productivity picture comparing the EU with the US for the total economy. This is followed by a brief discussion of the databases employed in this report, the performance measures used and measurement issues. Section 4 summarises the main findings from the main analytical chapters, II-V, covering industry structure and productivity performance, cyclical influences and analysis at the firm level. Concluding observations are given in section 5, largely summarising the discussion in chapter VI on policy implications.

I.2 An overview of EU-US productivity differentials

Table I.1 shows the aggregate developments of output, employment and productivity growth in the US, EU and Japan, as well as the growth rates for individual EU countries. Comparing the EU with Japan and the US, the table shows that during the 1980s, real GDP growth was fastest at 4.0 per cent per year on average in Japan, followed by 3.2 per cent in the US. Growth was slowest in the EU at only 2.4 per cent. During the early 1990s GDP growth slowed in all three regions, but both the US and the EU saw a substantial recovery during the second half of the 1990s.[2] However, the recovery was much faster in the US than in the EU. More importantly, the US recovery was accompanied by a large upswing in labour input and productivity growth. In contrast, the EU realised a substantial expansion in labour input but productivity growth slowed down to a rate that was substantially lower than that achieved during the 1980s.

These growth rates can also be seen in conjunction with estimates of the distance between countries in levels of GDP, labour productivity and employment rates; these levels estimates are shown in Table I.2 for 1980, 1990, 1995 and 2002. Starting from a higher level in 1980, and continuing through to the early 1990s, the EU GDP level fell below that of the US in the second half of the 1990s. Moreover the labour productivity gap between the EU and the US also widened at this time. This has been the first time since World War II that the productivity level in the EU did not converge to the US level for a sustained period. Table 1.2 also shows that the ratio of employment to total population improved in the EU, but it has not reached the levels in the US. Hence despite relatively high labour productivity levels, in

[2] In contrast, the Japanese economy entered a period of very slow growth, a decline in labour input, and a cost-reducing productivity growth track.

some European countries, per capita income levels are lower due to lower labour intensity levels in the EU (McGuckin and van Ark, 2003).

Table 1.1:

Aggregate annual growth rates of real GDP, total hours and labour productivity, 1980-2002

	real gdp				total hours				gdp/hour			
	1980 -90	1990 -95	1995 -00	2000 -02	1980 -90	1990 -95	1995 -00	2000 -02	1980 -90	1990 -95	1995 -00	2000 -02
Austria	2.3	2.0	2.8	0.9	0.6	0.3	-0.5	0.1	1.7	1.8	3.2	0.8
Belgium	1.9	1.6	2.7	0.7	-0.4	-0.7	0.0	1.4	2.3	2.3	2.8	-0.7
Denmark	2.0	2.0	2.7	1.5	0.1	-0.4	1.1	0.0	1.9	2.4	1.6	1.5
Finland	3.1	-0.7	4.8	1.1	0.1	-3.4	1.9	-0.2	3.0	2.8	2.9	1.4
France	2.3	1.1	2.7	1.4	-0.6	-0.4	1.4	-0.2	2.9	1.4	1.3	1.7
Germany	2.2	2.0	1.8	0.4	-0.3	-1.9	-0.3	-0.9	2.5	4.0	2.2	1.3
Greece	1.6	1.2	3.4	4.0	0.6	0.7	0.6	-0.2	1.0	0.6	2.8	4.2
Ireland	3.6	4.7	9.8	4.7	-0.4	1.1	3.9	1.4	4.1	3.6	5.7	3.2
Italy	2.2	1.3	1.9	1.1	0.3	-1.0	1.0	1.2	2.0	2.3	1.0	-0.1
Netherlands	2.2	2.1	3.7	0.7	0.2	0.7	3.1	0.4	1.9	1.4	0.6	0.3
Portugal	3.2	1.7	3.9	1.0	1.4	-1.8	0.8	1.0	1.7	3.5	3.1	0.1
Spain	2.9	1.5	3.8	2.2	-0.1	-0.7	4.2	2.6	3.0	2.3	-0.3	-0.4
Sweden	2.0	0.7	3.3	1.5	0.9	-1.3	1.0	-0.5	1.1	2.0	2.2	2.0
United Kingdom	2.6	1.8	2.9	1.7	0.5	-1.2	1.0	0.7	2.2	3.0	1.8	1.1
European Union	2.4	1.6	2.7	1.3	0.1	-1.0	1.1	0.4	2.3	2.6	1.5	0.8
United States	3.2	2.4	4.0	1.3	1.7	1.2	2.0	-0.4	1.4	1.1	2.0	1.7
Japan	4.0	1.4	1.4	-0.7	1.0	-0.4	-0.9	-0.9	3.0	1.8	2.3	0.2

Note: Germany 1980-90 refers to West Germany only; EU 1980-90 excludes Eastern Laender of Germany, the European Union excludes Luxembourg.

Source: GGDC/*The Conference Board*, Total Economy Database (June 2003)

An important question that arises is whether one can speak of a structural break in either US or EU output and productivity growth since 1995. Although it is too early to answer this question in a definitive way, many observers believe that the US has experienced a structural break leading to somewhat faster productivity growth, which may continue into the first decade of the 21st century. For example, Jorgenson, Ho and Stiroh (2003) develop a supply-side model which shows that although US labour productivity growth over the next decade is likely to be somewhat slower than the 2 per cent annual growth between 1995-2000, at 1.8 per cent (their base projection), it would still be up to 0.5 percentage point higher than US productivity growth before 1995.[3]

[3] It should be stressed, however, that Jorgenson et al. (2003) leave a wide margin of uncertainty of +0.5 to –0.6 percentage points in their labour productivity growth projections.

Table 1.2:

GDP share, employment/population ratio and GDP per hour worked as % of the US, 1980-2002.

	GDP as % of US GDP					**Employment/population rattios**					**GDP per hour worked as % of US**				
	1980	1990	1995	2000	2002	1980	1990	1995	2000	2002	1980	1990	1995	2000	2002
Austria	2.7	2.4	2.4	2.3	2.2	0.407	0.441	0.463	0.461	0.460	90.0	91.9	94.8	100.9	99.0
Belgium	3.5	3.0	2.9	2.7	2.7	0.371	0.374	0.366	0.384	0.386	95.2	103.5	109.8	114.1	108.8
Denmark	1.9	1.7	1.7	1.6	1.6	0.482	0.513	0.491	0.504	0.503	90.2	94.3	100.4	98.5	98.1
Finland	1.5	1.5	1.3	1.3	1.3	0.485	0.493	0.403	0.450	0.455	67.2	78.2	84.8	88.7	88.0
France	18.7	17.2	16.2	15.1	15.1	0.398	0.389	0.378	0.399	0.405	93.7	108.3	109.9	106.2	106.1
Germany	24.3	24.7	24.3	21.8	21.4	0.440	0.470	0.438	0.445	0.442	96.2	89.2	102.5	103.4	102.5
Greece	2.2	1.9	1.8	1.7	1.8	0.348	0.366	0.366	0.374	0.369	59.8	57.5	56.0	58.3	61.2
Ireland	0.7	0.8	0.9	1.1	1.2	0.335	0.328	0.353	0.439	0.447	58.2	75.1	84.6	101.2	104.2
Italy	19.2	17.4	16.5	14.9	14.8	0.379	0.399	0.384	0.400	0.411	94.6	99.4	105.3	100.3	96.8
Netherlands	5.2	4.7	4.6	4.5	4.5	0.390	0.419	0.435	0.497	0.507	108.3	113.7	115.2	107.6	104.5
Portugal	1.9	1.9	1.9	1.8	1.8	0.403	0.471	0.444	0.488	0.495	46.2	47.3	53.2	56.1	54.3
Spain	8.9	8.7	8.3	8.2	8.4	0.314	0.331	0.318	0.387	0.408	68.8	79.8	84.4	75.4	72.3
Sweden	3.0	2.7	2.4	2.3	2.4	0.508	0.527	0.459	0.478	0.486	85.3	82.1	85.5	86.7	87.1
United Kingdom	17.3	16.3	15.8	15.0	15.1	0.438	0.465	0.437	0.455	0.459	72.4	77.7	85.2	84.6	83.5
European Union	111.0	104.9	100.9	94.5	94.3	0.402	0.423	0.404	0.428	0.434	84.9	88.9	95.7	93.7	92.1
United States	100.0	100.0	100.0	100.0	100.0	0.436	0.475	0.475	0.489	0.478	100.0	100.0	100.0	100.0	100.0
Japan	37.4	40.3	38.4	33.8	32.5	0.474	0.506	0.514	0.508	0.497	61.4	71.3	73.6	74.9	72.7

The numbers in the above tables suggest that the EU might have entered onto a low productivity growth track. In contrast to the US position, however, there is as yet less evidence that this productivity slowdown is of a structural nature. Firstly, it should be noted that the productivity growth rates experienced in recent years in the EU are no less than those in the US in the 1980s and so recent experience may largely be driven by the end of catch-up growth, before any benefits from the new technology were manifest. Many EU countries are still in the midst of an adjustment process towards a new arrangement of their economies, with less emphasis on capital intensive manufacturing, and a greater emphasis on technology use and diffusion in services. Secondly, there is still a much greater potential in terms of underutilised resources to be employed in the EU. This latter view is consistent with the notion that the EU is merely lagging the US in the adoption of new technology and that the EU will see the benefits within the next decade. The key issue for the EU is whether these resources can be mobilised in a productive way. In the meantime productivity gains in the frontier economy, the US, will start to show diminishing returns so that the EU could eventually catch up to US levels, as it came close to doing in the early 1990s.

The question, however, is whether the European Union is best placed to resume the catching-up process. Among other things this may require a new role for markets relative to the state. There is strong evidence of continued structural change in the US economy since the 1970s. The oil crises of the 1970s seriously hit the energy-intensive US economy leading to important changes in energy use. During the 1980s there was serious concern about the deindustrialization of the US economy, as appears from various publications on this topic at the time (e.g. Dertouzos, Lester and Solow, 1989). Partly under the influence of Japanese investment and partly due to a first-mover advantage in ICT, the manufacturing sector in the US regained its competitive edge during the 1990s. At the same time service sector growth in the US took off and this is also likely to be linked to increased use of ICT (Stiroh, 2002; O'Mahony and Vecchi, 2003).

These developments did not entirely pass the EU by, but their impact on speeding up growth has been less than in the US for various reasons. Firstly, some EU countries (e.g, Germany) developed institutional and innovation systems focused on technology diffusion, which have been very effective during the catch-up phase. Others, in particular France and the UK, have aimed to compete head-on with US high technology industries (Ergas, 1987; Crafts and Toniolo, 1996). As the most advanced European countries were approaching the US productivity level, the benefits of technology borrowing got gradually exhausted. The joint process of European economic integration and more intensive global capital flows (including foreign direct investment) required these countries to find new ways to increase efficiency and develop new markets domestically and internationally. At the same time, lower income countries in the EU (e.g. Finland, Ireland, and to a lesser extent Spain and Portugal) have continued to benefit from their catch-up potential, but the realisation of that potential has been very much dependent on their specific initial conditions.

In their search for new economic arrangements, most EU countries face a backlog compared to the US in terms of investment in ICT (see the results in chapter III and van

Ark et al. 2002; Timmer et al. 2003). The latter studies show that the contributions from ICT investments to labour productivity growth in the EU were much lower than those in the US in both halves of the 1990s. An interesting finding from those and previous studies of the impact of ICT in EU countries (Oulton, 2001, Colecchia and Schreyer, 2001, Cette et al., 2002) is that the growth of ICT capital services was as high in the EU as in the US in the 1990s. The main driving force behind the lower EU contribution was its considerably lower shares of ICT in the value of output, reflecting the later start in adopting the new technology.

Two important considerations are the impacts of labour force skills and organisational change and their links with new technology. A large academic literature emerged in the early 1990s focusing on the idea that technology was inherently skill biased (Berman, Bound and Griliches, 1994) and this bias was linked to the use of information technology (e.g. Autor, Katz and Krueger, 1998).[4] Much of the evidence stemmed from the rise in wage inequality in the US. However the growth in wage premiums for highly skilled workers has diminished in the US in recent years at a time when ICT use has increased in importance. This might suggest that the use of highly skilled labour has been more important for initial adoption rather than continued use of the new technology. There is some evidence that a similar increase in demand for highly skilled labour is now emerging in Europe (O'Mahony, Robinson and Vecchi, 2003), consistent with the general picture of the EU lagging the US in information technology adoption. The issue for the EU is whether it has sufficient stocks of the required skilled labour and/or the flexibility to develop the necessary skills. For example Jacobebbinghaus and Zwick (2002) show that the share of employees qualified through the German dual apprenticeship system is lower in establishments that make intensive use of information technology which may be due to limited coverage of ICT-related skills by the apprenticeship system.

The need to combine investments in new technology inputs with organisational changes to reap the benefits from information technology is an issue at the forefront of research. Organisational changes can take various forms including new work practices (such as human resource management practices, teamwork, flexible work, job rotation etc.) or new business/management practices (total quality management, enterprise resource planning systems, supply chain management systems, customer relationship management etc.). Recent evidence that ICT investments have produced or fostered important organizational changes within firms and that such changes have had an important impact on productivity performance are provided in Brynjofsson and Hitt (1996), (2000) and Black and Lynch (2000), (2001). In a model presented in Basu et al. (2003), initial stages of adoption require investment in unmeasured complementary capital (learning, organisational changes) that may initially lead to disruption and hence lower measured total factor productivity. In this scenario there will be long lags between the time investment in ICT occurs and benefits appearing in the productivity figures.

[4] An overview of theoretical models can be found in Acemoglu (2002) and of empirical evidence in Chennells and van Reenen (1999).

Some studies on organisational changes in European firms have made clear that new forms of work-organisation represent an underutilised resource in Europe (NUTEK, 1999; Totterdill et al., 2002). As with all technological changes, convergence to the technological leader is not automatic but rather depends on the institutional environment in which firms operate. It is likely that there is some link between firm's capacity or willingness to instigate organisational changes and the competitive/regulatory environment in which they operate. A less flexible environment in the EU may then inhibit the necessary changes. In addition the EU may not have the appropriate skill mix required to implement the new technology and so lags in reaping the productivity benefits may be longer in the EU than those experienced earlier in the US. These issues are discussed further below in this and subsequent chapters.

I.3 Performance measures and measurement issues

I.3.1 Why adopt an industry perspective?

The focus of this report on industry performance of output and productivity is important for a number of reasons. Firstly, it is important to pinpoint in which industries the US is achieving superior performance in order to clarify whether the US productivity acceleration is just confined to a few sectors or is more generally widespread. Gordon (2000) suggested TFP growth was confined to ICT producing sectors whereas McKinsey (2002) emphasised the important contributions of a small number of service sectors, wholesale and retail trade and financial securities. Similarly it is useful to compare EU to US performance at the industry level, as an aid in understanding the sources of the divergent performance of these two regions in recent years. For example, it is useful to know if EU productivity growth rates have improved in those industries where the US has also shown an acceleration, with the poor EU performance attributable elsewhere. Alternatively, it might be that the EU fails to match the US in its best performing sectors. Or, if the picture that emerges involves an element of both explanations, then there is need to quantify the importance of each.

Secondly, an industry analysis can aid the understanding of forces underlying competitiveness. Under the influence from both intra-EU economic integration and the on-going globalization of product markets and factor markets, the EU industry structure is under continuous pressure from competitive forces, and traditional protection mechanisms are less and less effective. As a result, firms in 'old' industries are under continuous strain to adjust or disappear altogether, whereas firms in 'new' industries face an uphill struggle to enter new markets and develop capabilities to face off competitive pressures of incumbents or other new entrants.

Finally, the upsurge of opportunities for new technological applications may have very different implications for industries. Indeed the absorptive capacity for ICT differs greatly across industries, and has very different impacts on output, employment and productivity performance. For example, in most manufacturing industries ICT has largely contributed to rationalising the production processes, raising productivity through the use of less inputs, in particular unskilled labour. In many service industries, the introduction of ICT has had, in addition, an impact on 'product' innovation, in turn implying increased use of high technology inputs. Indeed, some service industries (in particular finance and part of business services) are among the most intensive users of ICT in the economy. The impact of ICT on the composition of labour in services is twofold. On the one hand, the rationalisation of processes and the introduction of more knowledge-intensive services have strengthened the skill-bias of service innovation in favour of very highly skilled workers. On the other hand, adaptations to information technology since its introduction may also have facilitated the increased use of labour with lower skill levels. An industry analysis aids in understanding this process of input use and technology adoption.

1.3.2 The industry databases

For the purpose of this study, a unique database, the *Industry Labour Productivity Database*, has been developed. It provides industry detail on output, labour input and labour productivity for all 15 EU member states and the United States at the level of 56 industries for 1979 to 2001. For most variables and countries, data are built up from the OECD STructural ANalysis (STAN) database, which in turn is largely based on the national accounts of individual OECD member states. However, in particular to achieve a greater degree of industry detail, STAN data is complemented, updated and backdated and further disaggregated by the use of industry statistics and more detailed information from the countries' own national accounts data. In addition, to achieve international consistency, US deflators were employed to obtain real output series in manufacturing sectors producing information and communications technology (ICT) equipment, and a common weighting system (Törnqvist weighting) based on value added shares is used to obtain aggregate series.

Below the measures employed in this database to assess relative performance are described and a summary of the major measurement issues is provided. Further details are provided in Chapter VII, *Data sources and methodology*.

Much of the analysis in this report concentrates on labour productivity defined as output per hour worked. Although only a partial measure of productivity, labour productivity has the advantage that it is readily transparent, relies less on methodological assumptions than other measures and is the measure most associated with increases in standards of living. There is also the practical consideration that it is possible to derive data on labour productivity covering a span of two decades for all EU countries.

Nevertheless labour productivity will be influenced by the use of other factor inputs and the types of inputs used. Hence the report also presents estimates for a subset of countries, namely France, Germany, the Netherlands, the UK, and the US of the measure preferred by many economists, total factor productivity (TFP). This is termed the *Industry growth accounting database for the European Union and the US.* This adjusts output growth not only for the growth in hours worked but also for the quality of those hours, defined in terms of labour force skills and physical capital input. The latter distinguishes two types, information and communication technology (ICT) capital assets and more traditional assets. Construction of TFP estimates uses the method of growth accounting, weighting factor inputs by their shares in the value of output. Further details on this method are provided in Chapter III, *Productivity and Competitiveness in the EU and the US* and in Chapter VII. Data limitations dictate that the growth accounting method can only be applied to a few countries and a smaller number of industry groups than is the case for labour productivity.

Finally in the sector most exposed to international competition, manufacturing, the report also presents estimates of unit labour costs, in the EU relative to the US measured as labour compensation per hour worked relative to labour productivity. This necessitates the consideration of cross country differences in labour productivity levels, which is a more difficult exercise than estimating growth rates across time.

The remainder of this section briefly considers general measurement issues. In recent years there have been increasing concerns about whether the macroeconomic statistics correctly trace output, employment and productivity changes in the knowledge economy. Most famous is of course the Solow quip that 'you can see computers everywhere, except in the statistics' (Solow, 1987). Griliches (1994) divided the US economy into 'measurable' sectors (agriculture, mining, manufacturing, transport and communication, and public utilities) and 'unmeasurable' sectors (like construction, trade, the financial sector, 'other' market services and government). There is likely to have been an increase in the importance of measurement error at the aggregate level due to a shift in activity towards the unmeasurable sectors of the economy. In addition there may be an increase in measurement problems in the 'unmeasurable' sector itself and this may, at least in part, be related to the increased use of ICT (van Ark, 2000, 2002).

The main issues in the measurable sector relate to measuring ICT output in constant prices. It is well known that the capabilities of semiconductors and computers have improved tremendously over the past few decades.[5] Since consumers essentially have been paying the same nominal price for computers with vastly more computing power, the price of computing power has declined continuously. However, traditional methods of sampling and calculating price indices for these goods will almost certainly underestimate the rate of price decline and through that, the rate of productivity growth. At present there are only a few countries, like the US and Canada that have an adequate system in place for measuring prices of computers and semiconductors. This means that measured productivity growth in all other countries is likely to be biased downwards. The *Industry Labour Productivity Database* avoids this problem by applying the detailed US

[5] See Nordhaus (2001) for a long-term perspective on the increase in computing power.

deflators for the computer and electronic industries (NACE 30-33) to all other countries after making a correction for the general inflation level[6]. While the impact of these adjustments can be significant for the above industries, the differences for aggregate manufacturing and for the total economy are generally small.

In contrast to manufacturing, measurement problems in the service sector are perhaps easier to deal with for inputs than for output. The most important technological inputs in the service sector are ICT products, which give rise to the same measurement issues as for ICT output. The share of computers and other high tech equipment in market services has strongly increased in most OECD countries. The distribution of ICT capital is also highly unequal. In measuring TFP the data therefore take account of appropriate quality-adjusted deflators for ICT capital.

The largest measurement problems, however, relate to the measurement of output in the service sector. In particular, changes in the quality of services are difficult to incorporate. The increased importance of ICT may have accelerated quality changes in services. For example, improved inventory management in the distributive trades sector makes it possible to differentiate the supply of goods in terms of time, place and type of product. The application of ICT has supported the customisation of financial products or combinations of products. Measurement problems in sectors loosely termed non-market services (public administration, health and education) are particularly acute, with outputs frequently measured by inputs, and little by way of international consensus on what should be done. Services such as healthcare, are also increasingly characterised by diversity and differentiation in time, place and type of treatment. Even though such changes have not exclusively led to upward adjustments of real output, on balance the bias is probably towards an understatement of the growth in real service output (Triplett and Bosworth, 2000). There is no easy way to resolve these issues without re-estimation by the national statistical offices so the results presented below need to be seen against this background of measurement uncertainty.

Additional problems in constructing internationally consistent databases relate to the method of aggregation. Many countries at present still use fixed-weight (Laspeyres) indices to calculate aggregate value added at constant prices. This can lead to serious substitution bias if the structure of the economy is changing over time. To correct for this problem, chain-weighted indices have been adopted in the national accounts of some countries (e.g., Denmark, France, the Netherlands), but not all. All three databases in this report employ Törnqvist indices in aggregation.

Although the adjustments reported above lead to greater consistency of the series across countries, it also means that the estimates for the total economy in this report will gener-

[6] These deflators had to be specifically constructed because implicit value added deflators are not available from the US National Income and Product Accounts at the requisite detail. The inflation level is measured here as the change in the deflator of all industries except the ICT-producing manufacturing industries. This procedure is similar to that in Schreyer (2000, 2002).

ally not conform to those from national statistical offices. Table 1.3 compares the aggregate economy wide estimates of output per hour, derived from the *Industry Labour Productivity Database*, using US hedonic deflators for ICT and Törnqvist aggregation, with the official national accounts based estimates shown in Table 1.1 above. First comparing the results for the total economy in the US and the EU, significant differences between the two sets of estimates only emerge in the final period. The industry-based growth rates during this period are mostly higher than the growth rates from the national accounts, although underlying this there are a few individual EU member states (Belgium, Austria and Finland) where the national accounts estimates are higher by a small amount. The use of US linked deflators in the ICT producing manufacturing sectors (NACE 30-33) should lead to an upward revision, whereas the use of the Törnqvist aggregation index can lead to an adjustment either way, depending on each economy's changes in industrial structure. In addition employment sources at the industry level are not always consistent with those employed in Table 1.1. The most notable, and well known case is the US where two inconsistent series produced by the Bureau of Labour Statistics and the Bureau of Economic Analysis, are available at the aggregate level. The choice of data source was dictated by the availability of data at the industry level. It goes beyond the scope of this report to discuss in any detail the intricacies of the various sources available or to discuss the advantages of using one source over another. Here it is merely noted that these differences are spread across all industries and so have no impact on the industry analysis that forms the main body of this report.

Table 1.3

Annual growth in output per hour, a comparison of aggregates, US and EU

	US			EU		
	National Accounts	Industry aggregate-Total Economy	Industry aggregate-Market Economy	National Accounts	Industry aggregate-Total Economy	Industry aggregate-Market Economy
1979-90	1.33	1.26	1.78	2.04	2.25	2.66
1990-95	1.13	1.10	1.72	2.39	2.29	2.61
1995-01	1.69	2.25	3.11	1.46	1.71	1.95

Sources: National Accounts as for Table I.1, Industry aggregates, chain linked indices derived by aggregating across 56 industries – see Chapter VII for details.

Finally in this section, it is also useful to consider the impact of excluding non-market services and dwellings on the aggregate picture. As mentioned in various parts of this report, these sectors are those where there are the most questions regarding the reliability and international comparability of output measurement. Table I.3 therefore also compares industry aggregate measures including and excluding these 'hard to measure' sectors – the latter is loosely termed the market economy. Labour productivity growth rates are generally higher in the market economy, as is to be expected since the excluded sectors frequently use inputs to measure outputs. This upward adjustment is considerably higher in the US than in the EU in all time periods. Therefore to the extent that differences across these two regions are affected by measurement problems in non-market service productivity growth, the results in this report, if anything, are likely to understate the US advantage in recent years.

I.4 A summary of the results

I.4.1 Sector results

Table I.4 presents value added shares and labour productivity growth by broad sector contrasting the EU and the US performance for three subperiods. In the 1980s and particularly in the first half of the 1990s labour productivity growth in the EU was faster than in the US in the majority of sectors. The important exception, in terms of size of the sector, in the first period is the distributive trades (including hotels and catering) and personal services and, in the early 1990s, financial services. The final period shows a reversal in the productivity growth advantage. The table shows US growth accelerating in many sectors, in particular in the distributive trades, communication services and financial services with smaller gains in manufacturing. The gain in manufacturing is entirely due to the strong acceleration of productivity growth in ICT-producing industries (see Chapter III). Of these three service sectors, distribution and financial services are quite large, and together represented about 19 per cent and 25 per cent of total economy GDP in the EU-15 and the US, respectively, in 2001 and their combined share has been growing (Table I.4a). The EU showed significant productivity gains only in communication services and financial services, with the remainder showing slower growth in the later period.

Table I.4a

Value added shares, broad sectors, EU-15 and US

	1979		2001	
	EU-15	US	EU-15	US
Agriculture, Forestry and Fishing	3.3	3.1	1.7	1.6
Mining and quarrying	1.9	2.8	0.9	1.3
Manufacturing	27.4	23.4	19.0	14.3
Electricity, gas and water supply	2.7	2.2	2.1	2.0
Construction	7.2	5.3	5.8	5.0
Distributive trades	12.9	16.3	14.0	15.6
Transport	4.3	4.0	4.4	3.1
Communications	2.3	2.9	2.7	2.4
Financial Services	4.7	4.7	5.4	9.1
Real Estate	6.7	8.7	9.9	10.5
Business Services	6.0	5.2	11.7	11.6
Other community, Social and Personal Services	3.3	2.3	4.4	2.8
Public Administration, Education and Health	17.3	19.2	17.9	20.7

Table I.4b

Annual labour productivity growth, EU-15 and US

	EU-15			US		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Total Economy	**2.2**	**2.3**	**1.7**	**1.4**	**1.1**	**2.3**
Agriculture, Forestry and Fishing	5.2	4.8	3.3	6.4	1.7	9.1
Mining and quarrying	2.9	13.1	3.5	4.4	5.1	-0.2
Manufacturing	3.4	3.5	2.3	3.4	3.6	3.8
Electricity, gas and water supply	2.7	3.6	5.7	1.1	1.8	0.1
Construction	1.6	0.8	0.7	-0.8	0.4	-0.3
Distributive trades	1.3	1.9	1.0	1.8	1.5	5.1
Transport	2.8	3.8	2.3	3.9	2.2	2.6
Communications	5.2	6.2	8.9	1.4	2.4	6.9
Financial Services	2.2	1.0	2.8	-0.7	1.7	5.2
Business Services*	0.7	0.7	0.3	0.1	0.0	0.0
Other community, Social and Personal Services	-0.3	0.4	0.3	1.2	0.9	-0.4
Public Administration, Education and Health	0.6	1.1	0.8	-0.4	-0.8	-0.6

* includes real estate

Within the EU there are large differences across countries in the fortunes of the various sectors. Full data series are provided in the CD-Rom accompanying this report. Here the main findings, focusing on the 1990s, are summarised. All EU countries with the exception of Ireland, Greece and Portugal, show either no change or a reduction in manufacturing labour productivity growth across the two halves of the 1990s. The very different relative position of the US and EU-15 in the distributive trades is mirrored at the country level. Only Greece, Ireland, Luxembourg and the Netherlands show an acceleration in labour productivity growth in this sector.

The position in the financial services sector is very different across countries. Some EU member states such as Spain, France, Ireland, Sweden and the UK improved their performance in the later period relative to the early 1990s. But other countries, such as Denmark, the Netherlands and Italy showed a marked deterioration. Similarly in business services there is wide variation in productivity growth experience across EU countries.

I.4.2 Decomposition of EU-15 labour productivity growth by country

It is also interesting to examine the contributions of various member states to the overall EU growth by multiplying each country's respective growth rates by its share in EU employment. It can be seen from Table I.5 that the major contributors to EU labour productivity growth in the 1980s are Germany, France, the UK and Italy. By the end of the 1990s, the slowdown can be seen to be chiefly the result of the decline in all of these large nations, excepting the UK. Many of the smaller EU-15 nations have seen modest reductions over this period, and a number of the Southern European nations have seen slight increases. But the fortunes of Germany and Italy in particular have had a large impact on the EU growth slowdown.

Table I.5

Contributions of member states to EU-15 annual labour productivity growth 1979-2001

	1979-1990	1990-1995	1995-2001
Total economy			
Belgium	0.08	0.09	0.03
Denmark	0.04	0.05	0.02
Germany	0.59	0.68	0.22
Greece	0.01	0.02	0.05
Spain	0.18	0.15	0.22
France	0.40	0.27	0.22
Ireland	0.02	0.04	0.10
Italy	0.27	0.36	0.18
Luxembourg	0.01	0.01	0.01
Netherlands	0.14	0.13	0.11
Austria	0.07	0.09	0.04
Portugal	0.02	0.02	0.04
Finland	0.05	-0.01	0.04
Sweden	0.06	0.03	0.06
UK	0.31	0.38	0.39
EU-15	2.26	2.31	1.72

I.4.3 Results using industry taxonomies

Underneath the sector trends in Table 1.4 lies considerable variation at the individual industry level. The main purpose of Chapter II of this report is therefore to attempt to group the 56 industries, for which labour productivity growth rates were constructed, into clusters or taxonomies based on common structural features. Four such taxonomies are included in the report. The first (the ICT taxonomy) divides industries into ICT producing, ICT using and non-ICT, with the latter two dependent on intensity of use of ICT equipment, and distinguishing manufacturing and service industries. The ICT occupational and Skills taxonomies group industries according to their intensities of use of skilled labour, with the former based on ICT specific skills and the latter based on general skills. Finally the innovation taxonomy considers the source of innovations. It distinguishes industries where innovations are largely embodied in equipment (in particular ICT) supplied outside the industry, those where innovation is based on internal R&D activity (scale intensive industries), specialised suppliers, science based industries, organisational innovators in services and service industries where innovations are largely driven by the demands of clients. The taxonomies show that the US has higher value added shares in both ICT producing sectors and ICT using services, and in industries that are more likely to use highly skilled labour. The EU has a higher share in (manufacturing) industries characterised by more traditional channels of process innovations due to internal R&D activity. This greater concentration in high technology industries can explain some of the US productivity advantage over the EU in recent years.

Chapter II also explores differences in industrial structure using two additional measures not used in the taxonomies, which are size distribution of firms and capital intensity. The first shows that smaller firms dominate in all sectors, not just services as is the popular perception. The EU tends to have a marginally greater concentration than the US of employment in very small firms, those with less than 10 employees. Looking across sectors, US employment is considerably more concentrated in larger firms in retail trade and financial and business services. In terms of capital intensity, the utilities, mining and 'heavy' manufacturing industries operate with relatively high levels of capital per hour worked. Outside manufacturing, only transport and communications have capital per hour worked ratios above that for the total economy for all countries. Capital intensity in financial and business services is, on average, about equal to that in the economy as a whole but with some variation across countries. In contrast the distributive trades including hotels and catering, personal services and non-market services operate with relatively low capital intensities.

Chapter III presents the main results at the industry level. First looking at the cross industry distribution of labour productivity growth rates, it is apparent that the US productivity acceleration, although widespread, is by no means ubiquitous. Thus 29 of the 56 individual industries show accelerating growth. Aggregate economy wide labour productivity growth is decomposed showing the contributions of each industry in the overall total, using employment shares as weights. This shows that a limited number of manufacturing industries in the ICT producing sector (computers, electronic valves and communication equipment), and the three major service industries (wholesale, retail and auxiliary financial services) account for the lions' share of the US improvement. There is also a significant, although smaller contribution to the US growth advantage from general financial services. In contrast, decelerating growth is the norm in the EU with lower growth in 1995-2001 than in 1990-95 in 45 of the 56 industries.

When grouped according to industry taxonomies, the most transparent results come from the use of the taxonomy that divides industries into ICT producing, ICT using and non-ICT industries. In ICT producing manufacturing (computers and other ICT related equipment), in both the US and EU-15, labour productivity growth rates are considerably greater than all other sectors and show a similar pattern over time with accelerated growth in the late

1990s, although at a much higher rate in the US. In contrast ICT producing service sectors (computer services and telecommunication) experienced high growth rates in the EU, outperforming the US in particular in the later period. The main differences between the US and the EU occur in ICT using service industries and non-ICT industries. In the former case, the results show a sharp acceleration in the US not matched in the EU. The deceleration in EU productivity growth, however, is largely due to industries that do not make intensive use of ICT equipment, in particular in service industries.

Dividing by skill group also yields some important insights, with the US productivity acceleration occurring in industries that intensively use the highest level skills (degrees and above) but also in those with high intensity of use of lower intermediate skills. The ICT producing sectors tend to be largely concentrated in the former but this also includes some ICT using sectors. However, some ICT using sectors, notably wholesale and retail trade, are included in the lower intermediate skill group. In contrast the EU performs best in (manufacturing) industries that intensively use highly skilled craftsmen, areas of traditional EU strength. Both regions show decelerating growth in low skill intensive sectors, in particular, in those low skill intensive industries also classified as non-ICT. These industries are those most affected by product cycle influences that intensify competition from countries outside the two regions, mainly developing nations.

The innovation taxonomy results show that the specialised supplier industries (ICT producing), supplier dominated services (in particular retail trade) and client led industries (in particular wholesale trade) had the familiar pattern of accelerating US labour productivity growth simultaneously with unchanged or declining EU growth. The EU outperformed the US in all other goods-producing industry groups, including traditional (manufacturing) industries, scale intensive industries that are characterised by process innovations based on internal R&D, and even in the science based innovation group.

1.4.4 Growth accounting results

The analysis in this section is confined to comparing the US with four EU countries, France, Germany, the Netherlands and the UK. The industry growth accounting results show ICT investments growing over time almost everywhere in both the US and the EU-4, but their contribution in the EU is generally smaller. ICT capital in the EU in the latest period has become more important than traditional capital in explaining labour productivity growth in the majority of industries, a result that was true for the US also in the 1980s. This has been due not only to increasing ICT shares but also because of a pronounced fall in the rate of growth of non-ICT capital deepening in the EU from the mid 1990s. This in turn is, at least partly, influenced by standard input substitution following a sustained period of real wage moderation in the EU.

Changes in labour quality make a small but significant contribution to labour productivity growth in all time periods. However, it is much more important in the US in the 1980s than in the second half of the 1990s. The higher US labour quality increases in the period

1979 to 1990 are most apparent in the main ICT producing and ICT using sectors, consistent with the notion that ICT requires a large input of skilled labour in adopting this new technology. The US uses higher proportions of university graduates in its workforce. In the 1990s both the US and EU-4 show greater increases in the proportion of graduates in the workforce in ICT producing and ICT using sectors than in non-ICT industries. The greater use of university educated labour is proceeding faster in the EU countries than in the US but there remains a large US advantage.

When labour productivity growth is adjusted for increases in the use of physical capital per worker and higher quality labour, the result is estimates of residual or total factor productivity growth. In its purest form TFP can be interpreted as costless increases in output. However, in practice TFP is also affected by measurement errors and deviations from the perfect market assumptions underlying growth accounting calculations. The results for TFP broadly mirror those for labour productivity with greater acceleration in the US in high technology sectors. This suggests that, to the extent that investing in ICT creates TFP spillovers, the US has been better at realising these gains than the larger EU countries.

I.4.5 Productivity and competitiveness in manufacturing.

Chapter III of the report ends with an examination of productivity levels and unit labour costs in manufacturing, which is the sector most exposed to international competition. It shows aggregate manufacturing productivity levels in the EU in 2001 lower relative to the US than they were in 1979. However this US dominance is concentrated in a few sectors, namely ICT producers, chemicals and transport equipment. Aggregate manufacturing unit labour costs in the EU are currently below those in the US but this again hides considerable diversity at the industry level. The EU is considerably less competitive than the US in the manufacture of high technology equipment. In many traditional manufacturing industries, however, the EU is now competitive relative to the US, reflecting both greater wage moderation in the late 1990s, less pronounced declines in labour productivity levels and a relatively favourable exchange rate between the EU currencies and the US dollar during the late 1990s. But comparisons with the US are less relevant here, since both the EU and US are likely to have high unit labour costs relative to their main competitors in developing countries.

I.4.6 Cyclical influences on productivity growth

Chapter IV examines the argument that cyclical developments affect the comparability of EU-US comparisons. Productivity growth is decomposed into trend and its cyclical components, to separate the short run impacts from long run trends. Using appropriate filtering techniques, it was found that the cyclical effects are generally small, except in the final year, 2000-2001. Thus the apparent trend breaks in the US and EU in the mid 1990s still hold when allowance is made for cyclical factors. In particular the results using the

ICT taxonomy are unchanged. The analysis also considers the behaviour of inventories in the US. This reveals that there has been a considerable change in the inventory/sales ratio, which has declined over time. The results support the idea that the inventory to sales ratio declines in industries with higher ICT intensity, consistent with the idea that an important ICT benefit is its support for just in time inventory control.

I.4.7 Results at the firm level

Chapter V contains a firm level analysis of productivity differences. The main analysis is based on data from company accounts. One important function of this chapter is to consider the direct effect of R&D on performance at the firm level. Predictably, simple averages across firms show that positive R&D expenditure improves company performance overall. This is largely confirmed by a more sophisticated econometric analysis of the relationship between R&D and productivity growth. But the results indicate that returns to R&D expenditure are higher in the US than in the EU overall. In fact when data for the EU-15 are combined, the results show that the returns to R&D are not significant in either manufacturing or services. Nevertheless returns to R&D are found to be positive and significant when the EU sample includes only the three largest EU countries, France, Germany and the UK. When account is taken of the possible existence of a structural break in 1995, however, both the EU-15 and US regressions show increases in the returns to R&D in the service sector. This could be a result of a more intensive use of ICT in services during the second half of the nineties. When dummy variables capturing the ICT taxonomy are included, R&D companies operating in ICT using services in the US do display higher productivity but this result does not extend to the EU.

The analysis also considers the impact of firm size on productivity growth. Simple averages suggest that productivity of small and medium sized firms are most enhanced by R&D expenditure in general. In an econometric analysis including all firms the results indicate that in general the small and intermediate companies enjoyed higher productivity gains than the large ones, while in Japan the largest companies were the best performers. However, when the sample is restricted to R&D reporting firms, R&D investment in both the EU and the US proved to be more productive in the largest companies in the manufacturing sector. Again performance in the US service sector is different than in other regions, with intermediate sized firms having higher R&D eleacticities than either small or large firms.

This chapter also reviews the literature on firm dynamics, i.e. the process by which entry and exit changes productivity growth. This literature emphasises the importance of process of firm turnover in raising productivity growth, in particular the impact of entry of high technology firms. In the most innovative industries (e.g. those that are ICT related) entry makes a strong contribution to aggregate productivity growth, while in more mature industries a higher contribution comes from either within-firm growth or the exit of obsolete firms. International comparative evidence on firm dynamics is sparse to date. Nevertheless there is some evidence that suggests that, compared to EU firms, the US presents a similar degree of turnover, smaller size and lower level of productivity of entering firms but a considerably stronger growth of surviving firms after entry. The literature suggests that the high start-up and adjustments costs in the EU, unlike the US, may hinder the creation and subsequent growth of small firms. This could be especially important in highly innovative industries such as ICT producing sectors, where new firms are likely to adopt the latest technologies.

I.5 Implications for policy

The results at both the industry and firm level highlight the importance of the earlier adoption and diffusion of information technology in the US as being at the heart of that country's superior productivity performance in recent years. Thus at the industry level, the US outperformed the EU in ICT producing and intensive ICT using sectors, whereas at the firm level the US got higher returns from R&D in firms located in service industries and in particular performed better if they were located in ICT using sectors. It is also clear from the results that the EU productivity growth advantage in manufacturing has eroded, and that the advantage has strongly moved in favour of the US in ICT producing industries. Hence manufacturing may not remain the 'power house' of the EU economy as it has been in the past. In contrast there is a strong potential to exploit productivity benefits in service industries, in particular in those that make intensive use of ICT.

Chapter VI, *The Policy framework: Does the EU need a productivity agenda?*, sets out a framework for translating these findings into policy implications. It discusses policies in terms of likely costs and benefits rather than reaching specific recommendations. Whilst recognising both the neoclassical and the evolutionary approaches to the theory of the firm, this chapter specifically considers ways in which productivity may be enhanced both by improving the operation of markets and creating an environment more conducive to innovation processes. In particular, the chapter considers the role that ICT has to play in these productivity improvements, drawing on evidence from the US experience to inform on the progress of the EU.

The chapter notes that the weaker productivity performance in the EU than in the US may be attributable in part to more restrictive institutional factors, such as the stringency of product market regulation and employment protection. But it is by no means concluded that the competitive/regulatory environment can explain all of the difference in productivity performance between the US and the EU. On balance the chapter suggests that policies to strengthen product market competition are usually worthwhile, in particular in service industries, but the arguments in favour of intervention in labour markets are weaker. It points to the trade off between static gains in efficiency and the more dynamic implications of deregulation on incentives to invest in human capital. If labour market deregulation serves to undermine incentives for individuals to accumulate human capital or firms to engage in on the job training, then this could have a negative impact on long run growth.

The chapter also suggests that there are strong arguments in favour of providing general support to build up the EU knowledge base. Examples include programmes to promote two-way knowledge transfer between enterprises and academic 'science base' institutions and to encourage enterprises to build up collaborative R&D networks in conjunction with supply-chain partners and with universities and research institutes. There should also be stronger emphasis on activities that support innovation in service industries. But the high degree of institutional variation among EU member-states suggests that policies aimed at promoting knowledge transfer and fostering innovation should also try to build on accumulated institutional strengths within individual EU countries.

Notwithstanding the main emphasis on new technology, the report also points to weaknesses in the EU in productivity growth in more traditional industries, in both manufacturing and service industries. Raising employment has long been on the agenda of EU policy. But this may have had negative consequences for labour productivity growth at least in the short run, as evidenced by the reduction in the rate of non-ICT capital deepening in a few of the larger EU countries. The potential conflict between employment and productivity objectives can be ameliorated if simultaneous efforts are made to upgrade the skills of new entrants and re-entrants to the labour force, in particular in the light of new opportunities for innovation in technology using industries.

Pinpointing the reasons why ICT adoption has not proceeded more rapidly in the EU is difficult. An extremely negative position is that the failure of the EU to reap benefits from new technology is down to the institutional structure, in particular product and labour market regulations. Without large scale and comprehensive reforms the EU will not see the kind of ICT productivity premium enjoyed in the US. A more positive position is that the EU is merely lagging the US and that earlier adoption in the US owed much to its factor endowments, in particular its relative abundance of the highly skilled labour required to adopt the new technology. EU countries instead had invested more in intermediate craft skills which were important in facilitating catch-up growth but was not so appropriate when the new technology came along. A more moderate interpretation of the findings would take elements of both extremes, suggesting EU catch-up is inevitable but the institutional environment may slow the process.

Chapter II:

Industry Structure and Taxonomies

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II.1 Introduction

The purpose of this chapter is to describe the industry structure in the EU as a whole and in individual EU countries and compare these to the US. It presents descriptive statistics covering the cross industry distribution of output and employment, the size distribution of firms within industries and capital labour ratios. It then presents a number of descriptors or taxonomies based on technology/skill/innovation propensity indicators to summarise the industry structure. First the chapter briefly describes the industry data set employed in this and subsequent chapters. Detailed descriptions of the data adjustments and methods of analysis are given in Chapter VII.

II.2 Data description

For the analysis of productivity growth in the EU and the US a unique database, the *Industry Labour Productivity Database* has been constructed, which contains information on value added, employment and hours worked in the 15 EU member states and the US for 56 separate industries between 1979 and 2001. The point of departure for most countries has been the new OECD STAN Database of national accounts. The STAN Database contains information on the most important national accounts variables from 1970 onwards on a common industrial classification.[7] However, for a number of industries STAN does not contain sufficient detail. For example, the electrical engineering sector does not distinguish between semiconductors, telecommunication equipment and radio and TV receivers. Wholesale and retail trade are aggregated in STAN as are all industries within transport services as well as those within business services. To obtain a sufficiently detailed perspective on industry performance, it was therefore necessary to supplement

[7] See *http://www1.oecd.org/dsti/sti/stat-ana/stats/new_stan.htm*. The STAN Database uses the international classification ISIC revision 3. This classification is very similar to NACE rev 1(the EU classification system), but especially in the US, much effort has to be put into reconciling differences in industrial classifications. See Chapter VII for a discussion of classification issues.

STAN with additional detail from annual production surveys, covering production industries, and services statistics, covering distribution and other market services. In addition, where necessary, more detailed national accounts were used from individual countries (e.g. in the case of Ireland). In general the method employed was to use STAN aggregates as control totals and data from alternative sources to divide these totals into sub-industries.

The data series available from STAN are value added in current and constant prices (at basic prices), numbers of persons engaged (including self-employed), number of employees, total labour compensation and, in a limited number of cases, working hours. Similar variables were available from survey statistics. These data were employed to calculate labour productivity and unit labour costs for use in Chapter III. Appendix Table II.A lists the industries and NACE codes included in this study together with value added shares in the EU and the US for 1999.[8]

II.3 Industry structure

II.3.1 Industry shares of aggregate economic activity

Chapter I discussed the shares of value added accounted for by broad sectors. Here the relative importance of industries at a more detailed level is considered. Disaggregating to the industry level results in considerable variation across countries (see also Appendix Table II.A). Correlations between employment and output shares for the 56 industries between the EU-15 and EU member states on the one hand, and the US on the other, are shown in Table II.1. Although the EU-15 has a reasonably similar cross industry distribution compared to the US in 1999, and more so than in 1979, a number of individual EU countries show patterns of industry concentration that are distinctly different from the US pattern. Thus the correlations for a number of countries are significantly lower than that for the EU-15 as a whole, in particular for some of the smaller EU member states with specific specialisation characteristics. For example, Ireland has a relatively high concentration in a few manufacturing industries. In Greece the correlation for employment in particular is very low in the earlier period. Overall, the cross industry pattern of employment and output in the EU is, however, closer now to the US than it was in 1979, which gives some indication of convergence.

Given that there are differences in industrial structure, it is useful to attempt to cluster industries into groups with common features related to technology or input use. This also facilitates the analysis of productivity growth and unit labour costs in Chapter III, since a simple description of productivity growth rates would be difficult for such a large set of industries. Therefore much of this chapter is devoted to describing how industries were

[8] At the detailed level, the pattern of cross industry value added shares is sensitive to the business cycle; hence the use of 1999 in this descriptive analysis.

Table II.1

Cross section industry structure: correlations between country or EU-15 shares and the US, 1979 and 1999

	1979		1999	
	EMP	VA	EMP	VA
EU-15	0.85	0.94	0.95	0.96
Belgium	0.92	0.77	0.89	0.77
Denmark	0.82	0.89	0.88	0.93
Germany	0.89	0.91	0.93	0.93
Greece	0.43	0.77	0.65	0.83
Spain	0.66	0.79	0.85	0.84
France	0.79	0.91	0.89	0.96
Ireland	0.66	0.51	0.88	0.52
Italy	0.75	0.81	0.89	0.93
Luxembourg	0.81	0.54	0.82	0.62
Netherlands	0.85	0.89	0.90	0.95
Austria	0.65	0.85	0.82	0.90
Portugal	0.56	0.68	0.79	0.79
Finland	0.68	0.80	0.85	0.84
Sweden	0.79	0.86	0.85	0.90
United Kingdom	0.90	0.89	0.94	0.93

EMP = Industry employment shares (hours based), VA = Industry value added shares.

Sources and methods: see Chapter VII.

grouped in a number of taxonomies. But first two additional aspects of industry structure are considered, namely size distributions of firms, which describe aspects of the markets facing firms, and capital intensities, which describe production methods.

II.3.2 The size distribution of industries

Summarising the size distribution of firms within an international context is difficult for a number of reasons. Firstly, countries have different definitions of the unit for which they present size distribution information, e.g. establishment, enterprise, or firm. Secondly, statistics also vary in the size bands published. Finally, due to concerns about disclosure, industry detail may be lacking for a number of sectors. The latter consideration is more important for smaller than larger countries and also feeds into the choice of size bands. This section provides an overview therefore of the aggregate EU-15 compared with the US.

Size distributions can be shown in terms of turnover or employment size bands. The latter is generally preferred since it is more difficult to match size bands in national currencies across countries. At the broad sector level, data are presented on the percentage of employment amongst the EU-15 by sector (Table II.2) and also for the US (Table II.3)[9]. It can be seen that there is considerable diversity of sizes of industries and firms within industries. The EU has considerably more small to medium sized enterprises (SMEs), with over one third of all employees being employed in establishments with less than 10 employees, compared with only 11.5 per cent in the US. The US is also characterised by larger firms, with over 47 per cent of all employees located in enterprises that employ more than 250 employees, compared to 34 per cent in the EU.

Considering the industrial breakdown in Tables II.2 and II.3, it can be seen that the structure of the EU-15 varies significantly from the US, although the utilities (electricity, gas and water) and transport and communications in both regions are industries for which the largest employment size bands represent a large proportion of employment. Retail trade shows very different patterns across the two tables, with the US having the majority of employees in the larger firms, whilst in the EU the majority are in the smallest size band. Overall though it is apparent that in the case of the EU-15 the smaller enterprises account for a much larger proportion of employees, than the US in most sectors.

A more detailed breakdown of employment size bands is available for the EU and the US for manufacturing. These data are presented in tables II.4 and II.5, respectively. By comparing tables II.4 and II.5, it can be seen that, in contrast to the general total economy picture, in the EU there is greater concentration of employment in the largest size band in manufacturing industries. Manufacturing industries with a high percentage of employees in large firms include chemicals, mineral oil refining, coke and nuclear fuel and transportation equipment, with more than 70 per cent of those employed in firms that employ over 250 people. In the case of the US, these industries are not so obviously concentrated, with the exception of transportation equipment that has almost 80 per cent of employees in firms with more than 250 employees. The US, in contrast to the aggregate economy picture and to the EU, has a substantial proportion of those employed located in the medium sized enterprises, employing between 50 and 249 workers.

There are a number of manufacturing industries in the EU, however, that have a substantial proportion of their workforce employed in the very smallest size band. In wood products and miscellaneous manufacturing, over a quarter of the workforce are located in firms that employ less than 10 people. Printing and publishing in the US has the most employees located in the smallest size band, with only 13 per cent. Comparatively then, the EU still has a larger proportion of small firms in manufacturing than the US.

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[9] Data from the EU are for 2001 and derived from the Eurostat's SME-database, which is primarily derived based on Structural Business Statistics. Since these sources only provide information up to 1997, trends were used to estimate distributions in more recent years; see European Commission (2002), Annex II. Data for the US were available for 1997 only. Whilst these years do not precisely correspond, these data represent long term industrial structures and so are unlikely to vary significantly over time.

Table II.2

EU-15, Percentage of employees by employment size band, all industries, 2000

Industry	**Employment size**			
	1-9	10-49	50-249	≥250
Mining	10.0	18.0	14.6	57.5
Manufacturing	15.5	20.7	19.9	43.8
Construction	49.2	27.6	12.2	11.0
Wholesale	37.1	27.9	16.5	18.5
Retail	51.6	15.8	6.1	26.5
Hotels & catering	52.5	20.4	8.4	18.7
Transportation & communications	23.0	15.0	10.2	51.8
Utilities	3.0	5.1	9.4	82.6
Finance, Insurance, Real Estate & Business Services	32.3	14.1	12.0	41.6
Health Services[10]	46.0	17.4	10.2	26.4
Other Services[11]	56.2	16.7	9.7	17.3
Total	**34.6**	**18.9**	**12.9**	**33.7**

Source: Eurostat, Observatory of European SMEs, 7th Edition.

[10] Health and social work

[11] Other community, social and personal services

Table II.3

US, Percentage of employees by employment size band, all industries, 1997

Industry	**Employment size**			
	1-9	10-49	50-249	≥250
Mining	10.6	26.1	29.3	34.0
Manufacturing	4.0	15.2	32.1	48.6
Construction	27.4	36.5	25.2	10.8
Wholesale*	13.5	27.1	59.4	-
Retail	12.6	17.6	12.6	57.2
Hotels & catering	8.3	27.0	19.6	45.1
Transport and communications[12]	6.9	14.5	14.2	64.4
Utilities	2.0	3.6	7.0	87.4
Finance, Insurance, Real Estate & Business Services	12.2	14.8	15.4	13.2
Educational Services	24.7	37.5	23.1	14.8
Health Services	9.7	13.2	17.6	59.4
Other Services[13]	24.4	28.4	19.2	27.9
Total	**11.5**	**19.0**	**22.0**	**47.5**

Notes: * The final group for this industry is >100 employees. Source: US Economic Census, 1997

[12] Communications includes 'Broadcasting and telecommunications'

[13] Includes 'Other services', (excluding public administration), 'Arts, entertainment & recreation', 'Software publishers', 'Motion picture and sound recording industries'.

Table II.4

EU-15, Percentage of employees classified to manufacturing industries in 2000, SIC 1992 by employment size band

SIC	Industry	Employment size			
		1-9	10-49	50-249	≥250
15-16	Food, drink & tobacco	20.9	19.8	18.3	41.0
17-19	Textiles, clothing, leather & footwear	19.2	32.0	26.5	22.3
20	Wood & products of wood and cork	36.1	30.6	18.6	14.7
21-22	Pulp, paper & paper products, printing & publishing	18.9	22.4	21.6	37.1
23	Mineral oil refining, coke & nuclear fuel	3.2	4.5	7.1	85.3
24	Chemicals	3.5	8.2	16.6	71.7
25	Rubber & plastics	8.9	21.8	26.3	43.0
26	Non-metallic mineral products	15.5	22.5	23.1	39.0
27-28	Basic metals and fabricated metal products	20.0	27.8	21.1	31.1
29	Mechanical engineering	9.8	20.3	23.0	46.9
30-33	Electrical & optical equipment	10.7	14.3	16.2	58.8
34-35	Transport equipment	3.3	5.9	8.9	81.9
36-37	Furniture, miscellaneous manufacturing recycling	26.0	26.1	22.9	25.0
15-37	**Total manufacturing**	**15.5**	**20.7**	**19.9**	**43.8**

Source: Eurostat, Observatory of European SMEs, 7th Edition.

Table II.5

US, Percentage of employees classified to manufacturing industries in 1997, SIC 92 by employment size band

SIC	Industry	Employment size			
		1-9	10-49	50-249	≥250
15-16[14]	Food, drink & tobacco	3.0	11.4	27.0	58.5
17-19	Textiles, clothing, leather & footwear	3.2	12.6	25.0	59.2
20	Wood & products of wood and cork	8.8	26.3	28.2	36.7
21	Pulp, paper & paper products	0.5	9.4	44.5	45.6
22	Printing & publishing	12.6	27.5	36.0	24.0
23	Mineral oil refining, coke & nuclear fuel	4.6	13.0	28.7	53.7
24	Chemicals	-	12.9	30.7	56.5
25	Rubber & plastics	2.2	15.0	44.9	38.0
26	Non-metallic mineral products	9.3	13.6	33.0	44.1
27	Basic metals	0.3	5.4	30.1	64.2
28	Fabricated metal products	2.5	29.7	42.5	25.3
29	Mechanical engineering	4.6	-	41.3	54.2
30-33	Electrical & optical equipment[15]	2.2	10.6	11.5	75.7
34-35	Transport equipment	-	4.8	15.7	79.5
36-37	Furniture, miscellaneous manufacturing; recycling	9.4	21.7	36.2	32.8
15-37	**Total manufacturing**	**4.0**	**15.2**	**32.1**	**48.6**

Source: US Economic Census, 1997

[14] SIC classification adapted from NAICS used in Economic Census 1997

[15] Includes 'Electrical equipment, appliance and component' and 'Computer and electronic products'.

Differences in the average size of firms are likely to have an impact on productivity growth, arising from returns to scale and industry concentration/market power. The direction of a size or concentration impact on productivity growth is an empirical issue. For example some market concentration may stimulate innovation as firms can more readily appropriate the returns. Against this, lack of competition may reduce incentives to increase productivity (see the discussion in Nickell, 1996 and Baumol, 2002). Given the problems in matching size distribution data at the industry level, this chapter does not attempt to develop a taxonomy based on the size dimension of industry structure. However, concerning returns to scale the report does not find faster labour productivity growth in US manufacturing industries that are characterised as scale intensive (see Chapter III). The impact of size is considered in more detail in Chapter V on firm level analysis and a discussion of the impact of competition on productivity growth in Chapter VI.

II.3.3 Capital intensity

Industries also vary according to basic production technologies, which can be summarised by capital labour ratios. In this project data were assembled, distinguishing six asset types, for the US and four EU countries, France, Germany, the Netherlands and the UK, for 26 industry groups. These data form the basis of the growth accounting calculations in Chapter III. Table II.6 presents the ratio of capital stocks per hour worked for 2000 in each sector to that in the total economy. These are shown for the US, an aggregate across the four EU countries and for each of the EU countries individually.

This table shows very large variation across industries, although a broadly similar pattern exists across countries. The utilities industry has much higher than average capital intensive industry in all countries. In the Netherlands mining and quarrying and mineral oil refining are ranked more capital intensive than the utilities due to the large share of natural gas extraction and processing in these industries. Within manufacturing, mineral oil and chemicals are considerably more capital intensive than other industries with investment goods producers occupying an intermediate position. Consumer goods producing industries tend, on balance, to be less capital intensive than other manufacturing sectors.

Outside manufacturing, communications and transport have capital per hour worked ratios above that for the total economy, whereas the distributive trades including hotels and catering and repairs and wholesale trade operate with relatively low capital intensities. The position in financial and business services varies considerably by country. The US has higher than average capital labour ratios in financial intermediation whereas France and Germany have higher ratios in business services. Thus there is also large variation across industries in the extent to which they employ capital and labour inputs to produce output. Capital intensities, in particular the use of ICT equipment, feature in one of the industry taxonomies discussed in the next section. The direct impact of capital input on labour productivity growth is discussed in Chapter III.

Table II.6

Capital per hour worked: industry to total economy ratios, 2000

	US	EU-4	France	Germany	Netherlands	UK
Agriculture, Forestry and Fishing	1.54	1.10	1.11	1.11	1.47	0.71
Mining and Extraction	5.01	4.45	1.77	3.36	20.31	5.81
Food, Drink & Tobacco	1.55	1.61	1.72	1.30	2.49	1.74
Textiles, Leather, Footwear & Clothing	0.78	1.16	0.80	1.40	1.27	1.22
Wood & Products of Wood and Cork	0.65	1.41	3.00	0.90	1.07	0.91
Pulp, Paper & Paper Products; Printing & Publishing	1.76	1.73	1.27	2.21	2.14	1.36
Mineral Oil Refining, Coke & Nuclear Fuel	8.09	6.93	7.31	6.22	17.74	5.43
Chemicals	4.30	3.19	1.24	2.86	5.55	4.46
Rubber & Plastics	1.52	1.92	3.91	1.26	2.30	1.48
Non-Metallic Mineral Products	1.64	1.97	1.74	2.00	2.59	1.47
Basic Metals & Fabricated Metal Products	1.35	1.38	1.32	1.36	1.48	1.29
Mechanical Engineering	1.04	1.16	1.30	0.99	1.02	1.19
Electrical and Electronic Equipment; Instruments	2.04	1.74	1.59	1.59	2.22	1.71
Transport Equipment	1.74	2.19	2.30	2.11	1.45	2.16
Furniture, Miscellaneous Manufacturing; Recycling	0.49	0.74	0.49	0.98	0.41	0.73
Electricity, Gas and Water Supply	10.61	10.96	10.88	9.25	10.43	14.84
Construction	0.36	0.40	0.41	0.42	0.51	0.23
Motor Vehicles & Wholesale Trade	1.76	0.66	0.52	0.77	0.74	0.39
Retail Trade & Repairs	0.38	0.33	0.45	0.33	0.29	0.29
Hotels & Catering	0.17	0.34	0.49	0.26	0.24	0.28
Transport	2.18	1.96	2.30	2.15	2.12	1.40
Communications	5.28	3.60	3.07	3.46	4.76	4.45
Financial Intermediation	3.26	0.93	1.11	0.87	1.59	0.81
Business Services*	0.97	1.45	1.84	1.74	0.75	0.88
Other Services	0.51	0.56	0.49	0.54	0.73	0.69
Non-Market Services	0.42	0.33	0.33	0.39	0.37	0.22

Notes: * Real estate is excluded as its output is mostly imputed rent on owner occupied housing and capital is mainly dwellings. The capital labour ratio in this table is used as a decription of technology and so capital input is defined in terms of stocks rather than service flows. The latter measure is employed however in the growth accounting section of Chapter III below. Sources and methods: see Chapter VII.

II.4 Industry taxonomies

A large number of variables can help determine and explain a country's or industry's growth performance. The growth accounting literature focuses attention on tangible inputs such as labour and capital as well as the importance of changes in the quality and composition of these inputs. Other strands of literature look more at intangible inputs such as R&D expenditure and other innovative activities.

In the end, there is no substitute for developing a database that presents detailed information by industry on many or all of these variables. However, developing taxonomies should give important insights into the importance of, for example, higher ICT capital intensity or more innovative activities. Taxonomies divide industries into a number of groups along a certain dimension such as ICT capital intensity, often based on data for only a limited number of countries.

There are a number of important dimensions of industry structure that may help distinguish groups of industries and facilitate a descriptive analysis of relative performance. In this draft four such taxonomies are considered. These are:

1. ICT taxonomy – this groups industries based on whether they produce ICT goods and services, whether they intensively use ICT or if they do not use ICT intensively.

2. IT occupational taxonomy – this concentrates on the use of Information Technology skilled labour.

3. Skill taxonomy – this focuses on general labour force skills, defined by educational attainment. The taxonomy distinguishes four groups ranging from high to low-skill intensive.

4. Innovation taxonomy - this is based on a description of the main channels through which innovation takes place.

Each of these taxonomies is considered in turn. The following section describes the methods used to construct the groupings, the data sources employed, and lists the industries included in each group. It then looks at variations across countries in value added shares in each group. At the end of this chapter, all taxonomies are summarised in a common industry table. Chapter III will focus on the productivity growth rates of the various industry groups distinguished.

II.4.1 ICT taxonomy

Industries were divided into the following seven groups; 1. ICT Producing Manufacturing; 2. ICT Producing Services; 3. ICT Using Manufacturing; 4. ICT Using Services; 5. Non-ICT Manufacturing; 6. Non-ICT Services; and 7. Non-ICT Other industries. ICT producing industries are those that directly produce ICT goods or services. This set of industries includes amongst others the computer, semiconductor, telecommunication and software industries. This distinction is based on a classification from the OECD (see, for example, OECD, 2002a). As well as distinguishing ICT producing industries, this taxonomy also aims to separate the industries that make intensive use of ICT from those that do not. This is a less straightforward undertaking since nearly every part of the economy uses some ICT. Nevertheless, research for the US has shown that a binary classification based on ICT intensity has its uses, mainly when the underlying capital data are very noisy.[16] The share of ICT capital in total capital services in the United States is used as a measure of ICT intensity, as derived from Stiroh (2002).

There are two reasons for applying the classification based on ICT intensity in the US to all countries. The first has to do with the very limited availability of data on ICT investment by detailed industry outside the US, let alone capital stocks and capital services measures.[17] Apart from that, given the leading role of the US, it is reasonable to assume that the distribution of ICT use in the US presents a set of technological opportunities, which may or may not have been taken up in other countries. Van Ark *et al.* (2002a) show that the ranking of ICT intensity across industries is reasonably similar in the US and the EU. Based on this, the top half of the ranked ICT using industries is classified as ICT-user and the bottom half as non-ICT.[18] This cut-off point is obviously arbitrary, but alternative cut-off points have few implications for the results on productivity growth (as discussed in Chapter III), except for retailing which has been included with intensive using industries. A distinction is also made between manufacturing and services industries and a group of other industries that include agriculture, mining, utilities and construction.

Table II.7 shows the shares of aggregate value added of these seven groups, again comparing the US with EU-15 and individual EU member states for 1999. The US has a considerably higher share than the EU-15 in ICT producing manufacturing and a marginally higher one in ICT producing services. ICT producing manufacturing is also important in Finland and Ireland, but other EU countries have output shares in this sector significantly below that in the US. There appears to be very little country variation in shares of ICT producing service sectors with six countries having the same or higher shares than the US. These again include Ireland and Finland but also the UK, Sweden and Luxembourg.

In terms of ICT intensive using sectors, value added shares in manufacturing sectors are higher in the EU-15 with only Belgium, Portugal, Greece, Spain and Luxembourg having shares lower than in the US. This confirms the continued strong presence of manufacturing industries in the European Union. The US dominates the EU in its share of activity accounted for by ICT using services. Luxembourg is the only EU nation to have a greater

[16] See McGuckin and Stiroh (2001) and Stiroh (2002).

[17] See van Ark *et al.* (2002b) for some of the difficulties in acquiring ICT investment even for the aggregate EU economies.

[18] The exceptions are education and health which, despite the high share of ICT in total capital services, are allocated to non-ICT services. Using alternative measures, namely ICT capital per worker or capital per unit of output, both these two industries rank near the bottom.

ICT Taxonomy

1. *ICT Producing - Manufacturing* (ICTPM): Office machinery (30); Insulated wire (313); Electronic valves and tubes (321); Telecommunication equipment (322); Radio and television receivers (323); Scientific instruments (331).

2. *ICT Producing – Services* (ICTPS): Communications (64); Computer & related activities (72).

3. *ICT Using – Manufacturing* (ICTUM): Clothing (18); Printing & publishing (22); Mechanical engineering (29); Other electrical machinery & apparatus (31-313); Other instruments (33-331); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment nec (352+359);Furniture, miscellaneous manufacturing; recycling (36-37).

4. *ICT Using – Services* (ICTUS): Wholesale trade and commission trade, except of motor vehicles and motorcycles (51); Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67); Renting of machinery & equipment (71); Research & development (73); Legal, technical & advertising (741-3).

5. *Non-ICT Manufacturing* (NICTM): Food, drink & tobacco (15-16); Textiles (17); Leather and footwear (19); Wood & products of wood and cork (20); Pulp, paper & paper products (21); Mineral oil refining, coke & nuclear fuel (23); Chemicals (24); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27); Fabricated metal products (28); Motor vehicles (34).

6. *Non-ICT Services* (NICTS): Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Hotels & catering (55); Inland transport (60); Water transport (61); Air transport (62); Supporting and auxiliary transport activities; activities of travel agencies (63); Real estate activities (70); Other business activities, nec (749); Public administration and defence; compulsory social security (75); Education (80); Health and social work (85); Other community, social and personal services (90-93); Private households with employed persons (95); Extra-territorial organizations and bodies (99).

7. *Non-ICT Other* (NICTO): Agriculture (01); Forestry (02); Fishing (05); Mining and quarrying (10-14); Electricity, gas and water supply (40-41); Construction (45)

Table II.7

Value added shares, 1999, ICT-7 taxonomy

	ICT Producing Manufac-turing	ICT Producing Services	ICT Using Manufac-turing	ICT Using Services	Non-ICT Manufac-turing	Non-ICT Services	Non-ICT Other
EU-15	1.3	4.9	6.9	23.3	13.6	38.3	11.7
US	2.7	5.0	5.1	29.5	10.6	36.5	10.6
Belgium	0.9	4.8	4.0	28.6	14.5	37.9	9.3
Denmark	1.2	4.1	7.0	22.9	10.6	42.6	11.7
Germany	1.6	4.5	8.4	23.6	15.1	36.6	10.2
Greece	0.3	3.9	4.1	20.7	8.7	41.6	20.7
Spain	0.7	3.8	4.9	19.1	14.3	41.4	15.9
France	1.6	4.6	5.6	23.1	13.3	40.8	11.0
Ireland	6.6	5.9	7.7	22.0	19.8	25.4	12.6
Italy	1.0	4.3	7.6	25.5	14.5	35.6	11.6
Luxembourg	0.3	7.4	2.3	44.4	9.4	27.6	8.6
Netherlands	1.4	4.6	5.2	26.2	11.1	38.5	13.1
Austria	1.8	3.5	6.2	24.2	14.3	35.5	14.6
Portugal	0.9	4.1	4.7	25.0	13.2	37.2	14.8
Finland	5.3	5.0	7.2	17.1	15.2	37.2	13.0
Sweden	2.4	5.8	6.5	19.5	14.8	41.4	9.6
United Kingdom	1.6	5.7	6.9	23.2	11.4	40.3	11.0

Sources and methods: see chapter VII.

share of value added in ICT using services than the US, with Finland, Spain and Sweden having the smallest, accounting for less than 20 per cent. Despite these variations in ICT producing and intensive using sectors, the cross country pattern shows a similarity in shares of non-ICT sectors taken together, and in particular non-ICT service sectors.

II.4.2 IT occupational taxonomy

This taxonomy relies on a cluster analysis carried out by Peneder (2003). This employs a sophisticated statistical clustering technique which starts with data for two countries, the US and the UK and seven data points based on three year averages from 1979 to 2001. The underlying data are the Labour Force Survey for the UK and the Current Population Survey for the US and consists of information on those employed in IT occupations, distinguishing between those with degree and above, and those with lower level qualifications. The list of occupations included in IT occupations in the two countries is shown below.

Definition of IT occupations

United Kingdom, Standard Occupational Classification 1990	
126	Computer systems manager
214	Software engineer
320	Computer analyst, programmer (incl. robot programmer)
490	Computer operator (incl. data processor, VDU operator, data entry clerk, database assistant)
526	Computer engineer, installation and maintenance (incl. computer repairer)

US, Occupational Classification from the 1980 Census	
64	Computer systems analyst and scientist
65	Operations and systems researcher and analyst
229	Computer programmer
233	Tool programmer, numerical control
304	Supervisor, computer equipment operator
308	Computer operator
309	Peripheral equipment operator
385	Data entry keyer
525	Data processing equipment repairer

Source: Mason et al. (2003).

Using various clustering techniques, Peneder reaches a four way split between these groups, showing that there are two individual industries with demand for IT personnel very different from all other groups, and each other. These are, unsurprisingly, the office machinery manufacturing sectors and the computing services sector. Note that this leads to a somewhat different definition of the ICT producing sector than the ICT taxonomy (see the previous section). Other ICT producing industries are classified to two other groups which Peneder describes as 'dynamic IT users' and 'other'. The first of these groups not only has a greater intensity of use of IT personnel but shows an increasing demand across time. The other group show both lower intensity and no discernible trend in IT to total employment shares.

In general the list of industries included in Peneder's IT user and non-user groups are similar but not identical to those in the ICT user versus non-ICT industries in the previous taxonomy. Notable among the differences are the inclusion of mining and quarrying in the user group and wholesale and retail trade in the non-user group. These differences are not surprising as the mining industry uses comparatively little IT capital, but some of its surveying technologies are of a high-tech nature and use IT-skilled labour (Olewiler, 2002). In contrast, the distribution sector is relatively IT-capital intensive (scanner techniques and tracking systems), but the users of these technologies do not necessarily have to be IT skilled. In summary the grouping derived is as follows: 1. IT producer service; 2. IT producer manufacturing; 3. Dynamic IT user and 4. IT user other.

IT Occupational Taxonomy

1. IT producer – services (IOPS): Computer and related activities (72).

2. IT producer – manufacturing (IOPM): Computers and office machinery (30).

3. Dynamic IT user with a high and growing IT-labour intensity (IOU): Mining and quarrying (10-14); Mineral oil refining, coke and nuclear fuel (23); Chemicals (24); Electrical machinery and apparatus (31); Radio, television and communication (32); Instrument engineering (33); Motor vehicles (34), Other transport equipment (35), Electricity, gas and water supply (40-41), Air transport (62); Telecommunications (642); Financial intermediation (65, 67), Insurance and pension funding (66), Research and development (73); Other business services (71, 74), Public administration and defence, incl. compulsory social security (75); Education (80).

4. Other IT user industries (NIO): Agriculture, forestry and fishing (01-05), Food, drink and tobacco (15-16), Textiles, leather, footwear and clothing (17-19), Wood, products of wood and cork; Pulp, paper and paper products, printing and publishing (20-22), Rubber and plastics (25), Non-metallic mineral products, furniture, miscellaneous manufacturing (26, 36-37), Basic metals and fabricated metal products (27-28), Mechanical engineering (29), Construction (45), Sale, maintenance and repair of motor vehicles and motor cycles (50), Wholesale trade (51), Retail trade (52), Hotels and catering (55), Railways (601), Other inland transport, Water transport (602-603, 61), Supporting and auxiliary transport activities, activities of travel agencies (63), Post and courier activities (641), Real estate (70), Health and social work (85), Other community, social and personal services (90-93).

The value added shares (contained in table II.8) for these four groups in many respects mirror those for the ICT taxonomy but show a greater share of the US in the dynamic user group with only Belgium and Luxembourg having shares in this group above those in the US.

II.4.3 General skills taxonomy

In developing the skills taxonomy a number of approaches have been adopted. Firstly, detailed skills data for the UK and US, were used, as in the occupation taxonomy above. The advantage of these data is that the breakdown over qualification levels allow for more detailed analysis than much of the data available for larger groups of countries which categorise individuals as being high or low skilled (or blue collar/ white collar, or

Table II.8

Value added shares, 1999, IT occupational taxonomy

	IT producer service	IT producer manufacturing	Dynamic IT user	IT User Other
EU-15	1.9	0.2	42.0	55.9
US	2.3	0.5	48.0	49.3
Belgium	3.0	0.0	48.6	48.4
Denmark	1.4	0.1	37.3	61.3
Germany	1.8	0.2	43.6	54.4
Greece	0.1	0.0	32.9	67.0
Spain	0.8	0.2	34.9	64.1
France	2.1	0.2	44.8	52.9
Ireland	3.2	3.4	44.5	48.9
Italy	1.8	0.1	37.7	60.5
Luxembourg	1.4	0.0	55.3	43.3
Netherlands	2.0	0.1	41.5	56.4
Austria	1.1	0.1	37.7	61.1
Portugal	0.9	0.0	40.5	58.6
Finland	1.7	0.0	35.5	62.8
Sweden	2.8	0.2	39.4	57.7
United Kingdom	2.5	0.4	41.8	55.3

Sources and methods: see Chapter VII.

production and non production workers). In particular, the UK and US data allow for the consideration of the intermediate skill categories more fully. In addition to this detailed approach, Eurostat data for all EU-15 countries on skills were also used to construct an additional taxonomy. These data are available over a number of years and for high, medium and low skilled workers by industry only.

II.4.3.1 Using the detailed skills data for the UK and US

This first dataset only contains information for the UK and the US but it provides more detail than earlier work which has focused on a dichotomous split of high and low skill sectors. Instead a taxonomy is introduced, based on four skill groups (high-, higher-intermediate, lower-intermediate or low-skill intensive) allowing for variation in the intermediate category. This distribution is derived using five skills categories derived from the original data sources, based on educational attainment, including graduates and above, three intermediate skill categories and those with very low skills (no high school graduation in the US). Note that it was not possible to match these data exactly to the disaggregated industry classification systems used throughout this report so that aggregates have been applied where appropriate.

In order to develop the taxonomy, a number of grouping methods were employed. Three basic approaches were adopted and the groupings that each approach offers are compared. Firstly, a manual grouping system, based on simple criteria was developed[19]. Secondly, a wage weighted grouping was derived[20] and, thirdly, these results were compared to a formal cluster analysis, using a standard statistical package[21].

The taxonomy based on the results of all three methodological approaches is listed in table II.9, below. Broadly, the groupings suggested by the approaches are similar and in line with *a priori* expectations. This appears to be a relatively robust taxonomy based on the different methods used to derive it, and with a strong similarity of findings between the UK and the US. The four skill groups derived from this taxonomy are: 1. High Skilled, 2. Higher Intermediate; 3. Lower Intermediate and 4. Low skilled.

II.4.3.2 Using Eurostat Skills database to develop a taxonomy

To check the robustness of the results presented above, a further taxonomy has been developed using Eurostat Labour Force Survey data. These data cover 15 European countries and so provide some indication on the degree of similarity of skill levels in industries across the EU area. The drawback of this survey is that data are only available for high, medium and low skill categories.

Data are available from 1992 until 2000 for 15 European countries, by industrial classification and by gender, on a high/medium/low basis. Skill intensity is measured by the number of people classified to each group so that the figures vary across industry and country. For this reason, skill intensity is converted to the proportion of total employment in the industry in that year for each skill group. The gender split available in these data is not utilised because of the complexity of the dataset with 56 industries, 15 countries and three skill groups.[22]

Initial inspection of the data reveals that there are a number of years missing for a number of countries. In fact there is only full coverage for 5 of the 15 countries, namely Belgium, Denmark, Spain, Italy and Portugal. Data for 1998 are missing for UK, Germany and Luxembourg. In addition, for a number of countries series do not begin until 1993 or 1995. Also the Irish data series do not continue past 1997. Hence 1995, 1996 and

[19] The average proportion of each skill category with respect to total employment was taken over the whole of the period for each industry, and a number of criteria were set to determine whether the industry was high, intermediate high, intermediate low or low skilled (20 per cent above all industry average were deemed to be high skill intensive, etc.).

[20] The employment data were weighted by the relative wages of each skill group.

[21] Following the work by Peneder (2003) a k-means method of clustering, using the Euclidean distance function to measure dissimilarity, was adopted.

[22] In addition to the three skill groups, there is a category labelled 'no answer'. In this instance, the observations have been excluded from the calculations, but it should be recognised that these responses were particularly prevalent in the German data and therefore excluding them is likely to have a larger impact on the skills structure in that country.

1997 are the only three years that are covered in all countries. However, these gaps in data do not prevent the comparison of skills distributions across countries.

The skill levels in the Eurostat LFS are based on the International Standard Classification of Education - 1976 (ISCED). The low, medium and high skilled groups are defined as follows:

low	Pre-primary, primary and lower secondary education - ISCED 0-2
medium	Upper secondary education - ISCED 3
high	Total tertiary education - ISCED 5-6

In the case of those with low skills, those leaving lower secondary education are expected to have basic skills, with some degree of specialisation. This is normally the level at which compulsory formal education ceases. Those with medium skills have achieved upper secondary education which requires typically 9 years of full time education, and which students normally enter at the age of 15 to 16. Total tertiary education is more difficult to define as it includes vocational training on a much more diverse scale. Broadly it consists of first stage tertiary education (not leading to an advanced research qualification) and second stage tertiary education, (leading to an advanced research qualification).The latter stage typically requires the submission of a thesis or dissertation of publishable quality.

There are problems with classifying vocational training between the categories. Each country may experience different levels of vocational training and also, when classifying these workers to skill groups, may deal differently with them. It should be noted that Eurostat does not attempt to harmonise the skill divisions across countries, taking data delivered by the member countries as given. European Commission (1997) mentions that for 1995 the ISCED 3 share in Ireland is underestimated, and that data for Italy is not comparable with other countries (pp. S-133).

Eurostat collects data from the EU countries on the basis of NACE rev. 1 industries. For each country these have been grouped and recoded to the industry list in the *Industry Labour Productivity Database*. In order to establish whether an industry in a particular country was high, medium or low skilled, the proportion of total employees for each skill group in each industry was calculated for each country. The average proportion of high, medium and low skills were calculated, and if an industry within a country had a proportion of high skills at 20 per cent higher than the average, it was classified as high skilled[23]. If an industry within a country had a medium skill level higher than 5 per cent above the

[23] These thresholds were chosen as this seemed to result in a reasonable distribution of industries across skill groups. However, it should be noted that certain industries (including wood products and paper products, among others) were particularly sensitive to the chosen threshold, as these were often close to the boundary between medium and low skill intensity.

average proportion of medium skills across all industries, then it was classified as medium skill intensive. If on the other hand, neither of these conditions were fulfilled, the industry was classified as low skill intensive. These findings were then averaged over time, to give a general skills profile for each country in each industry. Following this, a matrix of countries by industry was constructed based on the skill level that was highest in each industry.

The advantage of these data is that they provide an overview of the skill structures of industries throughout the EU, giving some indication of differences across countries. Overall, the differences are not large, especially for the larger countries. Industries such as education, research and development, and textiles are relatively easy to identify as belonging to a specific skill category. However, real estate activities, hotels and catering and fabricated metal products, for example, are more difficult to identify as being high, medium or low skilled.

Figures II.1 and II.2 contain the frequencies of high, medium and low skilled industries in production and manufacturing and services, respectively, for the 7 largest countries, i.e., Germany, Spain, UK, France, Italy, Belgium, Netherlands.

Figure II.1

Frequency of skill scores, production and manufacturing sectors (7 major countries)

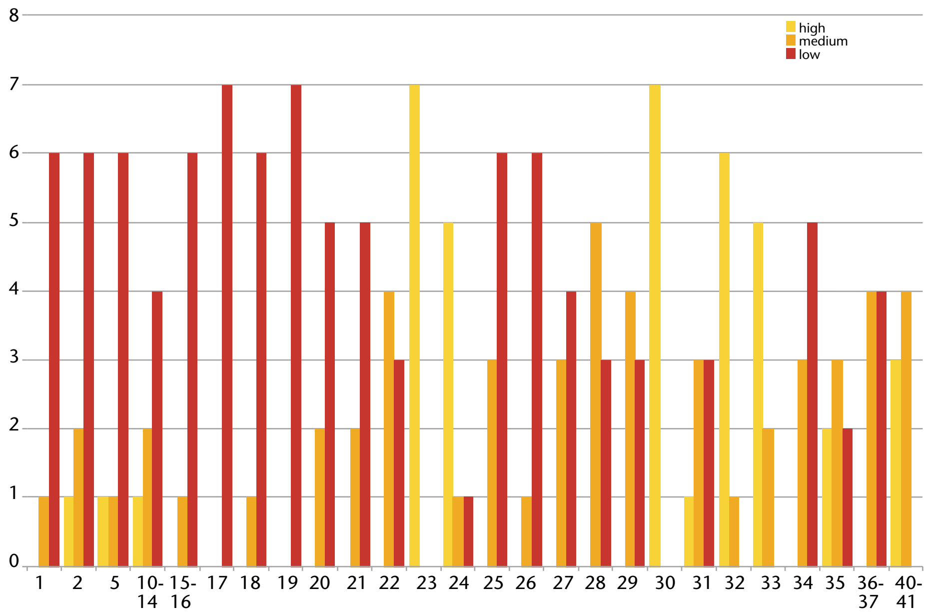
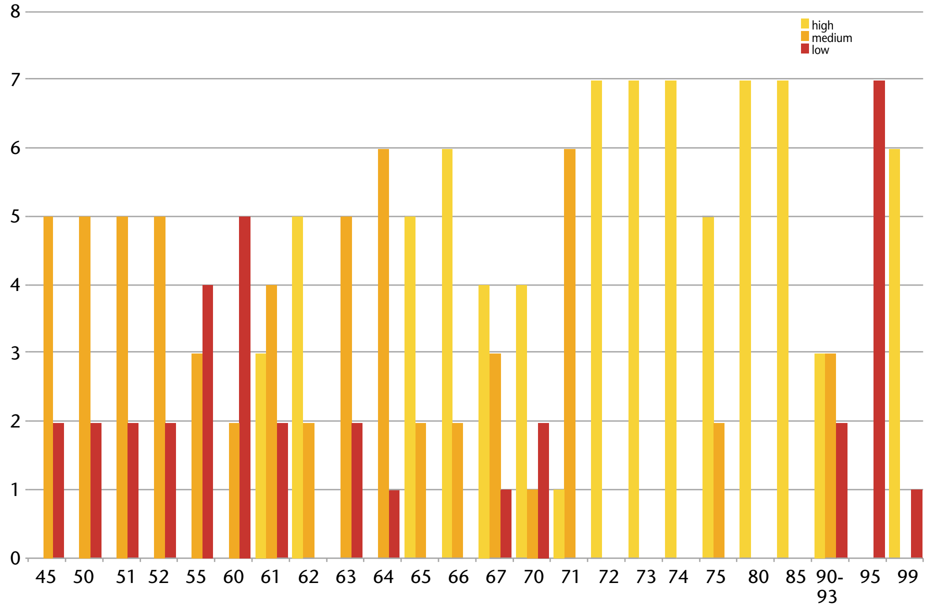


Figure II.2

Frequency of skill scores, service sector (7 major countries)



Note: seven major countries are Germany, Spain, UK, France, Italy, Belgium, Netherlands

In some industries such as Computer services and related activities (72), research and development (73), business activities (74) and electrical machinery (31) there is general agreement across the major countries. In other industries the split between medium and low skilled industries is not as discernable (e.g. water transport, furniture, miscellaneous manufacturing and recycling). This in part reflects the simplicity of the three-way skill classification but is also likely to be indicative of differences in the nature of industries within the same classification across the EU countries.

Tables II.9a and b compare the findings from the initial skill taxonomy based on the US and UK detailed skills data, with the total Eurostat data and the findings from the largest 7 EU countries (Germany, Spain, UK, France, Italy, Belgium, Netherlands). It can be seen that there is a broad consensus across the two Eurostat groupings, as expected, and despite there being some differences in the classifications used, the results from the Eurostat data are fairly similar to those from the detailed skills data from the UK and US.

Since the first skills taxonomy based on UK and US data alone allowed the division into two groups within the intermediate category, it was decided to base the taxonomy primarily on these data. Since the Eurostat Labour Force Surveys provide information on the diversity of skill structures within the EU, these data were used to inform the detailed skills taxonomy. Thus they were employed where additional information was necessary to be clearer about

Table II.9a

Comparison of skill taxonomies *(production and manufacturing)*

	Industry	Original Skill taxonomy US and UK	Eurostat taxonomy (all countries)	Eurostat taxonomy (7 largest countries)[24]	**FINAL TAXONOMY**
01	Agriculture	LS	LS	LS	LS
02	Forestry	LS	LS	LS	LS
05	Fishing	LS	LS	LS	LS
10-14	Mining and quarrying	LS	LS	LS	LS
15-16	Food, drink & tobacco	LS	LS	LS	LS
17	Textiles	LS	LS	LS	LS
18	Clothing	LS	LS	LS	LS
19	Leather and footwear	LS	LS	LS	LS
20	Wood & products of wood and cork	LIS	LS	LS	LIS
21	Pulp, paper & paper products	LIS	LS	LS	LIS
22	Printing & publishing	LIS	MS	MS	LIS
23	Mineral oil refining, coke & nuclear fuel	HS	HS	HS	HS
24	Chemicals	HS	HS	HS	HS
25	Rubber & plastics	LS	LS	LS	LS
26	Non-metallic mineral products	LS	LS	LS	LS
27	Basic metals	LS	LS	LS	LS
28	Fabricated metal products	LS	MS	MS	LIS
29	Mechanical engineering	LIS	MS	MS	LIS
30	Office machinery	HS	HS	HS	HS
313	*Insulated wire*	LIS	MS/LS	MS/LS	LIS
31	*Other electrical machinery and aparatus nec*	LIS	MS/LS	MS/LS	LIS
32	*Electronic valves and tubes*	HS	HS	HS	HS
32	*Telecommunication equipment*	HS	HS	HS	HS
32	*Radio and television receivers*	HS	HS	HS	HS
33	*Scientific instruments*	HIS	HS	HS	HIS
33	*Other instruments*	HIS	HS	HS	HIS
34	Motor vehicles	LS	MS	LS	LS
35	Other Transport Equipment	HIS	MS/LS	MS	HIS
35	*Building and repairing of ships and boats*	HIS	MS/LS	MS	HIS
35	*Aircraft and spacecraft*	HIS	MS/LS	MS	HIS
35	*Railroad equipment and transport equipment nec*	HIS	MS/LS	MS	HIS
36-37	Furniture, miscellaneous manufacturing; recycling	LS	LS	MS/LS	LS
40-41	Electricity, gas and water supply	LIS	MS	MS	HIS
45	Construction	LIS	MS	MS	LIS

[24] The seven countries used in this taxonomy are Germany, France, UK, Italy, Spain, Belgium and Netherlands.

Table II.9b

Comparison of skill taxonomies continued *(services)*

	Industry	Original Skill taxonomy US and UK	Eurostat taxonomy (all countries)	Eurostat taxonomy (7 largest countries)	**FINAL TAXONOMY**
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	LIS	MS	MS	LIS
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	LIS	MS	MS	LIS
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	LIS	MS	MS	LIS
55	Hotels & catering	LS	LS	LS	LS
60	Inland transport	LIS	LS	LS	LIS
61	Water transport	LIS	HS	MS	LIS
62	Air transport	HIS	HS	HS	HIS
63	Supporting and auxiliary transport activities; activities of travel agencies	HIS	MS	MS	HIS
64	Communications	HIS	MS	MS	HIS
65	Financial intermediation, except insurance and pension funding	HS	HS	HS	HS
66	Insurance and pension funding, except compulsory social security	HS	HS	HS	HS
67	Activities auxiliary to financial intermediation	HS	HS	HS	HS
70	Real estate activities	HS	HS	HS	HS
71	Renting of machinery and equipment	HS	MS	MS	HIS
72	Computer and related activities	HS	HS	HS	HS
73	Research and development	HS	HS	HS	HS
74	Legal, technical and advertising	HS	HS	HS	HS
74	Other Business Services	HS	HS	HS	HS
75	Public administration	HS	HS	HS	HS
80	Education	HS	HS	HS	HS
85	Health and social work	HIS	HS	HS	HIS
90-93	Other community, social and personal services[25]	LS	LS	LS	LS

the skill intensity of the industry, and they also acted as a check to see how applicable the initial 2-country taxonomy is to a wider collection of countries. For example, in the financial sector there is complete agreement across all taxonomies that this sector is highly skilled. The more detailed skills dataset does however allow for a much finer split of the data amongst the intermediate sectors, and this can be seen to be important when considering sectors such as transportation equipment (other than motor vehicles), where an equal number of countries fall between medium and low skilled intensity.

[25] including private households and extra-territorial organisations.

The box below lists the industries included in the four groups. In contrast to both ICT based taxonomies above there is a greater spread of skill clusters across the 56 industries. Nevertheless many of the industries in the bottom two skill groups are also those in the non-ICT groups in the ICT taxonomy or the 'other IT users' in the occupational taxonomy.

Skill Taxonomy

1. *High skilled* (HS): Mineral oil refining, coke and nuclear fuel (23); Chemicals (24); Office machinery (30); Radio, television and communications equipment (32); Electronic valves and tubes (321); Telecommunication equipment (322); Radio and television receivers (323); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66); Activities auxiliary to financial intermediation (67); Real estate activities (70); Computer and related activities (72); Research & development (73); Other business services (74); Public administration and defence; compulsory social security (75); Education (80).

2. *High-intermediate skilled* (HIS): Medical, precision & optical instruments (33); Scientific instruments (331); Other instruments (33-331); Other transport equipment (35); Building and repairing of ships and boats (351); Aircraft and spacecraft (353); Railroad equipment and transport equipment nec (352+359); Electricity, gas and water supply (40-41); Air transport (62); Supporting and auxiliary transport activities; activities of travel agencies (63); Communications (64); Renting of machinery & equipment (71); Health and social work (85).

3. *Low-intermediate skilled* (LIS): Wood & products of wood and cork (20); Pulp, paper & paper products (21); Printing & publishing (22); Fabricated metal products (28); Mechanical engineering (29); Electrical machinery and apparatus (31); Insulated wire (313); Other electrical machinery & apparatus (31-313); Construction (45); Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Wholesale trade and commission trade, except of motor vehicles and motorcycles (51); Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Inland transport (60); Water transport (61).

4. *Low skilled* (LS): Agriculture (01); Forestry (02); Fishing (05); Mining and quarrying (10-14); Food, drink & tobacco (15-16); Textiles (17); Clothing (18); Leather and footwear (19); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27); Motor vehicles (34); Furniture, miscellaneous manufacturing; recycling (36-37); Hotels & catering (55); Other community, social and personal services (90-93).

The value added shares of the four groups are shown in Table II.10. In 1999 the US had a greater share of value added in industries classified as high skilled and a smaller share in low skill industries than the EU-15, with less difference in the intermediate groups. The cross country variation is considerably lower than for the ICT taxonomy above, except that some smaller EU member states, namely Luxembourg, Belgium and Ireland, have a much larger proportion of value added in high skill industries than the US.

Table II.10

Value added shares, 1999, skill taxonomy

	High Skill	High-Intermediate	Low-Intermediate	Low
EU-15	33.2	17.3	29.7	19.9
US	39.9	16.7	28.1	15.3
Belgium	43.9	15.4	25.5	15.2
Denmark	29.9	20.0	32.3	17.8
Germany	33.3	17.2	30.8	18.7
Greece	24.8	14.6	29.8	30.7
Spain	25.8	14.8	31.0	28.4
France	37.4	17.2	25.7	19.8
Ireland	43.4	14.1	25.2	17.3
Italy	30.8	14.2	32.2	22.8
Luxembourg	48.7	13.2	24.1	14.0
Netherlands	34.8	16.4	29.7	19.1
Austria	29.9	13.8	35.2	21.1
Portugal	32.6	15.4	29.6	22.5
Finland	27.9	19.4	35.8	16.9
Sweden	30.9	21.6	30.3	17.3
United Kingdom	32.4	18.7	28.9	20.0

Sources and methods: see chapter VII

II.4.4 Innovation taxonomy based on the Pavitt taxonomy

The final taxonomy introduced in this chapter focuses on the role of innovation as a driver of productivity growth, beyond the role of ICT capital and skills emphasised above. Indeed there is substantial evidence from firm-level based research as well as case studies, that complementary innovation activities, such as organizational changes and other non-technological innovations, are of great importance in exploiting the productivity potential from investments in ICT and human capital. The innovation taxonomy developed in this section is meant to pick up the variety of innovation sources.

The taxonomy has been developed based on the early work by Pavitt (1984), who developed a clustering on the basis of four innovation patterns for goods-producing industries:

1. 'Supplier dominated': Found mainly in traditional sectors of manufacturing. Generally firms in this classification are small and in-house R&D and engineering capabilities are thought to be weak. These industries are mostly defined in terms of their professional skills, aesthetic design, trademarks and advertising; technologically, their trajectory is one of cost cutting and most innovation is process rather than product related.

2. 'Scale intensive': these are production intensive firms characterised by increasing division of labour and the simplification of production tasks that result in increased market share and enable the substitution of machines for labour, lowering production costs. These industries have a technological trajectory of large-scale, assembly production, and tend to be relatively strongly oriented towards process innovations arising from in-house R&D.

3. 'Specialised suppliers': These are also strong innovators, but the firms are relatively small and specialised, having close and complementary relationships with whom they work and a somewhat stronger focus on product innovations. These specialised firms have different technological trajectory from their users. Also, given the scale and the interdependence of the production systems, the costs of poor operating performances can be considerable and therefore technology may be more strongly oriented towards performance increasing rather than cost reducing.

4. 'Science based': Finally, there are the collection of industries such as chemicals and electronic sectors where the main sources of technology are the R&D that the firms themselves carry out, based on 'the rapid development of the underlying sciences in the universities and elsewhere'(Pavitt, 1984, p.362).

It can be seen from the categories above that Pavitt's initial work was primarily tailored towards manufacturing and the assumption made was that all services fell into the first supplier dominated pattern and did not have an autonomous innovation function. In a recent study on service innovation van Ark, Broersma and den Hertog (2003) have developed the work of Pavitt to provide a taxonomy for the service industries. Based on den Hertog (2000) they argue that there are 5 patterns of innovation in services, crucially dependent on the relationship between inputs (the supplier relationship), the client firm or final consumer (client relationship) and the nature of the innovation provided within the firm itself.

The service innovation patterns are outlined as follows:

Service innovation pattern 1: supplier-dominated innovation. Services innovations are largely based on technological innovations as supplied by hardware manufacturers. There is little scope for user industries to influence the actual innovation supplied. Still the adopting firm often has to bring about some organizational changes in order to be able to use the innovation – to adapt its organisation, train its employees, etc. – and to offer a more efficient and higher quality service as a result.

Service innovation pattern 2: innovation within services. The actual innovation and implementation is initiated and executed by the service firm itself. Such innovations may be of a technological nature, a non-technological nature, or (in many cases) a combination of both. But typically organizational changes within the firms are of fundamental importance for this type of service industries. Examples of this pattern involve a new product, product bundle, or delivery system, that is developed by the service firm itself, and implemented possibly with 'innovation support' from outside.

Service innovation pattern 3: client-led innovation. The service firm innovates on the basis of a specific need articulated by its client. In some cases the demand is expressed by segments of mass markets. In other cases it may come from a single client requiring a customised service, as is often the case in business services. For instance, a client may propose to a training firm that it facilitates its face-to-face sessions with computer-based aids.

Service innovation pattern 4: innovation through services. The service firm influences the innovation process that takes place within a client firm. It is therefore comparable with the 'supplier dominated' category in manufacturing. The provider of intermediate services may provide knowledge resources that support the innovation process in various ways. Here especially the role of knowledge intensive business services (KIBS) towards their clients can be referred to.

Service innovation pattern 5: paradigmatic innovations. These are complex and pervasive innovations that affect all actors in a value chain. When driven by fundamentally new technologies these can be labelled technological revolutions or new technology systems (Freeman and Perez, 1988). But they may also come about through deregulation or resource constraints that require innovation to take place across many segments in the value chain.

Combining the service innovation taxonomy and the original Pavitt taxonomy for manufacturing, results in nine patterns of innovation. The first and second groups are *supplier dominated* consisting of a goods-producing group and a services group. The primary source of innovation (mostly ICT) is outside the firm, although internal innovations are often required to exploit the productivity effects.

The third industry group is characterised as *scale intensive*. These are industries where the source of technology is mainly from (in-house) R&D, producing goods that are price sensitive, and with innovation being largely process driven. These industries include mining, several manufacturing industries and public utilities. Firms tend to be large, they are highly concentrated and there is a high degree of technological diversification (Table 5, Pavitt, 1984).

The fourth and fifth industry groups are *specialised suppliers*, in goods-producing industries and services ('innovation through services'). Firms are mostly relatively small with a strong emphasis on product (or service) innovation and a concentric pattern to diversification. In addition, as concerning the manufacturing industries in this group, they tend to be more product than process innovation orientated. ICT producers (both in manufacturing and services) are typically included in this group. A typical user of specialised supplier industries is likely to be performance rather than price sensitive. Chief sources of technology are design and development users (Pavitt, op cit.).

In the sixth and seventh industry group the emphasis is on the innovation process within the firms. *Science-based innovators* in manufacturing are generally large firms, with a mixture of product and process innovation, who are interested in both cost-cutting and product design, and whose technology comes from R&D and public science. For the *organisational innovators* in services the primary source of innovation is mostly a combination of organisational and technical innovations.

The eighth industry group are *client-led innovators in services*, identified by van Ark et al (op cit), as defined in pattern 3 above. Finally a residual group is made up of industries that are collectively called *non-market services*, who are believed to behave differently to innovators operating within the market.

Industries within the *Industry Labour Productivity Database*, were allocated to these patterns of innovative behaviour on the basis of the innovation attributes associated with that industry and how far they corresponded to the patterns described above. For manufacturing industries, the original industry groupings suggested by Pavitt (1984) are adopted. For services, results from the study by van Ark et al. (2003) on the characteristics of innovation have been used. They argue that although it is difficult to allocate individual service industries to a single pattern, most service industries clearly fit in with the organisational innovators ('innovation within services') and the client-led services category. This is a clear diversion from what is often suggested in the traditional innovation literature, that is biased towards manufacturing technologies and that sees service innovation mostly as being supplier (technology) dominated. The final innovation taxonomy is presented in the box below.

Table II.11 contains the value added shares by innovation patterns for 1999. It can be seen that whilst there is considerable variation within the EU-15, the similarities between the US and the EU are clearly apparent. The EU is characterised by somewhat higher shares than the US in all manufacturing groups except specialised goods suppliers. The US exceeds the shares of the EU-15 in non-market services and supplier dominated services. Other groups show similar shares in the two regions. Luxembourg has a very strong organisational innovative cluster of industries, accounting for 39 per cent of all industries. Greece and Portugal have significant supplier dominated goods shares, Ireland has a very high share in science based innovators and Greece has a very low proportion of its value added accounted for by specialised service suppliers. Otherwise there is a high degree of similarity in the shares across EU countries.

Innovation Taxonomy

1. *Supplier Dominated Goods* (SDG): Agriculture (01) Forestry (02) Fishing (05) Textiles (17); Clothing (18); Leather and footwear (19); Wood & products of wood and cork (20);Pulp, paper & paper products (21); Printing & publishing (22); Furniture, miscellaneous manufacturing; recycling (36-37); Construction (45).

2. *Scale Intensive industry* (SII): Mining and quarrying (10-14); Food, drink & tobacco (15-16); Mineral oil refining, coke & nuclear fuel (23); Rubber & plastics (25); Non-metallic mineral products (26); Basic metals (27);Fabricated metal products (28); Motor vehicles (34); Building and repairing of ships and boats (351);Aircraft and spacecraft (353);Railroad equipment and transport equipment nec (352+359); Electricity, gas and water supply (40-41).

3. *Specialised Goods Suppliers* (SGS): Mechanical engineering (29); Office machinery (30); Insulated wire (313); Electronic valves and tubes (321); Telecommunication equipment (322); Scientific instruments (331); Other instruments (33-331).

4. *Science Based Innovator* (SBI): Chemicals (24); Other electrical machinery & apparatus (31-313); Radio and television receivers (323).

5. *Supplier Dominated Services* (SDS): Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52); Water transport (61); Communications (64).

6. *Specialised Services Suppliers* (SSS): Computer and related activities (72); Research & development (73); Legal, technical and advertising (741-3).

7. *Organisational Service Innovators* (OSI): Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel (50); Inland transport (60); Air transport (62); Financial intermediation, except insurance and pension funding (65); Insurance and pension funding, except compulsory social security (66) Real estate activities (70); Renting of machinery & equipment (71).

8. *Client-Led Services* (CLS) Wholesale trade and commission trade, except of motor vehicles and motorcycles (51); Hotels and catering (55); Supporting and auxiliary transport activities; activities of travel agencies (63); Activities auxiliary to financial intermediation (67); Other business services nec. (749); Other Community, social and personal services (90-93); Private households with employed persons (95);

9. *Non-Market Services* (NMS) Public administration (75); Education (80); Health (85).

Table II.11

Value added shares*, 1999, innovation taxonomy

	Good producing industries				Service industries				
	SDG	SII	SGS	SBI	SDS	SSS	OSI	CLS	NMS
US	10.0	10.0	3.8	2.3	9.1	7.1	20.5	17.1	20.1
EU-15	12.0	11.8	3.2	2.9	7.5	6.7	20.6	17.3	18.0
Belgium	9.9	12.1	1.9	4.3	5.6	12.4	15.3	18.0	20.6
Denmark	11.1	10.0	3.7	2.4	7.5	5.0	20.9	17.2	22.3
Germany	10.0	12.6	4.6	3.8	6.9	6.4	21.7	17.4	16.6
Greece	19.3	8.5	0.7	0.8	10.9	1.7	23.9	17.1	17.2
Spain	15.9	12.8	1.8	2.3	8.4	4.0	19.7	18.7	16.4
France	10.7	11.4	2.9	2.7	6.7	8.1	21.2	16.3	20.0
Ireland	17.2	9.1	7.5	12.5	7.8	10.5	10.2	11.9	13.5
Italy	13.5	11.5	3.4	2.7	8.5	6.6	21.6	17.0	15.2
Luxembourg	8.4	8.2	1.0	0.9	8.9	5.7	38.7	15.4	12.7
Netherlands	12.4	10.9	2.0	2.9	6.8	6.9	19.2	20.1	18.8
Austria	15.2	12.5	3.8	2.2	6.7	4.8	21.6	16.7	16.5
Portugal	19.0	11.0	1.2	1.7	8.1	5.4	15.1	17.0	21.5
Finland	16.9	9.3	7.6	2.3	7.0	4.6	20.5	14.3	17.7
Sweden	10.8	11.4	4.7	2.5	6.4	7.0	20.2	14.4	22.6
United Kingdom	10.3	12.0	3.2	2.6	7.2	7.1	20.6	20.7	16.3

* Shares of value added in included industries. Sources and methods: see Chapter VII.

Notes: SDG = supplier dominated goods; SII = scale intensive industry; SGS = specialised goods suppliers; SBI = science based innovators; SDS = supplier dominated services; SSS = specialised service suppliers; OSI = organisational service innovators; CLS = client led services; NMS = non-market services

II.4.5 The taxonomies combined

In this Chapter a considerable number of different ways to group the total set of 56 industries have been reviewed. The taxonomies not only differ based on the dimension along which the grouping takes place but also according to the criteria used. For example, some taxonomies such as the ICT taxonomy only divide the set of industries into intensive and non-intensive ICT users (after taking out the ICT producing industries) while others seek to distinguish more groups based on channels through which innovation occurs. Also, cut-off percentages above which an industry becomes 'intensive' in a particular dimension differ.[26]

[26] This is largely related to the implicit goal of constructing groups of roughly equal size. As some of the measures that are used to construct the taxonomies show a higher dispersion than others, the criteria differ across taxonomies

Still despite these differences several groups of industries can be distinguished.[27] Table II.12 places all four taxonomies within the general 56 industry group. Firstly, a group of 'high-technology' industries seems to emerge. This group employs a large proportion of high-skilled workers, many IT workers, produces ICT goods or services or uses a relatively large amount of ICT capital. The industries in the high technology group include office machinery, electrical and electronic equipment, instruments, communications, financial services and some areas within business services. Other sectors such as agriculture, traditional consumer goods manufacturing and personal services are clearly in the low technology groups. Finally, there are a range of industries which appear to be high technology on some indicators and low on others including chemicals and aerospace in manufacturing and industries within the distributive trades.

Rather than being concerned with differences between taxonomies, they show that the dynamics of growth performance between industries can differ significantly, depending on the type of indicator one considers. It can be seen therefore that a comprehensive measurement framework at the detailed industry level should be developed to fully assess the driving factors of differences in growth performance between countries. The growth accounting framework introduced in the next chapter is one of the most widely used methods to begin to understand the determinants of growth.

II.5 Conclusions

The purpose of this chapter is to provide an overview of the industrial structure of the EU compared with the US, using the *Industry Labour Productivity Database*. Whilst there is considerable heterogeneity between industries and countries, industries generally display similar trends across countries. Taxonomies have therefore been constructed to provide a grouping structure that allows for the summarising of industry behaviour. These taxonomies are based on ICT use/production, employment of IT workers, skills and innovation patterns. It can be seen that there are some common groupings across the taxonomies, and the ICT taxonomy in particular seems to be a very useful way of summarising industry data. Chapter III goes on to describe in detail the evolution of productivity growth over time using the taxonomies developed.

[27] See also Kask and Sieber (2002) for a group of 'high-tech' industries based on taxonomies.

Table II.12[28]

Combined taxonomy lists

Industry	ICT taxonomy	Skill taxonomy	Occupational taxonomy	Innovation taxonomy
Agriculture	NICTO	LS	NIO	SDG
Forestry	NICTO	LS	NIO	SDG
Fishing	NICTO	LS	NIO	SDG
Mining and quarrying	NICTO	LS	IOU	SII
Food, drink & tobacco	NICTM	LS	NIO	SII
Textiles	NICTM	LS	NIO	SDG
Clothing	ICTUM	LS	NIO	SDG
Leather and footwear	NICTM	LS	NIO	SDG
Wood & products of wood and cork	NICTM	LIS	NIO	SDG
Pulp, paper & paper products	NICTM	LIS	NIO	SDG
Printing & publishing	ICTUM	LIS	NIO	SDG
Mineral oil refining, coke & nuclear fuel	NICTM	HS	IOU	SII
Chemicals	NICTM	HS	IOU	SBI
Rubber & plastics	NICTM	LS	NIO	SII
Non-metallic mineral products	NICTM	LS	NIO	SII
Basic metals	NICTM	LS	NIO	SII
Fabricated metal products	NICTM	LIS	NIO	SII
Mechanical engineering	ICTUM	LIS	NIO	SGS
Office machinery	ICTPM	HS	IOPM	SGS
Insulated wire	ICTPM	LIS	IOU	SGS
Other electrical machinery and aparatus nec	ICTUM	LIS	IOU	SBI
Electronic valves and tubes	ICTPM	HS	IOU	SGS
Telecommunication equipment	ICTPM	HS	IOU	SGS
Radio and television receivers	ICTPM	HS	IOU	SBI
Scientific instruments	ICTPM	HIS	IOU	SGS
Other instruments	ICTUM	HIS	IOU	SGS
Motor vehicles	NICTM	LS	IOU	SII
Other Transport Equipment		HIS	IOU	
Building and repairing of ships and boats	ICTUM	HIS	IOU	SII
Aircraft and spacecraft	ICTUM	HIS	IOU	SII
Railroad equipment and transport equipment nec	ICTUM	HIS	IOU	SII
Furniture, miscellaneous manufacturing; recycling	ICTUM	LS	NIO	SDG
Electricity, gas and water supply	NICTO	HIS	IOU	SII
Construction	NICTO	LIS	NIO	SDG

Table II.12 continued[28]

Combined taxonomy lists

Industry	ICT taxonomy	Skill taxonomy	Occupational taxonomy	Innovation taxonomy
Sale, maintenance and repair of motor vehicles and motorcycles retail sale of automotive fuel	NICTS	LIS	NIO	OSI
Wholesale trade and commission trade, except of motor vehicles and motorcycles	ICTUS	LIS	NIO	CLS
Retail trade, except of motor vehicles and motorcycles repair of personal and household goods	ICTUS	LIS	NIO	SDS
Hotels & catering	NICTS	LS	NIO	CLS
Inland transport	NICTS	LIS	NIO	OSI
Water transport	NICTS	LIS	NIO	SDS
Air transport	NICTS	HIS	IOU	OSI
Supporting and auxiliary transport activities activities of travel agencies	NICTS	HIS	NIO	CLS
Communications	ICTPS	HIS	IOU	SDS
Financial intermediation, except insurance and pension funding	ICTUS	HS	IOU	OSI
Insurance and pension funding, except compulsory social security	ICTUS	HS	IOU	OSI
Activities auxiliary to financial intermediation	ICTUS	HS	IOU	NMS
Real estate activities	NICTS	HS	NIO	OSI
Renting of machinery and equipment	ICTUS	HIS	IOU	OSI
Computer and related activities	ICTPS	HS	IOPS	SSS
Research and development	ICTUS	HS	IOU	SSS
Legal, technical and advertising	ICTUS	HS	IOU	SSS
Other Business Services	NICTS	HS	IOU	CLS
Public administration	NICTS	HS	IOU	NMS
Education	NICTS	HS	IOU	NMS
Health and social work	NICTS	HIS	NIO	NMS
Other community, social and personal services*	NICTS	LS	NIO	CLS
Private households	NICTS	LS	NIO	CLS

* including private households and extra-territorial organisations

[28] ICTPM=ICT Producing Manufacturing, ICTPS=ICT Producing Services, ICTUM=ICT Using Manufacturing, ICTUS=ICT Using Services, NICTM=Non-ICT Manufacturing, NICTS=Non-ICT Services; NICTO=Non-ICT Other. IOPS=IT Producer Service, IOPM=IT Producer Manufacturer, IOU=Dynamic IT User, NIO=IT User Other. HS=High skilled, HIS=High-intermediate skilled, LIS=Low-intermediate skilled, LS=low-skilled. SDG = supplier dominated goods; SII = scale intensive industry; SGS = specialised goods suppliers; SBI = science based innovators; SDS = supplier dominated services; SSS = specialised service suppliers; OSI = organisational service innovators; CLS = client led services; NMS = non-market services.

II.A Appendix Tables

Appendix Table II.A

Value added shares, EU-15 and US, 1999

Industry		EU-15	US
Agriculture	01	1.52	1.52
Forestry	02	0.18	0.06
Fishing	05	0.06	0.03
Mining and quarrying	10-14	0.69	1.07
Food, drink & tobacco	15-16	2.06	1.58
Textiles	17	0.68	0.34
Clothing	18	0.48	0.22
Leather and footwear	19	0.27	0.04
Wood & products of wood and cork	20	0.46	0.50
Pulp, paper & paper products	21	0.55	0.64
Printing & publishing	22	1.25	1.19
Mineral oil refining, coke & nuclear fuel	23	0.28	0.33
Chemicals	24	1.93	1.87
Rubber & plastics	25	1.02	0.66
Non-metallic mineral products	26	0.98	0.46
Basic metals	27	0.65	0.56
Fabricated metal products	28	1.86	1.21
Mechanical engineering	29	1.97	1.30
Office machinery	30	0.19	0.41
Insulated wire	*313*	0.07	0.06
Other electrical machinery and aparatus nec	*31-313*	0.90	0.38
Electronic valves and tubes	*321*	0.17	0.79
Telecommunication equipment	*322*	0.27	0.55
Radio and television receivers	*323*	0.09	0.06
Scientific instruments	*331*	0.41	0.54
Other instruments	*33-331*	0.14	0.11
Motor vehicles	34	1.45	1.36
Building and repairing of ships and boats	*351*	0.16	0.08
Aircraft and spacecraft	*353*	0.41	0.57
Railroad equipment and transport equipment nec	*352+359*	0.12	0.08
Furniture, miscellaneous manufacturing; recycling	36-37	0.81	0.62
Electricity, gas and water supply	40-41	2.29	2.03
Construction	45	5.76	4.81
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	1.86	0.65

Appendix Table II.A continued…

Value added shares, EU-15 and US, 1999

Industry		EU-15	US
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	4.92	5.96
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	4.55	6.51
Hotels & catering	55	2.63	2.45
Inland transport	60	2.35	1.90
Water transport	61	0.20	0.14
Air transport	62	0.47	0.92
Supporting and auxiliary transport activities; activities of travel agencies	63	1.39	0.34
Communications	64	2.70	2.46
Financial intermediation, except insurance and pension funding	65	3.80	4.46
Insurance and pension funding, except compulsory social security	66	0.90	1.61
Activities auxiliary to financial intermediation	67	0.67	2.14
Real estate activities	70	10.05	10.31
Renting of machinery and equipment	71	1.13	0.68
Computer and related activities	72	1.71	2.03
Research and development	73	0.43	0.47
Legal, technical and advertising	*741-3*	4.56	4.64
Other business activities, nec	*749*	3.23	3.46
Public administration and defence; compulsory social security	75	6.58	8.27
Education	80	5.07	4.70
Health and social work	85	6.28	7.15
Other community, social and personal services	90-93	4.06	2.60
Private households with employed persons	95	0.33	0.15

Chapter III:

Productivity and Competitiveness in the EU and the US

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III.1 Introduction

This chapter considers the issue of productivity and competitiveness in the EU and contrasts this with the position in the United States. Firstly, an overview of labour productivity growth by detailed industry is presented (Section III.2). Section III.3 provides labour productivity growth estimates, grouping industries according to the four taxonomies outlined in Chapter II. Section 4 presents growth accounting results for a subset of EU countries (France, Germany, the Netherlands and the UK), decomposing labour productivity growth into contributions from capital (ICT and non-ICT separately), labour quality (skills) and TFP. This section also looks at relative levels of capital intensity comparing these four EU countries with the US. Section 5 considers manufacturing competitiveness, and presents calculations of unit labour costs and relative levels of labour productivity.

III.2 Labour productivity in the EU-15 and US: an overview

The analysis in this chapter begins with an examination of labour productivity growth, which is the indicator most readily associated with increases in standards of living. Labour productivity growth is defined as the growth in value added at constant prices minus the growth in hours worked. This section looks at labour productivity growth contrasting the EU-15 with the experience in the US over the period 1979-2001. The results are shown for three time periods, 1979-1990, 1990-1995 and 1995-2001. The base calculations in this and subsequent sections employ GDP figures deflated by US (hedonic) price indices for the ICT industries (NACE 30-33, the computer and electronic industries).

Chapter I summarised labour productivity growth at the broad sector level. To recapitulate, the worsening in the EU-15 position relative to the US from 1995 was due mainly to a combination of decelerating labour productivity growth in manufacturing, distribution and business services and a failure to reach US growth rates in financial services. These broad sector trends, however, hide considerable diversity within each sector. As an aid to describing these diverse trends these sectoral breakdowns are linked to the industry taxonomies presented in Chapter II. However, this section first considers the growth rates for all 56 industries contrasting the total EU and the US.

Table III.1 shows labour productivity growth by industry for the EU-15 and the US for the three time periods. There appears immense diversity in performance between industries within each region, across the two regions and over time. Average annual growth rates range from over 50% per annum in electronic valves and tubes in both regions in the final period to –11% in US fishing industry in the early 1990s. These very large or small numbers appear largely in smaller industries, which is a common finding in productivity studies. Thus electronic valves and tubes represent about 0.3% of aggregate employment in the US and less than 0.2% in the EU. When larger industries are considered, in particular in service sectors, most growth rates occur in the plus to minus 4%-points range.

There are similarities between the US and EU-15 in the main ICT producing sectors in manufacturing, both in magnitudes of the growth rates and the pattern across time of industries. In these industries the US only marginally leads the EU in the earliest period and the EU catches up subsequently, although not fully. There are also some similarities in the time pattern in 'traditional' industries such as food, drink and tobacco, leather, fabricated metals and hotels and other services with declining growth rates through time in both regions, but on the whole productivity growth rates in EU manufacturing industries remain somewhat above that of the US counterparts. But differences across regions and time dominate the picture, in particular the finding that the US acceleration in wholesale trade, retail trade and auxiliary financial services in the second half of the 1990s is not matched in the total EU-15.

Labour productivity growth rates corresponding to Table III.1 are shown for each EU member state in Appendix Tables III.B. A useful summary measure to illustrate the variations in cross industry performance is their correlations shown in Table III.2 for the EU-15 and individual countries. The first panel, which includes all industries, suggests a high degree of similarity between EU countries and the US for the three time periods, but less so when the acceleration in productivity growth across the 1990s is considered. However these correlations are likely to be significantly affected by the very high growth rates in the ICT producing industries in manufacturing. A different picture emerges when these ICT producing industries are excluded, shown in the second panel of Table III.2. Then the correlations drop considerably and are frequently negative. Hence any similarity in the cross industry pattern of labour productivity growth appears to be confined largely to manufacturers of ICT equipment and components.

Table III.1

Annual labour productivity growth, 1979-2001, US and EU-15

	US			EU-15		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	6.7	2.2	9.0	5.3	5.1	3.5
Forestry	10.9	-9.7	3.7	4.6	3.3	2.4
Fishing	0.8	-11.3	13.5	3.1	1.4	0.3
Mining and quarrying	4.4	5.1	-0.2	2.9	13.1	3.5
Food, drink & tobacco	1.2	3.6	-6.0	2.6	2.7	0.8
Textiles	3.4	2.9	2.1	2.7	3.0	2.1
Clothing	3.0	2.7	5.4	2.6	5.1	3.3
Leather and footwear	4.2	4.5	0.1	2.6	3.5	1.2
Wood & wood products	2.6	-3.0	-0.8	2.3	2.9	2.2
Pulp, paper & paper products	1.4	-0.1	1.2	3.6	3.2	2.9
Printing & publishing	-1.4	-2.9	-0.5	2.3	2.0	1.9
Mineral oil refining, coke & nuclear fuel	7.0	5.5	0.6	-5.3	6.0	-1.0
Chemicals	3.4	3.0	1.9	4.7	6.5	3.8
Rubber & plastics	4.2	4.3	4.1	2.3	2.7	1.3
Non-metallic mineral products	1.9	2.3	-0.5	3.2	3.1	1.5
Basic metals	0.8	3.6	2.7	4.7	6.2	1.3
Fabricated metal products	2.1	2.9	0.2	2.2	2.5	1.1
Mechanical engineering	-0.7	0.3	-2.0	2.0	2.8	1.2
Office machinery	27.1	28.5	48.1	24.0	26.2	44.6
Insulated wire	5.2	2.4	3.8	4.5	6.1	0.2
Other electrical machinery	0.7	1.1	-3.2	1.1	0.3	1.9
Electronic valves and tubes	22.9	38.2	51.8	20.2	34.4	56.8
Telecommunication equipment	21.4	4.8	-1.2	19.4	3.8	0.3
Radio and television receivers	10.4	-5.3	-8.0	10.1	-2.9	-7.0
Scientific instruments	3.0	-4.7	-6.2	1.0	-4.0	-7.8
Other instruments	2.8	2.3	4.5	2.2	5.9	3.5
Motor vehicles	-0.7	3.8	1.3	4.0	3.3	0.5
Building and repairing of ships and boats	3.4	-4.4	3.3	6.1	1.3	0.8
Aircraft and spacecraft	1.3	-1.1	2.3	4.7	2.8	0.5
Railroad and other transport equipment	3.0	-2.4	4.3	3.8	4.1	1.0
Furniture & miscellaneous manufacturing	2.9	1.1	2.6	1.6	1.4	1.6
Electricity, gas and water supply	1.1	1.8	0.1	2.7	3.6	5.7
Construction	-0.8	0.4	-0.3	1.6	0.8	0.7
Sales and repair of motor vehicles[1]	0.6	-2.4	-6.9	1.4	2.3	0.8
Wholesale trade and commission trade[2]	2.6	2.9	7.5	1.8	3.4	1.7
Retail trade[2] and repairs[3],	2.8	2.0	6.6	1.7	1.8	1.2

Table III.1 continued

Annual labour productivity growth, 1979-2001, US and EU-15

	US			EU-15		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	-1.1	-1.0	-0.2	-1.0	-0.8	-0.9
Inland transport	1.7	1.0	0.6	2.6	3.0	2.4
Water transport	0.5	0.7	2.2	3.1	5.7	2.6
Air transport	1.0	2.0	3.5	3.4	9.5	3.6
Supporting transport activities	-0.9	-0.8	3.6	3.2	3.7	1.5
Communications	1.4	2.4	6.9	5.2	6.2	8.9
Financial intermediation,	0.1	1.0	4.4	2.3	1.2	4.2
Insurance and pension funding	-5.1	2.5	0.6	2.7	1.2	0.1
Auxiliary financial services	1.3	3.1	10.0	1.1	0.4	0.4
Real estate activities	0.3	1.6	0.9	-0.7	0.0	-0.6
Renting of machinery and equipment	-1.5	8.2	5.8	2.1	3.2	1.6
Computer and related activities	6.3	2.4	-4.4	1.5	1.4	1.6
Research and development	3.6	0.0	1.9	3.3	-0.5	-1.1
Legal, technical and advertising	-1.4	-0.9	-0.1	0.6	0.5	0.7
Other business activities	0.3	-0.7	0.8	-0.2	0.8	-1.1
Public administration[4]	0.8	0.2	0.8	1.1	1.3	1.0
Education	-0.3	0.3	-2.1	0.2	1.0	0.3
Health and social work	-1.5	-1.8	-0.3	0.4	1.2	1.0
Other services[5]	0.7	0.6	-0.7	0.3	0.7	0.4
Private households with employed persons	2.0	2.3	-1.0	-4.5	-0.5	0.1

Notes: 1. Includes motorcycles and retail sale of automotive fuel; 2. except of motor vehicles and motorcycles; 3. repair of personal and household goods; 4. Including compulsory social security; 5. Other community, social and personal services.

Sources and methods: see Chapter VII.

Table III.2

Correlations[1] between US and EU-15 labour productivity growth

	1979-90	1990-95	1995-01	acceleration[2]
A. all industries				
EU-15	0.84	0.87	0.93	0.50
Belgium	0.87	0.65	0.86	0.12
Denmark	0.81	0.53	0.83	0.17
Germany	0.88	0.79	0.92	0.57
Greece	0.84	0.64	0.86	0.38
Spain	0.84	0.75	0.92	0.44
France	0.69	0.81	0.85	0.30
Ireland	0.84	0.60	0.78	0.10
Italy	0.72	0.76	0.87	0.25
Netherlands	0.85	0.75	0.90	0.34
Austria	0.70	0.44	0.86	0.37
Portugal	0.78	0.51	0.72	0.02
Finland	0.84	0.60	0.89	0.36
Sweden	0.80	0.77	0.85	0.50
United Kingdom	0.79	0.73	0.76	0.02
B. Excluding ICT producing manufacturing[3]				
EU-15	0.11	0.31	0.23	0.16
Belgium	0.31	-0.29	0.14	-0.20
Denmark	0.29	0.15	0.06	-0.05
Germany	0.22	0.35	0.37	0.37
Greece	0.22	0.10	0.03	0.11
Spain	0.24	0.20	0.27	0.21
France	-0.06	0.33	0.01	-0.06
Ireland	0.28	0.10	-0.14	-0.20
Italy	0.11	0.05	0.04	0.00
Netherlands	0.13	0.05	0.20	0.09
Austria	-0.11	0.04	0.07	-0.08
Portugal	0.31	-0.15	0.03	-0.18
Finland	0.18	-0.12	0.15	-0.11
Sweden	0.27	0.29	0.06	0.30
United Kingdom	0.13	0.00	-0.09	-0.25

Notes: 1. cross section correlation between industry labour productivity growth in the US and each region/country; 2. growth 1995-2001 minus growth 1990-1995; 3. as in ICT taxonomy box, Chapter II.

Sources and methods: see Chapter VII.

III.3 Productivity growth grouped by industry taxonomies

III.3.1 ICT taxonomy

Table III.3 shows labour productivity growth rates for the ICT taxonomy described in Chapter II. This clustering shows considerable variation across the groups, apart from ICT producing manufacturing. In the latter group labour productivity growth rates in both the US and EU-15 are considerably greater than all other sectors and show a similar time pattern with accelerated growth in the late 1990s, although at a higher rate in the US. In contrast, ICT producing service sectors experienced high growth rates in the EU, outperforming the US, in particular in the later period. This is the only ICT group for which the EU shows an acceleration from the mid 1990s whereas the US shows a deceleration, which is mainly due to the negative productivity growth rates in US computer services. But overall this group represents only a small share of total economy value added, about 5% in both the US and EU in 2001.

Table III.3

Annual labour productivity growth of ICT-producing, ICT-using and non-ICT industries in the EU-15 and the US

	1979-1990		1990-1995		1995-2001	
	EU	US	EU	US	EU	US
Total Economy	**2.2**	**1.3**	**2.3**	**1.1**	**1.7**	**2.2**
ICT Producing Industries	7.2	8.7	5.9	8.1	7.5	10.0
ICT Producing Manufacturing	*12.5*	*16.6*	*8.4*	*16.1*	*11.9*	*23.7*
ICT Producing Services	*4.4*	*2.4*	*4.8*	*2.4*	*5.9*	*1.8*
ICT Using Industries	2.2	1.2	2.0	1.2	1.9	4.7
ICT Using Manufacturing	*2.4*	*0.5*	*2.4*	*-0.6*	*1.8*	*0.4*
ICT Using Services	*2.1*	*1.4*	*1.8*	*1.6*	*1.8*	*5.3*
Non-ICT Industries	1.8	0.5	2.1	0.3	1.0	-0.2
Non-ICT Manufacturing	*3.0*	*2.1*	*3.6*	*2.7*	*1.6*	*0.3*
Non-ICT Services	*0.6*	*-0.2*	*1.2*	*-0.5*	*0.5*	*-0.3*
Non-ICT Other	*3.4*	*2.0*	*3.2*	*1.2*	*2.1*	*0.7*

Notes: For industries 30-33 (NACE) the US deflators have been used for all countries. *Italics* indicate ICT-7 taxonomy, remaining groups refer to the ICT-3 taxonomy. Sources and methods: see Chapter VII.

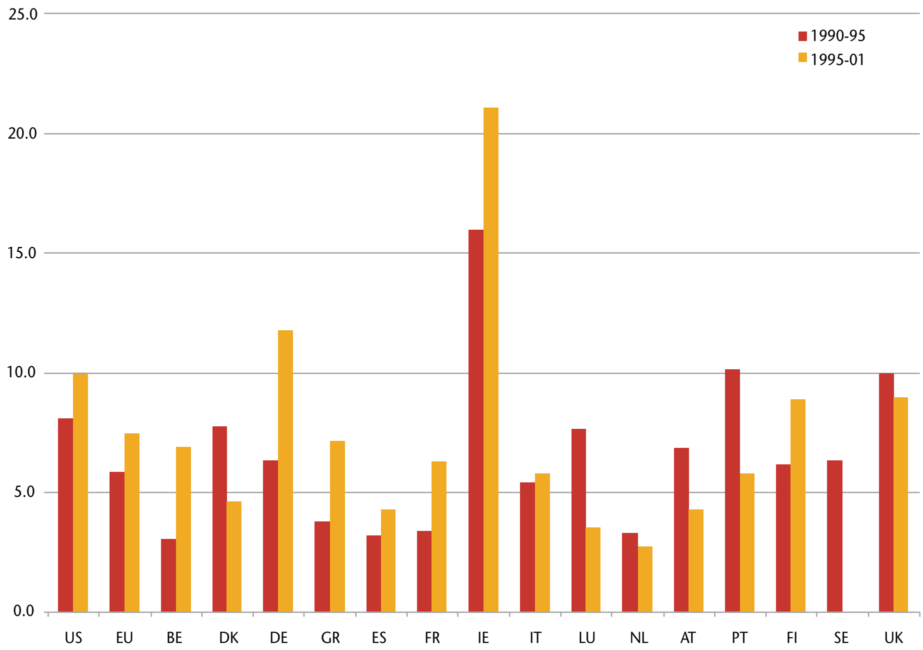
The two ICT using sectors generally show considerably lower growth rates than the corresponding ICT producing sectors with the important exception of the ICT using services group in the US which from 1995 onwards shows a sharp acceleration not matched in the EU-15. This was mainly due to a major increase in productivity and output growth in distribution and financial securities in the US as shown in Table III.1. Equally important in the Table is the pronounced deceleration in the EU in non-ICT industries, which occurs in all three subcomponents. In non-ICT manufacturing, labour productivity growth decreases in the final period in both the US and the EU-15 with a greater decline in the US. However the US shows a marginal improvement in non-ICT services, and since this comprises over 60% of the non-ICT group, the overall percentage point reduction in US non-ICT industries since 1995 is lower than in the EU. Nevertheless productivity growth rates in the non-ICT sectors are much lower in the US than in the EU.

In looking at the position across EU countries it is useful to combine the above groups into the three main groups, that is, ICT producing, ICT using and non-ICT. Figures III.1a-c show labour productivity growth rates in the final two periods for these three groupings. In the ICT producing sectors Ireland and Germany show the most pronounced growth between the two periods, with their very large ICT manufacturing sectors. But accelerating growth is also apparent in the ICT producing sector of a further six EU countries. The UK shows a deceleration but from a relatively high base.

In the ICT using sectors (Figure III.1.b) there are again differences in the experiences of individual countries with eight of the EU-15 showing accelerating growth. However these

Figure III.1.a

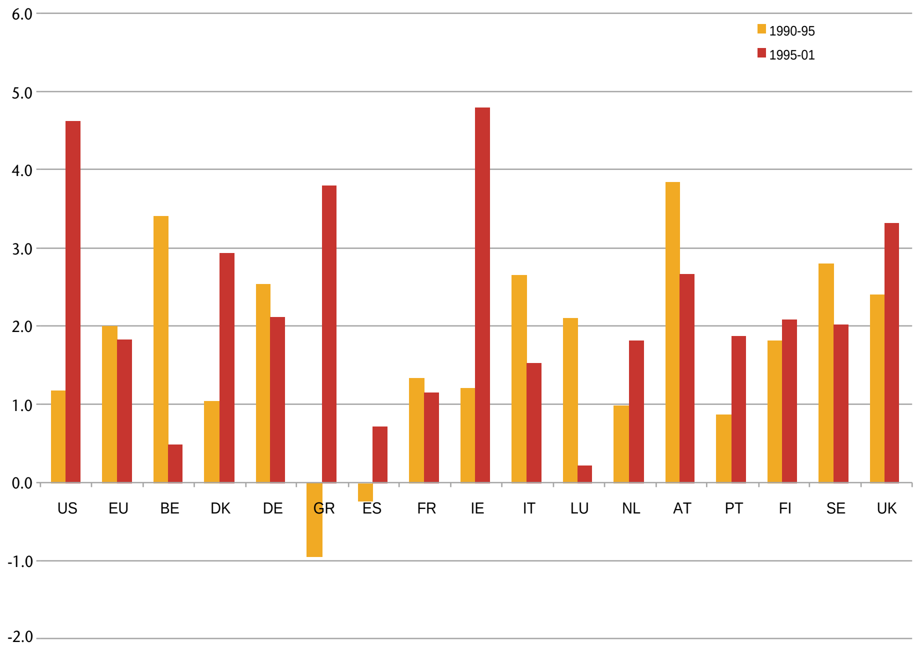
Annual labour productivity growth, ICT producing sectors



are mainly the smaller countries and their performance is counter-balanced by poor relative performance in large continental countries, Germany, France and Italy. Finally Figure III.1.c shows the position in the non-ICT sectors, which together make up about two thirds of economy wide value added in all countries. Here there is a pronounced deceleration in all countries except Greece, Ireland, Portugal and Sweden. These small countries are those with some of the largest productivity gaps relative to the US in the 1980s. Since the non-ICT group is largely made up of traditional mature industries, conventional convergence trends are more apparent. In the period up to 1995 labour productivity growth rates in these sectors were considerably above those in the US in most EU countries, but in many countries the growth advantage over the US diminished over time.

Figure III.1.b

Annual labour productivity growth, ICT using sectors

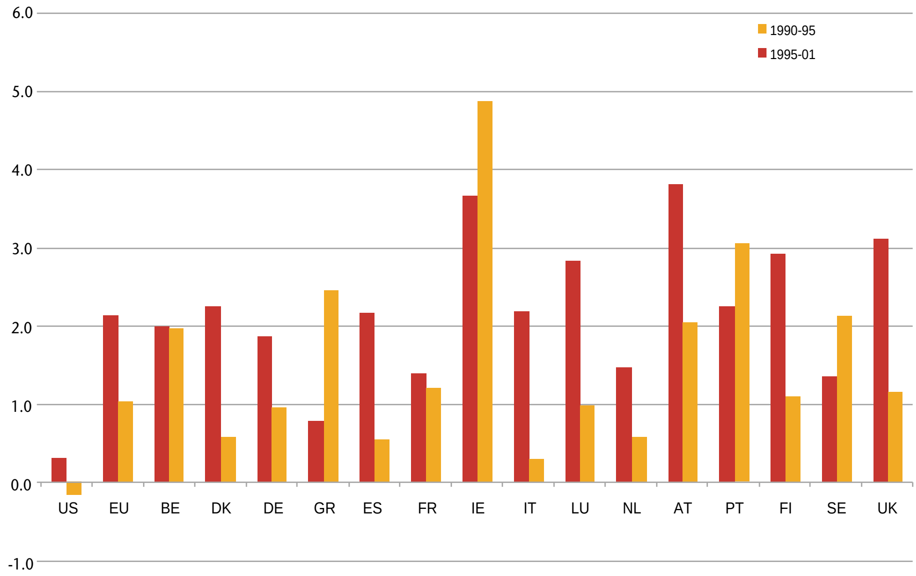


It is also useful to test for significance of the differences across the industry groups using this ICT taxonomy. Thus simple regression equations were estimated distinguishing between ICT-producing, ICT-using (excluding ICT-producing industries) and non-ICT industries:

$$\Delta P_{i,t} = \alpha + \gamma_1 P + \gamma_2 U + \varepsilon_{i,t} \qquad \text{(III.1)}$$

Figure III.1.c

Annual labour productivity growth, non-ICT sectors



where, $\Delta P_{i,t}$ is the annual productivity growth rate, *i* denotes the industry group and *t* is years between 1990 and 2001. The dummy variable *P* is one if the industry is an ICT-producing industry and *U* is one if it is an ICT-using industry. The estimated coefficients have the following interpretation: α is the average productivity growth rate for non-ICT industries and $\alpha + \gamma_1$ is the mean growth rate of ICT producing industries. Hence γ_1 shows the difference between the growth rate of ICT producing industries and non-ICT industries. Similarly coefficient γ_2 should be interpreted as the difference between the growth rate of ICT using industries and non-ICT industries. The regressions were run for two sub-periods, 1990-1995 and 1995-2001.[29]

In the period 1990-1995, a number of countries show a significant and positive difference between labour productivity growth rates in ICT producing and non-ICT sectors. There also appears a growth premium in ICT using sectors for some countries, although the regression coefficients (not shown here) suggest this difference is strongest in the US. A similar picture is apparent in the later period except that a larger number of countries join the US in seeing a significantly greater difference in ICT using and producing industries versus non-ICT industries.

[29] The data were weighted by industry employment shares.

Table III.4

Regression results, ICT taxonomy

	1990-95 Difference over non-ICT		1995-01 Difference over non-ICT	
	ICT producing	ICT using	ICT producing	ICT using
US	+	+	+	+
EU-15	?	+	+	+
Belgium	?	+	+	-
Denmark	+	?	+	+
Germany	?	+	+	?
Greece	?	-	+	+
Spain	?	?	?	?
France	?	+	?	+
Ireland	+	-	?	+
Italy	?	+	+	+
Netherlands	?	?	?	+
Austria	?	?	?	+
Portugal	?	?	?	?
Finland	+	?	+	+
Sweden	+	+	?	?
UK	+	+	?	+

+ denotes positive and significant at the 10% level

- denotes negative and significant at the 10% level

? denotes not significant at the 10% level

Up to this point industries have been considered as single observations, but not their importance in accounting for the changes in aggregate economy wide labour productivity growth. The impact of each industry group on labour productivity at the aggregate level depends not only on the average productivity growth rate of each industry, but also on the relative size of that industry. Hence labour productivity for the total economy (*P*) can be perceived as the sum of the productivity contributions of each industry group, *i*, weighted with their labour share ($L_i/L=S_i$):[30]

$$P = \frac{Y}{L} = \sum_{i=1}^{n} \left(\frac{Y_i}{L_i}\right)\left(\frac{L_i}{L}\right) = \sum_{i=1}^{n} \left(P_i S_i\right) \qquad \text{(III.2)}$$

Table III.5 shows the contributions of industries to the percentage point difference in aggregate economy labour productivity growth in the US and EU-15, cross classified by

[30] Based on Fabricant (1942).

the ICT taxonomy. In the period 1979-1990, nearly three quarters of the one percentage point higher EU average labour productivity growth was due to higher growth in more traditional non-ICT industries, with the EU maintaining a productivity advantage in these sectors through to 2001. In the 1980s ICT using sectors accounted for about 40% of the EU higher growth and this advantage continued into the early 1990s. The final period saw a reversal of this pattern as slower growth in ICT using sectors in the EU accounted for –0.6 percentage points slower aggregate growth in Europe. This was confined to service industries although the contribution to the EU-US differential growth from ICT using manufacturing also declined somewhat from its level in the 1980s. The US outperformed the EU in all periods in ICT producing manufacturing and this difference has been increasing over time. In contrast in all periods ICT producing services made a positive contribution to the EU-15 US differential and this became significant but still small by the latest period.

Table III.5

Contributions of industry groups to differences between EU-15 and US aggregate annual labour productivity growth

	Productivity growth differential EU15 over US Average annual percentage points		
	1979-1990	1990-1995	1995-2001
Total economy	**0.99**	**1.19**	**-0.54**
ICT Producing Industries	**-0.13**	**-0.25**	**-0.45**
ICT Producing Manufacturing	*-0.31*	*-0.29*	*-0.60*
ICT Producing Services	*0.08*	*0.04*	*0.15*
ICT Using Industries	**0.38**	**0.44**	**-0.61**
ICT Using Manufacturing	*0.19*	*0.18*	*0.14*
ICT Using Services	*0.19*	*0.26*	*-0.75*
Non-ICT Industries	**0.73**	**0.99**	**0.44**
Non-ICT Manufacturing	*0.27*	*0.01*	*0.24*
Non-ICT Services	*0.41*	*0.88*	*0.32*
Non-ICT Other	*0.06*	*0.10*	*-0.11*

Sources and methods: see Chapter VII.

Appendix Table III.A presents contributions by detailed industry group to growth in each region separately. This shows that much of the high growth in labour productivity in the US in the late 1990s is accounted for by a small number of industries. In the final period, the largest contributors to the US advantage were office machinery and electronic manufacturing in ICT producers, and wholesale, retail and auxiliary financial services (securities) in ICT using sectors. Financial intermediation (banking) and other business services also make a significant contribution. Together these industries contribute 2.1 percentage points to aggregate US growth. The same group of industries account for only 0.7 percentage points in the EU. Indeed the industry contributions to EU growth are more spread out.

At this stage it is important to highlight the impact of productivity growth in public services, (public administration, health and education) since problems in measuring output imply that international comparability is compromised. Although these services need to be included in a decomposition of aggregate productivity growth, it is important to warn the reader that part of the relatively favourable EU labour productivity performance in the 1980s and 1990s is due to these sectors. For example, Appendix Table III.A shows that for the period 1979-1990, 0.35 percentage points of the EU 2.2% labour productivity growth can be accounted for by these hard to measure sectors, with a greater contribution in the period 1990-1995. At the same time their contribution in the US is either very small or negative. Therefore to the extent that differences across the two regions are affected by measurement problems in non-market service productivity growth, the results in this report, if anything, are likely to understate the US advantage in recent years.

III.3.2 IT occupational, general skills and innovation taxonomies

Table III.6 presents labour productivity growth rates for the four groups in the IT occupational clustering, which is based on intensity of use of ICT specific skilled labour. Note that the first two categories in this taxonomy are individual and relatively small industries, computing services and office machinery manufacturing, which show very striking growth patterns.[31] The clustering of the last two groups gives a less clear cut story with both showing accelerating productivity growth in the US but not in the EU. Labour productivity growth rates in the dynamic user groups are, however, higher than in the 'Other group' but the reverse is true for the US, except in 1990-1995.

Table III.7 presents the labour productivity growth rates when industries are clustered according to their intensity of use of various skill types. The finding that the US shows accelerating growth in the final period in the high skilled group with little change in EU growth rates, mirrors the results for the previous two taxonomies. Many high skilled industries are those which intensively use ICT inputs and which are included in the first three groups of the occupational taxonomy. The acceleration in the lower intermediate group in the US is dominated by the fact that the distributive trades are largely concentrated there. The unfavourable performance of the EU in this group raises the possibility that the EU has not fully developed the skills required to intensively use new technology.

[31] The strong decline in labour productivity growth in computer services is partly the result of the estimation procedure for this sector showing a rapidly increasing value added deflator (due to rapid decline in intermediate input prices) and an extraordinary growth of employment. It should perhaps be stressed that even a labour productivity growth estimate for computer services based on gross output rather than value added (and therefore not requiring a separate value added deflator) shows little to no productivity growth in the U.S. since 1995.

Table III.6

Annual labour productivity growth, IT occupational taxonomy

	1979-1990		1990-1995		1995-2001	
	EU	US	EU	US	EU	US
Occupational taxonomy						
IT producer - services (IOPS)	1.5	6.3	1.4	2.4	1.6	-4.4
IT producer – manufacturing (IOPM)	24.0	27.1	26.2	28.5	44.6	48.1
Dynamic IT user (IOU)	1.9	0.9	2.0	1.2	1.7	2.0
IT user other (NIO)	2.1	1.0	2.2	0.8	1.3	2.1

Sources and methods: see Chapter VII.

The skills taxonomy however picks up a relatively favourable EU-15 performance in the final period in industries that are intensive in higher intermediate skills. These industries, which are dominated by engineering products and services such as communications (see the list in Chapter II) are traditional areas of EU strength based on high shares of workers with intermediate craft skills. Note that US productivity growth also accelerates in the higher intermediate group, but remains much lower than in the EU.

Both regions show poor relative performance in the later period in industries that are classified as low skill and in each case the downturn, in terms of percentage point reductions, is more pronounced than for the non-ICT group in the ICT taxonomy. This suggests that it is not just the low use of ICT inputs that are important drivers of low growth but that low workforce skills also have an impact. With the exception of two, relatively small, manufacturing industries (clothing and miscellaneous manufacturing), industries in the low skill category also belong to the non-ICT cluster in the ICT taxonomy. Most also appear in the IT 'Other occupational' taxonomy (the exceptions here are mining and quarrying and motor vehicles). Therefore there is evidence that industries where the workforce typically have low skills and have low intensities of use of ICT inputs show a worsening position across time in both countries.

In order to consider the significance of belonging to a specific skill classification on relative performance, and in line with the ICT producing/using section above, labour produc-

Table III.7

Annual labour productivity growth, skills taxonomy

	1979-1990		1990-1995		1995-2001	
	EU	US	EU	US	EU	US
Skill taxonomy						
High skilled (HS):	1.8	1.5	1.7	1.5	1.6	2.4
High-intermediate skilled (HIS):	2.2	-0.4	2.3	-0.6	2.7	1.0
Low-intermediate skilled (LIS):	1.9	1.3	2.0	1.2	1.3	3.0
Low skilled (LS):	2.5	1.4	2.7	1.8	1.1	0.6

Sources and methods: see Chapter VII.

tivity at the industry level was regressed on dummy variables, with low skills as the base category. This was carried out separately for each country as well as for the two areas, US and EU-15. In addition, the equations were weighted by industry employment shares. The results are summarised in table III.8. It can be seen from the table that for the earlier period, where high skills were found to be significant, they were generally positive, indicating that the high skilled industries are likely to have a higher labour productivity compared to the base category of low skilled. This was found not to be the case in Greece and Finland, and was not significant in a number of other countries. Over the second half of the period, 1995-2001, the results do not show more positive and significant coefficients than the earlier period.

Table III.8

Regression results, skills taxonomy

	1990-95			1995-01		
	Difference over low-skilled			Difference over low-skilled		
	High	High-intermediate	Low-intermediate	High	High-intermediate	Low-intermediate
US	+	-	+	+	?	+
EU-15	+	+	+	?	+	+
Belgium	+	+	?	?	+	?
Denmark	+	+	+	?	-	?
Germany	+	+	?	?	+	+
Greece	-	?	-	?	?	+
Spain	+	+	+	+	?	?
France	+	+	+	?	+	?
Ireland	?	+	?	+	+	+
Italy	?	-	+	?	?	+
Netherlands	?	?	?	+	-	+
Austria	?	+	+	?	-	+
Portugal	?	?	+	?	+	+
Finland	-	-	?	?	?	?
Sweden	?	+	+	?	+	?
UK	?	+	+	?	+	+

+ denotes positive and significant at the 10% level;

- denotes negative and significant at the 10% level;

? denotes not significant at the 10% level

Finally taxonomy effects were combined by including a variable that captures both non-ICT and low skill effects. This coefficient was negative for the US, although with low significance, suggesting a negative effect on labour productivity if industries are both part of the non-ICT and low skills group. In the case of the EU-15 however, the results indicate a weakly positive effect in the earlier period, though by the later period, this has become weakly negative.

Table III.9 presents labour productivity growth rates in the EU and the US when industries are grouped according to sources of innovation, the combined Pavitt-SIID taxonomy of Chapter II. For the goods producing industries (including agriculture, mining, manufacturing and construction) the following results stand out:

- In supplier dominated goods industries (which includes many traditional manufacturing industries, such as clothing, printing and publishing and furniture, but also agriculture and construction), EU growth rates are higher than in the US in the first two periods but more or less converged in the period since 1995. The EU slowdown in supplier dominated goods industries is rather broad across sectors, whereas the US picture is more mixed with some cases of improvements in productivity (agriculture, clothing, furniture) and some cases of continued slow growth (textiles, wood products and – a particularly large industry – construction).

- Scale intensive goods industries (which include much of the traditional heavy industries such as mining and quarrying, food, drink and tobacco products, mineral oil refining and motor vehicle manufacturing), demonstrate that the EU has seen higher levels of labour productivity growth than the US which, by the end of the 1990s, was experiencing negative growth rates. At the more detailed country breakdown, Ireland, Portugal and Greece see large increases in productivity growth in these industries which is indicative of catch-up within the EU.

- The overall levels of labour productivity growth are highest amongst specialist goods suppliers, which include many of the 'high-technology' industries such as office machinery, telecommunications equipment and scientific instruments. It can be seen that the EU lags behind the US in each period and the gap between the two growth rates is growing over the latter part of the 1990s, consistent with the findings for ICT producers above.

- In the case of the science based goods producers, table III.9 shows that the EU has consistently experienced faster growth than the US. This group contains industries such as chemicals, electronic equipment not directly related to ICT, and radio and television receivers.

In conclusion, the EU appears to have a continued productivity strength in the production of traditional manufacturing goods (supplier dominated), scale intensive industries and even in science-based manufacturing industries. But in all three of these goods-producing groups the EU has experienced a slowdown in productivity growth, which suggests that manufacturing may no longer be the 'power house' of the economy that it used to be. Also the EU has rapidly lost much of its productivity advantage relative to the US in specialised supplier industries, which is dominated by ICT producing manufacturing.

When focusing the attention on innovation patterns in services, the following observations stand out:

- In supplier dominated services, the US acceleration in productivity growth is mainly due to the retail trade industry. The US also shows an improvement in productivity growth in communication, but the productivity growth in the EU communications sector remains higher than in the US also after 1995.

- However, in specialised supplier services ('innovation through services'), the EU outperforms the US, which is mainly due to the strongly negative labour productivity growth rates in US computer services. Also knowledge intensive business services show a somewhat better performance in the EU. On the other hand, productivity growth rates in dedicated R&D firms in the US are higher than in the EU

- Organisational innovative services ('innovation in services') show a somewhat better performance in the EU than in the US during the period since 1995, but the gap between the two regions has been considerably reduced. Banking services have shown a strong productivity improvement in both regions, whereas insurance services have experienced a slowdown in both regions. But there is large heterogeneity across countries. The strong productivity advantage in EU air transport services over the US has been reversed after 1995.

- Considering client led industries, a heterogeneous pattern can be seen in table III.9. The US experiences considerable growth in this sector, which includes industries such as wholesale, hotel and catering and business services, in the latter part of the 1990s. The EU lags behind the US, but when the country breakdown is taken into account, Belgium, Denmark, Austria and Sweden are more similar to the US and experience less erratic labour productivity growth than their fellow EU members.

- It is difficult to draw any firm conclusions from the non-market services collection of industries since this is likely to consist of services where outputs and inputs are difficult to measure. When the EU is broken down into individual countries, it can be seen that there is much heterogeneity, within and between countries over the three time periods. Ireland again along with Luxembourg experiences high levels of labour productivity growth.

In summary, the most important observation on productivity growth in services related to innovation patterns, is the strong acceleration of US productivity growth in supplier-based services, which is dominated by retail trade. The strong improvement in US retail trade has also gone together with strong productivity growth in wholesale trade, which explains the US advantage in client led services. These industries benefited from the supply of ICT, but have also undergone significant organisational innovations. Indeed in industries that are primarily characterised by organisational innovations, US performance has also strongly improved, in particular in banking, and it is now about the same as in the EU. Within the EU the experience on service productivity growth is mixed across industries and countries. Although services will be an important engine for future productivity improvements, the exploitation of potential productivity advantages in services will be strongly dependent on national circumstances, including the nature of the innovation system and the working of product and labour markets (see also Chapter VI).

Table III.9

Annual labour productivity growth, combined Pavitt-SIID taxonomy

	1979-1990		1990-1995		1995-2001	
	EU	US	EU	US	EU	US
Good producing industries						
Supplier dominated manufacturing	3.1	1.8	2.7	0.3	1.9	1.8
Scale intensive industry	2.8	2.2	3.7	2.8	1.5	-0.3
Specialised suppliers manufacturing	5.8	8.7	5.4	9.7	5.5	14.5
Science based manufacturing	4.0	3.1	4.3	2.4	2.9	1.1
Service industries						
Supplier dominated services	2.8	2.2	3.0	2.0	3.9	6.7
Specialised suppliers services	1.0	0.3	0.6	0.1	0.9	-0.7
Organizational innovative services	2.3	0.4	2.5	1.1	1.7	1.5
Client led services	0.5	1.3	1.3	1.2	0.3	4.0
Non-market services	0.6	-0.4	1.1	-0.8	0.8	-0.6

III.3.3 Conclusions from the taxonomy approach

The discussion above shows that the most transparent results on comparing productivity growth across industries and countries come from the use of the ICT taxonomy. But distinguishing industries by skill group or source of innovation also yields some insights. Skill use is considered in much more detail in section III.5, where the contribution of increasing skill use to output growth is discussed. So far it is clear, however, that the US has an advantage over the EU in industries that are characteristic of high skills and lower intermediate skills, whereas the EU shows relative strength in industries with higher intermediate skills. The results from the innovation taxonomy are similar to the ICT taxonomy, underlining the US strength in specialised suppliers manufacturing and supplier dominated services. But it also shows US improvement in service industries characterised by organisational innovations which has converged to the EU growth rates. But there is also a great deal of heterogeneity amongst the services innovation groups, stressing the importance of country specific characteristics. Results employing an alternative approach to uncovering the role of technology, using a continuous variable, R&D expenditures, are presented in the firm level analysis in Chapter V below.

III.4 Decomposition of EU-15 labour productivity growth by country

In Chapter I, the aggregate labour productivity growth rates of the EU and the US are presented and it can be seen that over time, labour productivity growth has declined in the EU. This decline has been driven primarily by a fall in the growth rates of Germany and Italy. Here the country contributions to EU productivity growth in each of the three groups according to the ICT-3 taxonomy are considered.

Table III.10 presents the importance of each country in accounting for aggregate labour productivity growth in each industry group. This weights each country's growth rate by its share in EU-15 employment in each group. In absolute terms the larger countries (Germany, France, the UK and Italy and to a lesser extent Spain) account for the largest contributions, given their large shares of EU employment.

The more interesting feature of the Table is how these contributions have changed across time. As shown above, compared to the total economy growth rates, the ICT producing sector shows rapid and increasing growth rates. Of the larger countries, only the UK shows increasing contributions to overall EU growth in ICT producing sectors through time. In France and Germany, their contributions first decline, comparing the 1980s and early 1990s, but then increase in the final period. Italy shows a reverse pattern of higher contributions in the early 1990s but a decline thereafter. Ireland, the Netherlands and Finland show large increases in their contributions in the late 1990s. In fact overall these three countries' contribution is the same as that of France, despite their combined overall employment being only about half its size. Thus in ICT producing sectors, the smaller countries do have a significant impact on aggregate EU trends.

Considering the ICT using sectors, it has been noted above that these have not experienced as substantial growth rates as the ICT producing sectors, and show a slight slowdown in the EU in the final period. The UK again shows an increase in its contribution through time, although this is most marked in the final period. France and Germany show marked declines comparing the 1980s and late 1990s. In France this occurred in the early 1990s whereas Germany's reduced contribution occurred in the late 1990s. Italy showed no change overall across time but a marked decline post 1995. The large increase in Spain's contribution is the most notable with only small percentage point changes for the other member states. Thus the EU labour productivity growth deceleration in ICT using industries during the last period owes much to poor performance of Germany and Italy, with the decline between the period 1979-90 and the early 1990s dominated by France.

Finally in non-ICT industries, all four large countries show declining contributions with the largest decreases in Germany and Italy. Since non-ICT industries represent over 60% of employment in the EU, the results in Table III.10 suggest that poor relative performance in larger countries in these more traditional industries account for much of the overall decline in EU labour productivity growth rates in the late 1990s.

A further breakdown of these contributions into 'between' and 'within' country effects has also been considered using a shift/share analysis. However, the vast majority of variation was within countries. The major exceptions are Germany and Spain. In the German case the impact is strongly negative, in particular post 1995, so that a significant part of the lower German contribution to aggregate labour productivity growth in Table III.10 is its declining share in overall EU employment. In contrast, Spain increases its employment share over time.

Table III.10

Contributions of member States to EU-15 aggregate annual labour productivity growth

	1979-1990	1990-1995	1995-2001
ICT producing			
Belgium	0.13	0.09	0.17
Denmark	0.11	0.13	0.06
Germany	2.41	1.21	2.05
Greece	0.01	0.03	0.07
Spain	0.26	0.31	0.33
France	1.69	0.94	1.07
Ireland	0.09	0.16	0.50
Italy	0.68	0.78	0.67
Luxembourg	0.01	0.02	0.02
Netherlands	0.28	0.19	0.34
Austria	0.18	0.14	0.07
Portugal	0.03	0.07	0.05
Finland	0.11	0.10	0.23
Sweden	0.22	0.20	0.09
UK	1.14	1.58	1.78
EU-15	**7.37**	**5.97**	**7.51**
ICT using			
Belgium	0.08	0.12	-0.05
Denmark	0.03	0.01	0.04
Germany	0.53	0.67	0.30
Greece	0.01	0.01	0.06
Spain	0.10	0.03	0.17
France	0.56	0.13	0.13
Ireland	0.02	0.03	0.07
Italy	0.28	0.48	0.29
Luxembourg	0.01	0.01	0.02
Netherlands	0.14	0.15	0.14

Table III.10 continued

EU countries contributions to aggregate labour productivity growth.

	1979-1990	1990-1995	1995-2001
Austria	0.09	0.09	0.06
Portugal	0.02	0.02	0.03
Finland	0.04	-0.02	0.03
Sweden	0.04	0.05	0.05
UK	0.27	0.29	0.56
EU-15	**2.23**	**2.09**	**1.88**
Non-ICT using			
Belgium	0.08	0.07	0.06
Denmark	0.03	0.05	0.01
Germany	0.47	0.64	-0.01
Greece	0.01	0.03	0.04
Spain	0.21	0.20	0.23
France	0.23	0.28	0.17
Ireland	0.02	0.04	0.07
Italy	0.23	0.27	0.06
Luxembourg	0.01	0.01	0.01
Netherlands	0.13	0.11	0.07
Austria	0.05	0.08	0.02
Portugal	0.02	0.02	0.04
Finland	0.05	-0.01	0.03
Sweden	0.06	0.01	0.06
UK	0.26	0.32	0.16
EU-15	**1.84**	**2.12**	**1.02**

Sources and methods: see Chapter VII.

III.5 Growth accounting

III.5.1 Data and methods

This section considers in greater detail the contributions of physical capital (divided into ICT and non-ICT capital), human capital (labour force skills) and total factor productivity (TFP) on labour productivity growth for the US and four EU countries (France, Germany, the Netherlands and the UK) Data availability dictates that this analysis is carried out only up to 2000 and for a somewhat more aggregated industry classification (26 industries in total) than above. Details of the data sources and estimation methods are given in Chapter VII.

In this section the growth accounting method is employed, which has been used to estimate the impact of ICT on productivity by Jorgenson and Stiroh (2000) and Oliner and Sichel (2000). Essentially it is a method to decompose output growth into contributions of factor inputs, weighted by their shares in the value of output, and underlying residual productivity or total factor productivity (TFP). Thus the growth in output is given by:[32]

$$dq_t = w_l dl_t + w_l dh_t + r_i dki_t + r_n dkn_t + dtfp_t \qquad \text{(III.3)}$$

where q is real output, l is labour in volume terms (hours worked), h is labour quality, ki is ICT capital, kn is non-ICT capital, w and r are input shares in value added (averaged across period t and t-1). The operator d denotes percent growth rates. The method assumes perfect markets and constant returns to scale so that the share of total capital is one minus labour's share. Labour quality is measured by first dividing total hours by skill level, weighting the growth in each type by their wage share and subtracting total hours. Again, constant returns dictate that the weight on labour quality is equal to that on total hours. Subtracting total hours from both sides of the above equation, rearranging and employing constant returns to scale so that $w_l + r_i + r_n = 1$, gives a decomposition of average labour productivity growth as:

$$dp_t = w_l dh_t + r_i dkil_t + r_n dknl_t + dtfp_t \qquad \text{(III.4)}$$

where *p* is labour productivity and *kil* and *knl* are ICT and non-ICT capital labour ratios. Capital input is measured using a Törnqvist capital service index which comprises three assets for ICT - software, computers and communications equipment -, and three for non-ICT - non-ICT equipment, structures and vehicles -. Capital inputs are measured as service flows, and the share of each type in the value of capital is based on its user cost and not its acquisition cost. In the analysis below, for each country, total hours worked have been divided into a number of different skill types that vary across country, the number of types depending on data availability. All countries however include a high skill category, degree and above, and a low category, broadly equivalent to no high school graduation in the US. Variations across countries in the types of labour included are therefore confined to intermediate skill categories.

III.5.2 Growth accounting results

The contributions of labour quality, both types of capital and TFP to labour productivity growth are summarised in charts III.2a-c for industries loosely grouped according to the ICT-3 taxonomy.[33] Note the difference in scale when comparing ICT producers with the

[32] The growth equations are set out in more detail in Chapter VII.

[33] As stated above, this section presents data for only 26 industries and so it is not possible to match exactly the industry groupings used in discussed labour productivity. Nevertheless the matching is sufficiently close to bring out the main features of differences across the groups.

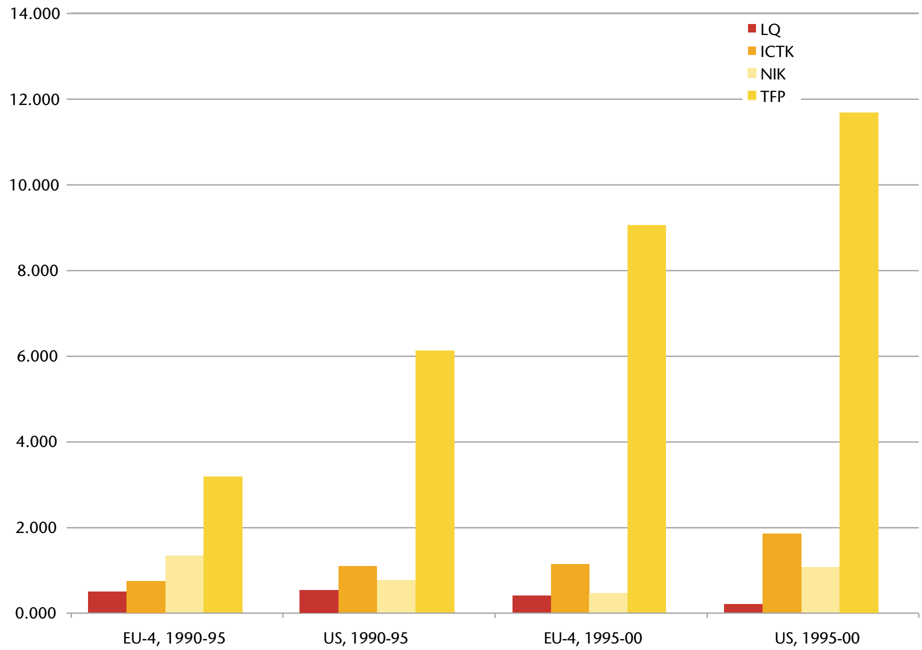
remaining two industry groups, driven by the very large TFP growth in the former. The percentage point contributions of inputs, such as labour quality, are in fact largest among ICT producers.

TFP growth obviously dominates in ICT producing sectors and this has been rising over time in both regions. The contribution from ICT capital deepening also increases across the two time periods but more so in the US than in the EU-4. Non-ICT capital deepening increases its contribution to US labour productivity growth but not in the EU-4, a trend also apparent in other groups as discussed below. Finally increases in the quality of the labour force, through increased employment of skilled workers, has a small positive impact in both regions but its contribution declines in the US over time.

In ICT using industries, ICT capital deepening makes a proportionally greater contribution to labour productivity growth than was the case for ICT producing industries, with again the US showing a significantly greater increase in the final period. In this group there has been a dramatic fall in the contribution of non-ICT capital in the EU-4 contrasting the late with the early 1990s (and a considerable decline from contributions in the 1980s). At the same time contributions from non-ICT capital have fallen only marginally in the US.

Figure III.2.a

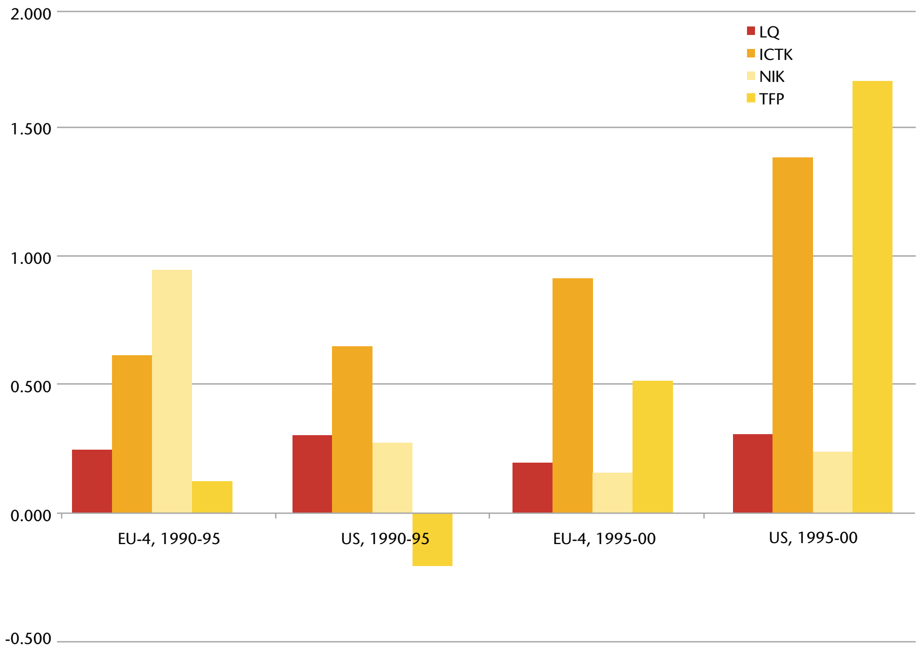
Annual labour productivity contributions*: ICT producing industries, EU-4 and US, 1990-2000



* Percentage point contributions

Figure III.2.b

Annual labour productivity contributions*: ICT using industries, EU-4 and US, 1990-2000

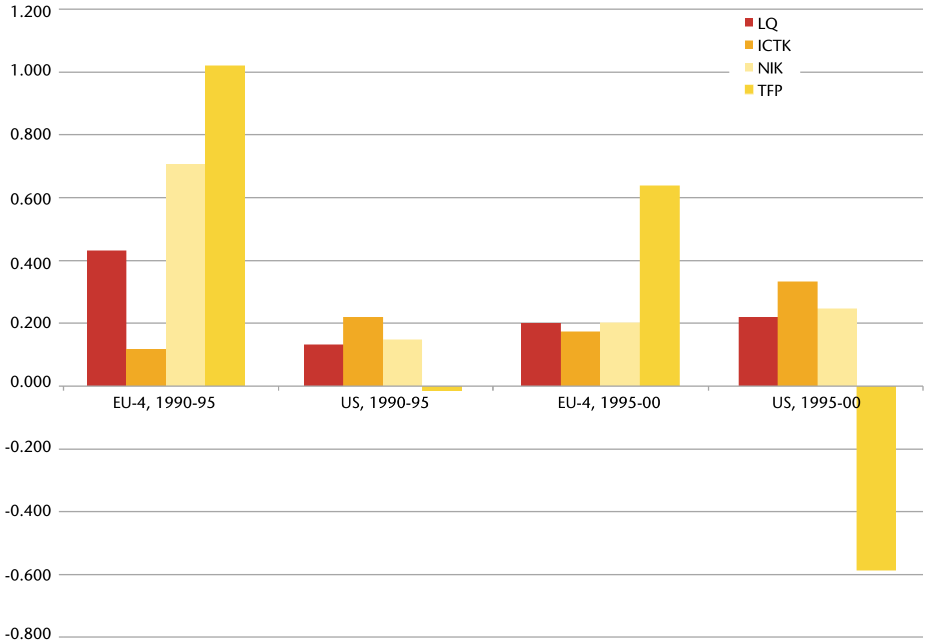


Labour quality is proportionally more important in explaining trends across time in ICT using sectors than in ICT producers, although the percentage point contributions are greater in the latter. Comparing the two halves of the 1990s the contribution of labour quality has fallen in the EU-4 but remained constant in the US. However over the longer term, the labour quality contribution, both in percentage point terms and proportionally, is smaller in the US in the late 1990s than in the 1980s. In ICT using industries there is a dramatic difference between the importance and trends in TFP growth comparing the two regions. The sharp US acceleration and EU deceleration mirror the findings for labour productivity growth.

Finally in non-ICT industries, ICT capital deepening makes a considerably lower percentage point contribution to labour productivity growth than in the previous two groups but again shows the US leading the EU-4. Non-ICT capital deepening is more important than ICT capital as a source of labour productivity growth in the EU-4 but its contribution falls dramatically over the two time periods. Surprisingly, even in this non-intensive ICT using group, US ICT capital deepening makes a greater contribution than non-ICT capital. In the early 1990s the labour quality contribution was large in the EU-4 non-ICT industries, larger than in ICT using industries and on a par with ICT producers. But the late 1990s saw a pronounced fall in the rate of upskilling in more traditional

Figure III.2.c

Annual labour productivity contributions*: non-ICT industries, EU-4 and US, 1990-2000



* Percentage point contributions

industries in these four EU countries. Finally there has been a strong fall in TFP growth rates in both regions in the non-ICT industry group in the late 1990s, with the US growth rates strongly negative. In that country this pattern is a continuation of a trend decline also over the 1980s. In the EU-4 the late 1990s growth rates are only a little below what they were in the period 1979 to 1990. Thus the labour productivity decline from 1.76% per annum in the 1980s to 1.17% in the period 1995-2000 was explained more by lower contributions from other inputs than for residual productivity.

Appendix Tables III.C present the results for all 26 industries, showing for the combined EU-4, the US and the four individual EU countries, labour productivity growth and its division into the percentage point contributions of labour quality, the two types of capital and TFP. The first striking feature of the Table is the widespread nature of the growing importance of ICT capital deepening in both regions. In the EU-4, in the first and second periods, non-ICT capital deepening has a larger contribution than ICT capital to labour productivity in all industries other than financial services and business services. ICT capital is more important in 12 of the 26 industries in the final period. The majority of US industries show larger contributions from ICT than non-ICT capital in all three periods and for most industries the magnitude of the ICT contribution is larger in the US than in the EU-

4. The contributions from labour quality tend to be considerably smaller but nonetheless significant. But there is a difference in the pattern of labour quality contributions across time in the two regions. In most industries the US labour quality contributions are lower in the late 1990s than in the 1980s whereas the EU-4 shows somewhat more upskilling in the final period relative to the 1980s. In both regions labour quality growth is higher in the middle period, but this is dominated by the cyclical downturn in the early 1990s and so this is likely to be picking up some element of high skill labour hoarding common in recessions.

Figures III.3a and III.3b illustrate the time pattern of TFP growth using the data in Appendix Tables III.B1-2. This shows that in the EU-4, increases in TFP, in particular comparing the two halves of the 1990s, are a rarity. This is confined largely to the manufacturing sector, primarily the ICT producers (electrical, electronic and office equipment and instruments), communications, and sectors subject to a high degree of deregulation (utilities and transport). There is also a small acceleration in financial services. Certainly the graph does not show a widespread acceleration of TFP growth in the EU region.

In terms of number of sectors showing accelerating growth, the US picture is not that different to the EU-4. But the location of the acceleration is different, in particular the increased TFP growth rates in wholesale and retail trade which mirror the findings for

Figure III.3.a

Annual labour productivity contributions: TFP, EU-4

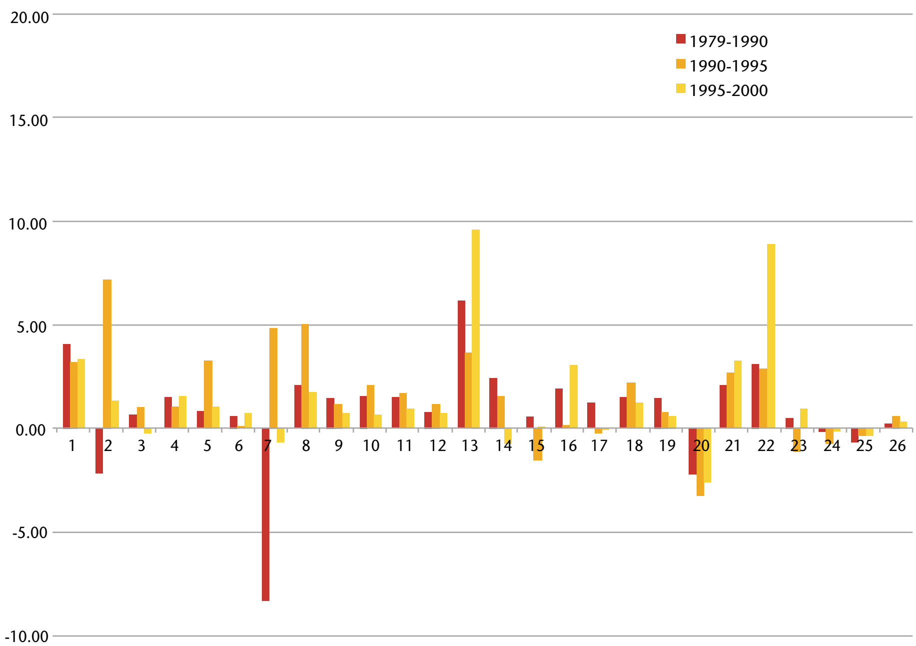
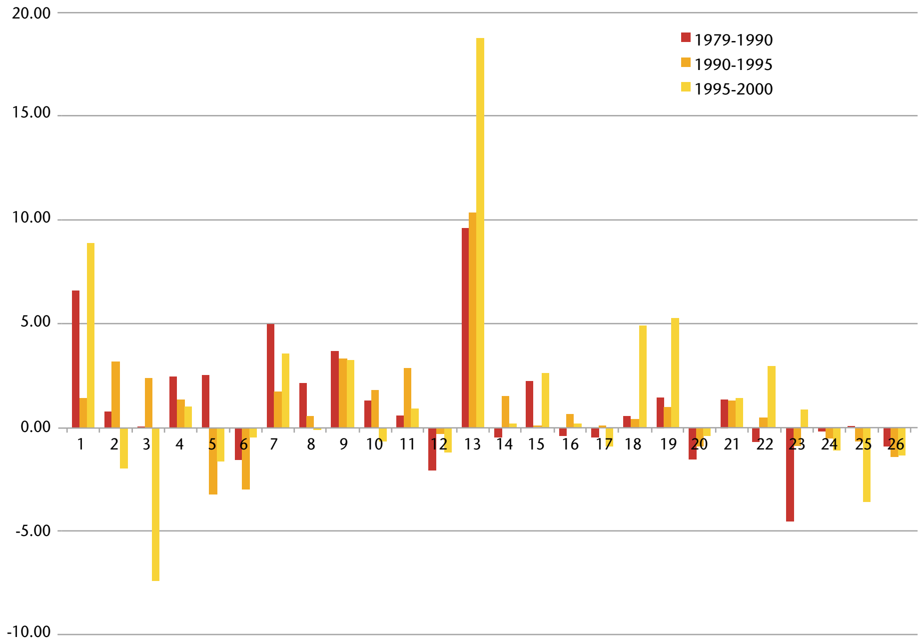


Figure III.3.b

Annual labour productivity contributions: TFP, US



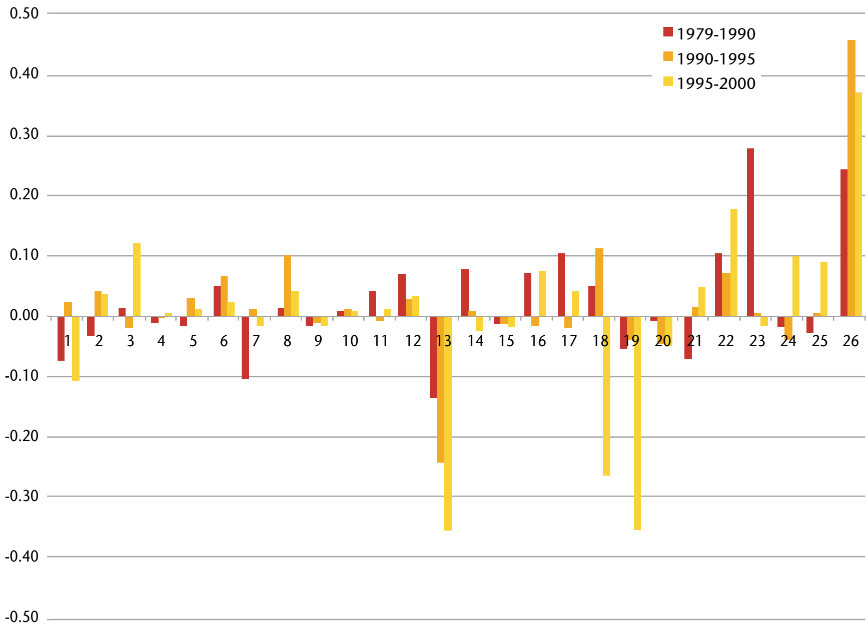
Notes: Appendix tables III.B show which numbers correspond to which industries.

labour productivity. The ICT producing manufacturing sector shows the largest gains in the final period with a smaller upsurge in communications. Agriculture also shows a significant upturn but this again is likely to be due to deregulation.

As with labour productivity growth, it is useful to identify the important sources of the difference in aggregate TFP growth between the EU-4 and the US. This is achieved by multiplying industry growth in TFP by their value added shares and taking the difference between the two regions. Figure III.4 shows the results by industry. Positive numbers represent an EU-4 advantage whereas negative numbers correspond to those where the US experienced higher growth. Total economy TFP growth in 1995-2000 was, on average, about equal in the US and the EU-4. The US benefited from better performance in the ICT producing manufacturing sector (industry 13), and in the large wholesale and retail trade sectors (18 and 19). Smaller contributions came from agriculture (1), hotels and catering (20) and financial services (23). The EU-4 benefited from better performance in communications (22), business and personal services (24) and most importantly from the large non-market services sector (26). But as argued above the latter may at least partly be due to measurement differences and not a reflection of superior EU performance in pure TFP growth. In earlier periods aggregate TFP growth was higher in the EU-4 than the US, by about 0.6% in 1979-90, and 0.5% in 1990 to 1995. These were dominated by non-market services, financial and business services, with better EU-4 performance across a broad spectrum of manufacturing industries, ICT producers excepted.

Figure III.4

Industry contributions to the difference in EU-4 minus US aggregate annual TFP growth



III.5.3 Further analysis of input contributions

It is useful at this point to consider in more detail differences in input growth between the EU and the US. As discussed above, capital deepening has declined in importance as a source of growth in the EU-4 across time. Table III.11 shows the pattern of capital per hour worked levels relative to the US in the four countries individually. These levels estimates use purchasing power parities for investment to convert to a common currency.[34] First looking at the total economy rows, from their relative positions, it can be seen that France, the Netherlands and the UK show a declining trend in ICT capital intensity relative to the US in the 1990s, and in particular since 1995. Germany shows a similar picture in the latter period but not across the whole decade.

When the industries are grouped according to the ICT-3 taxonomy it appears that capital intensity levels in non-ICT industries remain much higher in three of four the EU countries

[34] See Chapter VII for details

relative to the US. The exception is the UK, but even here relative levels of capital intensity in the non-ICT group are closer to the US than in the economy as a whole. This group includes several high capital intensive manufacturing industries. In general these sectors showed increased ratios relative to the US in the 1980s, continuing postwar trends of substituting capital for relatively high cost labour (O'Mahony, 1999). There is a decline in capital intensity in all EU countries relative to the US in the second half of the 1990s in both ICT using and non-ICT industries with the rate of decline being less in the latter than the former (except for the Netherlands).

Table III.11

Capital per hour worked, US=100

	1980	1990	1995	2000
France				
ICT producing	144	118	102	72
ICT using	123	123	120	96
Non-ICT	77	128	134	123
Total economy	99	126	125	103
Germany				
ICT producing	84	78	93	81
ICT using	110	116	128	113
Non-ICT	131	154	157	143
Total economy	113	129	141	131
Netherlands				
ICT producing	130	115	113	118
ICT using	73	82	77	76
Non-ICT	106	160	162	149
Total economy	103	127	123	115
UK				
ICT producing	60	73	73	73
ICT using	38	52	53	45
Non-ICT	76	84	86	76
Total economy	66	71	73	65

Notes: Values in national currencies were converted to $US using 1996 purchasing power parities for investment (OECD, 1999). Sources and methods: see Chapter VII.

These results partly reflect increased capital deepening in the US, in particular widespread ICT investment. Nevertheless the results in Figures III.2a-c, suggest that the relative decline in capital intensity is dominated by trends in traditional non-ICT capital. This is reinforced by the well documented observation, confirmed by the data used in this report, that greater ICT capital deepening in the US is mostly due to greater shares of ICT in total capital rather than higher investment rates. This in turn is most influenced by traditional economic channels of substitution of capital for labour. The late 1990s was a period of wage moderation in many EU countries. As shown in Table III.12, the EU has managed to reduce growth in real wages since the mid 1990s by about 0.4 %-point, at a time when the growth in real wages in the US increased by 1.5 %-points.[35] However, there is significant difference in wage developments between EU countries, with only 7 of the 15 EU countries experiencing real wage moderation since 1995. But, with the exception of Ireland, Portugal and Sweden none of the European countries shows an increase in real wages of more than 1 percentage point since 1995. The wage decline or slow wage growth in the EU may have served to lower the rate at which capital was substituted for labour. In turn, this lowered labour productivity growth below what it would otherwise have been.

It should be stressed, however, that testing whether and by how much changes in labour compensation are related to a decline in capital intensity in the EU and may have affected labour productivity growth rates, requires a more detailed testing of relative prices of labour and capital services. Moreover, an industry perspective may again be useful here, but this goes beyond the scope of this report.[36]

Finally it is worth commenting further on the labour quality calculations. By dividing the labour force into similar but not identical skill groups and weighting by relative wages, it is possible to compare the extent to which increases in labour quality add to labour productivity growth across countries, as was done above. Underlying this are very diverse trends and levels of skill use and the relative wages of various skill groups. The US has a much greater stock of graduates in its workforce, whereas European economies (the UK excepted) have invested more in intermediate level skills. The greater stock of highly skilled workers in the US is likely to have contributed to earlier adoption of ICT in that country.

Table III.13 shows the proportions of the workforce with degrees and above for the ICT taxonomy. This skill category is the one most readily matched across countries in terms of the qualifications acquired. The US has by far the greatest utilisation rates of highly skilled labour. In 1995, the rate of increase in the US highest in ICT producing industries but ICT using sectors shows the highest increase by 2000. In three of the four European countries the rate of increase is highest in ICT producing sectors in both periods, the exception being Germany which saw a small decline in the share of graduates in ICT

[35] Even after adjustment for upskilling, the US real wage growth rate increased by 1.8 percentage points since 1995.

[36] Naastepad and Kleinknecht (2002) provide an extensive overview of theoretical arguments on how wage moderation affects productivity negatively, including the substitution of labour for capital (emphasised here), a slowdown in the creation of new capital vintages, a capital-saving bias of newly developed technology, a decline in R&D investment and less effective demand.

Table III.12

Growth in annual nominal and real wages, US and EU-15, 1979-2001

	Nominal wage growth rates			Real wage growth rates		
	1979-1990	1990-1995	1995-2000	1979-1990	1990-1995	1995-2000
Belgium	6.3	4.3	3.4	2.3	1.7	1.8
Denmark	7.8	3.4	4.1	1.9	1.2	1.5
Germany	4.3	5.5	2.0	1.6	2.7	1.9
Greece	18.8	13.3	7.0	2.2	1.7	2.5
Spain	11.0	6.6	3.5	1.9	1.4	0.8
France	8.6	3.2	2.6	2.3	1.3	1.5
Ireland	10.4	5.4	7.4	3.6	3.4	5.0
Italy	12.2	5.4	2.7	1.7	1.5	0.4
Luxembourg	7.6	5.5	3.3	4.8	1.6	1.1
Netherlands	3.1	3.6	3.7	1.4	1.5	1.4
Austria	5.4	6.5	2.3	2.2	4.1	1.6
Portugal	17.7	10.1	7.4	1.9	2.6	3.9
Finland	9.9	3.3	3.3	3.2	1.5	1.6
Sweden	8.2	2.9	4.2	1.3	0.3	2.3
UK	9.4	5.5	4.7	2.3	2.6	2.4
EU-15	**7.7**	**5.1**	**3.2**	**1.9**	**2.0**	**1.6**
US	**5.8**	**3.5**	**3.8**	**1.3**	**0.7**	**2.2**

Notes: Nominal wages refer to total labour compensation. Real wage growth is nominal labour compensation per employee deflated by GDP deflator.

producing sectors in the early 1990s. All four European countries have been increasing their shares of graduates in ICT using sectors, and generally at a rate higher than in the US. The share of graduates in non-ICT industries shows no change in France, Germany and the Netherlands, comparing the two halves of the 1990s, but increases in both the UK and US. Note also that total employment has been growing less rapidly in non-ICT using industries, so that in terms of numbers employed, the growth in graduates is generally much greater in both ICT producing and ICT using sectors.

It is not easy to compare other skill categories across countries given differences in education systems so figures are not shown. However in general the shares of the 'higher intermediate' skills category has been increasing in all countries. This category includes highly skilled craftsmen and higher education below degree level. This trend is again dominated by ICT producing and using sectors. In contrast the shares of the lowest skill categories, lower intermediate and persons with no formal qualifications have been declining through time.

Table III.13

Proportion of the workforce with high level skills (degree or above), 1990-2000

	US	UK	France	Germany	Netherlands
1990					
Total economy	**23.7**	**10.9**	**15.5**	**11.3**	**6.6**
ICT Producing	23.3	9.1	11.4	9.8	3.3
ICT Using	23.9	12.6	10.9	6.3	6.3
Non-ICT	23.6	10.1	17.9	14.0	6.9
1995					
Total Economy	**25.2**	**14.9**	**15.2**	**10.6**	**7.8**
ICT Producing	27.3	12.1	13.0	9.6	4.2
ICT Using	26.3	16.3	11.7	6.6	7.7
Non-ICT	24.3	14.3	17.0	12.8	8.1
2000					
Total Economy	**27.2**	**18.2**	**16.4**	**10.4**	**9.3**
ICT Producing	29.3	16.1	18.7	10.1	6.4
ICT Using	28.8	20.3	14.3	7.1	10.4
Non-ICT	26.0	16.9	17.4	12.3	8.5

Sources and methods: see Chapter VII.

III.6 Competitiveness in manufacturing: productivity levels and unit labour costs

This section considers issues of competitiveness, focusing solely on the manufacturing sector since this is where most international trade occurs. Unlike previous sections this section focuses on relative (to the US) levels rather than growth rates. It concentrates on two measures, relative labour productivity and unit labour costs. Levels estimates require measures of cross country relative prices by industry. These were obtained using unit value ratios (average sales value per unit of quantity) for a large number of manufactured products. The database consists of unit value ratios for 21 manufacturing industries for 14 countries in the EU and the US for 1997. Relative trends in real value added in different countries are employed to extrapolate relative levels for the benchmark year (now expressed in a common currency) forwards and backwards in time.

Unit labour costs are defined as labour compensation per hour worked divided by labour productivity (in per hour worked terms). In common with other estimates of unit labour costs, wage compensation is deflated by the market exchange rate to convert the numerator to a common currency (e.g. see O'Mahony, 1995). Thus a country's (or industry within a country) relative competitive position at a point in time depends on its dollar levels of output per hour, its nominal compensation per hour and the market exchange rate. This section first considers relative levels of labour productivity and then discusses unit labour costs.

III.6.1 Relative labour productivity levels

This section begins with an overview of the long run changes in the relative position of EU total manufacturing with the US from 1979 to 2001. Figure III.5 shows a marginal improvement in the EU's relative position from 1979 to the mid 1990s, so that by then EU manufacturing output per hour reached about 90% of US levels. This trend was a continuation of the process of post-war convergence, discussed in van Ark (1990) (1996) and O'Mahony (1999). After 1995 followed a dramatic increase in the productivity gap, so that by 2001, EU labour productivity levels had fallen to 81% of US levels, which is below their 1979 level.

Figure III.5

Labour productivity in the EU-15 in manufacturing industries relative to the US, 1979-2001 (US=100)

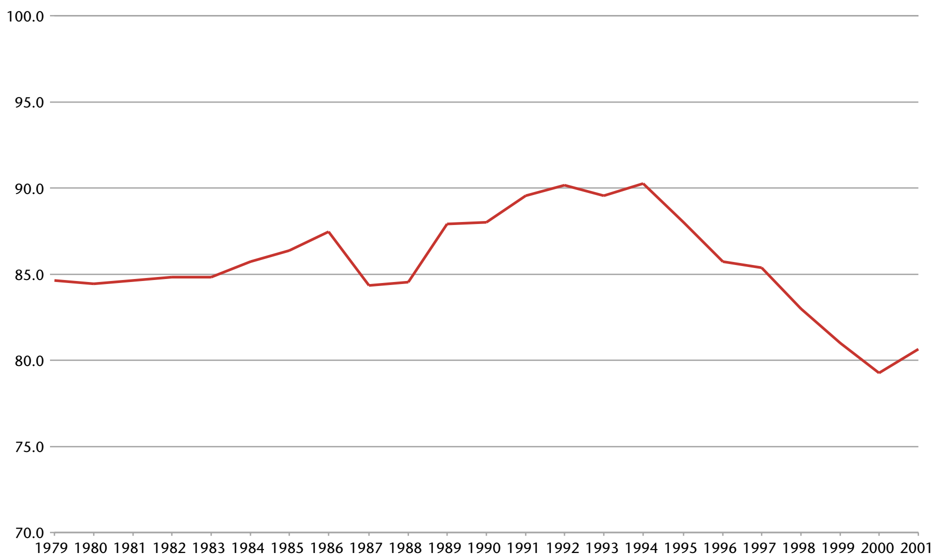


Table III.14 shows the position in individual EU countries for selected time periods. In the early 1980s manufacturing productivity levels were lower than those in the US in most EU member states considered here, the exceptions being Denmark, Germany and France. By the mid 1990s more countries had joined the group that overtook the US, including

Belgium, the Netherlands and Finland. In this period Ireland, Belgium and Finland showed the most dramatic changes in their relative position but other countries that were far behind, such as Greece and Portugal, saw a decline in their relative position. Thus the coefficient of variation (standard deviation across countries relative to the mean) only showed a small fall comparing these two periods. The catch up growth illustrated in the chart above was dominated by trends in the larger EU countries. By the end of the 1990s there were further changes in country's relative positions, with all bar Ireland, and to a smaller extent Austria, showing reductions in their position relative to the US. Proportionally, the largest reductions were in Sweden and Italy, followed by Spain, Germany, the Netherlands and the UK. The variance across EU countries increased significantly during this period.

Table III.14

Labour productivity levels in manufacturing, EU countries relative to the US (US=100)

	1979-81	1994-96	1999-01
Belgium	87.2	117.9	115.7
Denmark	114.0	94.3	88.5
Germany	100.3	92.7	82.7
Greece	45.7	30.7	27.4
Spain	60.5	73.5	62.1
France	103.9	104.3	101.6
Ireland	34.3	90.6	169.8
Italy	90.8	91.1	78.9
Netherlands	94.2	110.2	99.4
Austria	62.4	76.9	79.0
Portugal	37.1	33.4	34.3
Finland	73.7	102.6	101.8
Sweden	93.5	99.3	86.6
UK	63.3	81.9	75.3
EU-14	**84.6**	**88.0**	**80.3**
US	**100.0**	**100.0**	**100.0**

Note: Labour productivity is measured as value added per hour worked

Sources and methods: see Chapter VII.

The levels results above hide considerable diversity across manufacturing industries. Table III.15 shows levels in the EU-14 relative to the US for 26 sectors within manufacturing for the same time periods. Many sectors currently show the EU-14 either ahead or at US productivity levels. However the US is ahead in sectors that have the highest value added per head, in particular in computers, semiconductors and the telecommunication equipment sector. These sectors show a significant deterioration in the EU's relative position compared to the early 1980s. Thus again, this examination of relative levels highlights the importance of the main ICT producing sectors in evaluating the US's better productivity performance in the late 1990s. Only Ireland surpasses the US in productivity levels in both these industries although the Netherlands and Sweden also have marginally higher levels in computer manufacturing.

Table III.15

Labour productivity in EU-14 manufacturing industries relative to the US (US=100)

	ISIC rev 3	1979-81	1994-96	1999-01
Food, drink & tobacco	15-16	64.5	79.7	100.6
Textiles	17	103.4	99.1	100.8
Wearing apparel	18	66.1	67.7	61.0
Leather	19	95.2	88.0	89.9
Wood products	20	63.0	86.8	101.3
Pulp and paper products	21	76.8	104.9	120.0
Printing & publishing	22	67.0	120.3	134.5
Chemicals	24	54.7	70.5	78.4
Rubber & plastics	25	180.2	145.8	127.0
Non-metallic mineral products	26	121.2	142.6	148.8
Basic metals	27	65.1	109.1	107.8
Fabricated metal	28	108.9	108.5	111.4
Machinery	29	66.5	97.4	110.8
Computers	30	133.3	89.8	71.9
Insulated wire	313	87.3	93.7	77.6
Other electrical machinery	31-313	79.7	91.3	112.1
Semiconductors	321	47.8	31.8	41.6
Telecommunication equipment	322	71.9	63.9	65.7
Radio and television receivers	323	44.0	62.8	63.1
Scientific instruments	331	114.4	106.9	103.2
Other instruments	33-331	42.8	49.2	47.3
Motor vehicles	34	30.0	44.9	43.7
Ships and boats	351	59.2	95.8	88.7
Aircraft and spacecraft	353	46.7	71.1	71.8
Railroad and other transport	352+359	68.8	76.4	80.4
Furniture, miscellaneous manufacturing	36-37	110.5	100.8	94.4
Total manufacturing	**15-37**	**84.6**	**88.0**	**80.3**

Sources and methods: see Chapter VII.

III.6.2 Unit labour costs

Figure III.6 shows unit labour costs levels in the EU relative to the US for total manufacturing for the period 1979 to 2001 and Table III.16 shows the cross country distribution. The chart shows more volatile movements than for labour productivity levels, largely due to the influence of exchange rate changes. Until 1990, unit labour costs in the EU were below those in the US. From then they moved above US levels, where they remained until 1999, falling back below US unit labour costs in 2000. Within the EU, unit labour costs, averaged across 1999 to 2001, were lower than in the US in ten of the fourteen EU countries considered here. This was due primarily to the low value of the euro at that time. Over the entire time period Belgium, Sweden, Spain and Ireland have improved their relative position, but all countries, except the UK, show an improving position in the late 1990s relative to the mid 1990s. Hence, in general, the US higher labour productivity levels in manufacturing do not compensate sufficiently for its higher wage costs.

Figure III.6

Unit labour costs in the EU-15 in manufacturing relative to the US, 1979-2001 (US=100)

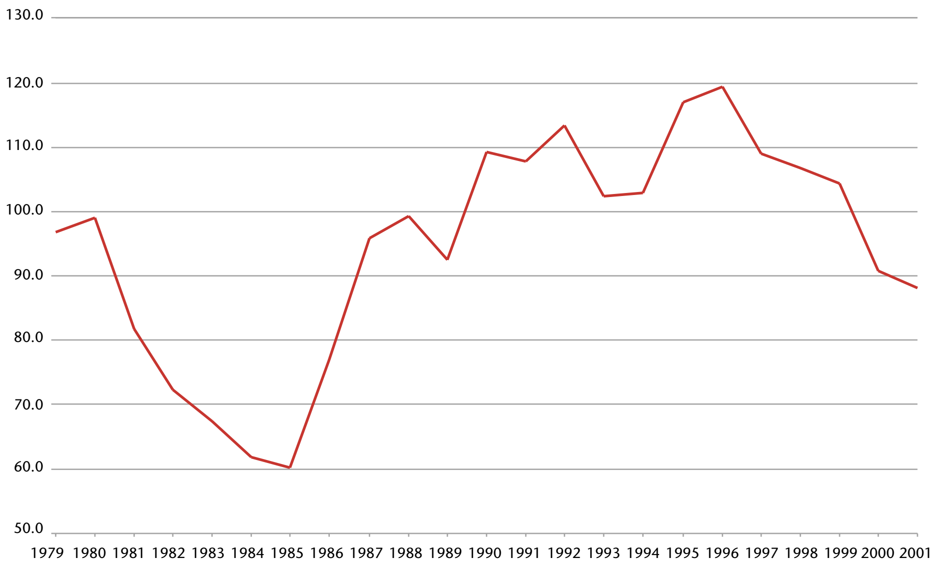


Table III.17 shows unit labour costs in the EU-14 relative to the US by industries within manufacturing. This is almost a mirror image of the productivity levels in Table III.15 above and shows US with a competitive advantage over the EU in the main ICT producing sectors, although its advantage is not significant in computers. The US is also more competitive in clothing, motor vehicles and manufacture of transport equipment other than shipbuilding. In most traditional manufacturing industries, however, the EU is now competitive relative to the US, reflecting the effects of both greater wage moderation and less pronounced declines in labour productivity levels.

Table III.16

Unit labour costs relative to the US: EU member states

	1979-81	1994-96	1999-01
Belgium	126.9	114.3	84.7
Denmark	80.6	120.9	101.6
Germany	91.9	139.7	110.7
Greece	77.2	125.5	109.1
Spain	100.4	93.3	79.9
France	100.4	114.5	84.8
Ireland	153.5	78.5	39.1
Italy	69.1	86.6	75.8
Netherlands	98.3	103.1	84.9
Austria	107.5	137.7	93.7
Portugal	53.4	89.5	78.3
Finland	96.5	100.7	76.6
Sweden	131.9	108.6	94.1
UK	108.3	108.0	119.5
EU-14	**92.5**	**113.1**	**94.4**
US	**100.0**	**100.0**	**100.0**

Unit labour cost is defined as labour compensation over real value added; Labour compensation is corrected for changes in effective exchange rates; Value added is corrected for price differences using PPPs. Sources and methods: see Chapter VII.

Table III.17

Unit labour costs in EU-14 manufacturing industries relative to the US (US=100)

	ISIC rev 3	1979-81	1994-96	1999-01
Food, drink & tobacco	15-16	116.8	124.5	78.9
Textiles	17	82.7	106.2	79.4
Wearing apparel	18	128.8	151.4	124.6
Leather	19	82.3	98.6	68.2
Wood products	20	116.5	116.3	77.6
Pulp and paper products	21	109.4	99.5	70.2
Printing & publishing	22	140.7	93.4	65.2
Chemicals	24	162.7	144.5	93.5
Rubber & plastics	25	55.1	79.3	72.4
Non-metallic mineral products	26	60.5	70.9	53.4
Basic metals	27	108.0	98.2	83.2
Fabricated metal	28	64.2	89.9	72.0
Machinery	29	123.1	110.3	69.3
Computers	30	82.5	138.2	105.4
Insulated wire	313	73.2	94.7	81.0
Other electrical machinery	31-313	113.1	129.8	74.4
Semiconductors	321	167.8	245.8	132.1
Telecommunication equipment	322	184.3	211.9	142.1
Radio and television receivers	323	189.5	129.0	88.6
Scientific instruments	331	81.5	90.0	64.6
Other instruments	33-331	135.0	144.1	135.7
Motor vehicles	34	220.1	203.5	181.1
Ships and boats	351	117.1	119.1	90.1
Aircraft and spacecraft	353	165.4	137.2	117.2
Railroad and other transport	352+359	95.8	130.0	123.2
Furniture, miscellaneous manufacturing	36-37	80.9	101.0	82.2
Total manufacturing	**15-37**	**92.5**	**113.1**	**94.4**

Sources and methods: see Chapter VII.

III.7 Conclusions

This chapter forms the main body of the industry level analysis of productivity growth. It began by highlighting the large variation in labour productivity performance across industries, time and countries. Its primary purpose is to use this variation to highlight aspects of productivity performance not observable in aggregate data while at the same time not getting lost in too much detail. The taxonomy groupings, constructed in Chapter II were therefore used to summarise the industry data into manageable numbers.

This industry focus has yielded a number of useful conclusions. First much of the industry variation can be explained in terms of changes due to the development of information and communications technology and differential rates of adoption and use of this technology, in particular in services, in the EU compared to the US. The acceleration in US labour productivity growth from the mid 1990s is heavily concentrated in industries that either produce or intensively use the new technology. The EU has not experienced the same growth spurt in these sectors with its poorer performance most apparent in ICT intensive using service sectors. The use of other taxonomies, based on the intensity of use of ICT specific labour, general labour force skills and channels through which innovation occurs, reinforces this picture that the US is now dominant in high technology industries in manufacturing and intensive ICT users in services.

US labour productivity growth benefits from a greater contribution of ICT capital deepening, and from having greater endowments of high skilled graduates in its workforce. Nevertheless, the US productivity acceleration (in total factor productivity terms) is also apparent when account is taken of investments in physical and human capital.

The experience in both regions is more similar in other (non-ICT) industries, with decelerating growth across time being the norm. This group includes mature traditional manufacturing industries that are likely to be adversely affected by competition from third countries, mostly developing nations. Although the EU remains competitive relative to the US in these industries, in the sense of having lower unit cost level, this is not much consolation given that competition is not primarily with the US. It is at least questionable if traditional manufacturing production can remain the 'power house' of future productivity growth in the European Union.

While focusing on new technology explains much of the US resurgence, it is by no means the entire story. One of the striking features of the results is the very large drop in the rate of non-ICT capital deepening in the EU. This chapter rather tentatively suggests that wage moderation in the EU in recent years may have led to substitution of labour for capital, in particular in traditional industries. To the extent that this has long run consequences for growth, it may be a worrying trend.

III.A Appendix Tables

Table III.A

Industry contributions to annual labour productivity growth

		US			EU-15		
		1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	01	0.143	0.056	0.123	0.044	0.026	0.006
Forestry	02	0.008	-0.007	0.003	0.008	-0.003	-0.002
Fishing	05	0.004	-0.006	0.002	0.001	0.000	-0.001
Mining and quarrying	10-14	0.011	-0.001	-0.023	-0.015	0.038	-0.014
Food, drink & tobacco	15-16	-0.003	0.033	-0.108	0.034	0.058	-0.011
Textiles	17	0.001	0.012	-0.019	-0.011	-0.007	-0.009
Clothing	18	-0.006	-0.005	-0.014	0.002	0.002	-0.010
Leather and footwear	19	-0.003	-0.001	-0.005	-0.002	-0.003	-0.008
Wood & products of wood and cork	20	0.002	-0.020	-0.013	0.003	0.011	0.004
Pulp, paper & paper products	21	0.000	0.007	-0.012	0.014	0.014	0.008
Printing & publishing	22	-0.007	-0.058	-0.034	0.032	0.015	0.004
Mineral oil refining, coke & nuclear fuel	23	0.028	0.004	-0.004	-0.049	0.010	-0.010
Chemicals	24	0.030	0.025	-0.005	0.089	0.086	0.044
Rubber & plastics	25	0.025	0.040	0.012	0.030	0.033	0.012
Non-metallic mineral products	26	-0.015	0.004	-0.004	0.012	0.016	0.004
Basic metals	27	-0.082	0.017	0.000	0.013	0.009	-0.008
Fabricated metal products	28	-0.022	0.032	-0.013	0.012	0.029	0.008
Mechanical engineering	29	-0.101	-0.002	-0.060	0.026	-0.005	0.003
Office machinery	30	0.186	0.138	0.238	0.112	0.077	0.123
Insulated wire	*313*	0.002	0.000	0.001	0.005	0.005	-0.001
Other electrical machinery and aparatus nec	*31-313*	-0.019	-0.005	-0.026	0.009	-0.009	0.009
Electronic valves and tubes	*321*	0.129	0.312	0.548	0.029	0.057	0.128
Telecommunication equipment	*322*	0.106	0.015	-0.010	0.055	0.003	0.001
Radio and television receivers	*323*	0.007	-0.001	-0.007	0.021	-0.011	-0.009
Scientific instruments	*331*	0.010	-0.063	-0.043	0.005	-0.021	-0.032
Other instruments	*33-331*	-0.008	-0.005	0.001	0.002	0.006	0.003
Motor vehicles	34	-0.051	0.106	-0.011	0.033	0.012	0.019
Building and repairing of ships and boats	*351*	0.004	-0.010	0.001	0.000	-0.002	0.000
Aircraft and spacecraft	*353*	0.027	-0.097	-0.001	0.012	-0.004	0.003
Railroad equipment and transport equipment nec	*352+359*	-0.002	0.002	0.006	0.001	0.001	0.001

Table III.A continued…

Industry contributions to annual labour productivity growth

		US			EU-15		
		1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Furniture, miscellaneous manufacturing; recycling	36-37	0.007	0.004	0.006	0.002	0.006	0.002
Electricity, gas and water supply	40-41	0.029	0.010	-0.052	0.082	0.048	0.030
Construction	45	-0.051	-0.021	0.087	0.081	0.026	0.008
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	0.014	-0.014	-0.011	0.036	0.034	0.027
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	0.158	0.153	0.375	0.123	0.183	0.112
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	0.173	0.114	0.371	0.108	0.113	0.061
Hotels & catering	55	0.014	-0.012	0.000	0.026	0.016	0.014
Inland transport	60	-0.013	0.063	0.017	0.070	0.061	0.040
Water transport	61	-0.004	0.002	0.002	-0.003	0.007	0.002
Air transport	62	0.041	0.044	0.026	0.015	0.032	0.030
Supporting and auxiliary transport activities; activities of travel agencies	63	0.010	0.009	0.011	0.037	0.055	0.049
Communications	64	-0.002	0.058	0.157	0.145	0.139	0.249
Financial intermediation, except insurance and pension funding	65	0.016	-0.033	0.190	0.165	0.071	0.130
Insurance and pension funding, except compulsory social security	66	-0.058	0.023	-0.001	0.032	0.014	-0.003
Activities auxiliary to financial intermediation	67	0.053	0.086	0.261	0.018	0.013	0.017
Real estate activities	70	0.000	0.000	0.000	0.000	0.000	0.000
Renting of machinery and equipment	71	0.012	0.038	0.048	0.039	0.041	0.065
Computer and related activities	72	0.113	0.110	0.095	0.050	0.069	0.152
Research and development	73	0.021	0.003	0.010	0.019	0.004	-0.002
Legal, technical and advertising	*741-3*	0.082	-0.043	0.051	0.145	0.161	0.178
Other business activities, nec	*749*	0.133	0.094	0.143	0.084	0.130	0.123

Table III.A continued…

Industry contributions to annual labour productivity growth

		US			EU-15		
		1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Public administration and defence; compulsory social security	75	0.009	-0.146	-0.020	0.144	0.144	-0.020
Education	80	0.005	0.010	-0.054	0.068	0.123	0.011
Health and social work	85	0.063	-0.010	0.035	0.137	0.228	0.097
Other community, social and personal services	90-93	0.036	0.035	-0.011	0.094	0.112	0.068
Private households with employed persons	95	-0.004	0.001	-0.007	0.003	0.011	0.005
Extra-territorial organizations and bodies	99						
Total Economy growth rate		**1.260**	**1.099**	**2.250**	**2.249**	**2.285**	**1.712**

Table III.B

Annual labour productivity growth, 1979-2001, EU countries

	Belgium			Denmark		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	5.1	6.5	3.9	8.2	7.4	6.9
Forestry	4.7	13.7	5.2	0.4	-4.9	10.3
Fishing	3.9	9.9	3.5	-3.7	8.3	1.3
Mining and quarrying	2.8	11.7	-1.7	9.9	8.0	6.6
Food, drink & tobacco	3.7	2.4	2.0	1.7	3.0	1.7
Textiles	5.2	0.3	8.0	1.2	2.7	7.1
Clothing	5.7	17.7	3.8	3.4	3.1	11.2
Leather and footwear	1.9	-5.6	0.5	3.5	1.6	10.2
Wood & wood products	7.8	-0.4	5.1	-0.5	4.4	1.8
Pulp, paper & paper products	4.4	2.8	1.6	0.5	5.6	4.0
Printing & publishing	4.0	6.9	0.9	-0.1	-0.8	1.0
Mineral oil refining, coke & nuclear fuel	7.9	-4.0	-8.4	3.6	-19.0	16.2
Chemicals	9.0	6.1	6.2	2.3	5.1	9.1
Rubber & plastics	9.7	5.9	1.0	3.1	-3.8	7.1
Non-metallic mineral products	6.5	4.2	-0.4	1.2	1.6	-0.2
Basic metals	7.8	0.8	4.5	5.9	4.8	2.3
Fabricated metal products	3.7	2.2	2.3	1.9	3.3	0.1
Mechanical engineering	3.7	-1.4	4.0	1.2	2.5	2.0
Office machinery	28.2	30.4	38.7	24.8	24.9	51.5
Insulated wire	7.3	8.3	-2.4	1.9	16.1	-11.3
Other electrical machinery	4.2	3.1	-0.5	-1.2	7.8	0.1
Electronic valves and tubes	21.7	31.5	57.3	20.7	32.3	54.1
Telecommunication equipment	20.9	3.5	-0.3	19.9	-4.5	4.9
Radio and television receivers	14.1	0.5	-11.4	13.2	2.2	-11.4
Scientific instruments	4.6	-2.0	-10.2	0.8	1.3	-9.5
Other instruments	4.2	6.3	-6.5	0.5	11.0	9.7
Motor vehicles	5.1	3.7	4.0	2.8	-3.4	5.0
Building and repairing of ships and boats	5.1	3.7	2.4	1.5	10.5	-12.1
Aircraft and spacecraft	5.1	3.7	7.8	0.8	-19.8	-1.5
Railroad and other transport equipment	5.1	3.7	8.6	0.8	3.7	4.5
Furniture & miscellaneous manufacturing	2.7	0.0	2.3	2.8	0.7	1.4
Electricity, gas and water supply	2.0	4.4	6.3	1.0	5.4	-1.5
Construction	3.3	-0.4	1.8	3.1	-0.6	-1.3
Sales and repair of motor vehicles[1]	0.1	2.2	0.2	-2.2	3.6	-0.8
Wholesale trade and commission trade[2]	0.1	2.2	0.1	1.2	2.1	4.6
Retail trade[2] and repairs[3],	0.1	2.2	-1.6	2.0	2.3	2.3

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Belgium			Denmark		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	2.1	0.2	0.2	0.4	2.0	-0.9
Inland transport	4.1	1.6	3.3	0.2	1.1	-0.2
Water transport	5.0	1.6	12.1	-1.4	2.3	1.9
Air transport	2.1	1.6	-0.9	-0.7	-6.6	-0.2
Supporting transport activities	1.8	1.6	1.2	3.1	0.5	0.5
Communications	4.3	2.5	6.2	4.3	5.0	6.1
Financial intermediation,	2.2	4.7	-0.3	0.8	-1.2	3.8
Insurance and pension funding	2.2	4.7	-0.3	4.0	-6.6	7.4
Auxiliary financial services	2.2	4.7	-0.3	7.6	1.8	-11.2
Real estate activities	2.2	0.8	5.0	-2.0	1.4	1.1
Renting of machinery and equipment	2.2	0.8	15.7	-14.9	38.3	-0.3
Computer and related activities	2.2	0.8	5.0	4.9	12.2	4.2
Research and development	2.2	0.8	5.4	1.6	-2.7	2.0
Legal, technical and advertising	2.2	0.8	-1.3	3.9	-2.3	1.5
Other business activities	2.2	0.8	5.3	2.6	1.5	-0.1
Public administration[4]	0.1	1.6	0.5	0.6	1.7	-0.6
Education	0.8	1.4	0.9	0.6	1.6	-0.4
Health and social work	2.8	2.4	0.7	0.3	1.3	-1.0
Other services[5]	3.1	3.9	0.8	2.1	1.2	0.0
Private households with employed persons	-2.2	1.3	-2.1	-0.2	-0.9	-2.3

Notes: 1. Includes motorcycles and retail sale of automotive fuel; 2. except of motor vehicles and motorcycles; 3. repair of personal and household goods; 4. Including compulsory social security; 5. Other community, social and personal services.

Sources and methods: see Chapter VII.

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Germany			Greece		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	5.5	6.1	5.5	1.8	4.9	1.4
Forestry	4.5	-4.2	5.0	5.3	3.5	-3.5
Fishing	4.8	-2.9	8.5	-5.4	-5.2	8.3
Mining and quarrying	-0.6	9.7	-2.1	2.7	7.9	3.2
Food, drink & tobacco	1.7	2.4	0.8	1.8	5.4	2.2
Textiles	3.7	1.7	1.2	-4.4	-0.5	1.2
Clothing	2.8	3.9	5.0	0.6	-1.4	0.5
Leather and footwear	2.8	3.7	1.9	-0.8	2.2	2.0
Wood & wood products	0.5	5.3	2.5	-1.2	2.7	3.2
Pulp, paper & paper products	2.8	0.3	4.9	3.4	2.7	-2.2
Printing & publishing	1.2	2.6	2.3	1.5	0.7	4.5
Mineral oil refining, coke & nuclear fuel	0.1	-5.4	9.9	0.9	13.6	6.7
Chemicals	2.4	7.3	2.5	3.9	0.0	2.4
Rubber & plastics	1.8	2.6	1.1	1.8	-2.4	-2.0
Non-metallic mineral products	2.1	4.6	1.3	0.3	0.7	5.7
Basic metals	1.8	7.7	2.6	0.5	-3.2	1.8
Fabricated metal products	1.9	2.0	1.1	-0.7	2.9	3.6
Mechanical engineering	1.4	2.2	1.2	0.9	6.0	3.9
Office machinery	24.0	24.6	51.9	23.4	19.1	43.6
Insulated wire	5.7	-0.1	2.5	2.5	9.4	5.7
Other electrical machinery	1.4	-0.5	4.3	-0.6	5.0	4.9
Electronic valves and tubes	19.0	30.5	61.9	16.9	23.0	66.1
Telecommunication equipment	18.3	4.8	5.6	16.1	-2.8	11.4
Radio and television receivers	11.5	-4.0	-7.8	9.4	1.2	-1.8
Scientific instruments	2.0	-4.3	-3.8	-0.2	-3.2	-12.8
Other instruments	1.1	2.9	5.2	-0.6	-7.1	-2.4
Motor vehicles	1.6	2.9	-3.6	-4.4	6.0	8.7
Building and repairing of ships and boats	1.4	-1.2	-0.7	-1.3	8.0	5.3
Aircraft and spacecraft	2.9	-3.6	8.3	-1.3	2.3	0.2
Railroad and other transport equipment	2.1	0.6	5.4	-1.3	1.1	-1.5
Furniture & miscellaneous manufacturing	0.6	-0.5	1.2	0.6	1.0	2.3
Electricity, gas and water supply	0.9	3.5	6.2	2.1	2.0	5.5
Construction	0.6	-2.7	1.0	0.9	-2.6	3.5
Sales and repair of motor vehicles[1]	1.7	-0.3	0.1	-0.8	-2.6	4.9
Wholesale trade and commission trade[2]	1.5	4.2	2.2	-0.8	-2.6	4.0
Retail trade[2] and repairs[3],	1.4	3.3	1.0	-0.8	-2.6	4.6

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Germany			Greece		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	-0.8	-3.4	-3.5	-0.8	-3.3	2.6
Inland transport	2.0	2.8	3.6	4.6	4.2	4.6
Water transport	2.4	11.8	12.5	4.6	4.2	8.5
Air transport	1.5	17.7	3.9	4.6	4.2	6.9
Supporting transport activities	2.0	7.8	3.7	4.6	4.2	7.1
Communications	5.0	7.9	15.2	4.6	4.2	7.7
Financial intermediation,	3.1	2.7	8.0	-0.6	-2.5	3.4
Insurance and pension funding	2.6	2.4	-6.8	-0.6	-2.5	6.1
Auxiliary financial services	2.2	-2.2	1.9	-0.6	-2.5	5.4
Real estate activities	1.8	-2.0	-1.9	-0.6	-1.4	-1.6
Renting of machinery and equipment	7.4	3.2	2.4	-0.6	-1.4	8.6
Computer and related activities	5.7	1.6	4.4	-0.6	-1.4	13.6
Research and development	0.6	0.3	5.6	-0.6	-1.4	8.2
Legal, technical and advertising	0.9	0.3	-2.5	-0.6	-1.4	1.3
Other business activities	0.9	0.3	-2.5	-0.6	-1.4	1.3
Public administration[4]	1.3	3.1	1.6	-1.8	-4.3	0.4
Education	0.6	1.2	0.5	-1.6	0.1	-1.5
Health and social work	-1.0	1.9	0.5	-1.6	0.9	-0.5
Other services[5]	1.4	0.3	0.1	-1.6	0.4	3.8
Private households with employed persons	0.5	1.2	0.2	-1.6	-5.3	0.9

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Spain			France		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	6.2	1.3	2.6	5.8	7.1	4.8
Forestry	5.3	2.4	-2.5	2.7	-5.7	-5.8
Fishing	6.2	-3.9	0.8	-0.1	-1.3	-2.3
Mining and quarrying	2.8	9.4	1.7	2.6	6.1	12.8
Food, drink & tobacco	4.9	1.3	0.4	1.3	1.3	-0.6
Textiles	2.9	4.6	-0.5	0.9	5.3	2.3
Clothing	3.5	4.5	0.8	1.5	2.6	7.6
Leather and footwear	4.5	3.4	0.6	1.0	-1.1	2.8
Wood & wood products	3.2	2.4	-2.7	3.1	2.9	4.7
Pulp, paper & paper products	6.1	8.9	-1.5	3.2	2.6	5.3
Printing & publishing	6.1	-1.0	0.9	1.7	0.7	0.7
Mineral oil refining, coke & nuclear fuel	2.2	-0.1	-1.3	-12.7	9.3	0.2
Chemicals	7.6	6.2	0.6	3.8	6.0	5.0
Rubber & plastics	3.9	5.2	0.6	1.3	3.0	3.2
Non-metallic mineral products	5.1	2.9	0.4	5.2	1.7	2.9
Basic metals	5.0	11.2	-1.2	4.8	5.7	-0.2
Fabricated metal products	3.7	2.3	0.4	0.3	1.2	1.2
Mechanical engineering	3.2	3.3	0.6	3.1	4.3	2.3
Office machinery	31.3	28.8	43.0	21.8	22.3	39.9
Insulated wire	7.2	5.0	-1.5	4.5	4.5	5.2
Other electrical machinery	2.0	1.3	-0.8	1.4	0.0	2.7
Electronic valves and tubes	18.3	31.4	50.1	19.6	29.7	55.3
Telecommunication equipment	23.6	-4.7	-7.8	17.1	5.4	1.0
Radio and television receivers	11.5	0.0	-15.2	10.3	1.9	-13.7
Scientific instruments	2.5	-3.6	-8.0	0.5	-4.1	-8.4
Other instruments	2.8	3.8	1.2	0.1	7.9	3.1
Motor vehicles	5.4	3.7	-0.1	4.5	3.7	9.1
Building and repairing of ships and boats	4.8	2.6	-1.7	8.6	-2.8	15.1
Aircraft and spacecraft	10.0	-3.5	3.0	1.3	11.4	-7.4
Railroad and other transport equipment	6.1	7.4	3.9	8.8	8.9	-0.8
Furniture & miscellaneous manufacturing	3.1	1.8	2.1	3.6	1.8	1.8
Electricity, gas and water supply	3.4	1.7	5.5	5.4	2.2	3.6
Construction	3.4	2.0	0.3	2.6	1.7	-1.3
Sales and repair of motor vehicles[1]	-0.2	2.6	-0.8	3.2	-1.6	0.0
Wholesale trade and commission trade[2]	-0.7	2.0	-0.2	4.7	3.7	0.8
Retail trade[2] and repairs[3],	1.6	0.3	0.2	4.0	2.0	1.2

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Spain			France		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	0.4	0.7	-0.7	-2.1	-2.4	0.9
Inland transport	2.7	6.3	2.3	3.4	0.8	0.7
Water transport	-0.6	5.9	6.6	-0.1	4.2	7.2
Air transport	5.9	1.3	8.5	1.8	6.0	3.4
Supporting transport activities	3.9	-6.7	-0.1	4.0	1.1	0.0
Communications	3.7	4.1	5.4	7.3	2.4	7.6
Financial intermediation,	3.8	-2.3	4.2	6.7	-1.5	0.4
Insurance and pension funding	2.1	-9.9	-1.6	3.5	0.1	6.5
Auxiliary financial services	4.0	-6.2	1.0	3.5	3.9	-1.6
Real estate activities	-0.5	5.2	-5.3	-0.8	3.3	2.5
Renting of machinery and equipment	-5.2	5.7	0.0	-2.0	-3.2	-1.2
Computer and related activities	-0.2	-6.1	-3.3	2.6	-0.8	-0.6
Research and development	0.7	10.5	-2.6	5.0	-0.6	-0.8
Legal, technical and advertising	-0.6	1.0	0.4	3.8	-0.5	1.5
Other business activities	-0.6	1.0	-2.7	-0.4	-0.3	-2.3
Public administration[4]	-0.3	1.3	1.0	1.4	0.8	1.6
Education	1.5	0.8	0.6	0.7	1.1	0.9
Health and social work	0.3	1.8	-0.3	3.2	0.8	1.6
Other services[5]	-0.1	-1.2	0.1	-2.3	-2.8	-0.4
Private households with employed persons	n.a.	n.a.	n.a.	-2.9	-2.1	-0.5

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Ireland			Italy		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	4.3	3.5	1.9	4.6	7.8	3.5
Forestry	4.3	4.1	1.4	14.5	1.6	6.9
Fishing	4.3	4.1	-5.0	4.1	6.6	1.3
Mining and quarrying	-0.6	22.0	1.6	3.0	6.3	-1.2
Food, drink & tobacco	10.1	3.2	3.1	2.7	2.5	1.6
Textiles	5.4	0.1	1.2	2.2	1.9	1.4
Clothing	4.0	1.4	9.3	4.1	8.3	3.6
Leather and footwear	8.7	2.6	-3.4	3.6	4.2	-0.6
Wood & wood products	5.5	0.6	1.9	4.0	3.4	2.7
Pulp, paper & paper products	7.0	4.7	-1.5	0.9	4.4	0.8
Printing & publishing	3.8	7.7	13.1	5.2	1.1	3.0
Mineral oil refining, coke & nuclear fuel	6.0	8.5	12.8	-15.3	6.2	-5.6
Chemicals	9.9	10.8	14.7	8.6	4.0	0.4
Rubber & plastics	6.3	-0.1	-1.0	1.0	2.6	-0.9
Non-metallic mineral products	7.5	2.5	-3.6	1.9	1.9	0.4
Basic metals	9.7	-4.0	1.3	8.4	5.9	-2.9
Fabricated metal products	4.6	0.2	-1.5	2.9	4.5	1.5
Mechanical engineering	7.3	-0.7	-2.1	1.2	3.7	0.5
Office machinery	31.9	27.3	44.6	23.6	29.8	39.9
Insulated wire	11.9	14.8	-8.7	2.2	10.5	-2.0
Other electrical machinery	8.8	6.7	13.8	-0.9	1.3	-0.2
Electronic valves and tubes	26.3	31.1	74.0	23.5	36.2	49.6
Telecommunication equipment	25.5	0.6	0.8	22.7	-3.8	-8.0
Radio and television receivers	18.7	-11.7	4.9	15.9	0.9	-18.8
Scientific instruments	6.4	-6.8	-4.1	-0.6	-6.9	-10.0
Other instruments	6.0	5.7	6.5	-0.9	5.5	2.6
Motor vehicles	5.3	2.3	-2.1	6.3	1.3	1.1
Building and repairing of ships and boats	4.2	5.0	-1.5	0.3	2.7	-2.3
Aircraft and spacecraft	n.a.	n.a.	n.a.	1.6	-4.9	1.9
Railroad and other transport equipment	7.2	-1.5	1.7	1.3	5.7	1.1
Furniture & miscellaneous manufacturing	3.6	0.5	4.2	-0.5	4.4	3.0
Electricity, gas and water supply	2.0	18.2	7.9	-1.2	3.2	3.6
Construction	-0.9	2.4	3.9	2.2	-0.1	0.2
Sales and repair of motor vehicles[1]	2.9	-5.5	5.3	0.9	6.2	-0.5
Wholesale trade and commission trade[2]	3.9	-5.3	4.0	0.9	2.9	-1.2
Retail trade[2] and repairs[3],	2.4	-3.0	3.1	0.9	1.7	1.3

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Ireland			Italy		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	-0.3	-0.2	0.9	-1.5	-0.9	-0.5
Inland transport	-0.4	9.2	8.2	2.1	3.5	2.0
Water transport	0.3	11.3	2.0	3.9	5.0	-8.4
Air transport	-0.4	11.1	10.2	6.1	17.0	-10.2
Supporting transport activities	0.4	10.5	6.3	5.2	5.6	-6.9
Communications	0.1	12.1	1.1	6.1	9.3	9.1
Financial intermediation,	-0.2	11.0	-0.4	0.0	1.1	3.3
Insurance and pension funding	-1.3	16.5	-2.9	0.0	3.7	-1.1
Auxiliary financial services	-1.2	12.7	-0.5	0.0	2.0	-1.2
Real estate activities	-1.2	-1.5	6.0	-3.4	-0.4	0.0
Renting of machinery and equipment	0.7	-0.1	17.6	-3.4	-1.2	-3.9
Computer and related activities	0.3	-2.1	4.1	-3.4	0.5	3.6
Research and development	1.4	-4.1	9.1	-3.4	1.3	3.7
Legal, technical and advertising	-0.7	-2.2	-0.6	-3.4	1.3	0.1
Other business activities	-1.8	-2.3	-0.7	-3.4	1.3	-2.9
Public administration[4]	7.4	-1.5	0.4	1.9	3.0	1.6
Education	1.5	3.0	8.4	-0.8	0.5	0.1
Health and social work	3.5	3.9	2.3	0.3	-0.9	-0.4
Other services[5]	2.6	1.9	-1.1	-1.1	-0.3	-0.4
Private households with employed persons	-0.6	-7.7	11.0	-7.1	-0.9	-0.4

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Luxembourg			Netherlands		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	4.4	15.3	1.1	3.9	5.1	2.2
Forestry	6.3	14.2	2.3	n.a.	n.a.	n.a.
Fishing	7.8	15.7	2.0	3.8	0.0	-1.0
Mining and quarrying	9.2	3.6	5.0	-4.1	0.6	4.7
Food, drink & tobacco	1.9	-1.3	-5.2	3.1	6.5	1.4
Textiles	11.2	12.4	4.6	3.8	2.7	6.6
Clothing	11.2	12.4	4.6	7.0	1.5	2.1
Leather and footwear	n.a.	n.a.	n.a.	3.2	3.4	8.1
Wood & wood products	5.2	0.0	10.3	5.1	5.8	1.9
Pulp, paper & paper products	4.0	-0.1	-3.2	4.6	2.9	3.2
Printing & publishing	4.0	-0.1	-3.2	2.7	3.5	2.7
Mineral oil refining, coke & nuclear fuel	n.a.	n.a.	n.a.	5.2	6.6	-7.3
Chemicals	4.9	1.3	1.7	4.3	5.6	3.9
Rubber & plastics	6.0	10.4	3.0	5.1	1.8	3.1
Non-metallic mineral products	4.4	5.7	-2.4	4.7	0.5	4.1
Basic metals	4.3	6.5	11.2	2.0	2.8	2.7
Fabricated metal products	2.6	5.6	1.0	3.1	2.1	1.6
Mechanical engineering	2.6	-0.6	-0.2	3.0	2.9	2.6
Office machinery	31.3	19.1	47.2	24.6	35.0	43.5
Insulated wire	10.4	-3.1	3.5	6.5	13.0	-3.2
Other electrical machinery	7.3	-8.3	1.0	3.4	8.3	-8.5
Electronic valves and tubes	n.a.	n.a.	n.a.	18.9	31.0	53.1
Telecommunication equipment	n.a.	n.a.	n.a.	18.1	3.0	-5.1
Radio and television receivers	n.a.	n.a.	n.a.	11.4	0.0	-13.7
Scientific instruments	7.7	-13.4	-8.4	4.3	-0.4	-7.7
Other instruments	7.3	-5.1	1.5	4.0	4.8	4.6
Motor vehicles	5.1	-7.0	-0.3	3.5	5.9	5.4
Building and repairing of ships and boats	5.1	-7.0	-0.3	7.1	0.8	-0.3
Aircraft and spacecraft	5.1	-7.0	-0.3	4.1	3.3	3.9
Railroad and other transport equipment	5.1	-7.0	-0.3	0.5	18.8	8.5
Furniture & miscellaneous manufacturing	2.5	12.6	-1.8	3.9	1.5	1.5
Electricity, gas and water supply	3.2	5.2	5.4	2.4	1.9	4.5
Construction	2.2	-0.4	2.1	3.2	-0.7	0.1
Sales and repair of motor vehicles[1]	4.6	2.0	2.4	4.0	0.1	1.7
Wholesale trade and commission trade[2]	4.2	2.3	6.2	2.9	-0.2	3.9
Retail trade[2] and repairs[3],	2.4	0.0	2.4	2.8	0.7	1.2

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Luxembourg			Netherlands		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	3.5	-3.6	-0.2	-0.3	-1.3	0.0
Inland transport	5.6	9.7	1.7	2.3	-1.1	1.2
Water transport	5.6	9.7	1.7	3.1	4.7	5.2
Air transport	n.a.	n.a.	n.a.	4.4	9.3	1.0
Supporting transport activities	5.6	9.7	1.7	0.1	2.3	2.8
Communications	7.2	13.7	7.2	2.5	2.5	7.0
Financial intermediation,	1.6	3.7	-0.1	-0.2	4.0	-0.4
Insurance and pension funding	3.8	9.7	-25.4	7.1	1.4	-1.0
Auxiliary financial services	-4.4	-4.2	-1.2	-2.7	-1.6	1.4
Real estate activities	0.4	-2.1	-3.1	4.7	-2.5	-0.1
Renting of machinery and equipment	6.8	2.8	-1.7	1.4	1.0	3.4
Computer and related activities	2.3	-5.7	-1.6	0.6	0.2	0.8
Research and development	1.6	-3.3	-1.6	3.7	-3.9	-0.6
Legal, technical and advertising	1.6	-3.3	-3.3	0.1	-1.3	0.4
Other business activities	1.6	-3.3	-4.9	-0.3	1.9	1.2
Public administration[4]	4.2	0.5	0.1	2.6	1.3	2.0
Education	4.3	0.6	0.0	1.2	0.8	0.1
Health and social work	5.8	6.1	3.8	0.3	0.1	-0.7
Other services[5]	-1.3	-0.7	-3.6	0.0	1.8	0.1
Private households with employed persons	1.9	0.3	-2.5	2.0	12.5	-1.1

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Austria			Portugal		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	3.7	8.3	4.4	7.3	7.3	-0.7
Forestry	3.7	8.3	4.3	4.8	8.1	5.0
Fishing	3.7	8.3	4.4	3.6	6.4	3.0
Mining and quarrying	1.7	0.3	4.3	4.4	2.4	10.9
Food, drink & tobacco	4.0	5.2	2.6	1.0	1.5	3.9
Textiles	2.0	2.0	4.8	3.5	1.7	3.6
Clothing	3.5	4.3	3.9	4.1	2.1	3.4
Leather and footwear	2.8	2.9	3.6	3.5	3.2	5.0
Wood & wood products	1.8	2.7	3.7	1.9	1.9	4.3
Pulp, paper & paper products	6.7	9.9	4.5	4.6	8.3	10.0
Printing & publishing	5.4	0.8	6.7	0.0	2.2	3.5
Mineral oil refining, coke & nuclear fuel	-10.4	53.0	19.3	4.0	0.7	10.9
Chemicals	5.9	4.9	5.9	3.1	2.3	3.6
Rubber & plastics	4.8	6.4	6.1	-1.9	-1.8	2.8
Non-metallic mineral products	1.6	0.8	3.9	5.3	2.4	7.9
Basic metals	7.8	5.4	5.4	6.7	-9.7	6.0
Fabricated metal products	3.8	5.9	2.0	1.7	4.9	4.3
Mechanical engineering	4.3	3.4	2.7	-1.2	1.6	-0.1
Office machinery	28.8	26.1	85.3	15.0	38.8	51.5
Insulated wire	4.2	0.9	5.8	2.3	12.0	-14.3
Other electrical machinery	1.2	6.6	5.3	-0.8	6.8	1.9
Electronic valves and tubes	22.4	31.0	49.3	21.4	34.8	58.0
Telecommunication equipment	21.6	5.8	-4.5	20.6	6.8	0.6
Radio and television receivers	14.8	4.1	-13.6	13.9	3.8	-7.0
Scientific instruments	3.6	-3.2	-5.9	1.7	16.2	-4.7
Other instruments	3.2	9.6	6.4	1.4	24.5	9.4
Motor vehicles	-1.0	9.4	1.3	2.8	8.6	17.2
Building and repairing of ships and boats	0.2	28.8	0.6	5.2	-3.1	15.1
Aircraft and spacecraft	3.3	6.5	6.7	5.8	-2.2	12.6
Railroad and other transport equipment	3.3	6.5	0.9	5.8	13.9	12.6
Furniture & miscellaneous manufacturing	4.2	1.2	3.8	0.8	4.7	4.2
Electricity, gas and water supply	3.4	3.5	3.5	1.4	8.7	14.4
Construction	1.6	3.5	2.5	2.8	2.9	2.3
Sales and repair of motor vehicles[1]	1.0	0.8	1.8	1.4	1.6	3.0
Wholesale trade and commission trade[2]	3.3	3.1	1.1	1.4	1.6	3.7
Retail trade[2] and repairs[3],	1.5	1.3	3.7	1.4	1.6	1.2

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Austria			Portugal		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	0.7	0.5	2.0	0.7	0.2	-1.1
Inland transport	2.4	3.4	2.3	3.6	4.5	0.2
Water transport	16.5	-1.2	0.1	3.6	4.5	-4.5
Air transport	6.9	13.8	0.0	3.6	4.5	0.4
Supporting transport activities	-0.9	2.6	1.6	3.6	4.5	2.6
Communications	5.0	7.3	4.8	10.5	11.0	4.3
Financial intermediation,	2.9	6.8	4.2	7.2	-1.3	7.3
Insurance and pension funding	2.4	1.1	3.4	-2.5	-29.9	8.1
Auxiliary financial services	-8.7	-1.6	-5.3	n.a.	n.a.	n.a.
Real estate activities	3.7	1.1	0.2	-1.9	-6.6	-1.2
Renting of machinery and equipment	8.6	7.4	3.3	-1.9	-6.6	12.1
Computer and related activities	2.3	2.8	-3.3	-1.9	-6.6	10.2
Research and development	-3.1	15.1	-2.0	-1.9	-6.6	46.6
Legal, technical and advertising	0.6	3.1	-0.8	-1.9	-6.6	-14.4
Other business activities	0.6	3.1	2.4	-1.9	-6.6	5.3
Public administration[4]	1.5	2.7	1.0	0.3	-0.1	1.1
Education	-0.5	0.1	0.4	1.2	0.0	2.9
Health and social work	-0.1	2.2	-3.6	0.5	0.2	2.3
Other services[5]	-0.7	1.3	-1.6	4.5	1.5	2.8
Private households with employed persons	4.4	2.8	-2.1	n.a.	n.a.	n.a.

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Finland			Sweden		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Agriculture	5.2	-0.2	6.0	6.4	-5.2	1.2
Forestry	2.8	9.5	2.5	3.3	9.1	4.1
Fishing	5.0	7.5	-0.3	5.7	-8.3	4.5
Mining and quarrying	10.3	5.0	-0.4	2.5	3.9	2.1
Food, drink & tobacco	3.7	6.4	3.2	4.7	4.1	1.9
Textiles	4.0	8.3	0.7	4.1	6.8	2.9
Clothing	3.4	2.1	0.2	-2.0	7.3	-8.2
Leather and footwear	3.8	3.9	1.6	2.7	6.5	1.9
Wood & wood products	4.9	5.7	4.3	1.7	-4.9	2.3
Pulp, paper & paper products	5.6	7.4	2.8	2.5	0.1	0.8
Printing & publishing	3.8	3.9	2.5	0.5	9.8	2.1
Mineral oil refining, coke & nuclear fuel	2.4	5.7	-1.4	7.4	9.7	1.8
Chemicals	4.3	4.3	3.9	2.7	4.4	3.8
Rubber & plastics	5.4	3.9	0.1	1.6	3.8	3.7
Non-metallic mineral products	3.8	4.3	1.4	3.7	0.6	-0.8
Basic metals	5.8	7.7	4.0	2.5	5.7	-1.1
Fabricated metal products	6.0	5.2	-0.3	2.1	4.5	0.1
Mechanical engineering	4.6	4.4	0.9	2.0	1.5	1.7
Office machinery	34.4	12.5	43.6	19.8	31.4	49.8
Insulated wire	3.6	9.4	4.7	4.0	9.5	7.2
Other electrical machinery	5.2	4.4	1.5	0.9	3.0	3.4
Electronic valves and tubes	19.4	32.8	60.0	17.9	28.5	39.2
Telecommunication equipment	21.9	7.4	7.0	17.2	4.5	-12.9
Radio and television receivers	12.5	-7.7	-2.7	10.4	-5.4	-20.7
Scientific instruments	5.4	-1.2	-7.9	10.2	-1.8	-14.9
Other instruments	3.6	8.6	1.6	9.9	7.7	-5.8
Motor vehicles	2.8	1.5	3.8	0.5	9.3	3.7
Building and repairing of ships and boats	1.6	9.8	-1.3	-6.6	-1.2	-2.1
Aircraft and spacecraft	8.0	11.6	-0.2	5.0	-0.3	-2.9
Railroad and other transport equipment	7.8	-9.7	-12.9	1.3	-1.2	2.7
Furniture & miscellaneous manufacturing	4.0	3.6	1.5	0.9	7.8	1.1
Electricity, gas and water supply	4.0	7.9	5.4	3.3	1.6	0.6
Construction	1.5	0.2	-0.8	1.0	1.9	-0.3
Sales and repair of motor vehicles[1]	0.8	3.7	1.5	2.2	3.6	2.1
Wholesale trade and commission trade[2]	3.5	-2.2	2.7	2.2	3.6	1.1
Retail trade[2] and repairs[3],	3.7	4.0	1.3	2.2	3.6	3.7

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	Finland			Sweden		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Hotels & catering	1.6	3.9	-1.5	-2.5	1.6	0.6
Inland transport	2.0	2.6	1.4	1.4	3.3	1.1
Water transport	1.1	4.1	3.7	1.5	-9.2	-0.7
Air transport	4.3	5.8	1.0	6.7	6.4	-2.6
Supporting transport activities	2.9	3.5	3.0	3.4	2.3	-1.1
Communications	5.6	5.9	12.3	4.2	8.4	4.6
Financial intermediation,	4.7	-0.5	8.7	2.4	1.4	2.2
Insurance and pension funding	4.9	-1.5	-1.8	1.2	2.8	11.0
Auxiliary financial services	n.a.	n.a.	n.a.	2.1	2.2	10.8
Real estate activities	1.7	6.5	1.0	-3.2	3.3	5.7
Renting of machinery and equipment	-2.5	3.0	2.1	1.4	-3.9	-1.7
Computer and related activities	-0.7	-1.5	-1.1	1.4	1.4	-0.6
Research and development	1.0	-0.5	-0.7	1.4	-4.9	0.0
Legal, technical and advertising	-0.4	3.0	1.2	1.4	-0.4	-0.2
Other business activities	0.5	-0.8	-1.9	1.4	-0.4	-0.2
Public administration[4]	0.9	-0.9	1.5	0.1	-1.7	-2.1
Education	0.2	-0.2	-0.4	0.1	0.5	2.2
Health and social work	0.8	-0.6	-0.4	0.1	0.5	4.9
Other services[5]	1.2	-0.1	0.5	0.2	0.8	5.2
Private households with employed persons	-0.3	0.6	-1.0	n.a.	n.a.	n.a.

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	UK		
	1979-90	1990-95	1995-01
Agriculture	2.9	2.6	3.3
Forestry	2.8	8.6	-1.8
Fishing	4.0	13.5	-9.9
Mining and quarrying	6.5	24.1	0.4
Food, drink & tobacco	3.2	3.2	0.2
Textiles	2.7	1.8	0.0
Clothing	3.6	4.4	1.5
Leather and footwear	3.1	7.0	7.4
Wood & wood products	-0.4	0.4	0.0
Pulp, paper & paper products	3.1	2.6	1.4
Printing & publishing	2.4	1.7	0.4
Mineral oil refining, coke & nuclear fuel	-0.6	9.3	-5.6
Chemicals	5.4	7.9	4.5
Rubber & plastics	3.1	2.0	0.5
Non-metallic mineral products	2.7	4.7	1.9
Basic metals	7.1	4.4	3.3
Fabricated metal products	2.4	1.2	1.1
Mechanical engineering	1.8	2.8	0.7
Office machinery	26.0	28.0	39.0
Insulated wire	2.8	8.9	-3.0
Other electrical machinery	4.1	0.0	0.0
Electronic valves and tubes	18.3	43.0	54.5
Telecommunication equipment	18.8	14.6	0.7
Radio and television receivers	11.9	2.6	8.7
Scientific instruments	4.4	0.1	-9.2
Other instruments	3.8	7.1	2.7
Motor vehicles	6.2	3.4	1.5
Building and repairing of ships and boats	11.9	4.0	-2.4
Aircraft and spacecraft	6.6	4.5	0.1
Railroad and other transport equipment	6.8	3.0	-9.1
Furniture & miscellaneous manufacturing	1.2	-0.9	0.3
Electricity, gas and water supply	5.2	5.2	10.4
Construction	1.6	4.1	1.5
Sales and repair of motor vehicles[1]	1.5	6.4	4.2
Wholesale trade and commission trade[2]	1.5	6.4	4.5
Retail trade[2] and repairs[3],	2.0	1.4	2.2

Table III.B continued…

Annual labour productivity growth, 1979-2001, EU countries

	UK		
	1979-90	1990-95	1995-01
Hotels & catering	-0.3	0.0	-2.8
Inland transport	5.6	5.2	23.2
Water transport	9.7	11.2	2.1
Air transport	1.5	7.5	9.6
Supporting transport activities	2.7	3.6	4.1
Communications	4.1	6.6	9.0
Financial intermediation,	-0.6	2.0	6.3
Insurance and pension funding	2.5	1.3	2.0
Auxiliary financial services	-0.1	0.8	2.0
Real estate activities	-3.7	-4.6	-2.7
Renting of machinery and equipment	3.1	5.4	-1.6
Computer and related activities	0.8	5.1	-0.4
Research and development	4.8	2.1	-11.5
Legal, technical and advertising	0.2	1.1	8.1
Other business activities	0.2	1.1	0.2
Public administration[4]	1.4	-0.5	0.1
Education	-0.3	2.1	-1.1
Health and social work	-0.6	2.3	3.0
Other services[5]	1.5	5.2	1.2
Private households with employed persons	n.a.	n.a.	n.a.

Appendix Table III.C.1

Decomposition of annual labour productivity growth (EU-4)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	5.12	-0.09	0.02	1.18	4.00
Mining and Quarrying	2	3.23	0.28	0.15	4.85	-2.05
Food, Drink & Tobacco	3	2.15	0.27	0.27	0.94	0.66
Textiles, Leather, Footwear & Clothing	4	2.59	0.27	0.05	0.79	1.48
Wood & Products of Wood and Cork	5	1.23	0.21	0.11	0.31	0.59
Pulp, Paper & Paper Products; Printing & Publishing	6	2.26	0.19	0.38	0.97	0.72
Mineral Oil Refining, Coke & Nuclear Fuel	7	-5.53	0.11	0.75	1.82	-8.20
Chemicals	8	3.71	0.42	0.46	0.78	2.05
Rubber & Plastics	9	2.13	0.37	0.22	0.50	1.04
Non-Metallic Mineral Products	10	3.14	0.25	0.34	1.01	1.55
Basic Metals & Fabricated Metal Products	11	2.50	0.48	0.11	0.38	1.53
Mechanical Engineering	12	2.01	0.47	0.24	0.70	0.59
Electrical and Electronic Equipment; Instruments	13	8.15	0.58	0.40	1.13	6.05
Transport Equipment	14	4.33	0.61	0.38	0.88	2.45
Furniture, Miscellaneous Manufacturing; Recycling	15	1.90	0.27	0.17	0.96	0.50
Electricity, Gas and Water Supply	16	3.44	0.17	0.27	1.11	1.90
Construction	17	1.35	0.02	0.08	0.03	1.22
Motor Vehicles & Wholesale Trade	18	2.30	0.17	0.35	0.26	1.53
Retail Trade & Repairs	19	2.30	0.24	0.28	0.33	1.45
Hotels & Catering	20	-1.27	0.28	0.10	0.52	-2.17
Transport	21	2.84	0.52	0.06	0.22	2.04
Communications	22	5.29	0.24	0.84	1.20	3.01
Financial Intermediation	23	2.41	-0.02	1.32	0.51	0.60
Real Estate Activities and Business Services	24	1.46	0.12	1.00	0.66	-0.33
Other Services	25	0.19	0.25	0.20	0.38	-0.63
Non-Market Services	26	0.82	0.35	0.06	0.17	0.24

Appendix Table III.C.1 continued…

Decomposition of annual labour productivity growth (EU-4)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	5.00	0.02	0.03	1.79	3.16
Mining and Quarrying	2	15.29	0.22	0.17	7.93	6.97
Food, Drink & Tobacco	3	2.68	0.37	0.19	1.10	1.02
Textiles, Leather, Footwear & Clothing	4	3.03	0.36	0.12	1.50	1.06
Wood & Products of Wood and Cork	5	3.76	0.26	0.10	0.23	3.17
Pulp, Paper & Paper Products; Printing & Publishing	6	1.94	0.32	0.43	1.11	0.08
Mineral Oil Refining, Coke & Nuclear Fuel	7	6.59	0.10	0.53	1.21	4.75
Chemicals	8	7.06	0.45	0.29	1.45	4.88
Rubber & Plastics	9	2.44	0.47	0.24	0.55	1.17
Non-Metallic Mineral Products	10	3.96	0.35	0.13	1.41	2.06
Basic Metals & Fabricated Metal Products	11	3.00	0.51	0.10	0.72	1.67
Mechanical Engineering	12	2.77	0.59	0.21	0.79	1.18
Electrical and Electronic Equipment; Instruments	13	5.52	0.68	0.33	0.93	3.58
Transport Equipment	14	3.40	0.41	0.26	1.19	1.54
Furniture, Miscellaneous Manufacturing; Recycling	15	0.12	0.38	0.25	0.96	-1.47
Electricity, Gas and Water Supply	16	3.49	0.26	0.31	2.74	0.18
Construction	17	0.80	0.46	0.12	0.44	-0.21
Motor Vehicles & Wholesale Trade	18	3.38	0.25	0.49	0.49	2.15
Retail Trade & Repairs	19	2.31	0.42	0.34	0.78	0.77
Hotels & Catering	20	-1.66	0.77	0.06	0.60	-3.09
Transport	21	3.97	0.50	0.13	0.72	2.62
Communications	22	5.69	0.30	1.05	1.51	2.82
Financial Intermediation	23	1.21	0.46	1.31	0.49	-1.05
Real Estate Activities and Business Services	24	0.89	0.19	0.57	0.83	-0.70
Other Services	25	1.01	0.38	0.07	0.91	-0.34
Non-Market Services	26	1.27	0.42	0.07	0.19	0.60

Appendix Table III.C.1 continued…

Decomposition of annual labour productivity growth (EU-4)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	4.72	-0.02	0.06	1.43	3.26
Mining and Quarrying	2	4.98	0.29	0.14	3.36	1.20
Food, Drink & Tobacco	3	0.02	0.19	0.20	-0.21	-0.16
Textiles, Leather, Footwear & Clothing	4	3.13	0.28	0.26	1.10	1.49
Wood & Products of Wood and Cork	5	2.00	0.02	0.32	0.77	0.90
Pulp, Paper & Paper Products; Printing & Publishing	6	2.09	0.20	0.67	0.51	0.72
Mineral Oil Refining, Coke & Nuclear Fuel	7	-0.43	0.10	-0.29	0.09	-0.32
Chemicals	8	3.92	0.35	0.52	1.30	1.76
Rubber & Plastics	9	1.63	0.02	0.35	0.49	0.75
Non-Metallic Mineral Products	10	2.06	0.08	0.27	0.88	0.83
Basic Metals & Fabricated Metal Products	11	1.57	0.14	0.18	0.12	1.12
Mechanical Engineering	12	1.50	0.21	0.37	0.36	0.57
Electrical and Electronic Equipment; Instruments	13	10.48	0.27	0.62	0.21	9.38
Transport Equipment	14	-0.16	0.41	0.15	-0.04	-0.68
Furniture, Miscellaneous Manufacturing; Recycling	15	1.24	0.10	0.36	0.53	0.25
Electricity, Gas and Water Supply	16	6.63	0.07	0.58	2.94	3.04
Construction	17	0.47	0.11	0.16	0.22	-0.02
Motor Vehicles & Wholesale Trade	18	2.46	0.15	0.99	0.10	1.22
Retail Trade & Repairs	19	1.71	0.15	0.53	0.25	0.79
Hotels & Catering	20	-1.90	0.14	0.08	0.31	-2.43
Transport	21	3.59	0.02	0.25	0.03	3.28
Communications	22	11.43	0.50	1.59	0.65	8.70
Financial Intermediation	23	2.79	0.19	1.55	0.02	1.03
Real Estate Activities and Business Services	24	0.59	0.27	0.90	-0.45	-0.14
Other Services	25	-0.06	0.23	0.22	-0.21	-0.30
Non-Market Services	26	0.86	0.31	0.07	0.15	0.34

Appendix Table III.C.2

Decomposition of annual labour productivity growth (US)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	6.42	0.13	0.04	-0.32	6.58
Mining and Quarrying	2	4.37	0.05	0.30	3.21	0.80
Food, Drink & Tobacco	3	1.19	0.28	0.33	0.51	0.07
Textiles, Leather, Footwear & Clothing	4	3.32	0.31	0.14	0.39	2.49
Wood & Products of Wood and Cork	5	2.58	0.14	0.21	-0.31	2.54
Pulp, Paper & Paper Products; Printing & Publishing	6	-0.46	0.27	0.47	0.31	-1.50
Mineral Oil Refining, Coke & Nuclear Fuel	7	6.95	0.23	0.23	1.49	5.01
Chemicals	8	3.36	0.26	0.44	0.47	2.19
Rubber & Plastics	9	4.20	0.34	0.11	0.07	3.68
Non-Metallic Mineral Products	10	1.87	0.17	0.17	0.16	1.37
Basic Metals & Fabricated Metal Products	11	1.40	0.23	0.18	0.36	0.65
Mechanical Engineering	12	-0.66	0.50	0.49	0.35	-2.00
Electrical and Electronic Equipment; Instruments	13	12.38	0.77	1.02	0.99	9.59
Transport Equipment	14	0.28	0.41	0.33	-0.06	-0.39
Furniture, Miscellaneous Manufacturing; Recycling	15	2.89	0.15	0.28	0.19	2.26
Electricity, Gas and Water Supply	16	1.12	0.19	0.54	0.74	-0.36
Construction	17	-0.78	0.13	0.02	-0.50	-0.43
Motor Vehicles & Wholesale Trade	18	2.31	0.26	1.10	0.36	0.59
Retail Trade & Repairs	19	2.76	0.18	0.64	0.45	1.49
Hotels & Catering	20	-1.09	0.22	0.10	0.05	-1.45
Transport	21	1.41	0.31	0.12	-0.40	1.38
Communications	22	1.38	0.38	0.91	0.74	-0.64
Financial Intermediation	23	-0.66	0.46	1.79	1.43	-4.33
Real Estate Activities and Business Services	24	0.08	0.29	0.62	-0.67	-0.16
Other Services	25	1.22	0.70	0.36	0.02	0.14
Non-Market Services	26	-0.44	0.26	0.10	0.06	-0.87

Appendix Table III.C.2 continued…

Decomposition of annual labour productivity growth (US)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	1.65	0.22	0.11	-0.11	1.43
Mining and Quarrying	2	5.08	0.10	0.20	1.60	3.18
Food, Drink & Tobacco	3	3.62	0.26	0.33	0.60	2.44
Textiles, Leather, Footwear & Clothing	4	3.00	0.94	0.39	0.28	1.40
Wood & Products of Wood and Cork	5	-3.00	0.53	0.25	-0.64	-3.13
Pulp, Paper & Paper Products; Printing & Publishing	6	-1.92	0.28	0.53	0.17	-2.90
Mineral Oil Refining, Coke & Nuclear Fuel	7	5.53	0.07	0.24	3.45	1.77
Chemicals	8	2.96	0.19	0.66	1.57	0.54
Rubber & Plastics	9	4.31	0.54	0.21	0.21	3.34
Non-Metallic Mineral Products	10	2.33	0.63	0.08	-0.21	1.82
Basic Metals & Fabricated Metal Products	11	3.14	0.20	0.21	-0.11	2.84
Mechanical Engineering	12	0.32	0.17	0.50	-0.09	-0.27
Electrical and Electronic Equipment; Instruments	13	12.90	0.74	1.05	0.81	10.30
Transport Equipment	14	2.20	0.24	0.08	0.35	1.53
Furniture, Miscellaneous Manufacturing; Recycling	15	1.10	0.60	0.35	0.08	0.07
Electricity, Gas and Water Supply	16	1.81	0.14	0.29	0.71	0.67
Construction	17	0.41	-0.01	0.27	0.06	0.10
Motor Vehicles & Wholesale Trade	18	2.24	0.10	1.10	0.57	0.47
Retail Trade & Repairs	19	1.96	0.06	0.31	0.59	1.01
Hotels & Catering	20	-1.03	-0.31	0.08	0.08	-0.88
Transport	21	1.11	0.16	0.20	-0.59	1.33
Communications	22	2.41	0.36	0.87	0.68	0.50
Financial Intermediation	23	1.65	0.38	1.46	0.62	-0.81
Real Estate Activities and Business Services	24	0.00	0.52	0.22	-0.29	-0.45
Other Services	25	0.95	0.45	0.60	0.49	-0.59
Non-Market Services	26	-0.79	0.22	0.12	0.22	-1.36

Appendix Table III.C.2 continued…

Decomposition of annual labour productivity growth (US)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	10.35	0.13	0.13	1.27	8.81
Mining and Quarrying	2	0.36	-0.02	0.28	2.01	-1.91
Food, Drink & Tobacco	3	-6.00	0.00	0.46	0.82	-7.28
Textiles, Leather, Footwear & Clothing	4	2.90	0.19	0.42	1.25	1.05
Wood & Products of Wood and Cork	5	-0.90	0.21	0.29	0.15	-1.54
Pulp, Paper & Paper Products; Printing & Publishing	6	1.10	0.21	0.92	0.41	-0.44
Mineral Oil Refining, Coke & Nuclear Fuel	7	4.54	0.17	0.08	0.74	3.56
Chemicals	8	2.40	0.17	0.76	1.50	-0.03
Rubber & Plastics	9	4.75	0.03	0.37	1.08	3.27
Non-Metallic Mineral Products	10	1.22	0.19	0.49	1.14	-0.60
Basic Metals & Fabricated Metal Products	11	1.37	0.21	0.34	-0.10	0.93
Mechanical Engineering	12	-0.12	0.35	0.58	0.09	-1.14
Electrical and Electronic Equipment; Instruments	13	21.73	0.26	1.60	1.25	18.62
Transport Equipment	14	1.34	0.41	0.41	0.25	0.26
Furniture, Miscellaneous Manufacturing; Recycling	15	3.65	0.20	0.57	0.26	2.63
Electricity, Gas and Water Supply	16	2.32	0.11	0.33	1.66	0.22
Construction	17	-0.06	0.16	0.34	0.29	-0.84
Motor Vehicles & Wholesale Trade	18	7.19	0.15	1.78	0.41	4.85
Retail Trade & Repairs	19	6.62	0.08	0.69	0.52	5.34
Hotels & Catering	20	0.20	0.02	0.14	0.39	-0.36
Transport	21	2.53	0.20	0.51	0.38	1.45
Communications	22	5.93	0.23	1.89	0.82	3.00
Financial Intermediation	23	4.99	0.15	3.06	0.95	0.82
Real Estate Activities and Business Services	24	-0.60	0.22	0.72	-0.52	-1.02
Other Services	25	-1.65	0.30	1.04	0.49	-3.49
Non-Market Services	26	-0.61	0.35	0.19	0.17	-1.32

Appendix Table III.C.3

Decomposition of annual labour productivity growth (France)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	5.57	0.00	0.01	2.09	3.47
Mining and Quarrying	2	2.62	-0.19	0.13	1.73	0.96
Food, Drink & Tobacco	3	1.30	0.16	0.13	1.77	-0.77
Textiles, Leather, Footwear & Clothing	4	1.24	0.31	0.06	1.01	-0.14
Wood & Products of Wood and Cork	5	3.14	0.05	0.13	1.28	1.68
Pulp, Paper & Paper Products; Printing & Publishing	6	2.25	0.25	0.17	1.40	0.43
Mineral Oil Refining, Coke & Nuclear Fuel	7	-12.72	0.22	0.28	3.45	-16.66
Chemicals	8	3.82	0.34	0.22	2.05	1.21
Rubber & Plastics	9	1.29	0.19	0.15	1.19	-0.24
Non-Metallic Mineral Products	10	5.17	0.30	0.05	0.55	4.26
Basic Metals & Fabricated Metal Products	11	1.42	0.20	0.07	0.72	0.42
Mechanical Engineering	12	3.07	0.26	0.21	2.61	-0.01
Electrical and Electronic Equipment; Instruments	13	8.10	0.32	0.21	1.67	5.90
Transport Equipment	14	4.58	0.30	0.08	0.80	3.40
Furniture, Miscellaneous Manufacturing; Recycling	15	3.56	0.31	0.18	1.64	1.42
Electricity, Gas and Water Supply	16	5.39	0.02	0.27	1.18	3.92
Construction	17	2.56	0.02	0.04	0.51	1.99
Motor Vehicles & Wholesale Trade	18	4.21	0.29	0.12	0.48	3.32
Retail Trade & Repairs	19	3.98	0.09	0.15	0.50	3.24
Hotels & Catering	20	-2.08	0.04	0.21	0.81	-3.14
Transport	21	3.27	0.19	0.11	0.39	2.58
Communications	22	7.27	-0.43	0.49	0.95	6.27
Financial Intermediation	23	5.90	0.18	1.09	-0.33	4.96
Real Estate Activities and Business Services	24	1.98	0.21	0.10	-1.37	3.02
Other Services	25	-2.43	0.28	0.18	-1.10	-1.79
Non-Market Services	26	1.81	0.33	0.02	-0.10	1.56

Appendix Table III.C.3 continued...

Decomposition of annual labour productivity growth (France)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	6.33	0.00	0.01	2.58	3.75
Mining and Quarrying	2	6.10	-0.26	0.01	0.06	6.29
Food, Drink & Tobacco	3	1.31	0.26	0.08	1.29	-0.32
Textiles, Leather, Footwear & Clothing	4	3.33	0.22	0.07	1.68	1.37
Wood & Products of Wood and Cork	5	2.88	0.55	0.05	0.76	1.52
Pulp, Paper & Paper Products; Printing & Publishing	6	1.22	0.47	0.08	1.40	-0.73
Mineral Oil Refining, Coke & Nuclear Fuel	7	9.33	-0.39	0.09	1.23	8.40
Chemicals	8	5.96	0.32	0.14	1.97	3.52
Rubber & Plastics	9	2.95	0.64	0.08	0.54	1.70
Non-Metallic Mineral Products	10	1.74	0.04	0.06	0.79	0.85
Basic Metals & Fabricated Metal Products	11	2.37	0.30	0.07	0.93	1.07
Mechanical Engineering	12	4.25	0.59	0.07	0.95	2.64
Electrical and Electronic Equipment; Instruments	13	6.39	0.83	0.04	0.71	4.81
Transport Equipment	14	5.04	0.38	0.12	1.66	2.88
Furniture, Miscellaneous Manufacturing; Recycling	15	1.76	0.02	0.06	1.04	0.65
Electricity, Gas and Water Supply	16	2.24	-0.06	0.09	0.17	2.05
Construction	17	1.67	0.23	0.06	1.05	0.34
Motor Vehicles & Wholesale Trade	18	2.09	-0.39	0.13	0.77	1.58
Retail Trade & Repairs	19	2.01	0.22	0.12	0.77	0.90
Hotels & Catering	20	-2.39	0.33	0.11	0.91	-3.74
Transport	21	1.45	0.20	0.13	0.86	0.26
Communications	22	2.41	-0.39	0.21	0.57	2.02
Financial Intermediation	23	-1.04	0.33	0.96	-0.19	-2.13
Real Estate Activities and Business Services	24	-0.75	0.13	0.10	-1.16	0.18
Other Services	25	-2.73	0.32	0.00	-0.94	-2.12
Non-Market Services	26	0.85	0.07	0.04	-0.05	0.79

Appendix Table III.C.3 continued...

Decomposition of annual labour productivity growth (France)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	4.88	0.00	0.03	2.12	2.73
Mining and Quarrying	2	14.28	2.30	0.39	3.55	8.04
Food, Drink & Tobacco	3	-0.83	0.32	0.13	-0.44	-0.84
Textiles, Leather, Footwear & Clothing	4	4.30	0.27	0.20	1.48	2.36
Wood & Products of Wood and Cork	5	3.05	-0.12	0.32	1.29	1.55
Pulp, Paper & Paper Products; Printing & Publishing	6	2.56	0.00	0.26	0.72	1.58
Mineral Oil Refining, Coke & Nuclear Fuel	7	-0.28	0.29	0.36	1.27	-2.20
Chemicals	8	5.64	0.42	0.51	1.87	2.84
Rubber & Plastics	9	3.30	0.52	0.30	0.50	1.97
Non-Metallic Mineral Products	10	3.38	-0.19	0.20	0.72	2.66
Basic Metals & Fabricated Metal Products	11	1.35	0.07	0.11	-0.55	1.71
Mechanical Engineering	12	3.12	0.26	0.34	1.59	0.93
Electrical and Electronic Equipment; Instruments	13	9.95	0.25	0.17	-0.17	9.69
Transport Equipment	14	5.71	0.44	0.23	0.20	4.84
Furniture, Miscellaneous Manufacturing; Recycling	15	2.36	0.14	0.17	-0.55	2.60
Electricity, Gas and Water Supply	16	3.72	0.41	0.66	0.02	2.62
Construction	17	-1.44	0.30	0.08	-0.07	-1.75
Motor Vehicles & Wholesale Trade	18	0.39	0.51	0.28	-0.10	-0.30
Retail Trade & Repairs	19	1.66	0.62	0.26	-0.15	0.92
Hotels & Catering	20	1.14	0.12	0.23	0.00	0.78
Transport	21	0.87	0.39	0.21	-0.65	0.92
Communications	22	8.44	0.54	0.55	-0.28	7.63
Financial Intermediation	23	0.20	0.05	1.59	-0.24	-1.21
Real Estate Activities and Business Services	24	-0.26	0.43	0.17	-1.95	1.09
Other Services	25	-0.77	0.47	0.30	-1.04	-0.50
Non-Market Services	26	0.98	0.57	0.03	-0.01	0.38

Appendix Table III.C.4

Decomposition of annual labour productivity growth (Germany)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	5.63	0.00	0.01	0.19	5.43
Mining and Quarrying	2	-0.59	0.21	0.11	0.52	-1.44
Food, Drink & Tobacco	3	1.71	0.28	0.30	0.32	0.81
Textiles, Leather, Footwear & Clothing	4	3.36	0.29	0.03	0.75	2.29
Wood & Products of Wood and Cork	5	0.53	0.44	0.11	-0.18	0.15
Pulp, Paper & Paper Products; Printing & Publishing	6	1.71	0.20	0.60	0.72	0.19
Mineral Oil Refining, Coke & Nuclear Fuel	7	0.15	0.18	1.67	-0.83	-0.86
Chemicals	8	2.43	0.27	0.59	-0.02	1.60
Rubber & Plastics	9	1.81	0.28	0.28	-0.01	1.26
Non-Metallic Mineral Products	10	2.06	0.19	0.22	0.63	1.02
Basic Metals & Fabricated Metal Products	11	1.84	0.20	0.07	-0.07	1.65
Mechanical Engineering	12	1.38	0.37	0.28	0.19	0.54
Electrical and Electronic Equipment; Instruments	13	6.26	0.50	0.42	0.78	4.56
Transport Equipment	14	1.87	0.23	0.51	0.58	0.55
Furniture, Miscellaneous Manufacturing; Recycling	15	0.61	0.29	0.22	0.71	-0.61
Electricity, Gas and Water Supply	16	0.86	0.13	0.26	1.08	-0.61
Construction	17	0.59	0.30	0.08	-0.15	0.37
Motor Vehicles & Wholesale Trade	18	1.56	0.22	0.19	-0.11	1.25
Retail Trade & Repairs	19	1.36	0.24	0.24	-0.11	0.99
Hotels & Catering	20	-0.85	0.58	0.01	-0.05	-1.39
Transport	21	1.94	0.12	0.02	-0.03	1.82
Communications	22	4.95	0.50	1.40	1.27	1.77
Financial Intermediation	23	2.93	0.15	1.39	0.96	0.43
Real Estate Activities and Business Services	24	1.90	0.12	1.96	1.99	-2.18
Other Services	25	0.98	0.17	0.27	0.89	-0.35
Non-Market Services	26	0.38	0.34	0.08	0.37	-0.41

Appendix Table III.C.4 continued…

Decomposition of annual labour productivity growth (Germany)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	4.31	0.00	0.01	0.49	3.81
Mining and Quarrying	2	9.70	0.27	0.09	0.96	8.37
Food, Drink & Tobacco	3	2.39	0.26	0.20	0.97	0.96
Textiles, Leather, Footwear & Clothing	4	2.78	0.42	0.05	2.32	-0.02
Wood & Products of Wood and Cork	5	5.34	0.19	0.12	0.14	4.89
Pulp, Paper & Paper Products; Printing & Publishing	6	2.00	0.32	0.45	1.29	-0.05
Mineral Oil Refining, Coke & Nuclear Fuel	7	-5.38	0.34	2.20	1.72	-9.64
Chemicals	8	7.26	0.33	0.29	0.90	5.73
Rubber & Plastics	9	2.63	0.26	0.34	0.90	1.13
Non-Metallic Mineral Products	10	4.62	0.21	0.11	1.25	3.04
Basic Metals & Fabricated Metal Products	11	3.65	0.35	0.09	0.66	2.55
Mechanical Engineering	12	2.21	0.61	0.18	0.72	0.70
Electrical and Electronic Equipment; Instruments	13	2.21	0.63	0.29	0.85	0.45
Transport Equipment	14	2.47	0.40	0.33	0.97	0.77
Furniture, Miscellaneous Manufacturing; Recycling	15	-0.52	0.39	0.31	1.03	-2.26
Electricity, Gas and Water Supply	16	3.53	0.26	0.25	1.82	1.21
Construction	17	-2.74	-0.03	0.10	-0.83	-1.98
Motor Vehicles & Wholesale Trade	18	3.12	0.25	0.49	0.15	2.23
Retail Trade & Repairs	19	3.33	0.18	0.34	0.70	2.11
Hotels & Catering	20	-3.41	0.31	0.01	-0.02	-3.71
Transport	21	5.80	0.12	0.03	0.24	5.41
Communications	22	7.85	0.64	2.03	2.71	2.48
Financial Intermediation	23	2.09	0.21	1.55	0.48	-0.15
Real Estate Activities and Business Services	24	0.50	0.15	0.42	1.77	-1.83
Other Services	25	-0.07	0.21	0.02	1.30	-1.60
Non-Market Services	26	2.08	0.29	0.04	0.30	1.45

Appendix Table III.C.4 continued…

Decomposition of annual labour productivity growth (Germany)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	6.01	0.00	0.05	0.63	5.33
Mining and Quarrying	2	-2.90	0.18	0.04	0.23	-3.35
Food, Drink & Tobacco	3	0.83	0.03	0.27	-0.33	0.86
Textiles, Leather, Footwear & Clothing	4	2.84	0.16	0.03	0.62	2.04
Wood & Products of Wood and Cork	5	2.47	0.05	0.24	0.74	1.43
Pulp, Paper & Paper Products; Printing & Publishing	6	3.27	0.09	0.91	1.26	1.00
Mineral Oil Refining, Coke & Nuclear Fuel	7	12.28	0.10	-1.52	1.15	12.54
Chemicals	8	2.67	0.13	0.53	0.88	1.12
Rubber & Plastics	9	1.09	-0.14	0.33	0.43	0.47
Non-Metallic Mineral Products	10	1.26	0.08	0.27	0.65	0.26
Basic Metals & Fabricated Metal Products	11	1.41	0.08	0.12	0.19	1.02
Mechanical Engineering	12	1.16	0.11	0.17	0.06	0.82
Electrical and Electronic Equipment; Instruments	13	8.94	0.37	0.40	-0.12	8.28
Transport Equipment	14	-3.12	0.14	0.12	-0.19	-3.18
Furniture, Miscellaneous Manufacturing; Recycling	15	1.19	0.11	0.28	0.52	0.28
Electricity, Gas and Water Supply	16	6.38	0.03	0.71	2.88	2.76
Construction	17	1.12	0.03	0.22	0.12	0.76
Motor Vehicles & Wholesale Trade	18	1.76	0.12	0.64	0.13	0.86
Retail Trade & Repairs	19	1.13	-0.01	0.68	0.16	0.30
Hotels & Catering	20	-4.21	0.09	0.01	-0.14	-4.17
Transport	21	4.03	0.04	0.26	0.08	3.65
Communications	22	17.25	0.19	1.91	2.05	13.10
Financial Intermediation	23	4.59	0.07	1.59	0.57	2.36
Real Estate Activities and Business Services	24	-0.75	0.03	1.11	-0.24	-1.65
Other Services	25	-0.03	0.04	0.26	0.31	-0.64
Non-Market Services	26	0.64	-0.04	0.09	0.23	0.36

Appendix Table III.C.5

Decomposition of annual labour productivity growth (Netherlands)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	3.83	0.00	0.03	0.91	2.89
Mining and Quarrying	2	-4.13	0.00	0.24	0.12	-4.49
Food, Drink & Tobacco	3	3.15	0.00	0.22	1.13	1.80
Textiles, Leather, Footwear & Clothing	4	4.68	0.00	0.09	0.16	4.43
Wood & Products of Wood and Cork	5	5.09	0.00	0.06	0.36	4.67
Pulp, Paper & Paper Products; Printing & Publishing	6	3.21	0.00	0.48	1.02	1.71
Mineral Oil Refining, Coke & Nuclear Fuel	7	5.20	0.00	0.67	4.36	0.17
Chemicals	8	4.33	0.00	0.56	0.92	2.85
Rubber & Plastics	9	5.12	0.00	0.13	-0.05	5.04
Non-Metallic Mineral Products	10	4.72	0.00	0.24	1.62	2.86
Basic Metals & Fabricated Metal Products	11	2.61	0.00	0.55	0.80	1.27
Mechanical Engineering	12	3.04	0.00	0.25	0.04	2.75
Electrical and Electronic Equipment; Instruments	13	10.85	0.00	0.34	0.37	10.13
Transport Equipment	14	4.97	0.00	0.20	0.41	4.35
Furniture, Miscellaneous Manufacturing; Recycling	15	3.92	0.00	0.03	0.03	3.85
Electricity, Gas and Water Supply	16	2.39	0.00	0.10	1.19	1.11
Construction	17	3.24	0.00	0.12	0.57	2.55
Motor Vehicles & Wholesale Trade	18	3.26	0.00	0.57	0.51	2.18
Retail Trade & Repairs	19	2.83	0.00	0.13	0.21	2.49
Hotels & Catering	20	-0.35	0.00	0.06	0.87	-1.28
Transport	21	2.03	0.00	0.09	0.36	1.58
Communications	22	2.46	0.00	0.36	1.26	0.84
Financial Intermediation	23	1.36	0.00	2.39	0.80	-1.83
Real Estate Activities and Business Services	24	0.02	0.00	0.17	-0.45	0.30
Other Services	25	0.42	0.00	0.08	0.60	-0.26
Non-Market Services	26	1.46	0.00	0.08	0.24	1.14

Appendix Table III.C.5 continued...

Decomposition of annual labour productivity growth (Netherlands)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	5.19	-0.01	0.06	1.43	3.71
Mining and Quarrying	2	0.61	0.03	0.18	1.72	-1.33
Food, Drink & Tobacco	3	6.53	0.27	0.35	1.03	4.88
Textiles, Leather, Footwear & Clothing	4	2.62	0.28	0.13	0.87	1.34
Wood & Products of Wood and Cork	5	5.82	0.31	0.12	0.57	4.83
Pulp, Paper & Paper Products; Printing & Publishing	6	3.28	0.11	0.54	1.09	1.55
Mineral Oil Refining, Coke & Nuclear Fuel	7	6.55	0.18	0.65	-0.01	5.74
Chemicals	8	5.58	0.33	0.48	1.96	2.80
Rubber & Plastics	9	1.81	0.37	0.24	0.32	0.88
Non-Metallic Mineral Products	10	0.53	0.22	0.19	1.06	-0.93
Basic Metals & Fabricated Metal Products	11	2.05	0.19	0.16	0.18	1.52
Mechanical Engineering	12	2.94	0.21	0.42	0.30	2.01
Electrical and Electronic Equipment; Instruments	13	5.36	0.20	0.44	0.90	3.82
Transport Equipment	14	5.15	0.25	0.13	0.58	4.20
Furniture, Miscellaneous Manufacturing; Recycling	15	1.51	0.33	0.10	0.20	0.89
Electricity, Gas and Water Supply	16	1.85	0.05	0.24	1.83	-0.27
Construction	17	-0.68	0.12	0.19	0.23	-1.22
Motor Vehicles & Wholesale Trade	18	-0.12	0.34	0.37	-0.19	-0.64
Retail Trade & Repairs	19	0.72	0.35	0.18	0.20	-0.01
Hotels & Catering	20	-1.29	0.31	0.06	-1.01	-0.65
Transport	21	1.62	0.08	0.15	0.29	1.10
Communications	22	2.51	0.14	0.67	1.28	0.43
Financial Intermediation	23	2.28	0.47	1.68	1.63	-1.50
Real Estate Activities and Business Services	24	0.08	0.26	0.26	-0.60	0.16
Other Services	25	3.31	-0.03	0.21	2.44	0.69
Non-Market Services	26	0.45	0.48	0.09	0.26	-0.38

Appendix Table III.C.5 continued...

Decomposition of annual labour productivity growth (Netherlands)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	2.68	-0.04	0.12	0.84	1.76
Mining and Quarrying	2	3.08	0.02	0.50	3.54	-0.99
Food, Drink & Tobacco	3	1.46	0.19	0.42	0.60	0.24
Textiles, Leather, Footwear & Clothing	4	7.90	0.14	0.31	1.03	6.42
Wood & Products of Wood and Cork	5	2.58	0.14	0.35	0.89	1.20
Pulp, Paper & Paper Products; Printing & Publishing	6	3.71	0.07	1.02	0.70	1.91
Mineral Oil Refining, Coke & Nuclear Fuel	7	-11.37	0.11	-0.25	3.02	-14.25
Chemicals	8	4.08	0.15	0.15	1.81	1.97
Rubber & Plastics	9	4.19	0.22	0.28	0.37	3.32
Non-Metallic Mineral Products	10	4.48	0.10	0.43	1.35	2.61
Basic Metals & Fabricated Metal Products	11	1.98	0.12	0.38	0.26	1.21
Mechanical Engineering	12	3.44	0.13	0.78	0.18	2.35
Electrical and Electronic Equipment; Instruments	13	-1.69	0.12	1.08	0.15	-3.05
Transport Equipment	14	5.10	0.14	0.30	-0.71	5.38
Furniture, Miscellaneous Manufacturing; Recycling	15	2.26	0.16	0.21	0.26	1.62
Electricity, Gas and Water Supply	16	3.73	-0.01	0.30	4.27	-0.83
Construction	17	0.15	0.04	0.41	0.47	-0.77
Motor Vehicles & Wholesale Trade	18	4.67	0.03	0.78	0.05	3.80
Retail Trade & Repairs	19	2.04	0.03	0.44	0.33	1.24
Hotels & Catering	20	0.87	-0.04	0.13	-0.54	1.32
Transport	21	2.90	0.14	0.20	0.25	2.31
Communications	22	8.23	0.38	1.26	1.68	4.91
Financial Intermediation	23	-0.02	0.42	2.79	0.34	-3.57
Real Estate Activities and Business Services	24	1.02	0.44	0.55	-0.33	0.35
Other Services	25	-0.26	-0.18	0.22	-0.47	0.17
Non-Market Services	26	0.52	0.12	0.17	0.04	0.20

Appendix Table III.C.6

Decomposition of annual labour productivity growth (UK)

1979-90	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	3.00	0.14	0.06	-0.07	2.87
Mining and Quarrying	2	6.51	0.12	0.11	7.83	-1.56
Food, Drink & Tobacco	3	3.23	0.34	0.44	0.81	1.65
Textiles, Leather, Footwear & Clothing	4	3.04	0.21	0.04	0.59	2.19
Wood & Products of Wood and Cork	5	-0.35	0.28	0.07	-0.21	-0.49
Pulp, Paper & Paper Products; Printing & Publishing	6	2.58	0.07	0.17	0.86	1.48
Mineral Oil Refining, Coke & Nuclear Fuel	7	-0.59	0.62	0.30	2.07	-3.57
Chemicals	8	5.43	0.29	0.29	0.97	3.89
Rubber & Plastics	9	3.13	0.18	0.15	0.59	2.20
Non-Metallic Mineral Products	10	2.71	0.26	1.04	1.80	-0.39
Basic Metals & Fabricated Metal Products	11	4.05	0.33	0.10	0.28	3.35
Mechanical Engineering	12	1.83	0.25	0.13	0.37	1.08
Electrical and Electronic Equipment; Instruments	13	12.47	0.49	0.52	1.34	10.12
Transport Equipment	14	6.96	0.14	0.18	0.57	6.07
Furniture, Miscellaneous Manufacturing; Recycling	15	1.22	0.31	0.10	0.92	-0.11
Electricity, Gas and Water Supply	16	5.21	0.17	0.32	1.01	3.70
Construction	17	1.65	0.04	0.11	-0.42	1.92
Motor Vehicles & Wholesale Trade	18	1.51	0.30	0.86	0.60	-0.24
Retail Trade & Repairs	19	1.99	0.60	0.59	1.00	-0.20
Hotels & Catering	20	-0.35	0.52	0.08	0.75	-1.70
Transport	21	3.54	1.25	0.03	0.10	2.17
Communications	22	4.07	0.42	0.62	1.59	1.44
Financial Intermediation	23	-0.05	-0.02	1.17	0.91	-2.10
Real Estate Activities and Business Services	24	0.79	0.07	0.50	1.72	-1.50
Other Services	25	1.48	0.84	0.02	0.45	0.17
Non-Market Services	26	-0.17	0.77	0.04	0.11	-1.09

Appendix Table III.C.6 continued…

Decomposition of annual labour productivity growth (UK)

1990-95	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	3.16	0.27	0.10	2.07	0.71
Mining and Quarrying	2	24.06	0.48	0.16	14.11	9.31
Food, Drink & Tobacco	3	3.24	0.85	0.26	1.00	1.14
Textiles, Leather, Footwear & Clothing	4	3.41	0.60	0.22	0.69	1.90
Wood & Products of Wood and Cork	5	0.42	0.33	0.11	-0.34	0.32
Pulp, Paper & Paper Products; Printing & Publishing	6	1.94	0.12	0.60	0.66	0.55
Mineral Oil Refining, Coke & Nuclear Fuel	7	9.31	0.49	0.07	-1.05	9.80
Chemicals	8	7.92	0.72	0.34	1.43	5.43
Rubber & Plastics	9	2.02	0.64	0.23	0.10	1.06
Non-Metallic Mineral Products	10	4.73	0.33	0.32	1.77	2.31
Basic Metals & Fabricated Metal Products	11	2.07	0.78	0.11	0.42	0.76
Mechanical Engineering	12	2.79	0.43	0.38	0.33	1.65
Electrical and Electronic Equipment; Instruments	13	12.76	0.61	0.65	0.87	10.62
Transport Equipment	14	4.01	0.46	0.12	0.61	2.82
Furniture, Miscellaneous Manufacturing; Recycling	15	-0.91	0.34	0.37	0.93	-2.56
Electricity, Gas and Water Supply	16	5.19	0.43	0.61	5.91	-1.76
Construction	17	4.08	0.31	0.16	1.23	2.37
Motor Vehicles & Wholesale Trade	18	6.41	0.59	0.91	0.87	4.04
Retail Trade & Repairs	19	1.40	0.85	0.65	1.13	-1.23
Hotels & Catering	20	0.02	1.50	0.07	1.20	-2.76
Transport	21	4.41	1.79	0.23	1.05	1.34
Communications	22	6.63	0.43	1.01	0.48	4.71
Financial Intermediation	23	1.35	1.03	1.07	0.40	-1.15
Real Estate Activities and Business Services	24	1.92	0.17	0.96	0.55	0.23
Other Services	25	5.18	1.17	0.07	0.66	3.27
Non-Market Services	26	0.97	0.70	0.12	0.29	-0.15

Appendix Table III.C.6 continued…

Decomposition of annual labour productivity growth (UK)

1995-2000	Ind no.	Lab prod	Quality	ICT	Non-ICT	TFP
Agriculture, Forestry and Fishing	1	2.94	0.21	0.10	0.78	1.85
Mining and Quarrying	2	1.24	0.12	-0.03	-1.08	2.22
Food, Drink & Tobacco	3	-0.79	0.30	0.06	-0.06	-1.09
Textiles, Leather, Footwear & Clothing	4	1.48	0.56	0.50	0.86	-0.43
Wood & Products of Wood and Cork	5	-0.68	0.15	0.51	0.13	-1.47
Pulp, Paper & Paper Products; Printing & Publishing	6	0.15	0.34	0.62	-0.43	-0.37
Mineral Oil Refining, Coke & Nuclear Fuel	7	-4.82	0.29	-0.02	-1.60	-3.49
Chemicals	8	3.94	0.69	0.67	0.93	1.65
Rubber & Plastics	9	0.51	0.42	0.45	0.36	-0.72
Non-Metallic Mineral Products	10	1.30	0.17	0.28	1.21	-0.36
Basic Metals & Fabricated Metal Products	11	1.49	0.14	0.30	0.34	0.71
Mechanical Engineering	12	-0.04	0.20	0.90	-0.11	-1.04
Electrical and Electronic Equipment; Instruments	13	15.68	0.41	1.41	0.95	12.91
Transport Equipment	14	0.13	0.51	0.13	0.31	-0.82
Furniture, Miscellaneous Manufacturing; Recycling	15	0.19	0.16	0.61	1.14	-1.71
Electricity, Gas and Water Supply	16	11.08	0.19	0.49	5.97	4.43
Construction	17	1.23	0.30	0.07	0.57	0.29
Motor Vehicles & Wholesale Trade	18	4.70	0.19	2.05	0.21	2.25
Retail Trade & Repairs	19	2.88	0.32	0.60	0.72	1.24
Hotels & Catering	20	-2.68	0.45	0.02	1.26	-4.40
Transport	21	5.60	0.01	0.28	0.30	5.01
Communications	22	9.74	0.67	3.01	0.19	5.86
Financial Intermediation	23	3.64	0.50	1.05	-0.53	2.63
Real Estate Activities and Business Services	24	2.75	0.63	1.30	0.04	0.79
Other Services	25	0.97	0.44	0.09	0.03	0.40
Non-Market Services	26	1.06	0.65	0.05	0.22	0.14

Chapter IV:

Structural and Cyclical Performance

Robert Inklaar and Robert McGuckin

IV.1 Introduction

As is usually the case in studies focusing on industry productivity, the analysis to this point has adopted a long-run framework and ignored complications arising from economic cycles and related macroeconomic factors. The key question addressed in this chapter is how much of the strong ICT-driven productivity growth in the United States described in previous chapters can be attributed to cyclical macroeconomic factors instead of structural forces. If most of the upsurge in productivity growth is associated with short-term macroeconomic factors, then it is possible that the impact of ICT on productivity has been overstated. To answer this question, productivity is decomposed into a trend, or structural, component and a cyclical component. By filtering out the influence of the business cycle, it is possible to isolate changes in the long run, or structural rate, of productivity growth and so assess the importance of ICT for economic growth.

Just as ICT can affect the long-term or structural growth rate through its impact on productivity, it is also possible that ICT affects the cyclical behaviour of economies. For example, ICT should make it easier for firms to respond to changing conditions since it provides them with more up-to-date information. This increased flexibility means firms will be able to respond faster to changes in projected sales by changing production levels accordingly. Similarly, ICT makes it possible to improve information about customer demands and the resources available to meet them. This allows purchases of materials and production plans to be better coordinated with demand and as a result, desired inventory holdings should be reduced.

A deeper understanding of the business cycle and the impact of new technologies is interesting for obvious reasons having to do with macroeconomic stability. But it is also important to recognise that the structural growth rate can be affected by cyclical episodes. For example, recessions are often thought of as times of restructuring and reallocation that set the stage for enhanced growth and faster job creation later. On the other hand, deep recessions can lead to the degradation of human capital during long spells of unemployment and this can reduce the long-term growth rate over considerable periods of time.

Developing a complete model of the link between ICT, inventory behaviour and business cycles is beyond the scope of this chapter. The elements of these relationships would focus on the role of ICT in facilitating just-in-time production and improved information management, particularly in the area of forecasts of order and purchase flows. Some preliminary evidence on the likelihood of such links is offered below.

IV.2 Decomposing productivity growth rates into cycle and trend

Business cycles are traditionally defined as sequences of expansions and contractions in the level of economic activity. In other words, classical recessions and expansions are signalled by negative and positive growth in economic activity. In contrast, growth cycles are sequences of high and low growth rates. Growth cycles involve slowdowns, where growth rates decline, but remain positive. All recessions involve slowdowns, but not all slowdowns include recessions. Therefore, growth cycles occur with greater frequency then business cycles.

While they are related, they represent distinctly different phenomena and are typically analysed separately. (See BCI handbook (2001) and Zarnowitz and Ozyildirim (2001)) Here we are interested in identifying the growth in trend productivity so the focus is on growth cycle analysis. Moreover, the period studied includes only one classical business recession, although the beginning of our period (1980) and end (2001) involve recessions. Thus, even if the focus on business cycles were desirable, there is essentially one observation to work with.

Because cyclical slowdowns and speedups in growth rates characterise growth cycles they require trend estimation in order to separate the long run or structural component from cyclical or short-run deviations in the productivity series. There are a wide variety of methods used to accomplish this task. Zarnowitz and Ozyildirim (2001) compare and contrast various methods for separating trend and cycle and find that several alternative methods provide very similar results. While for their analysis of business cycle turning points they prefer the phase average trend (PAT), they also show that the more widely used Hodrick and Prescott (1997) filter, hereafter referred to as H-P, also does a good job of separating trend and cycle.

The H-P filter estimates a trend by minimizing the deviations from this trend. This minimization is constrained by a smoothness parameter, generally referred to as the lambda parameter. The filter takes the following form:

$$\min_{T_t} \left[\sum_{t=1}^{N} (X_t - T_t)^2 + \lambda \sum_{t=2}^{N} [(T_{t+1} - T_t) - (T_t - T_{t-1})]^2 \right] \qquad \text{(IV.1)}$$

In this formula X_t represents the original series and T_t the trend. This formula makes clear that if lambda is set to zero, cyclical deviations are minimised without constraint so the trend will be equal to the original series. Conversely, if lambda goes to infinity the trend converges to a linear trend.

The primary reason for the choice of the H-P filter is that recent analysis of the cyclical aspects of productivity growth has employed this filter and its use provides a convenient way to compare the results with those in the literature, particularly Gordon (2003) on the US economy. In addition the HP filter provides estimates for trend growth at the end of the sample. Although such estimates are less reliable than those in the middle of the sample, in this case they are most interesting.

End-points are always a problem with trend filters because they generally use a form of (weighted) moving averages to smooth the time series. This means filters need both past and future values of the times series to calculate the trend at a certain point in time. Although the most commonly used filters produce similar trends for intermediate points of the sample (as long as the appropriate parameters are chosen well), the behaviour at the end of the sample will generally deviate. Given the short series and the importance of the recessions and/or slowdowns at the end of the 1979-2001 period, the H-P filter provides a sensible filter choice. Nevertheless, various experiments suggest that the results would not change if alternative filters were used.[37]

A key characteristic of all the decomposition techniques investigated is that they estimate non-linear trends. This is an essential characteristic since the use of a non-linear trend component makes it possible to identify shifts or changes in the structural or trend growth rate. Arguably, the introduction of ICT technologies has raised the long run or structural growth rate, and a non-linear filter provides an opportunity to examine the structural component for changes to assess this ICT impact by industry.

There are other methods of looking at structural changes. For example breakpoint tests such as described in Hansen (2001) can also be used to test for (sequential) breaks. These methods essentially use dummy variables to look for piece-wise discontinuities, rather than rely on an estimate of a non-linear trend. Some experiments with these methods on data for the US found results similar to those in Stiroh (2002). While the tests did not identify statistically significant structural breaks, the most likely break in the sample period (1979-2001) was 1995.

Implementation of the H-P filter requires setting a value for the smoothing parameter lambda. This is not unique to H-P, as all filters require similar choices. Following standard practice the suggestion of Hodrick and Prescott (1997) is followed and the lambda for quarterly data was set equal to 1600. Ravn and Uhlig (2002) suggest a simple formula to find the lambda for a different frequency of observations that delivers the same amount

[37] Specifically, the H-P filter and the Baxter and King (1999) band-pass filter were compared. The assumptions needed to produce plausible trends at the end-points of the sample proved somewhat more involved for the band-pass filter than for the H-P filter. The PAT is also not very parsimonious with data near end-points.

of smoothing. If we use this formula and divide the quarterly lambda of 1600 by 4^4 we arrive at a lambda for annual data of 6.25.[38]

Zarnowitz and Ozyildirim (2001) find that a lambda of 108000 closely replicates the US business cycle turning points identified by the NBER using monthly data. Once again using the formula of Ravn and Uhlig (2002) we divide the monthly lambda of 108000 by 3^4 to arrive at a quarterly lambda of 1333. A lambda of 1333 performs almost the same amount of smoothing as a lambda of 1600 so we see the results of Zarnowitz and Ozyildirim (2001) as an indication that a lambda of 1600 will capture the relevant business cycle movements.

The choice of lambda is somewhat lower than the lambda of 6400 used by Gordon (2003). His main argument for this choice is that the trend during the Great Depression in the US declines too steeply, and that a higher value fits the full historical series better. We are sceptical of applying this kind of argument to the post-World War II trends studied. But below it is shown that the decomposition with a lambda of 6400 does not change the results substantially.

IV.2.1 Data

Data collected at high frequencies are required for cyclical analysis since cycles are usually short and do not always coincide with yearly intervals. Business cycle work typically involves monthly observations, although quarterly data are often used. The productivity data developed in this report, however, are only available at annual frequencies. Therefore time series of quarterly labour productivity are constructed for the total economy to examine its cyclical properties. To construct these quarterly series we use quarterly GDP from the OECD Quarterly National Accounts and data on the civilian labour force from the OECD Quarterly Labour Force Statistics. This means the productivity figures are on an employment basis instead of on a per hour basis.[39]

This analysis is then extended to data at an annual frequency and the same analysis is undertaken with value added per person employed and value added per hour worked, the preferred labour productivity measure. After verifying that the various economy-wide series provide qualitatively similar results, this chapter proceeds to study the ICT producing and using industries to identify structural changes in labour productivity growth.

[38] In moving from a quarterly to an annual frequency, the number of observations per year drops from four to one. Ravn and Uhlig (2002) use spectral methods to establish that one should then divide the lambda by 4^4. Similarly, in moving from monthly to quarterly data the number of observations per quarter decreases from three to one so the lambda should be divided by 3^4.

[39] Although the Bureau of Labor Statistics (BLS) publishes quarterly data on output per hour for the United States, these figures only refer to non-farm business output instead of GDP.

IV.2.2 Structural and cyclical effects in the productivity series

The basic results of the decomposition analysis are summarised in Tables IV.1-IV.3. Each table has the same structure and shows the growth in productivity, the growth in trend productivity and the resulting cyclical effect for various subperiods between 1979 and 2001. The tables show in turn this decomposition using quarterly data on GDP per person employed (Table IV.1), annual data on GDP per person employed (Table IV.2) and annual data on GDP per hour (Table IV.3). In these tables only results for the United States and the EU as a whole are reported. While there are some differences in timing and magnitude, the basic picture is very similar for individual EU countries.

For each table the upper rows show the periods 1979-90, 1990-95, and 1995-2001, which conforms to the periods identified in the earlier long-term work. The second panel uses the periods suggested by Gordon namely 1985-95, 1995-2000 and 2000-2001. In all cases, trend growth is calculated using an H-P filter with a lambda of 1600 for quarterly data and a lambda of 6.25 for annual data.

Based on the high frequency quarterly data (Table IV.1) the cyclical effects are generally pretty small, except for 2000-2001, where they dominate (row 6). This is as expected as actual productivity growth fell dramatically with the onset of the recession in the US and slowdown in Europe. Notwithstanding the recession, US trend growth accelerated in the second half of the 1990s, while the EU decelerated and the growth in trend productivity fell below the US level. This conclusion holds, even if 2001 is included in the post 1995 period.

Table IV.2 provides a bridge between the quarterly and annual data using the same measure of productivity, GDP per person employed. It shows a similar pattern to that in Table IV.1 and gives us confidence that the annual data can be used with the preferred measure of productivity, GDP per hour. As in Table IV.1, the exclusion of the recession years in the early 1980s does not affect the basic trends in the data.

Table IV.3, which shows the results for the GDP per hour productivity measure, show the same patterns in the data: US acceleration after 1995 and a deceleration in the growth of trend productivity in the EU at about the same time. While the magnitudes in Tables IV.2 and IV.3 are somewhat different from those in Table IV.1, particularly for the EU, this probably has more to do with data inconsistencies than real differences.[40] The quarterly employment data are based on labour force statistics derived from household surveys, while the annual employment data are based on national accounts. For some countries these different sources of data show large and persistent differences. These well-known statistical issues are always worrying, but they fall outside the scope of this project to try

[40] It was not possible to construct a quarterly labour productivity series for the full EU, but our EU-9 series covers around 90 percent of EU-15 GDP so EU-9 labour productivity growth should be broadly representative of EU-15 labour productivity growth

and resolve. So all in all it appears that the story of long-run structural change story linked to ICT diffusion remains, even with due account for the cyclical effects.

Table IV.1

Actual and trend growth of quarterly labour productivity in the total economy in EU-9 and the US between 1979 and 2001

	US			EU-9		
	Actual	*Trend*	*Cyclical*	*Actual*	*Trend*	*Cyclical*
Total economy						
1979Q1-1990Q4	1.05	1.23	-0.18	1.35	1.40	-0.05
1990Q4-1995Q4	1.56	1.49	0.07	1.87	1.77	0.10
1995Q4-2001Q4	1.82	1.87	-0.05	0.94	1.05	-0.11
1985Q4-1995Q4	1.24	1.38	-0.13	1.82	1.83	-0.01
1995Q4-2000Q2	2.21	1.92	0.28	1.30	1.19	0.11
2000Q2-2001Q3	-0.03	1.62	-1.65	0.09	0.84	-0.76

Notes: labour productivity is measured as quarterly GDP per person employed
EU-9 includes Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain and UK
Trend growth is calculated using a Hodrick-Prescott filter with lambda=1600

Sources: OECD Quarterly National Accounts,OECD Quarterly Labour Force Statistics

Table IV.2

Actual and trend growth of annual labour productivity in the total economy in EU-15 and the US between 1979 and 2001

	US			EU-15		
	Actual	*Trend*	*Cyclical*	*Actual*	*Trend*	*Cyclical*
Total economy						
1979-1990	1.11	1.21	-0.10	1.70	1.77	-0.07
1990-1995	1.03	1.10	-0.06	1.93	1.83	0.10
1995-2001	2.21	2.21	0.00	1.39	1.50	-0.11
1985-1995	0.91	1.05	-0.13	1.88	1.85	0.03
1995-2000	2.54	2.23	0.31	1.51	1.54	-0.03
2000-2001	0.57	2.12	-1.54	0.79	1.31	-0.53

Notes: Labour productivity is defined as annual GDP per person employed
Trend growth is calculated using a Hodrick-Prescott filter with lambda=6.25
EU-15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, Sweden and UK

Table IV.3

Actual and trend growth of annual labour productivity in the total economy in EU-15 and the US between 1979 and 2001

	US			EU-15		
	Actual	*Trend*	*Cyclical*	*Actual*	*Trend*	*Cyclical*
Total economy						
1979-1990	1.27	1.35	-0.09	2.26	2.35	-0.09
1990-1995	1.10	1.12	-0.02	2.32	2.20	0.12
1995-2001	2.25	2.17	0.08	1.73	1.82	-0.10
1985-1995	0.97	1.10	-0.13	2.27	2.24	0.03
1995-2000	2.46	2.15	0.31	1.81	1.85	-0.04
2000-2001	1.21	2.23	-1.02	1.30	1.70	-0.40

Notes: Labour productivity is defined as annual GDP per hour worked
Trend growth is calculated using a Hodrick-Prescott filter with lambda=6.25
EU-15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, Sweden and UK

IV.2.3 A note on the sensitivity of the results to choice of lambda

Before proceeding, this section briefly outlines evidence that suggests that the analysis based on the structural/cyclical decomposition in Tables IV.1-IV.3 is relatively insensitive to the choice of the smoothness parameter lambda. Table IV.4 reproduces the earlier analysis using quarterly data, but this time using the lambda of 6400 preferred by Gordon.

A glance at the table shows that the cyclical effects for the US are indeed larger than reported in Table IV.1 for the 1995-2000 period when productivity growth accelerated so dramatically. But, the difference 0.09 (0.37- 0.28) is only about 4 percent of actual productivity growth. In short, the qualitative results do not change. The EU conclusions also seem to hold up quite well.

Table IV.4

Actual and trend growth of quarterly labour productivity in the total economy in EU-9 and the US between 1979 and 2001, using λ = 6400

	US			EU-9		
	Actual	*Trend*	*Cyclical*	*Actual*	*Trend*	*Cyclical*
Total economy						
1979Q1-1990Q4	1.05	1.29	-0.24	1.35	1.49	-0.13
1990Q4-1995Q4	1.56	1.53	0.03	1.87	1.72	0.15
1995Q4-2001Q4	1.82	1.83	-0.01	0.94	1.11	-0.17
1985Q4-1995Q4	1.24	1.42	-0.18	1.82	1.80	0.03
1995Q4-2000Q2	2.21	1.84	0.37	1.30	1.23	0.07
2000Q2-2001Q3	-0.03	1.74	-1.77	0.09	0.95	-0.86

Notes: labour productivity is measured as quarterly GDP per person employed
EU-9 includes Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain and UK
Trend growth is calculated using a Hodrick-Prescott filter with lambda=6400

Sources: OECD Quarterly National Accounts, OECD Quarterly Labour Force Statistics

IV.3 Structural trends in productivity growth

The focus now turns to the trend or structural component from the decomposition analysis. This allows us to examine whether the relationships identified in the industry data show up for the economy as a whole. The structural or trend effects reported in the earlier tables are graphically reported in Figures IV.1a and 1b for the US and the EU, respectively. Each figure plots the trend values derived from the H-P decomposition for lambda equal to 1600 and 6400.

In the case of the US the larger lambda tends to flatten the endpoints and make the change in trend somewhat less distinct. This is not unexpected given the earlier discussion of the impact of the choice of lambda. But the acceleration in the US in the last half of the decade of the 1990s is evident in the economy-wide data regardless of the smoothness parameter that is chosen.

Turning to Figure IV.1b, the picture for the EU is very different from the US. The dominant feature of the trend line for the EU in the 1990s is a persistent downward movement in the growth of trend productivity. Again, while the higher value for lambda tends to flatten the end points, it does not mute the strong trends discussed above.

Figure IV.2 compares the structural or trend component of the decomposition for both the EU and the US using the preferred productivity measure, GDP per hour worked. This picture suggests that the US acceleration began about one year earlier than the 1995 cut-off used in constructing the basic tables. Notwithstanding the particular cut-off date, the high stable growth in productivity in the EU until 1993-94 and the declining growth in the US until about 1990 account for the steady convergence of productivity levels from the 1980s. This convergence slowed dramatically around 1995-6 when accelerating US productivity and decelerating EU productivity made trend growth about equal. After 1995-96, productivity in the EU began to diverge from the US levels.

Figure IV.1a

Trend growth of quarterly US labour productivity per person using different H-P smoothing parameters, 1979Q1-2001:Q4

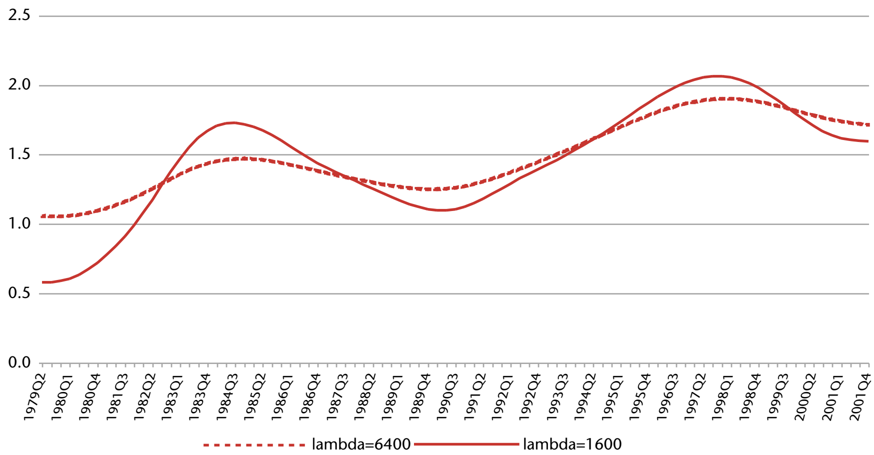
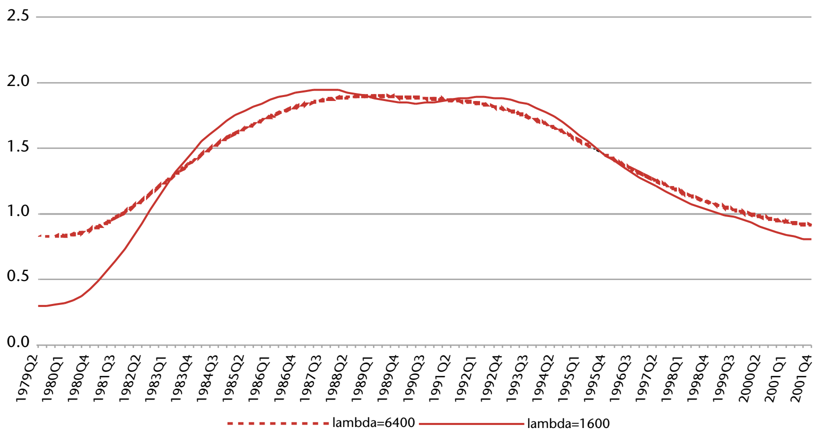


Figure IV.1b

Trend growth of quarterly EU-9 labour productivity per person using different H-P smoothing parameters, 1979Q1-2001:Q4



IV.3.1 Structural and cyclical decomposition by sector

Table IV.5 presents the results of the decomposition of productivity growth for the ICT producing, ICT using, and non-ICT sectors. The sectoral definitions are as described in earlier chapters. (Appendix IV.A provides the same information for the more detailed 7-sector breakdown.) The sub-periods in the table are the same as were used in the earlier analysis for the total economy in tables IV.1-IV.3.

Table IV.5

Actual and trend growth of annual labour productivity in ICT producing, ICT using and non-ICT industries in EU-15 and the US between 1979 and 2001

	US			**EU-15**		
	Actual	*Trend*	*Cyclical*	*Actual*	*Trend*	*Cyclical*
ICT producing industries						
1979-1990	8.80	8.62	0.18	7.40	7.49	-0.09
1990-1995	8.06	8.56	-0.51	6.03	6.18	-0.15
1995-2001	9.99	9.80	0.19	7.54	7.68	-0.14
ICT using industries						
1979-1990	1.19	1.35	-0.16	2.23	2.33	-0.10
1990-1995	1.20	1.46	-0.26	2.02	1.97	0.05
1995-2001	4.67	4.24	0.43	1.88	1.96	-0.08
Non-ICT industries						
1979-1990	0.53	0.61	-0.08	1.84	1.93	-0.09
1990-1995	0.31	0.13	0.18	2.12	1.94	0.18
1995-2001	-0.16	-0.09	-0.07	1.02	1.12	-0.10

Note: Labour productivity is defined as annual real value added per hour worked
Trend growth is calculated using a Hodrick-Prescott filter with lambda=6.25
EU-15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, Sweden and UK

The first panel in the table shows the decomposition for ICT producing industries. Cyclical effects play a relatively small role here. Trend growth is very fast in both the EU and the US, with the US slightly ahead. It is important to note that the EU is on a similar productivity growth path as the US in ICT producing industries and the acceleration in the 2nd half of the 1990s was much faster in the EU.[41] In contrast to the other sectors, ICT producing industries already experienced very high growth rates in the 1980s.

[41] The trend for ICT producing industries as a whole does hide the fact that ICT producing manufacturing has shown faster growth in the US, while Europe has led in ICT producing services.

Growth of trend productivity in the ICT using industries accelerated greatly in the US in the second half of the 1990s, while the trend remained flat in the EU. This is a key factor in the divergence of US and EU productivity growth in the second half of the 1990s. Moreover, the pattern is quite consistent with the slower diffusion of ICT in the EU found

Figure IV.2

Trend growth of annual GDP per hour worked in the US and EU-15, 1979-2001

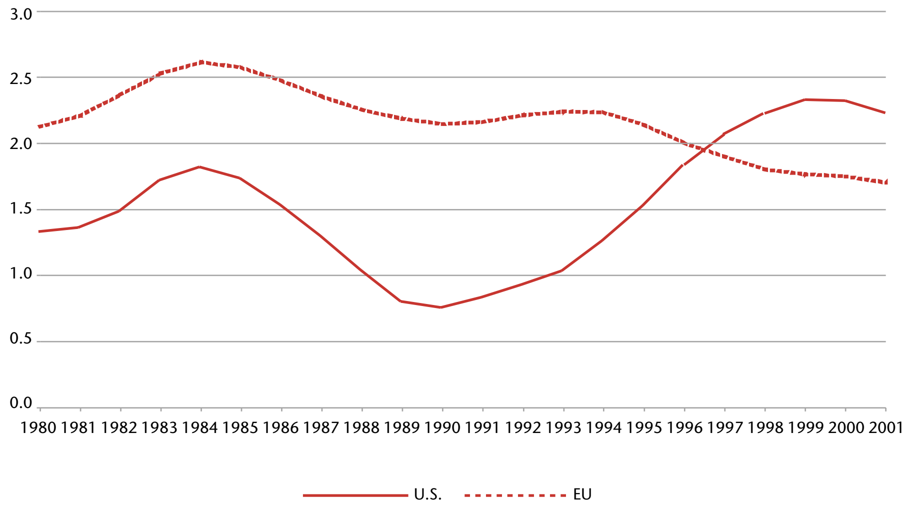


Figure IV.3a

Trend growth of labour productivity per hour in US ICT-producing, ICT-using and Non-ICT industries, 1979-2001

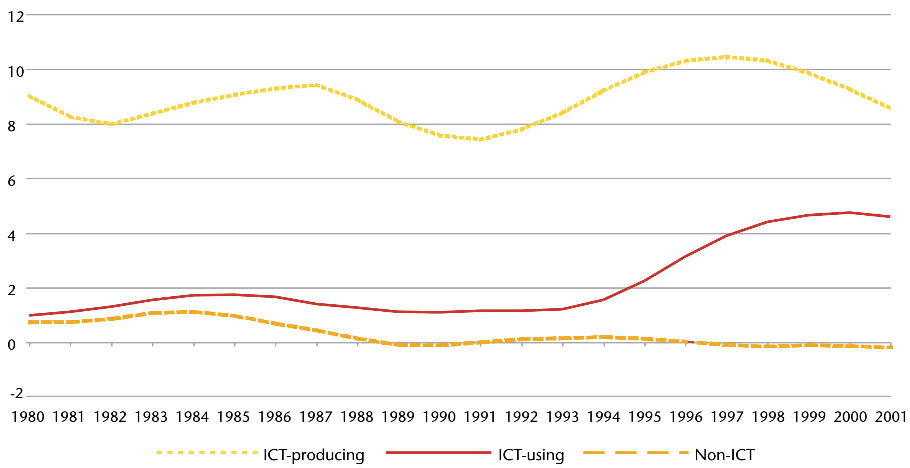
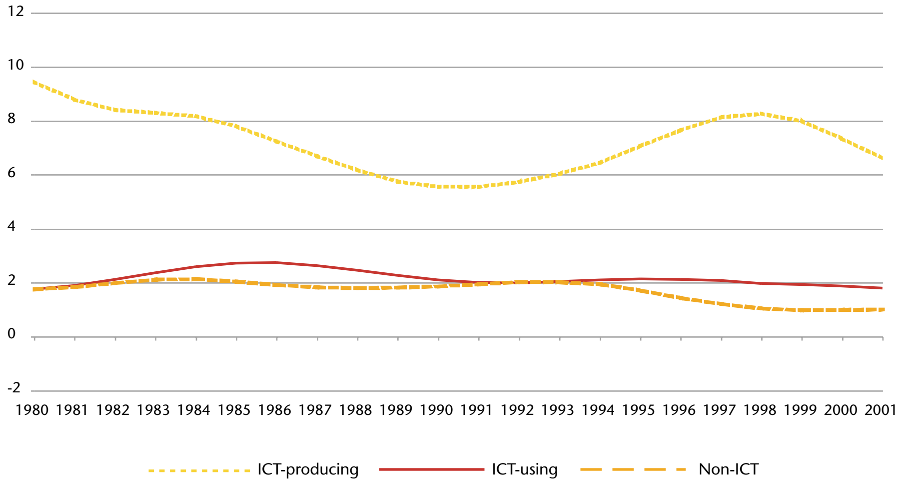


Figure IV.3b

Trend growth of labour productivity per hour in EU-15 ICT-producing, ICT-using and Non-ICT industries, 1979-2001



earlier. This pattern was described earlier and taking into account cyclical adjustments does not change it.

Compared to the 1980s and early 1990s, growth in trend productivity of non-ICT industries in the EU decelerated sharply after 1995. Although the fall in trend growth is less steep than the fall in actual productivity growth, the 0.82 percent deceleration is still quite substantial. Nevertheless, compared to slow or even negative growth in US trend productivity, the non-ICT industries in the EU still showed relatively strong performance.

IV.4 Inventories and ICT

While, as illustrated above, it is possible to measure changes in the cyclical variations over time, linking such changes to ICT or other potential causes is not straightforward. There is not a fully satisfactory theory of the business cycle so it is difficult to identify potential channels by which ICT can affect cyclical behaviour. Nonetheless, inventory behaviour is likely to be an important potential channel and it has been frequently discussed in the literature on the stabilization of the US economy in recent years and linked to ICT circumstantially as well as through simulation exercises.[42]

There are several ways in which ICT is likely to affect inventories. Articulating such links requires a model of inventory behaviour and how inventories relate to final sales levels.

[42] See for example McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Stock and Watson (2003) and, particularly Kahn, McConnell and Perez-Quiros (2002).

Here we simply sketch out a few of the relevant considerations and present some suggestive results.

IV.4.1 Inventories to sales ratios

Inventories provide buffer stocks of goods for sale and ensure that consumer's demands can be met without waiting for new production and deliveries. Inventories are costly to business, but they ensure supplies and thus are valuable to customers. Providing such service at a minimum cost is an important business task with substantial impacts on profits in most industries.

Thus business holds inventories but also seeks to economise on them. Most models of inventory behaviour formulate such strategies in terms of the ratio of inventory holdings to (expected) sales. This is because desired inventories are not independent of sales volume and volatility. Higher sales mean more turnover and higher levels of desired inventory levels.

Just-in-time is an important technique for economising on inventories and this technique is greatly facilitated with ICT. Just-in-time refers to close co-ordination of production and sales to reduce inventory requirements. While these practices are used within firms, typically the term has been associated with co-ordination of production and sales across independent firms dealing through markets. ICT provides improved methods for tracking production and shipments information. It also helps in scheduling trucking and other transportation services. Moreover, ICT advances improve information flows on customer demands as well as the processing capabilities for assessing the information and forecasting inventory requirements. For example, automated checkouts at retail outlets can keep track of inventory directly and in 'real' time.

IV.4.2 Inventories and volatility

Recent empirical work established a link between decreased volatility in US GDP growth and inventories with most of the impact coming through reduced volatility in durable goods manufacturing (Kahn, McConnell and Perez-Quiros, 2003). This work was entirely based on US data and, despite a variety of attempts to develop some simple tests of whether inventories in the EU have become less volatile, in the end the work was simply too speculative to report. The problems with the data are outlined in the next section.

IV.4.3 Data

Data is a difficult problem in this area and so the focus is on the US since the EU data are less extensive and primarily consist of qualitative business surveys or on measures of changes in inventories instead of inventory levels. Thus, inventory / sales ratios are not readily available for the EU.

The US Census Bureau collects data on inventories and shipments in manufacturing industries (the M3 Database) and this forms the basis of the National Income and Product Accounts (NIPA), published by the US Bureau of Economic Analysis, on total private inventories and relevant price deflators. The survey of the US Census Bureau of manufacturing establishments directly requests the value of inventories and similarly, data on the level of inventories are provided in the NIPA. Such data are not, however, available from either EU surveys or from the National Accounts of individual countries.

In EU National Accounts, only the change in inventories is reported and this is derived indirectly as the difference between production and sales. This measure is therefore very sensitive to revisions and also much harder to evaluate since the base level from which the change occurs is not known. Following Jorgenson, Ho and Stiroh (2002) inventory stocks were estimated in a fashion similar to that used in constructing capital stocks from investment data by assuming that inventories do not depreciate. Unfortunately, the results were somewhat problematic and more work on the basic data is needed.[43]

For EU countries there are also survey data on deviations of inventories from normal levels published by the OECD in its Main Economic Indicators. The EU survey asks respondents to evaluate whether inventory levels are above or below 'normal'. The balance of positive (above normal) and negative (or below normal) responses is then published to give an indicator of the inventory situation.

Such survey information on inventory changes is available for 8 EU countries for the entire period 1970- present. There are a number of difficulties in evaluating these data for present purposes, namely ascertaining the trend in inventory volatility. Most important the differences are all expressed relative to a 'normal' level, which is not well defined. Based on arguments in Section IV.4.1 desired inventory to sales ratios should be declining because of the ICT supported just-in-time procedures. In turn, firms' survey responses will depend on how their view of 'normal' changes with movements in desired inventory/ sales ratios. Various experiments with these data were performed, but in the end it was decided they had too many problems to be a useful addition to this report.

IV.4.4 Empirical findings

It appears that there have been major changes in the behaviour of US inventory to sales ratios in the past 20 years or so. In particular there has been a systematic decline in the economy-wide ratio of inventory stocks to sales in the US. This decline dates from the early 1980s and has been fairly steady as shown in Figure IV.4. The picture is much less dramatic for manufacturing overall, but the basic patterns remain when the manufacturing data are broken down by stage of processing (Figure IV.5).

[43] The NIPA also contains a similar 'change' measure of inventories. If these are used to construct inventory stocks, there is a positive correlation of 0.57 with the survey-based inventory levels. This correlation is largest if no depreciation is assumed.

As a way to test for a link between ICT and inventories data were examined on the ratio of inventory to sales for individual manufacturing industries from the US Census data described above. These data are shown in Table IV.6, sorted by the inventory to sales ratio in the 1995-2001 period. It was possible to identify 13 industries and obtain information for three time periods corresponding closely to those used in the earlier structural analysis. The data includes a measure of ICT intensity for each industry based on the growth accounts of Chapter III – the share of computers, communication equipment and software in total capital compensation.

Table IV.6

Average inventory to sales ratio and ICT intensity for manufacturing industries in the United States

Industry	ISIC rev3	Inventory to sales			ICT intensity
		1970-1985	1985-1995	1995-2001	1995-2001
Machinery and equipment	29	2.80	2.40	2.05	27.5
Electrical and electronic equipment and instruments	30-33	2.56	2.20	1.71	26.0
Textiles, wearing apparel and leather products	17-19	1.83	1.67	1.70	9.9
Furniture and miscellaneous manufacturing	36-37		1.95	1.70	12.9
Basic and fabricated metal products	27-28	2.12	1.85	1.61	7.8
Transport equipment	34-35	1.82	1.88	1.48	10.6
Chemical and allied products	24	1.47	1.38	1.33	9.5
Wood products	20		1.38	1.27	6.7
Non-metallic mineral products	26	1.52	1.46	1.23	7.3
Rubber and plastics	25	1.55	1.35	1.21	7.7
Paper products,printing and publishing	21-22	1.17	1.12	1.05	16.9
Food, beverages and tobacco	15-16	1.16	1.02	0.98	7.6
Petroleum and coal products	23	0.79	0.90	0.81	2.4

Notes: Data on inventories and value of shipments are from the Census M3 database. SIC (1970:1-2001:3) and NAICS (1992:1-2001:12) are linked in 1992 for additional industry detail. Sorted by 1995-2001 inventory to sales ratio. ICT intensity is defined as the share of computer equipment, communication equipment and software in total capital compensation.

It is clear that the inventories to sales ratios are declining over time in most industries. This conforms to the more aggregate data described earlier. Moreover, there are wide variations across industries in the proportion of sales held in inventories. While the relationship is not particularly strong, there is a tendency for industries that hold higher proportions of their sales in inventories to have somewhat higher ICT intensities. What is not clear from the table is whether industries with high inventory requirements (because of volatility in sales, long production lead times and other factors) invest more in ICT goods to help them economise or whether other factors that influence ICT acquisition are associated with inventory holdings.

Table IV.7

Change in inventory to sales ratio and correlation with ICT intensity for the United States

Industry	ISIC rev3	Change in I/S ratio		
		85-95/ 70-85	95-01/ 85-95	95-01/ 70-85
Machinery and equipment	29	-15.6	-15.7	-31.3
Electrical and electronic equipment and instruments	30-33	-15.1	-25.3	-40.4
Textiles, wearing apparel and leather products	17-19	-9.1	1.8	-7.3
Furniture and miscellaneous manufacturing	36-37		-13.6	
Basic and fabricated metal products	27-28	-13.7	-13.5	-27.2
Transport equipment	34-35	3.3	-24.0	-20.7
Chemical and allied products	24	-6.6	-3.6	-10.3
Wood products	20		-7.9	
Non-metallic mineral products	26	-4.0	-17.3	-21.4
Rubber and plastics	25	-13.9	-11.0	-24.9
Paper products, printing and publishing	21-22	-4.0	-6.9	-10.9
Food, beverages and tobacco	15-16	-12.7	-4.2	-16.9
Petroleum and coal products	23	12.3	-10.5	1.9
Average		-7.2	-11.7	-19.0
Correlation with ICT intensity		-0.51	-0.42	-0.66

Note: Change in I/S ratio: total percentual change in inventory to sales ratio from Table IV.6.
Calculated as the log of (I/S(85-95)/I/S(70-85)).
85-95/70-85: Change between period 1970-1985 and period 1985-1995

Table IV.7 shows the change in the average inventory to sales ratio over the three periods identified in Table IV.6. With just three exceptions, two of them in petroleum and coal products, the inventory to sales ratios declined. Generally the declines were in the 15-20 percent range for comparisons of the latest period (1995-2001) with the earliest (1970-1985). For each comparison the correlation between the decline in the inventory to sales ratio and ICT intensity is negative and significant, even with such a small sample and the correlations range from 0.42 to 0.66. A simple regression showed a highly significant negative estimate for ICT intensity and the change in the inventory to sales ratio, but the change in the ICT intensity did not have a significant effect on the ratio.

Figure IV.4

US Inventory to sales ratio, total private and manufacturing, 1960-2001

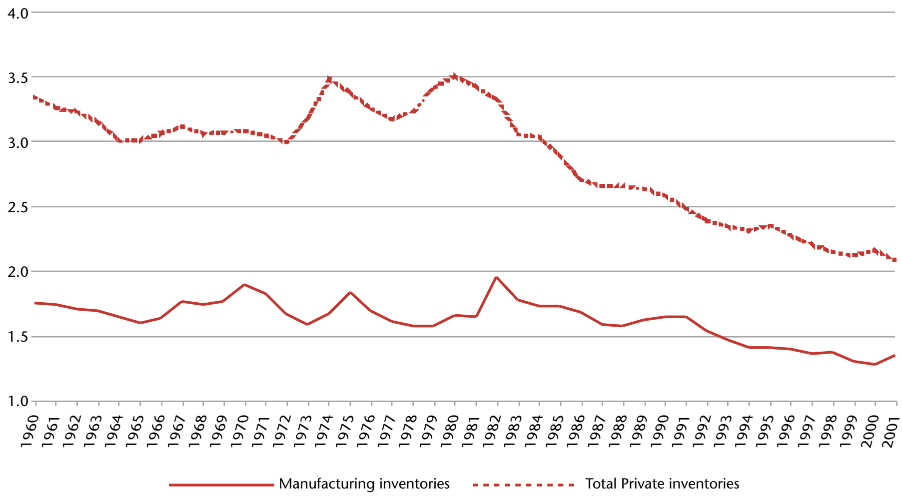
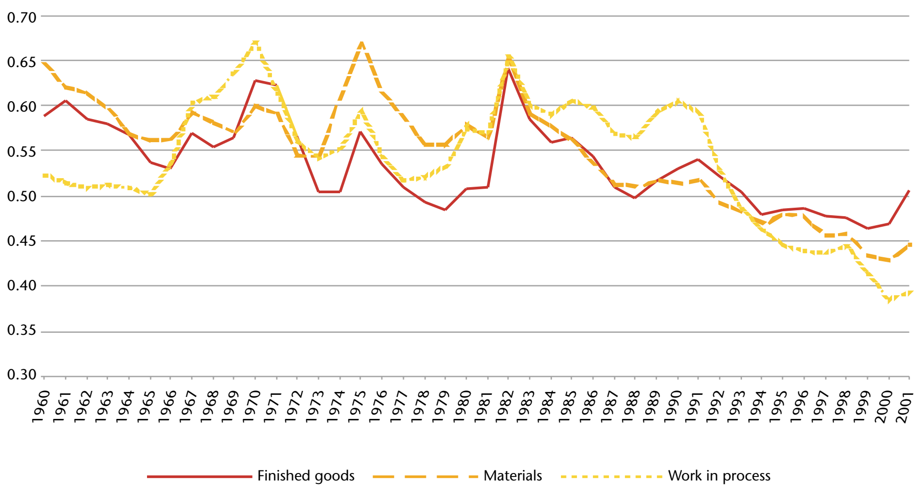


Figure IV.5

US manufacturing inventory to sales ratio by stage of processing, 1960-2001



IV.5 Conclusions

The aim of this chapter has been to evaluate the importance of cyclical factors in labour productivity growth. In particular, we have decomposed the growth in labour productivity into a growth in trend productivity and a cyclical component. Using appropriate filtering techniques we found that these cyclical effects are generally small, except in the most recent year, 2000-2001. The results were also not very sensitive to the value of the smoothness parameter. Based on this we can conclude that in the late 1990s productivity trends in the EU and US diverged sharply.

Analysis at the industry level reveals that the EU experienced similar levels of growth as the US in ICT producing sectors, but there was considerable divergence across the two regions between the ICT using industries, suggesting slower diffusion of ICT technology in the EU. These results confirm those found in Chapter III.

The analysis also considered the behaviour of inventories in the US. This revealed that there has been a considerable decline in the inventory to sales ratio over time. The results support the idea that the inventory to sales ratio declined more in industries with a higher ICT intensity, consistent with the idea that an important ICT benefit is its support for just-in-time inventory control. The data for the EU were not considered robust enough to carry out a similar analysis but this is a useful area for future research.

IV.A Appendix Table

Appendix Table IV.1

Actual and trend growth of annual labour productivity in ICT producing, ICT using and non-ICT industries across manufacturing and services in EU-15 and the US between 1980 and 2001

	US			EU-15		
	Actual	*Trend*	*Cyclical effect*	*Actual*	*Trend*	*Cyclical effect*
ICT producing manufacturing						
1980-1990	16.73	16.47	0.26	13.09	13.68	-0.59
1990-1995	16.05	17.99	-1.93	9.05	9.11	-0.05
1995-2001	23.75	23.45	0.30	12.17	12.48	-0.32
ICT producing services						
1980-1990	2.42	2.29	0.13	4.40	4.33	0.07
1990-1995	2.44	2.63	-0.19	4.76	4.97	-0.22
1995-2001	1.83	1.27	0.56	5.87	5.97	-0.10
ICT using manufacturing						
1980-1990	0.53	0.59	-0.07	2.39	2.52	-0.13
1990-1995	-0.61	-0.48	-0.13	2.66	2.31	0.36
1995-2001	0.42	0.70	-0.28	1.90	2.15	-0.25
ICT using services						
1980-1990	1.43	1.61	-0.19	2.10	2.17	-0.08
1990-1995	1.61	1.88	-0.27	1.82	1.87	-0.06
1995-2001	5.33	4.78	0.55	1.84	1.86	-0.02
Non-ICT manufacturing						
1980-1990	2.13	2.48	-0.35	2.98	3.21	-0.24
1990-1995	2.72	1.92	0.80	3.61	3.15	0.46
1995-2001	0.27	0.87	-0.60	1.64	1.91	-0.28
Non-ICT services						
1980-1990	-0.15	-0.15	0.00	0.61	0.62	-0.01
1990-1995	-0.53	-0.54	0.00	1.23	1.08	0.15
1995-2001	-0.29	-0.41	0.12	0.53	0.58	-0.05
Non-ICT other						
1980-1990	1.95	1.98	-0.03	3.43	3.55	-0.13
1990-1995	1.24	1.25	-0.01	3.22	3.24	-0.02
1995-2001	0.71	0.72	-0.01	2.12	2.14	-0.02

Note: Labour productivity is defined as annual real value added per hour worked
Trend growth is calculated using a Hodrick-Prescott factor with lambda=6.25
EU-15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Spain, Portugal, Sweden and UK

Chapter V:

Productivity Performance at the Company Level

Ana Rincon and Michela Vecchi

V.1 Introduction

In this chapter productivity performance at the micro-economic level is analysed using a large sample of companies across different countries and industries. The level of detail in the company account data set used in this study can provide a wider and more complete picture of the way firms have responded to changes in the economic environment and to the ICT revolution. The availability of information on R&D investment and firm size, for example, will allow a closer examination of whether the productivity slowdown has been a general phenomenon or whether it has affected R&D and non R&D performers to a different extent. An additional question that this chapter aims to address is whether smaller firms have been able to adjust more easily to the technological changes, compared to large companies.

The analysis at the company level will also use information at the industry level on ICT intensity, innovation and skills by using the taxonomies presented in Chapter II. Better performance of companies operating in say ICT intensive sectors can be considered evidence of the presence of technological spillovers/externalities. The essence of a spillover effect is that the research carried out by other firms may allow a given firm to achieve results with less investment effort (Jaffe 1986). If a firm operates in a high technology environment, it is more likely to absorb new developments quickly and to boost productivity further. More specifically, there is increasing evidence that ICT investments have fostered important organizational changes within firms and such changes have had an important impact on productivity performance (Brynjofsson and Hitt 1996, 2000, Black and Lynch 2001). Also, recent models of growth resulting from general-purpose technologies point to ICT as a source of generating spillover effects (Bresnahan and Trajtenberg 1995, Helpman 1998). A range of methods to account for spillovers can be found in the literature. Here the approach of Griliches (1992) is followed, considering the technical similarities across firms as a source of externalities. In this case, companies belonging to the same taxonomy group can be defined as similar and this can aid in identifying spillover effects.

In the following section a detailed description of the data used in the analysis is presented, together with some descriptive statistics. Section V.3 discusses the main trends in labour productivity growth, while section V.4 presents a more technical framework that will be used in the econometric analysis and the main empirical results. To give a more complete picture of performance at the firm level, section V.5 considers firm dynamics, i.e. the process by which entry, exit and firm growth changes productivity. Such information is not available in the company accounts data set employed in this chapter. Indeed international comparative research on this topic is still in its infancy. Therefore this section merely reviews the existing literature on this important topic. Finally Section V.6 concludes this chapter.

V.2 Description of the data set

V.2.1 Data sources and transformations

The company accounts database employed in the analysis, Compustat, includes financial and market data on more than 13,000 international companies in more than 80 countries. The dataset covers all sectors of the private market economy except agriculture, private health and education sectors. From this, information for the United States, Japan and the 15 EU member states was extracted for the time period 1991-2001. The primary data series extracted from the company accounts were net sales, employment, net physical capital, defined as equipment and structures (PPE) and R&D expenditures. A number of 'outlier' companies were dropped so that they do not unduly influence the results. These include those with zero or negative values for net sales, employment or net physical capital as were those companies for which the growth rate of these variables was more than 150% or lower than –150%[44].

Table V.1 presents a summary of the number of companies available in the sample for the US, Japan, EU-15 and for each EU member state. The sample is an unbalanced panel of 39,809 annual observations for EU, 36,245 for Japan and 27,467 for the US. Table V.1 shows the distribution of the companies in the three broad sectors (other production industries, manufacturing and services), distinguishing firms reporting R&D expenditures from others.

The US, EU-15 and the Japanese samples are roughly comparable. Within the EU-15, the UK, Germany and France dominate the sample. Coverage in the latter two is about to their shares of total EU employment but both the UK and Sweden appear to be over-represented relative to the size of those countries whereas Italy and Spain are somewhat under-represented. The sample splits almost equally between manufacturing and services in the US, Japan and total EU, again contrary to these sectors shares of total employment.

Looking across sectors, a larger number of companies undertaking R&D investments can be found in manufacturing in all countries. A high proportion of companies in the service

[44] This criterion to remove outliers has been used recently in Aghion, Bloom, Blundell, Griffith and Howitt (2002) and Bloom, Griffith and Van Reenen (2000).

sector do not disclose figures on R&D. In addition only 27% of EU companies report R&D expenditures throughout the period, while this percentage goes up to 46% in the US and 65% in Japan. Therefore it is necessary to exercise some caution in interpreting changes in aggregate sector productivity based on this sample. However, in the regression analysis the relatively large number of observations should yield unbiased results.

Table V.1

Distribution of companies across countries and industries

	Total	Other production industries[1]		Manufacturing		Services[2]	
		R&D>0	R&D=0	R&D>0	R&D=0	R&D>0	R&D=0
US	2443	20	215	857	297	251	803
All EU	3311	51	194	573	860	264	1369
Japan	3292	225	55	1540	104	356	1010
UK	879	23	50	174	136	97	399
Germany	664	5	36	129	187	62	245
France	559	7	18	74	158	42	260
Sweden	204	5	4	44	43	22	86
Italy	183	-	19	7	84	-	73
Netherlands	159	1	7	24	47	10	70
Denmark	125	1	5	21	39	2	57
Spain	121	2	16	-	54	2	47
Finland	109	2	3	52	12	13	27
Belgium	74	-	6	10	32	4	22
Austria	74	2	8	16	30	2	16
Greece	55	3	7	8	15	2	20
Ireland	54	-	7	11	6	7	23
Portugal	40	-	6	-	16	-	18
Luxembourg	11	-	2	-	4	-	5

1. Includes mining and quarrying, electricity, gas & water and construction; 2. Includes transport, wholesale and retail trade, eating and drinking places and hotels, personal and amusement services, business and professional services.

V.2.2 Descriptive statistics

Table V.2 presents some descriptive statistics on employment, physical capital stock, R&D capital stock and sales for the EU, US and Japan. These figures are based on the average across all years and all companies. In terms of the number of employees, capital and turnover, US firms are on average the largest, followed by the EU and the Japanese companies. US companies are also more capital intensive, as can be seen from the capital to labour ratio. The Japanese companies included in this sample appear to be characterised by a lower capital stock, and capital to labour ratio, compared to the US and the EU-15. Finally, Japanese and EU companies are characterised on average, by a higher sales to employment ratio than the US.

Table V.2

Descriptive statistics from the company sample[1]

	Obs.	*Mean*	*Std. Dev.*	*Min*	*Max*
US					
Employment	22,139	12,296	40,862	1	1,383,000
Capital	23,122	1,066,046	3,942,878	7	100,259,000
R&D	9,850	542,104	2,417,862	17	44,970,710
Sales	23,383	2,423,915	8,409,796	26	218,227,000
Capital-Employment ratio	21,904	262	3,975	0.07	193,797
Sales-Employment ratio	22,092	261	525	0.15	24,268
EU-15					
Employment	21,950	10,187	29,726	1	484,000
Capital	23,044	1,049,554	4,724,870	1	107,786,700
R&D	4,426	681,159	2,460,442	13	29,616,120
Sales	24,493	1,962,303	6,522,790	2	156,786,500
Capital-Employment ratio	21,755	161	1,292	0.056	85,548
Sales-Employment ratio	21,881	361	2,650	31	175,410
Japan					
Employment	13,066	2,285	9,886	9	323,897
Capital	28,409	472,560	2,684,473	5	89,802,570
R&D	10,765	213,049	1,116,690	26	18,398,430
Sales	28,419	1,204,004	5,204,831	1245	118,629,000
Capital-employment ratio	13,037	125	314	1	10,622
Sales-Employment ratio	13,065	360	433	10	7,984

1. The measurement unit for the employment variable is number of employees and for capital, R&D and sales is US dollars in constant prices.

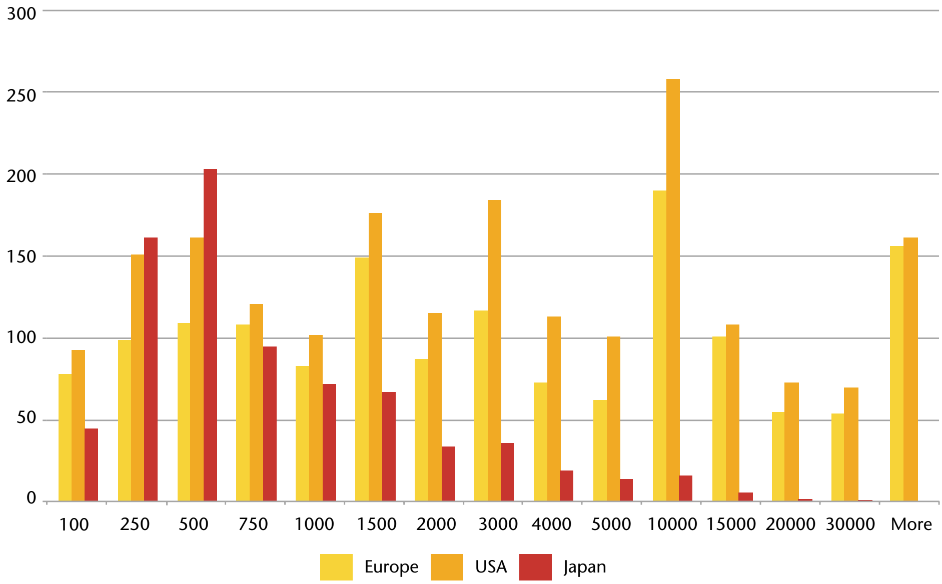
Figure V.1 presents the size distribution of companies in the US, Japan and the EU-15 based on the average number of employees in 1995. Japanese companies are quite small in size and this is a characteristic feature of its industrial system[45]. Figure V.1 shows a

[45] Small business, defined as establishments with less than 300 employees, formed over 99% or total establishments in 1991 according to the Establishment Census; family oriented business and sub-contracting is more widespread in Japan than in other Western economies (Hart and Kawasaki 1999).

skewed distribution for Japan, with the highest number of companies employing between 250 and 500 employees and very few companies employing more than 1500 employees. In both the US and the EU the highest proportion of companies employ between 5000 and 10000 employees. The data on size distributions in Chapter II suggest a much smaller average size. It should be borne in mind that generally small businesses are usually under-represented in company account datasets. This can also be seen in the appendix Table V.A.1, which presents a more detailed description of the size distribution across countries and broad industrial sectors.

Figure V.1

Size distribution of EU, US and Japanese companies
Average number of employees in 1995



V.2.3 Merging company and industry information

One limitation of the company account data set is the lack of information on ICT and skills. Such information is rarely available at the micro level and, when available, is generally not comparable across countries. On the other hand, the analysis based on industry data is sometimes considered too aggregated. One of the aims of this investigation is to extend the standard analysis at the micro level to include industry information using the taxonomies developed in Chapter II. To keep the analysis simple, only two of the four taxonomies were used, namely the ICT and general skills clusterings. This should improve the understanding of the factors affecting productivity performance at the company level.

All companies in the data set are mapped into the various taxonomies, which helps to identify companies with similar characteristics, operating in different industries, which can be an important source of information in evaluating productivity performance (Griliches, 1992). The classification of companies into fairly homogeneous groups is not new (see, for example, the classification into R&D and non-R&D intensive companies in Griliches, 1984 and O'Mahony and Vecchi, 2000). The distribution of companies according to the different taxonomies is presented in table V.3. Beginning with the ICT-3 taxonomy, in the US, EU and Japan roughly half of the companies are within the non-ICT group and approximately 30% belong to the ICT using industries. Within the EU countries, Finland and Sweden have a fairly large proportion of companies in the ICT producing sector (26% and 29% respectively), higher than in the US (22%). A more refined ICT classification is also presented in table V.3 where all companies are mapped into the ICT-7 taxonomy. Here the US companies are homogeneously represented in all 7 groups while in the EU, the highest percentage of companies is concentrated in the non-ICT manufacturing group. In Japan the highest concentration is in the ICT using manufacturing and ICT using services groups.

Table V.3

Distribution of firms according to the ICT-7, ICT-3, and Skill taxonomies (%)

	EU-15	EU-3[46]	US	Japan
ICT-3 Taxonomy				
ICT Producing	17.21	18.89	21.61	9.74
ICT Using	34.15	33.68	33.85	40.07
Non-ICT	48.56	47.43	44.53	50.06
ICT-7 Taxonomy				
ICT Producing Manufacturing	5.10	5.20	11.21	5.41
ICT Producing Services	12.17	13.70	10.39	4.35
ICT Using Manufacturing	14.28	14.13	15.10	17.08
ICT Using Services	19.87	19.55	18.74	23.04
Non-ICT Manufacturing	23.89	21.50	20.92	27.47
Non-ICT Services	17.27	19.31	13.99	14.13
Non-ICT Other	7.41	6.61	9.62	8.52
Skills taxonomy				
Low Skills	26.67	26.59	22.55	24.89
Low Intermediate Skills	28.75	28.16	25.26	45.68
High Intermediate Skills	10.66	10.61	15.96	5.32
High Skills	33.92	34.63	36.23	24.10

[46] EU-3 includes only Germany, France and the UK.

According to the skills taxonomy, the US also has the higher proportion of firms in the high intermediate and high skills groups, 16% and 36% respectively. In the EU these groups represent 11% and 34% of the total, and in Japan only 5% and 24%. In Japan firms are more concentrated in the low skills and low intermediate skills groups.

V.3 Trends in labour productivity growth

V.3.1 General trends

In this section the evolution of labour productivity growth in the US, Japan and the EU is analysed by industry group, using company data for the period 1991-2001. The aim is to see if companies' performance does indeed reflect what happens at the aggregate level. The analysis compares labour productivity movements in the 1992-1995 period with the last six years of the sample (1996-2001). Consistently with the conclusions in Chapter III, company account data point to a productivity slowdown in the EU-15 in the second half of the 90's and to an important recession in the Japanese economy. Conversely the data shows a productivity boost in the US economy, provoked by an important growth in the service sector.

Starting with the US (Figure V.2) labour productivity growth in the total company sample has experienced an increase in the period 1996-2001, compared to the previous 5 years[47]. This is the result of rapid growth in the service sector, that has more than compensated the slowdown occurred in the production sector (manufacturing and other production industries combined). The productivity acceleration in services has been noticeable, growing from 0.71% in the period 1992-1995 to 1.75% in the last 6 years of the sample, while the production industries have suffered a decline from a 0.82% growth to a 0.54% growth towards the end of the period[48].

Amongst the EU-15, labour productivity growth decreased from a weighted average rate of 0.94% in the period 1992-1995 to 0.71% in the period 1996-2001 (Figure V.3). Contrary to the US, both manufacturing and service sectors suffered a reduction in labour productivity performance across the two periods. In the production sector, the rate of growth of productivity decreased from 0.77% to 0.47% and in services from 1.20% to 1%. These trends are consistent with the industry analysis in Chapter II, even though the actual growth rates differ.

[47] Note that the aggregate economy results are based on weighted average growth rates, since the sample was not considered representative of the actual industry structure. The weights were calculated for each country using the average shares of manufacturing, other production industries and services in total GDP over the period 1990-2001.

[48] Note that the weighted averages for the two sub-periods are not based on equal number of observations. The sub-period 1992-1995 comprises one year less than the sub-period 1996-2001 and during the first years far less companies report data.

Figure V.2

The evolution of US annual labour productivity growth (%)

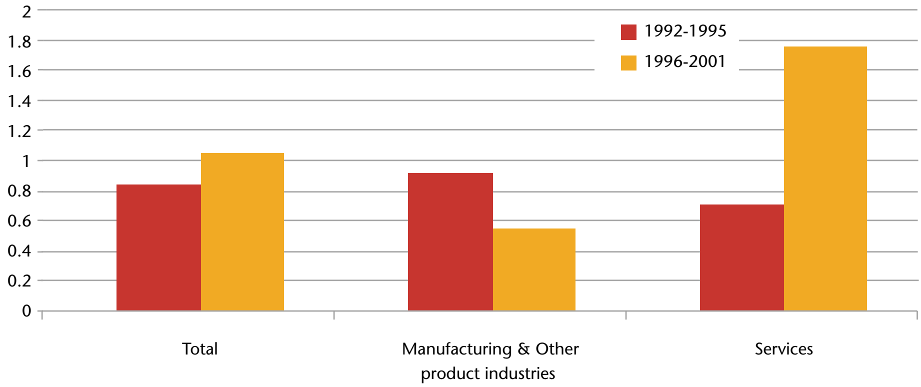


Figure V.3

The evolution of EU-15 annual labour productivity growth (%)

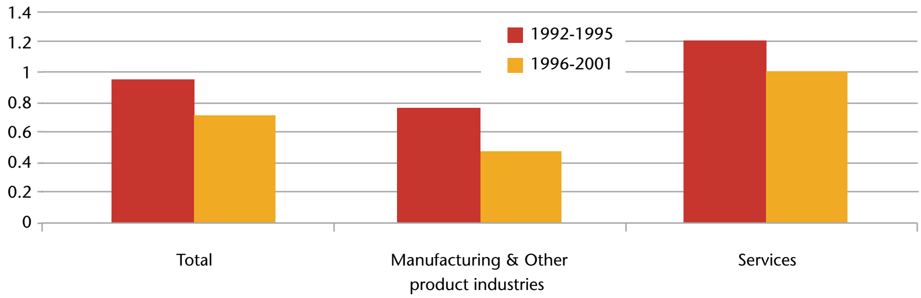
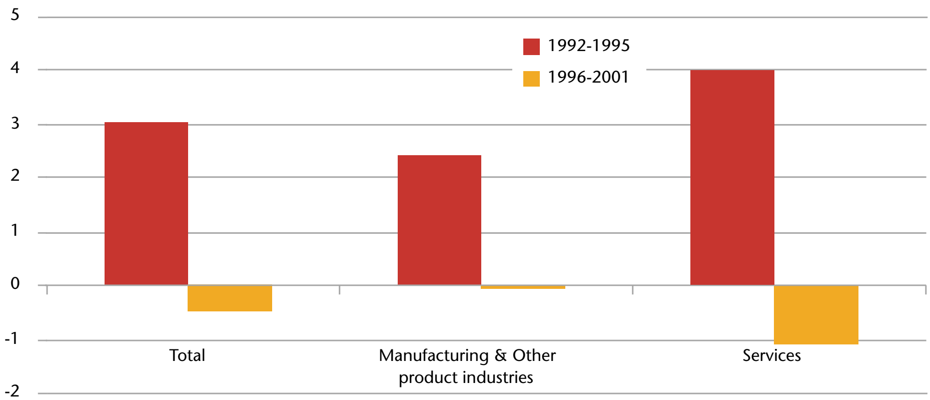


Figure V.4

The evolution of Japanese annual labour productivity growth (%)



Japan is the country with the highest labour productivity slowdown across the two periods, losing ground to both the EU and the US. Average labour productivity growth decreased from a rate of 3.02% in the period 1992-1995 to a negative -0.5% in 1996-2001 (Figure V.4).

The service sector experiences the most severe deceleration with growth rates going from 3.97% to -1.09%. These trends are not surprising given the economic difficulties the Japanese economy had to face since the late 1980s. In fact, labour productivity growth at the aggregate economy level has been decreasing since 1985.

V.3.2 R&D, firm size and productivity performance

This chapter now considers the difference in productivity growth between R&D and non-R&D reporting companies.[49] There is a large literature on the relationship between R&D and productivity and the general conclusion is that R&D investments affect productivity positively, both directly, that is via the firms' own investments, and indirectly via spillover effects[50]. Information on R&D is complemented with information on the size distribution of the companies in the sample. This is in order to have a more in depth analysis of the industry structure in the various countries and to see whether size matters, in terms of productivity performance and R&D investments. Small enterprises are generally more flexible and they might be more able to adapt to changes in technologies and in the general economic environment. On the other hand, larger firms have more resources to devote to R&D investments and therefore the interaction between R&D and size can underline some interesting patterns.

Table V.4 shows the different growth rates of R&D reporting and non-R&D reporting firms. On average R&D reporting firms have been more productive than non-R&D reporting firms throughout the whole time period, with a higher advantage in Japan than in either the US or the EU. In fact for the US these differences for the whole sample are very small. The performance across broad sectors shows similar trends. Table V.5 shows performance by size group. In the US and EU, the labour productivity growth of small firms was greater than that of intermediate firms, and growth of intermediate firms was greater than that of large firms. In Japan, the intermediate firms displayed greater growth rates than the small firms and both performed better than the large ones. Across sectors, better performance in the small and intermediate groups in the EU, the US and Japan occurred mainly in the service sector. In fact, in the manufacturing sector in Japan, the large firms experienced higher growth than the small and intermediate firms.

[49] The analysis from here on does not show figures separately for other production industries, given their small sample size, although they are included in the total economy figures. Also growth rates in this section are weighted as in the previous charts – see footnote 49.

[50] See, for example, Griliches (1998) for a collection of papers on various issues related to the relationship between R&D and productivity. Some new evidence on R&D spillovers can be found in O'Mahony and Vecchi (2002).

Table V.4

Annual labour productivity growth rates: R&D Reporting (%)

	R&D>0			R&D=0		
	92-01	92-95	96-01	92-01	92-95	96-01
US						
Total	1.02	1.25	0.89	0.94	0.53	1.15
Manufacturing	0.85	1.20	0.65	0.40	0.57	0.30
Services	1.89	1.71	1.96	1.33	0.52	1.70
EU-15						
Total	0.87	1.43	0.69	0.75	0.84	0.72
Manufacturing	0.71	1.04	0.60	0.53	0.72	0.45
Services	1.53	3.55	1.08	1.00	1.01	0.99
Japan						
Total	1.15	2.55	0.50	0.22	3.41	-1.43
Manufacturing	1.44	2.84	0.82	-0.18	2.68	-2.20
Services	0.63	3.73	-0.31	0.38	4.01	-0.26

Table V.5

Annual labour productivity growth rates: firm size (%)

	N<250			250<N<1000			N>1000		
	92-01	92-95	96-01	92-01	92-95	96-01	92-01	92-95	96-01
US									
Total	2.04	2.27	1.90	1.36	1.02	1.54	0.73	0.56	0.81
Manufacturing	1.25	1.78	0.93	1.00	1.11	0.93	0.94	0.83	0.39
Services	4.65	3.91	5.13	2.18	1.09	2.59	0.99	0.27	1.31
EU-15									
Total	1.34	1.28	1.36	0.82	1.09	0.75	0.61	0.85	0.50
Manufacturing	0.62	0.63	0.62	0.66	1.02	0.54	0.55	0.75	0.45
Services	1.78	1.64	1.81	1.12	1.39	1.06	0.75	1.06	0.62
Japan									
Total	0.77	3.02	-0.35	1.02	3.42	-0.28	0.05	2.34	-0.89
Manufacturing	0.77	2.68	-0.29	0.95	2.78	-0.22	1.08	2.92	0.51
Services	0.88	4.03	-0.46	1.27	5.03	-0.36	-0.93	2.56	-2.36

In order to see how performance varies with R&D activities and firm size, differences in labour productivity growth rates between R&D reporting and non-R&D reporting firms were obtained for the three size groups (Table V.6). In the US the higher growth of the R&D reporting firms relative to non-R&D reporting firms occurred mainly in the small and intermediate firms. In contrast, in the group of large firms, R&D reporting firms experienced lower labour productivity growth than non-R&D reporting firms. In the service sector, these differences were even more pronounced, in particular there was much lower growth in non R&D reporting firms in larger firms. In the EU, the greatest difference in growth between the R&D reporting and non-reporting firms occurred in the intermediate group of the service sector while in the manufacturing sector this difference was important for the small group. For Japan, the R&D reporting manufacturing firms displayed greater labour productivity growth rates than the non-R&D reporting in all size groups, with higher differences in the intermediate and large groups. In services, only in the largest group did the R&D reporting firms present higher growth rates than the non-R&D reporting.

Table V.6

Difference between annual labour productivity growth rates of R&D Reporting and non-R&D Reporting firms, by size of firm

	N<250			250<N<1000			N>1000		
	92-01	92-95	96-01	92-01	92-95	96-01	92-01	92-95	96-01
US									
Total	0.21	0.30	0.15	0.11	-0.22	0.25	-0.15	0.86	-0.66
Manufacturing	0.89	0.86	0.87	0.48	0.79	0.31	0.32	0.46	0.24
Services	0.26	0.73	-0.22	0.2	-3.23	1.12	-0.51	2.02	-1.56
EU-15									
Total	-0.11	1.04	-0.25	0.40	0.50	0.43	0.13	0.65	-0.07
Manufacturing	0.86	0.35	0.94	-0.19	0.25	-0.2	0.21	0.38	0.15
Services	-0.51	3.87	-0.89	2.04	1.84	2.12	0.27	2.59	-0.58
Japan									
Total	0.02	-0.52	0.45	0.45	-1.55	1.49	2.47	0.11	3.75
Manufacturing	0.93	-0.04	1.75	2.06	-0.09	3.82	1.81	1.27	3.25
Services	-2.1	1.04	-2.14	-1.06	-2.13	-0.46	3.27	1.64	4.42

According to expectations, the results in tables V.4 to V.6 therefore show that R&D reporting companies are on average more productive than non-R&D reporting. Also the interaction of R&D with size offers important conclusions. As a general trend, the small-intermediate sized companies that undertake R&D investments have been the most productive in the US, and mainly the intermediate firms in the service sector in the EU. In Japan, however, in the service sector only the large R&D reporting firms performed better than the non-R&D reporting ones.

V.4 Econometric analysis

V.4.1 Modelling the impact of R&D on productivity growth

The main analytical tool used to investigate the relationship between R&D and productivity is to specify a log linear (Cobb-Douglas) production function[51] where R&D investments or R&D capital appear in addition to the standard inputs, labour and capital. Letting lower case letters denote the log of a variable, i.e. x = log(X), this can be written as:

$$y_{it} = a_i + \alpha k_{it} + \beta l_{it} + \gamma r_{it} + \xi_{it} \qquad \text{(V.1)}$$

Equation (V.1) is estimated by taking (log) first differences, that is:

$$\Delta y_{it} = a_i + \alpha \Delta k_{it} + \beta \Delta l_{it} + \gamma \Delta r_{it} + \Delta \xi_{it} \qquad \text{(V.2)}$$

The heterogeneity of the data suggests that this specification is the most appropriate since it is equivalent to including firm specific fixed effects to a specification in levels (Baltagi, 1995). Additionally, the first difference specification addresses another issue that usually affects results based on levels specifications including R&D capital, which is the problem of double counting (Schankerman 1981)[52] This equation is estimated using Ordinary Least Squares (OLS). For a discussion of an alternative estimation methodology and some additional results, see Appendix B.

One of the main targets of the empirical analysis is to check whether factor elasticities have varied over time and, in particular, to see whether they have changed in the second half of the 90s. Thus a post-1995 dummy (D95) is introduced and interacted with the three factors of production:

$$\begin{aligned}\Delta y_{it} = a_i + \alpha \Delta k_{it} + \beta \Delta l_{it} + \gamma \Delta r_{it} + \lambda^* D95 + \\ \phi^*(D95^* \Delta k_{it}) + \mu^*(D95^* \Delta l_{it}) + \kappa^*(D95^* \Delta r_{it}) + \Delta \xi_{it}\end{aligned} \qquad \text{(V.3)}$$

[51] The use of other function forms, such as the CES or the translog function, has sometimes been suggested. However, these alternative formulations do not seem to provide substantial improvements to the estimates (Griliches and Mairesse, 1984).

[52] The problem of double counting is common in the literature on R&D and productivity and it is related to the lack of data on employment and capital used in research departments. This problem causes a downward bias of the estimates of the elasticity of output to R&D capital. First difference data can account for this problem under the weaker assumption that the shares of R&D inputs in total labour and physical capital do not change from one year to the next. Moreover, existing evidence shows that, when comparing estimates in levels and in first difference, the latter display a higher R&D coefficient. (Mairesse and Hall 1996, O'Mahony and Vecchi, 2000).

As previously discussed, labour productivity changes according to the size of the company and to the sector where the company operates. In order to account for these different productivity patterns equations are estimated including size dummy variables. In addition an extended version of equation (V.2) is estimated by additionally introducing the dummies derived from the ICT and skill taxonomies (equation V.3). A positive coefficient on these dummy variables implies that companies are enjoying some productivity gain by operating in a particularly ICT/skill intensive environment. These extra gains can be interpreted as evidence of spillover effects.

V.4.2 Basic production function results[53]

This section begins by presenting the results for the estimation of a standard production function where the only factors of production are employment and fixed capital. These results are compared with the coefficient estimates from a second production function specification that includes R&D, as in equation (V.2). Tables V.7 and V.8 show the coefficient estimates for the EU sample and for the US and Japan respectively.

For the EU two sets of results are presented, a first set for the EU-15 countries and a second one for the EU-3, which only includes the UK, France and Germany. Ideally results for each individual country would be obtained but the small number of observations prevent this. Combining the UK, France and Germany yields a reasonable sized sample and comparing these three countries with the total for the EU-15 can show some interesting features, set out below.

Starting with the results for the EU countries, it can be seen that the employment elasticities are higher in the R&D reporting companies in manufacturing and services for both the EU-15 and the EU-3. On the other hand, the capital elasticities are higher in R&D-reporting companies only in services in both the EU-15 and EU-3. The EU-3 is characterised by a high return to R&D, in manufacturing, of nearly 20%. This is according to prior expectations and to existing evidence of R&D concentration in manufacturing (Chauvin and Hirschey, 1993). In the EU-15 the same coefficient is not statistically significant at the conventional 95% confidence level. In the service sector R&D capital does

53 Lack of R&D data for companies in the sample could mean that the firm did in fact carry out R&D but did not report this. Unlike in the UK and the US, R&D disclosure is not compulsory in many continental European countries. Accounting regulation of European Union (4th directive) does not require disclosure of R&D expenditures. The only obligation is a general description of research and development activities must be included in the annual report. (Fourth Directive, art.46 1978). This description does not imply a requirement to indicate annual amount of R&D costs (KPMG, 1995). In addition, although all OECD countries generally collect and report R&D in line with the Frascati Manual, some detailed national specifications may vary from OECD standards. They mainly deal with breaks in series, and whether or not the data cover all fields of science. R&D statistics capture imperfectly development of technology in small firms, where technology producing activities do not have a separate functional and accounting identity. Nearly all manufacturing firms with more than 1000 employees have R&D laboratories. Most with fewer than 1000 do not (Pavitt et al., 1989). These problems with data on firm-level reporting can potentially create sample selection bias (Belcher, 1996). However there is no easy way to deal with this problem in the current sample. Hence the term R&D reporting is used throughout.

Table V.7

OLS coefficient estimates of the production function for the EU

(standard errors in parentheses)

	EU-15	EU-15 + R&D	EU-3	EU-3 + R&D
Manufacturing	8680 obs 1394 companies	2362 obs 489 companies	5481 obs 845 companies	1574 obs 326 companies
Constant	0.054* (0.027)	-0.016 (0.012)	-0.010 (0.012)	0.066* (0.015)
N	0.536* (0.025)	0.629* (0.039)	0.569* (0.034)	0.665* (0.046)
K	0.158* (0.016)	0.132* (0.030)	0.152* (0.021)	0.112* (0.038)
R&D		0.045 (0.032)		0.199* (0.067)
Services	8643 obs 1659 companies	835 obs 240 companies	5803 obs 1112 companies	667 obs 183 companies
Constant	0.062† (0.037)	-0.009 (0.044)	0.007 (0.010)	0.107* (0.033)
N	0.511* (0.023)	0.599* (0.069)	0.524* (0.026)	0.569* (0.074)
K	0.136* (0.015)	0.138* (0.040)	0.134* (0.018)	0.151* (0.045)
R&D		0.077 (0.052)		0.089 (0.058)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

Notes: The regressions include a constant, year dummies and country dummies for each EU member state. Equations were estimated in first differences. Given the unbalanced nature of the panel, the number of observations is the result of multiplying the number of companies by the number of years each company appears in the sample. Coefficients for the EU (and Japan) change minimally when the deflators for the sectors 'industrial machinery and equipment' and 'electronic and other electrical equipment' are linked to those in the US.

not have a significant impact on productivity in both the EU-3 and the EU-15 countries, as shown in the last section of the table.

In the US (first two columns in table V.8) a similar pattern is revealed of higher employment elasticity and lower capital elasticity in the R&D reporting companies, compared to the total sample. The returns to R&D capital are high and positive in all sectors, including services, where the coefficient is even slightly higher than in manufacturing, although the difference between the two is not statistically significant. In manufacturing as well as in services a 1% increase in R&D invested by the companies produces roughly a 0.16% increase in output growth. This result is consistent with existing estimates for the US (Schankerman, 1981; Griliches and Mairesse, 1984; O'Mahony and Vecchi, 2002). Also note that in manufacturing the returns to R&D capital are higher in the US than in the EU.

Table V.8

OLS coefficient estimates of the production function for the US and Japan

(standard errors in parentheses)

	US	US + R&D	Japan	Japan + R&D
Manufacturing	9679 9bs 1149 companies	6680 obs 843 companies	4330 obs 1561 companies	2790 obs 1443 companies
Constant	0.035* (0.005)	0.064* (0.007)	-0.098* (0.009)	0.116* (0.015)
N	0.477* (0.020)	0.516* (0.027)	0.410* (0.034)	0.453* (0.046)
K	0.201* (0.016)	0.159* (0.020)	0.086* (0.017)	0.120* (0.024)
R&D		0.155* (0.029)		0.029 (0.021)
Services	8665 obs 1165 companies	1383 obs 236 companies	3908 obs 1200 companies	595 obs 293 companies
Constant	0.021* (0.006)	-0.009 (0.020)	0.073* (0.007)	-0.087* (0.017)
N	0.422 (0.019)	0.548* (0.046)	0.374* (0.035)	0.385* (0.150)
K	0.253* (0.016)	0.201* (0.033)	0.132* (0.020)	0.185* (0.063)
R&D		0.168* (0.049)		-0.007 (0.047)

(*) = Coefficient significant at 95% level

Notes: see Table V.7

The results for Japan differ from those for the EU and the US, primarily the non significant impact of R&D on productivity. This seems at odds with Japan's well-known reputation as a high R&D investor, especially in the high tech sectors of the economy. However, similar results have already been found in existing studies (Sassenou 1988, Mairesse and Sassenou 1991). Among the reasons provided for a possible bias in the R&D coefficient estimate is the omission of variables reflecting short-term adjustments to business cycle fluctuations by firms, such as hours of work and capacity utilisation. This misspecification is likely to affect the Japanese results more than the other countries because changes in factor utilisation rates, rather than changes in the factors employed, are particularly common in the Japanese industrial structure (Odagiri, 1994; Hart and Malley, 1996; Vecchi, 2000). There is also evidence that financial statements vastly under-report R&D expenditure in Japan (Goto and Suzuki 1989). As for the other factors of production, and contrary to the EU and US results, the fixed capital coefficient is always higher in the R&D reporting companies than in the total sample.

V.4.3 Results for the sample split at 1995 and firm size

Table V.9 contains the results of the estimation of equation (V.3), which includes dummies for the structural break in 1995 as well as the size dummies. The base case is the large companies in the first half of the decade (1992-1995). Regarding the coefficients of the production function, the main difference compared to table V.7 is the higher coefficient on the R&D elasticity for EU-3 countries in the manufacturing sector, since the R&D elasticity in the service sector remains insignificant after the inclusion of the structural break dummies.

However for completeness the interactions between the factors and the 1995 dummy need to be taken into account to see their evolution between the two sub-periods. These interactions show a post-1995 decrease in productivity in the manufacturing sector (the 1995 shift dummy is negative and significant) while there are no negative impacts on the EU-3 countries. As for the service sector, there is some improvement in productivity after 1995 and a significantly higher R&D coefficient in the EU-15. This differs from the previous table where no significant R&D coefficient was found in the service sector. It also shows that some more investment in R&D is taking place in services in the more recent years, probably fostered by the more intensive use of ICT. This result is consistent with the notion that the EU is in the process of catching up with the US in the ICT revolution and that the downturn post-1995 might be reversed in the next few years. Also, this result emerges only for the total EU-15 so it is likely to be driven by countries like Sweden and Finland that have highly invested in R&D and in ICT.

In manufacturing, the size dummies do not show any particular pattern, quite unexpectedly, and the employment coefficient is significantly higher in the second half of the decade in the EU-3. In the service sector, the size dummies do pick up a higher productivity growth in the small and intermediate companies, compared to the large ones, when considering the basic production function with no R&D capital. The coefficients of the small and intermediate dummies in services are positive and significant at 95% level of confidence, which means that these groups of firms experienced higher labour productivity growth than the group of large firms for which the dummy variable has been omitted. When R&D is included in the specification, intermediate sized firms enjoy higher productivity compared to the other two size groups in both EU-15 and EU-3.

Table V.10 presents the results for the US and Japan. In the US there is a decrease in productivity in manufacturing after 1995, but not in the service sector. Here the 1995 dummy is either positive or insignificant. The results also show a significantly higher R&D coefficient in the service sector after 1995. This is consistent with the labour productivity patterns discussed in Section V.3 and shown in Figure V.2. The size dummies suggest that the small companies (less than 250 employees) and intermediate companies (between 250 and 1000 employees) are more productive in manufacturing while only the small ones enjoy productivity gains in the service sector.

Japan experiences negative productivity growth after 1995 in companies operating in both manufacturing and services. Contrary to the results in table V.8, the fixed capital elasticities become very low and insignificant in this specification suggesting either the presence of inefficiencies in large companies or over-investment in capital stock in the first half of the sample. This second explanation seems to be confirmed by the evidence of a significantly higher capital coefficient in the second half of the decade, at least in the service sector. The size dummies show that the large companies enjoy higher productivity compared to the small and intermediate ones, contrary to the evidence for the EU and the US. However, as discussed above the group of large companies in Japan is composed of much smaller firms compared to the other two countries.

A more comprehensive treatment on the impact of firm size on productivity can be seen in table V.11 where the factor inputs are interacted with firm size.[54] The interaction between R&D, capital and employment with size indicates how the returns of production vary for the different size groups. The results are very different for manufacturing and services firms. Examining the results for manufacturing, the returns to R&D in the large establishments are particularly high in the EU-3 and in the US. Since the omitted group is the group of large companies, the negative and significant coefficients observed for the interaction terms R&D*Intermediate and R&D*Small indicate higher R&D returns for firms with more than 1000 employees. After including these interactions, Japan, where previous estimates did not show significant returns to R&D, is now characterised by a positive and significant R&D coefficient. On the other hand there are significantly negative returns to R&D in the intermediate companies in the EU-3 countries. Moreover, in Japan the fixed capital coefficients in this specification are high and significant, as opposed to the results in table V.10. This suggests that the previous negative results were a consequence of the inefficient capital investment through time rather than being related to firm size.

Some differences also emerge between the EU and the US in relation to companies in the service sector. In the EU-15 and in the EU-3 countries the interaction coefficients are not significant, but productivity growth remains higher in intermediate size firms when these are included. In contrast in the US, the group of intermediate companies experiences very high returns to R&D, suggesting that innovative activity among these firms is an important driver of US productivity growth.

[54] Including both 1995 interactions and size interactions reduces the sample size and reliability of the results.

Table V.9

OLS coefficient estimates of the production function, with structural break and size dummies for the EU

(standard errors in parentheses)

	EU 15	EU-15 + R&D	EU-3	EU-3 + R&D
Manufacturing	8672 obs 1394 companies	2361 obs 489 companies	5481 obs 845 companies	1574 obs 326 companies
Constant	0.065* (0.027)	-0.006 (0.007)	0.044* (0.004)	0.031* (0.010)
N	0.461* (0.053)	0.537* (0.089)	0.401* (0.070)	0.471* (0.104)
K	0.178* (0.029)	0.064 (0.054)	0.170* (0.037)	0.059 (0.078)
R&D		0.025 (0.024)		0.287* (0.134)
95dummy	-0.008* (0.003)	-0.017* (0.007)	-0.003 (0.004)	-0.009 (0.010)
95dummy x N	0.103† (0.060)	0.114 (0.100)	0.215* (0.079)	0.240* (0.117)
95dummy x K	-0.037 (0.033)	0.062 (0.065)	-0.034 (0.043)	0.049 (0.088)
95dummy x R&D		0.033 (0.053)		-0.098 (0.151)
Small	0.008 (0.008)	0.035* (0.018)	0.010 (0.010)	0.011 (0.020)
Intermediate	0.003 (0.004)	-0.009 (0.009)	0.001 (0.005)	-0.008 (0.012)

Table V.9 continued…

OLS coefficient estimates of the production function, with structural break and size dummies for the EU

(standard errors in parentheses)

	EU 15	EU-15 + R&D	EU-3	EU-3 + R&D
Services	8633 obs 1659 companies	834 obs 240 companies	5803 obs 1112 companies	667 obs 183 companies
Constant	0.076* (0.034)	0.058 (0.037)	0.054* (0.007)	0.089* (0.022)
N	0.565* (0.048)	0.933* (0.078)	0.568* (0.058)	0.924* (0.089)
K	0.120* (0.021)	0.139* (0.057)	0.123* (0.026)	0.092 (0.063)
R&D		-0.110 (0.076)		-0.025 (0.147)
95dummy	0.019* (0.005)	-0.029† (0.015)	0.019* (0.006)	-0.025 (0.147)
95dummy x N	-0.058 (0.054)	-0.361 (0.101)	-0.047 (0.063)	-0.388* (0.116)
95dummy x K	0.023 (0.028)	-0.003 (0.070)	0.015 (0.033)	0.070 (0.080)
95dummy x R&D		0.190* (0.091)		0.106 (0.158)
Small	0.016* (0.007)	0.016 (0.023)	0.017† (0.009)	0.014 (0.027)
Intermediate	0.020* (0.005)	0.057* (0.018)	0.025* (0.006)	0.046* (0.019)

(*) = Coefficient significant at 95% level

(†) = Coefficient significant at 90% level.

The year dummies were eliminated from this specification

Table V.10

OLS coefficient of the production function with structural break and size dummies for United States and Japan

(standard errors in parentheses)

	US	US + R&D	Japan	Japan + R&D
Manufacturing	9679 obs 1149 companies	6680 obs 843 companies	4330 obs 1561 companies	2790 obs 1443 companies
Constant	0.053* (0.003)	0.049* (0.006)	0.094* (0.005)	0.086* (0.006)
N	0.498* (0.029)	0.530* (0.036)	0.532* (0.072)	0.551* (0.153)
K	0.189* (0.021)	0.161* (0.027)	0.010 (0.020)	0.028 (0.031)
R&D		0.169* (0.071)		0.047 (0.036)
95dummy	-0.020* (0.004)	-0.025* (0.007)	-0.074* (0.004)	-0.056* (0.007)
95dummy x N	-0.007 (0.038)	0.007 (0.049)	-0.030 (0.080)	-0.051 (0.162)
95dummy x K	0.011 (0.030)	-0.007 (0.037)	0.005 (0.028)	0.001 (0.040)
95dummy x R&D		-0.037 (0.077)		0.070 (0.052)
Small	0.029* (0.009)	0.030* (0.010)	-0.036* (0.006)	-0.036* (0.008)
Intermediate	0.022* (0.005)	0.024* (0.006)	-0.022* (0.005)	-0.015* (0.006)

Table V.10 continued…

OLS coefficient of the production function with structural break and size dummies for United States and Japan

(standard errors in parentheses)

	US	US + R&D	Japan	Japan + R&D
Services	8665 obs 1165 companies	1383 obs 236 companies	3908 obs 1200 companies	595 obs 293 companies
Constant	0.035* (0.004)	0.026* (0.012)	0.060* (0.006)	0.113* (0.015)
N	0.379* (0.030)	0.536* (0.099)	0.541* (0.051)	0.651* (0.183)
K	0.252* (0.026)	0.199* (0.080)	0.023 (0.019)	0.021 (0.038)
R&D		0.027 (0.079)		0.009 (0.066)
95dummy	0.015* (0.004)	-0.024 (0.015)	-0.080* (0.004)	-0.063* (0.017)
95dummy x N	0.075* (0.038)	0.046 (0.109)	-0.083 (0.062)	-0.207 (0.239)
95dummy x K	-0.004 (0.030)	-0.009 (0.086)	0.069* (0.027)	0.073 (0.077)
95dummy x R&D		0.181* (0.090)		0.058 (0.087)
Small	0.030* (0.0.14)	0.050* (0.019)	0.022* (0.008)	-0.071* (0.025)
Intermediate	0.011 (0.006)†	0.016 (0.011)	0.037* (0.006)	-0.050* (0.016)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

Table V.11

OLS coefficient estimates of the production and impact of size on R&D reporting companies

(standard errors in parentheses)

	EU-15	EU-3	US	Japan
Manufacturing	2362 obs 489 companies	1574 obs 326 companies	6680 obs 843 companies	2790 obs 1443 companies
Constant	-0.012 (0.012)	0.053* (0.015)	0.049* (0.008)	0.123* (0.016)
N	0.635* (0.045)	0.645* (0.051)	0.456* (0.027)	0.371* (0.064)
K	0.111* (0.032)	0.096* (0.038)	0.193* (0.023)	0.194* (0.030)
R&D	0.050 (0.041)	0.374* (0.089)	0.222* (0.042)	0.083* (0.039)
Small	0.023 (0.025)	0.029 (0.027)	0.059* (0.012)	-0.012 (0.009)
intermediate	-0.007 (0.010)	0.014 (0.014)	0.029* (0.008)	0.000 (0.006)
Small*n	0.006 (0.122)	-0.004 (0.136)	0.012 (0.077)	0.070 (0.124)
Small*k	0.012 (0.070)	0.003 (0.080)	-0.051 (0.055)	-0.130* (0.044)
Small*R&D	0.089 (0.167)	-0.201 (0.129)	-0.212* (0.081)	-0.064 (0.052)
Intermediate*n	-0.015 (0.097)	0.037 (0.129)	0.202* (0.055)	0.114 (0.098)
Intermediate*k	0.050 (0.063)	0.063 (0.084)	-0.070* (0.036)	-0.059* (0.030)
Intermediate*R&D	-0.053 (0.059)	-0.352* (0.132)	-0.120† (0.064)	-0.076 (0.048)

Table V.11 continued...

OLS coefficient estimates of the production and impact of size on R&D reporting companies

(standard errors in parentheses)

	EU-15	EU-3	US	Japan
Services	835 obs 240 companies	667 obs 183 companies	1383 obs 236 companies	595 obs 293 companies
Constant	-0.036 (0.048)	0.090* (0.031)	-0.012 (0.020)	0.143* (0.024)
N	0.585* (0.072)	0.579* (0.079)	0.613* (0.054)	0.447* (0.178)
K	0.135* (0.039)	0.119* (0.044)	0.166* (0.033)	0.229* (0.082)
R&D	0.130* (0.063)	0.156* (0.076)	0.041 (0.030)	0.003 (0.054)
Small	0.034 (0.030)	0.033 (0.032)	0.033 (0.024)	-0.045† (0.025)
Intermediate	0.055* (0.027)	0.049† (0.028)	-0.011 (0.017)	-0.024† (0.015)
Small*n	-0.036 (0.167)	-0.035 (0.193)	-0.105 (0.106)	-0.143 (0.316)
Small*k	-0.001 (0.093)	-0.009 (0.116)	0.096 (0.083)	0.028 (0.125)
Small*R&D	-0.111 (0.105)	-0.110 (0.119)	0.106 (0.123)	0.037 (0.078)
Intermediate*n	0.083 (0.145)	-0.023 (0.147)	-0.061 (0.087)	0.003 (0.237)
Intermediate*k	-0.009 (0.082)	0.088 (0.083)	-0.017 (0.049)	-0.106 (0.073)
Intermediate*R&D	-0.113 (0.150)	-0.129 (0.158)	0.288* (0.091)	-0.049 (0.105)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

V.4.4 Introducing the taxonomy dummies

The next two tables (V.12 and V.13) present the results of the estimation of equations including industry taxonomy dummies. Each section of the table refers to the introduction of a different set of industry taxonomy dummies. In order to make the presentation easier only the coefficient estimates for the dummy variables and the coefficients on factor inputs are presented, as the1995 interactions and the size dummies are not significantly different from those presented above. Table V.12 refers to the production function specification without R&D while Table V.13 refers to the specification with R&D.

In both tables it emerges that companies operating in the ICT producing industries enjoy quite substantial productivity gains of around 4%. Considering the total sample of companies, in the US and Japan the returns are higher in the ICT producing manufacturing than in the ICT producing services, while for EU-15 and EU-3 the returns are higher in ICT producing services than in ICT producing manufacturing. No significant gains, or even a negative impact, is experienced by those companies operating in the ICT using services, particularly in the results presented in table V.12. When R&D is included (Table V.13) the impact of operating in the ICT using services is always positive although not significant.

As for the skill taxonomy, manufacturing companies operating in the high skill industries enjoy between 2% and 4% productivity gains compared to firms in low skill industries. In the US service sector particularly high productivity gains are enjoyed by companies operating in all three skill groups, while in Japan it is the low intermediate group to have an extra productivity advantage compared to the others. The impact of belonging to the high skills sectors in Japan in even significantly negative.

Finally, to address the issue of whether these results be interpreted as spillover effects, it may be argued that only the results from table V.13 can pick up the impact of spillover effects. In table V.12 the estimates of the dummy variables can reflect the impact of the missing R&D capital. This does not happen when R&D is taken into account in the production function. Given that effect of the dummy variables is positive and significant in several entries in table V.13, it may be argued that there are important spillover effects that particularly affect companies operating in the ICT producing industries, particularly in manufacturing. Spillover effects tend to be less significant in the service sector, although the coefficients are significant in ICT producing services in the EU, ICT using services in the US (but only at 90% significance) and the low intermediate skills group in the US. These results are consistent with the findings in Chapter III, i.e. better than average performance in the EU in ICT producing services and in the US in ICT using services and industries intensive in lower intermediate skills.

Table V.12

Coefficient estimates of taxonomy dummies, total company sample

(standard errors in parentheses)

	EU 15	EU-3	US	Japan
ICT-3				
ICT Producing	0.043* (0.006)	0.040* (0.007)	0.043* (0.004)	0.040* (0.009)
ICT Using	-0.004 (0.003)	-0.001 (0.003)	0.000 (0.003)	-0.004 (0.003)
ICT-5				
ICT Producing Manufacturing	0.030* (0.007)	0.033* (0.009)	0.054* (0.005)	0.064* (0.010)
ICT Producing Services	0.052* (0.007)	0.043* (0.009)	0.028* (0.006)	0.008 (0.016)
ICT Using Manufacturing	-0.000 (0.003)	-0.001 (0.004)	-0.005 (0.003)	0.005 (0.004)
ICT Using Services	-0.007* (0.003)	-0.000 (0.004)	-0.006† (0.003)	-0.009* (0.004)
SKILLS				
Total sample				
Low Intermediate Skills	0.006† (0.003)	0.005 (0.004)	0.006* (0.003)	0.013* (0.003)
High Intermediate Skills	0.021* (0.005)	0.021* (0.006)	0.025* (0.004)	0.017* (0.008)
High Skills	0.018* (0.004)	0.022* (0.005)	0.024* (0.004)	-0.013* (0.005)
Manufacturing				
Low Intermediate Skills	0.007* (0.003)	0.009 (0.005)	-0.004 (0.003)	0.009† (0.004)
High Intermediate Skills	0.018* (0.007)	0.020* (0.008)	0.015* (0.005)	0.014 (0.008)
High Skills	0.025* (0.005)	0.032* (0.006)	0.042* (0.005)	0.018* (0.005)
Services				
Low Intermediate Skills	-0.008 (0.007)	-0.009 (0.008)	0.021* (0.005)	0.016* (0.005)
High Intermediate Skills	0.019* (0.008)	0.004 (0.010)	0.037* (0.006)	0.017 (0.014)
High Skills	0.009† (0.007)	0.002 (0.009)	0.011* (0.006)	-0.041* (0.008)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

The base groups or omitted dummies for each taxonomy are non-ICT (ICT-3 and ICT-5 taxonomies), and low skills (skills taxonomy).

Table V.13

Coefficient estimates of the taxonomy dummies for companies reporting R&D

(standard errors in parentheses)

	EU-15	EU-3	US	Japan
ICT-3				
ICT Producing	0.032* (0.008)	0.024* (0.010)	0.039* (0.006)	0.046* (0.011)
ICT Using	0.010* (0.006)	0.013† (0.007)	0.005 (0.004)	0.021* (0.005)
ICT-5				
ICT Producing Manufacturing	0.037* (0.010)	0.039* (0.012)	0.053* (0.006)	0.073 (0.009)
ICT Producing Services	0.026* (0.011)	0.008 (0.013)	0.010 (0.008)	-0.010 (0.024)
ICT Using Manufacturing	0.008 (0.006)	0.011 (0.007)	0.003 (0.004)	0.023 (0.006)
ICT Using Services	0.023 (0.019)	0.025 (0.023)	0.034† (0.020)	0.013 (0.009)
SKILLS				
Total sample				
Low Intermediate Skills	0.009 (0.007)	0.007 (0.009)	0.000 (0.004)	0.007 (0.005)
High Intermediate Skills	0.027* (0.008)	0.022* (0.008)	0.009† (0.005)	0.014† (0.008)
High Skills	0.028* (0.007)	0.021* (0.009)	0.027* (0.005)	0.009 (0.006)
Manufacturing				
Low Intermediate Skills	0.009 (0.007)	0.012 (0.009)	-0.003 (0.004)	0.017* (0.006)
High Intermediate Skills	0.035* (0.010)	0.027* (0.011)	0.011* (0.005)	0.002 (0.008)
High Skills	0.033* (0.008)	0.035* (0.010)	0.037* (0.005)	0.012* (0.006)
Services				
Low Intermediate Skills	0.034 (0.024)	-0.009 (0.008)	0.074* (0.024)	0.035* (0.016)
High Intermediate Skills	0.020 (0.017)	0.004 (0.010)	0.026 (0.022)	0.047* (0.019)
High Skills	0.017 (0.021)	0.002 (0.009)	0.019 (0.017)	-0.005 (0.023)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

V.5 Firm dynamics

Productivity gains within firms, which depend on changes in the efficiency and intensity with which inputs are used in production, make a significant contribution to the process of technological progress. But also the process of reallocation of resources affects aggregate productivity trends, through reallocation in market shares between high and low productivity firms and entering and exiting firms. This phenomenon has motivated recent research into the relationship between productivity growth and firm dynamics, driven by a growing availability of longitudinal firm-level data for different countries. The objective of these micro-data surveys is to confirm many of the facts presented in the literature on firm demographics and post-entry growth, usually based on US firm-level data. Recent examples of international comparisons include articles include those by Bartelsman, Scarpetta and Schivardi (2003), by Scarpetta, Hemmings, Tressel and Woo (2002), and by Ahn (2001). This literature is summarised below. This section also comments on the underlying theory and other empirical results on the relationship between turnover and productivity growth.

The first basic observation from the literature on firm dynamics is that there has been a high flow of firms entering and exiting the markets every year, with an average firm turnover rate[55] in the business sector between 15% and 20% in most countries[56]. Entry and exit of firms is seen to play a very important role in the process of reallocation of resources. There exist many theories about what determine whether firms enter or exit markets, from more strategic factors like profitability and market growth to more structural factors such us the existence of economies of scale, cost advantages, product differentiation or sunk costs. The role of profitability has been especially controversial in the literature, and many empirical studies found low responses by entrants to profitable opportunities, for example, Bresnahan and Reiss (1987). If entries were driven by high profits in some industries and exits driven by relatively low profits, then negative cross-sectional correlation between entry and exit rates should be observed. But the evidence shows that entry and exit rates are generally positive correlated across industries in different countries.[57] This is shown for UK manufacturing firms in Disney, Haskel and Heden (1999), also in Geroski (1991, 1992) for British industries, in Dunne et al (1988) for the US, and in Cable and Schwalbach (1991) for eight different countries.

The fact that entries and exits are part of a process in which a large number of new firms displace a similar number of obsolete ones and the high rates of failure for new entrants in years following entry may help to explain these findings. This Schumpeterian-type process is referred to as *creative destruction* in the literature and is thought to contribute

[55] Defined as entry plus exit of firms.

[56] Firm turnover rates are higher than employment-based turnover rates, due to the fact that entrants usually are smaller than incumbents.

[57] Entry rate is usually defined as number of entering firms during a certain period divided by total number of firms in a given sector, and exit rate as the number of exiting firms during a certain period divided by the number of firms in the sector.

to the observed heterogeneity in firms' performance. The factors behind this process in which new products and new processes lead to the destruction of old products and processes include uncertainty about market conditions and profitability, establishment-level differences in managerial ability, capital vintage effects, location and disturbances and diffusion of knowledge.

A second finding is that new firm survival is positively related with age and size and new firm growth is negatively related with age and size, at least for small and young firms. Bartelsman, Scarpetta, and Schivardi (2003) look at the survival and hazard functions, which exploiting the longitudinal feature of the data, specify the probability that firms survive a given duration and the probability that they exit a market. For the United States, the UK, and Italy the probability of exiting the market increases from the first to the second year. Estimations indicate that between 20% (United States) and 40% (UK) of the entering firms fail within the first two years. In the other countries, this probability declines with age in the first years and then stabilises to constant values. Firms that remain in the market after the first two years have a 60-70% chance of surviving for five more years. However, only about 40-50% of total entering firms in a given year survive beyond the seventh year.

Audretsch (1995) argues that firms enter the markets at a small initial size relative to the minimum efficient scale and so will exit unless they can grow. In the *Passive Learning* models of Jovanovic (1982) and Ericsson and Pakes (1995), the survivors will be those who have good abilities and therefore become large. According to this theory, firms enter a market without ex-ante knowing its profitability, and their success will depend on learning about ability. In the Jovanovic model (1982) the firms have a time-invariant efficiency parameter, implying that a firm's productivity will vary initially but then settles down to a constant value, whilst in the Ericsson and Pakes model (1995), the efficiency is more stochastic and negative shocks can lead to efficiency losses. Ericsson and Pakes (1995) also proposed an *Active Learning* model, in which firms learn about their economic environment, taking strategic decisions to adapt themselves to the changing environment. The firms, for example, will invest in uncertain but expected profitable innovations, will grow if successful and will shrink or will exit if unsuccessful.

As Caves (1998) argues, entering firms experience higher hazard rates[58] (infant mortality) that decrease over time, and successful entrants achieve high averages rates of growth, that also decline with their age. Other studies confirm the decline of hazard rates over time (Churchill, 1955; Baldwin, 1995; Audretsch, 1991). Research also indicates that young firms that fail are often very small, while those firms that survive are larger and experience further increases in the initial years. Therefore, the average size of a given cohort of entrants will increase quickly towards the minimum efficient scale in an industry, taking into account that exits are concentrated among the smallest firms and the survivors experience a considerable post-entry growth. See Geroski (1995), Evans

[58] Usually defined as number of exiting firms in a given *t* divided by total number of survivors in *t-1*

(1987a, 1987b), Hall (1987), and Dunne, Roberts and Samuelson (1988, 1989) for US, Baldwin (1995) for Canada, Mata *et al* (1995) for Portugal and Wagner (1994) for Germany. The observed connections between firm's growth and size and age are consistent with theoretical models of both passive and active learning and reflect selection and learning effects. In fact, learning (measured by chronological age) and the accumulation of basic competitive assets or skills (reflected by firm size) can be important determinants of which entrants survive and which entrants fail (Geroski, 1995).

Much of the literature considers the relative contributions of turnover and within-firm growth to productivity growth.[59] In the OECD countries the evidence indicates that for short-term periods (generally less than five years) the within-firm component makes the largest contribution to aggregate growth, whilst between and net entry components show only small fluctuations. In years of expansion, (such as the second half of the 1980's) the contribution of the within-firm growth is significant while in years of recession (such the early 1990's) the contribution of turnover via entry of highly productive and exit of low productive firms increases considerably.

Research shows that entering plants have lower productivity than average incumbent firms (Bartelsman, Doms, 2000), and higher productivity than exiting establishments. In fact, many studies find that low productivity predicts exit, Baily, Hulten and Campbell (1992), Olley and Pakes (1996) and Dwyer (1995). Large productivity differentials are a necessary element for an important role for reallocation in aggregate productivity growth, as Haltiwanger (2000) points out. However, sometimes productivity statistics do not reflect these efficiency gains. This could be due to the fact that the differences between productivity of the exiting and entering firms are rather small, or that entering firms usually represent a smaller share of activity. Alternatively, since economies can differ in structural and cyclical factors, some inefficiencies in product, capital or labour markets may affect the nature, magnitude and timing of the process of reallocation (Haltiwanger, 2000; Caballero and Hammour, 2000).

An interesting finding is that in the long term, turnover of firms has a larger contribution for multifactor productivity growth than to labour productivity growth while within-firm growth contributes more to overall labour productivity than to multifactor productivity growth. The evidence for OECD countries indicates that in the second half of the 1980s the within-firm component accounted for three-quarters or more of labour productivity growth in all but one country (Italy), with a smaller role in the first half of the 1990s[60]. The between effect or reallocation across existing enterprises is rather small and the net contribution to overall productivity growth of entry and exit of firms is positive in most

[59] Most of the literature trying to establish a link between turnover and industry-productivity growth use accounting decompositions of aggregate productivity growth into within establishments and reallocation effects, which seeks to account for entry, exit, and expansion and contraction in the continuing firms. A well accepted decomposition includes a within firm component that represent firm-level changes, a between-firm that represents changing shares and a cross term that represent the contribution of entering and exiting firms.

[60] OECD Economic Outlook 2001

countries (except Germany over the nineties) representing between 10 per cent and 40 per cent of total productivity growth. Evidence suggests that in the cases in which net entry had a positive impact the exit of low productivity firms had the greatest impact.

The decomposition of multifactor productivity shows some differences compared to the decomposition of labour productivity. The main difference is that the within-firm component makes a much smaller contribution to total productivity growth. In most of the countries this contribution is estimated to be between 40 and 60%, except in UK where the contribution is just below 20%. The reallocation of resources across continuing firms has a much more important role for multifactor productivity, contributing on average between 10% and 20%. However the largest contribution comes from net entry, and mainly from the entry of new and highly innovative firms.

Apart from these OECD studies, other empirical literature has tried to estimate the contribution of firm dynamics to overall productivity growth using different methodologies, for different countries, time periods, frequency of measured changes, productivity concepts, and measurement methodologies. Much of this literature does show important contributions of turnover to overall productivity growth. The earliest studies were largely confined to manufacturing. In one of the most widely cited studies, Baily, Hulten and Campbell (1992) decomposed five-year productivity growth for 23 US manufacturing industries, for the periods 1972-77, 1977-82, 1982-87. They concluded that entry and exit play only a very small role in industry growth over five year periods. However, the increasing market shares in high-productivity plants and the decreasing shares of output in low productivity plants are very important to the growth of manufacturing productivity, accounting for nearly half of the growth in the period. Also a cyclical pattern to entry and exit is observed. In the periods of growth in manufacturing (1972-77 and 1982-87) there is a negative net effect of entry and exit. However, during the recession period 1977-1982 there is a small net positive contribution from entry and exit.

Similarly Haltiwanger (1997) undertakes the decomposition of TFP suggested by Baily, Hulten and Campbell (1992) for the four-digit US manufacturing industry. He uses firm-level data for the periods 1977-1987, 1977-1982, 1982-1987. The main finding is that during the period 1977-1987 half of the increase in productivity for the average industry is accounted for by composition effects involving reallocation of output, although the contribution of the various components varies over time and throughout the cycle.

These results confirm that reallocation of output towards the most productive establishments, plays a very important role in accounting for aggregate measures of productivity growth in the US, as reported in Baily, Hulten and Campbell (1992), Olley and Pakes (1996) and Bartelsman and Dhrymes (1994). In the US manufacturing sector, about 50 per cent of total factor productivity growth over a decade is thought to be caused by the reallocation of outputs and inputs from the less productive to the more productive companies. US studies focusing on intermediate-long term horizon (five to ten years) find significantly higher contribution of net entry to aggregate productivity growth as reviewed in Foster, Haltiwanger, Krizan (1998). On the one hand, by construction the contribution of entering and exiting firms is greater the longer the time period considered, and on the other hand, learning and selection effects of new entrants have an effect on productivity over time.

Olley and Pakes (1996) analysed sources of aggregate productivity growth for a particular industry, the telecommunications industry in US from 1974 to 1987. During this period technological change and deregulation caused major restructuring that provided many new firms the incentive to enter as well as provoked major changes in incumbent firms. The authors find that a more competitive structure lead to a more effective reallocation among firms, while the reallocation within-firms played a minor role. In particular, the results indicate that the changes in telecommunications industry improved performance by inducing a reallocation of capital to more productive plants, process that seems to be facilitated by entry and exit of firms.

For the UK, Disney, Haskel and Heden (2000), using 4-digit level industry data for the period 1980-1992, examine the impact of restructuring on manufacturing growth due to factors such as the introduction of new technology, organisational change or increased competition. After controlling for compositional and cyclical effects, they find a large role for external restructuring in explaining labour productivity growth. The effect of the external restructuring is higher for total factor productivity growth, representing a 80% of the total growth, compared to a low 18% attributed to the within-effect. A possible explanation to the fact that between-firm growth contributes more to multifactor productivity growth than to labour productivity growth is that entering firms usually invest in new technologies or new organisational change, while incumbents increase labour productivity by capital/labour substitution. Also for UK manufacturing firms, Oulton (1998) analyses determinants of labour productivity growth in the sub-periods 1973-1979 and 1979-1989. During the sub-period 1973-1979 there was a small increase in productivity, favoured by the entry and exit process, since productivity fell amongst survivors. Contrary to Disney, Haskel and Heden (2000) he finds that the upsurge in productivity during the sub-period 1979-1989 was due to growth within survivors, since the exiting and entering firms displayed similar levels of productivity and lower than the productivity of the survivors. The largest contribution took place in the 3-year period 1979-1982, in which the survivors accounted for 61% of overall growth and all their contribution was due to internal growth rather than to reallocation effects.

Most of the evidence on the relationship between reallocation and productivity growth comes from manufacturing. However, Foster, Haltiwanger, Krizan (1998, 2002) examine the role of reallocation for aggregate productivity growth for a set of service sector industries subject to rapid technological change. Considering 4-digit industries within the automobile repair shops industry for the period 1987-1992 they find large rates of entry and exit, which dominate productivity growth in the industry. They also study retail trade sector in the US over the 1990s and find that retail trade businesses display continuous large scale reallocation of output and labour across establishments within the same narrowly defined industries. A substantial part of the reallocation is due to within firms reallocation but most of it is accounted for by entry and exit of firms. Net entry in retail trade accounts for almost all industry productivity growth in contrast to the results for US manufacturing where net entry accounts only about one third. Other studies that have investigated firm dynamics and productivity growth in the service sector include Santarelli (1998) for a panel of Italian firms in the tourist industry, Audretsch *et al.* (1997) for a panel of Dutch firms in the retail and hospitality sectors and Hamdani (1998) for a panel of Canadian firms. In general the evidence in these studies suggest that entry and exit of firms are more volatile and contribute more to aggregate productivity growth in the service sector than in manufacturing.

The literature suggests that entry rates, likelihood of survival and growth rates of surviving firms vary systematically across industries characterised by different innovative environments. Evidence shows that the selection process of firms is more specific to particular industry environments than to overall macroeconomic conditions. Innovation can be seen as a different dimension of product differentiation that can be considered as a barrier to entry as well as a barrier to survival. High technology manufacturing and some business services like ICT related industries, display higher entry rates and failure rates than average. This supports vintage models of technological change where the innovative firms replace the outpaced ones and therefore there is a high flow of firms entering and exiting the markets. However, those firms that do survive for the first few years after entry have greater likelihood of surviving in the long term. These findings are consistent with *product life cycle* models. When industries are new, there is a lot of entry of firms, the rate of product innovation is high, firms offer many different versions of the product and market shares change quickly. Subsequently entry slows and exit overtakes entry, rate of innovations and diversity of competing versions decrease and market shares stabilise (Klepper, 1996).

In ICT industries the entry component makes a stronger than average contribution to aggregate productivity growth[61], given that in highly innovative industries the entrants are likely to adopt the latest technologies. Productivity growth will be dependent upon the entry of new units of production that displace the outpaced firms, consistently with vintage models of technological change. In more mature industries a higher contribution comes from either within-firm growth or the exit of obsolete firms.

Finally, although overall differences in turnover between the US and the EU are not highly significant comparing firms demographics some differences across countries can be observed. First, after controlling for sectoral composition, the UK and Finland present the highest turnover rates, and Germany and Italy are the only European countries with smaller turnover rates than the United States[62]. Secondly, in the US the entrants on average are smaller and display lower labour productivity levels than incumbents. But most important, in the US, the surviving firms on average experience higher post-entry

[61] OECD Economic Outlook 2001.

[62] OECD Economic Outlook 2001.

employment growth. If successful, the firms expand much more rapidly to reach a higher average size, which indicate a higher degree of experimentation amongst entering firms. Some factors can explain these observed differences, like greater financing possibilities for entrepreneurs with small or innovative projects and reduced administrative costs to entering the markets in the US.

V.6 Conclusions

The purpose of this chapter has been to consider the determinants of productivity growth at the firm level, first to see if the results are broadly consistent with the industry analysis in previous chapters and secondly to see if focusing on the firm dimension can highlight additional factors not apparent in industry data. In terms of the first of these, the results broadly confirm the industry concentration on the importance of information technology in driving differences in productivity trends in the US compared to the EU, particularly in service sectors. They suggest higher total factor productivity growth in firms located in ICT producing manufacturing industries in the US than in the EU with the reverse being the case for ICT producing services. US firms in ICT using services appear to have a productivity advantage when these firms also engage in R&D activities.

The main advantage of using company level data is that it can consider the direct effects of R&D activity and firm size on TFP. The results show positive returns to R&D within firms reporting these expenditures and higher productivity overall in R&D reporting relative to non-R&D reporting firms. These results are subject to the qualification that not all non-reporting firms may have zero R&D expenditures but may merely not be disclosing these. Nevertheless the differences are quite strong in the sample and so are unlikely to be merely a statistical artefact. The results show that the impact of R&D on output growth is greater in the US than in the EU in service sectors, but that returns to R&D appear to be rising over time in service industries in both the US and the EU. This is consistent with the notion of a lagged response in the EU to new technology adoption discussed elsewhere in this report. Among the three largest EU countries, returns to R&D in manufacturing have been decreasing since 1995.

The results also suggest that, in terms of achieving productivity gains, small to intermediate size firms are generally more successful than larger firms. This fits in with the literature on firm dynamics reviewed in this chapter. This literature suggests that a substantial part of the productivity growth within an industry is generated by factors outside the firm, like the dynamics of entry and exit of firms. The entering firms are usually more productive although their market shares are generally low, and the exiting firms are the most inefficient ones. These firm dynamic impacts are likely to be more important in services than in manufacturing.

These findings suggest that policy not only should focus on stimulating growth and performance within existing firms, but also on eliminating restrictions to the process of experimentation and creative destruction. More restrictive product and labour markets in many European countries may discourage entry and posterior growth of new firms, reduce innovative efforts, technology spillovers, and competitive pressures, which affects negatively productivity growth (Scarpetta, Hemmings, Tressel, Woo, 2002). In the US however, the administrative start-up costs and labour adjustment cost are relatively low, what stimulates the entrepreneurs to start on a small scale and if successful grow to reach the minimum efficient scale. This process of experimentation can be especially important in highly innovative sectors, (like ICT related industries), where the entry of firms, which are likely to adopt the latest technologies, can make a significant contribution to technological progress and growth.

V.A Appendix: Methods and Tables

V.A.1 Data transformation

Data in nominal values were transformed in real values using country specific deflators. Current revenue was transformed into 1995 constant prices using producer price indices. Some controversy exists on the most appropriate price deflator to use for ICT and related goods, included in the sectors 'industrial machinery and equipment' and 'electronic and other electrical equipment'. Since only a few countries produce computers or semiconductors, and much produce peripheral equipment, it is not clear whether it is better to use national deflators or US deflators. A number of robustness checks were undertaken using both sets of deflators and there were no significant differences. Therefore, the results presented in this report are all based on national deflators.

As for the stock of physical capital, this is recorded in the company account data set at historic cost and was converted into capital at replacement costs (Arellano and Bond, 1991). Nominal values were converted into real terms using investment deflators, which were constructed from data on gross capital formation at current and at constant prices. R&D expenditure was converted into a stock measure using a perpetual inventory method, together with the assumption of a pre-sample growth rate of 5% and a depreciation rate of 15% (see Hall, 1990 for details). Nominal R&D capital was converted into real values using retail deflators.

The original data was available in US dollars for all countries. However, since the output, investment and retail deflators obtained from national sources are based in the national currencies, a double transformation in the data was undertaken for Japan and the EU countries. Firstly, the variables in dollars and in real terms were converted into the respective national currencies using annual market exchange rates. Secondly, these variables were transformed into dollars dividing the national currency data by a measure of Purchasing Power Parity (PPP). The PPP for the benchmark year 1995 was used since the individual country deflators were allowed to track changes in relative prices across time. The simplest method of using a single GDP PPP was employed for all industries and the same conversion factor was applied to sales, capital and R&D. This is not strictly correct, since industry specific deflators are used for output and investment and consumer price deflators for capital and R&D. If models employing levels (fixed effects) were used then it is preferable to use specific PPPs, but since a first difference model is applied, a single PPP is sufficient.

4-digit industry deflators based on the US-SIC classification were used for the US companies, for both manufacturing and non-manufacturing sectors. These were extracted from the *Bureau of Labour Statistics* US for the period 1991-2001. For the EU countries and Japan, 2-digit industry deflators were used for manufacturing and mining and quarrying sectors and broader deflators for the service and construction sectors were applied.

For the UK, Spain and France most of the deflators were available from national sources. For the UK companies belonging to manufacturing, mining and quarrying sectors, deflators from *UK Annual Abstract of Statistics* 1999 and 2002, based on the SIC-92 industrial classification were used. For Spanish companies belonging to those sectors, industrial price indexes (IPRI 2003) constructed by the *Spanish Statistical Institute (INE)* were used. These are based on the *NACE-93* industrial classification. For France, a combined national source, *Comptes et indicateurs economiques* INSEE 1997 and 1999, and *Annuaire Statistique de la France* 2002 INSEE were used to obtain deflators for all manufacturing, mining and quarrying, construction and most of the service sectors.

For the rest of the EU-15 countries and Japan, the deflators for manufacturing and mining and quarrying firms were drawn from the OECD Compendium, from *Indicators of activities for Industry and Services, Producer Prices,* based on *ISIC Rev 3*, and also from *Indicators of Activities for Industry and Services Historical Review Rev. 2, (1975-1998)*. Annual averages of the Price Indices were used from 1991 to 2000, and due to its availability, the average for the three first quarters was used for 2001.

Data for service sector deflators and construction sector deflators were rather poor, except for the US. Therefore industry price deflators were constructed using information on gross output at current prices and gross output volume indices, according to classification NACE Rev. 1. These data were obtained from the STAN database for all countries except Spain, Belgium, and Luxembourg. For these countries and for the other countries with missing data in the STAN database source, the *National Accounts of OECD countries, volume II*, 1989-2000 and 1983-1995 were used. These price deflators were constructed using information about gross domestic product at current prices and gross domestic product at 1995 prices for broad sectors (manufacturing, construction, wholesale and retail trade, financial intermediation and other services activities).

V.A.2 Appendix Tables

Table V.A.1

Number of companies by size

	Total			Manufacturing			Other production industries			Services		
Size	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
US	482	912	1850	241	438	858	57	78	165			
EU	970	1331	1850	305	587	877	42	87	157	623	659	816
Japan	671	1492	1463	282	733	788	51	121	135	338	639	541
UK	282	392	501	83	148	185	15	31	46	184	214	270
Germany	205	252	361	58	115	201	4	13	30	143	124	130
France	188	218	276	61	86	128	7	6	15	120	127	133
Sweden	85	93	82	27	40	39	-	4	7	58	49	36
Italy	23	62	127	7	34	67	5	7	10	11	21	50
Netherlands	42	54	101	17	25	46	-	2	7	25	27	48
Denmark	43	54	99	15	28	34	2	2	2	26	24	23
Spain	15	38	86	6	23	37	1	4	14	8	11	35
Finland	25	45	59	9	28	38	-	1	4	16	16	17
Belgium	17	27	50	8	16	29	2	2	3	8	9	18
Austria	10	33	44	7	22	17	3	3	6	-	8	11
Ireland	19	30	30	3	6	15	2	5	1	14	19	14
Greece	9	21	37	4	8	16	-	6	7	5	7	14
Portugal	5	10	29	-	7	11	1	-	5	4	3	13
Luxembourg	2	2	8	-	1	5	1	1	-	1	-	4

S_1= Small firms (less than 250 employees), S_2=Intermediate firms (between 250 and 1000 employees), S_3=Large firms (more than 1000 employees).

Table V.A.2

Weighted average annual labour productivity growth rates for the two sub-periods By broad and detailed sectors, UK, Germany and France

	UK		Germany		France	
	92-95	96-01	92-95	96-01	92-95	96-01
Total	**1.39**	**0.51**	**0.98**	**1.43**	**0.01**	**0.83**
Manufacturing	0.96	0.56	0.79	0.61	0.23	0.63
Other production	0.85	0.10	0.27	0.49	0.11	0.23
Mining and Quarrying	1.23*	1.00*	1.25*	0.54*	0.87*	0.14*
Electricity, Gas & Water	0.92*	-0.23	0.08*	0.37	-0.01*	0.41*
Construction	0.72*	0.00	0.44*	0.68*	-0.04*	0.13*
Services	1.86	0.54	1.72	2.71	-0.30	1.08
Distributive Trades	2.17	-0.50	0.23*	1.64	0.48	0.57
Transport	2.04*	1.28	1.91*	6.41*	-0.60*	4.61*
Communications	7.05*	1.56*	2.82*	-0.35	0.27*	10.87*
Financial Services	0.08	0.39	3.00	5.62	-2.43*	1.11
Real State & Business Serv.	1.95	1.35	1.51*	0.85	0.17*	-0.65
Other Services	1.65*	0.99	3.51*	2.46*	0.27*	1.60*

* Less than 100 observations

V.B Appendix: Generalised Method of Moments (GMM) Estimates

A fundamental problem in estimating equation V.2 is dealing with the issue of endogeneity. Simple Ordinary Least Squares (OLS) estimation of equation (V.2) usually gives reasonable results, in line with prior knowledge on factor shares. However, simultaneity problems and random measurement errors might affect the OLS estimates and produce biased estimates. An instrumental variable estimator should correct the bias and provide consistent estimates. Unfortunately reliable instruments are not easy to find.

A technique that has recently found wide application is the Generalised Method of Moments (GMM) estimator, and in particular its extension by Blundell and Bond (1998, 1999) referred to as *system GMM*. This is a system composed of equations in first difference and equations in levels. Lagged levels are used as instruments for the equations in first difference and lagged first difference for the equations in level. Monte Carlo simulations show that this system estimator offers considerable efficiency gains (Blundell and Bond, 1998, 1999; Griffith, 1999).

This technique, however, presents some limitations in this particular case where a series of dummy variables are introduced in order to account for the different factors that affect productivity, such as firm size and ICT/skill intensity of the environment where a company operates. In a standard estimation in first differences, the dummy variables can be included directly into the estimation and the sign and magnitudes of such dummies can be interpreted as the impact on output growth. However, when these dummies are included in the system GMM, which compounds a specification in first difference and in levels, they pick up level effects, which are comparing across industries and, in the EU sample, across countries. This makes it impossible to interpret the coefficients on the dummy variables.

In some applications a two-step technique has been employed to evaluate the impact of the dummy variables (see, for example, Black and Lynch, 2001, and O'Mahony and Vecchi, 2002). In the first step a standard production function is estimated and the fixed effect or the error terms are retrieved. In the second step, the fixed effects/error terms are regressed on the various dummy variables. However, two step estimation procedures are generally less efficient and, in this particular case, they produce results that are not directly comparable with the OLS analysis.

Table V.B presents the GMM estimates of equation (V.2) for all countries and for the total sample, the manufacturing and the service sector. The table also shows the Sargan test of overidentifying restrictions, testing the null hypothesis of the validity of the instruments, and a first and second order serial correlation test of the first differenced residuals (AR(1) and AR(2) respectively). In order to obtain consistent GMM estimates the assumption of no serial correlation in the residual in levels is essential. This assumption holds if there is evidence of significant and negative first order serial correlation and no evidence of second order serial correlation in the first differenced residual (Arellano and Bond, 1998).

Comparing the results in the first two columns of table V.B with table V.7, it can be seen that the GMM estimates imply smaller employment and larger capital coefficients in the EU countries compared to the OLS results. In both cases, however, the coefficient estimates are still consistent with prior knowledge of factor shares and they generally suggest either constant or slightly decreasing returns to scale. The impact of R&D capital is still positive and significant in all GMM estimates for the EU-3 countries, while they are not generally significant for the EU-15. Note however that the standard errors in table V.B are much higher than the ones for the OLS regressions in table V.7, implying less efficient estimates. In most cases the Sargan test does not reject the null of the validity of the instruments used in the estimation. However, the AR(1) and AR(2) tests do detect problems of serial correlation.

As for the US, the GMM results suggest a very similar pattern to the OLS estimates in table V.8. The employment and fixed capital coefficients are generally higher in the GMM estimates and the R&D capital are slightly different in the two sets of results but they are not significantly different. The Sargan test rejects the hypothesis of the validity of the instruments but this is not too much of a concern, as there is evidence that this test tends to over-reject the null (Blundell and Bond, 1998). More importantly the serial correlation tests for the total sample and for manufacturing are consistent with the assumption of no serial correlation in the residuals in levels.

The results for Japan presented in table V.B differ substantially from those in table V.8. In the total sample and in manufacturing the GMM estimates produce much higher employment and capital elasticities and, in the total sample, a negative and significant R&D coefficient. In manufacturing, they imply a very large R&D elasticity (0.216) which goes against most of the existing evidence based on firm level data (Mairesse and Sassenou, 1991), as discussed above. Moreover, the serial correlation tests suggest that these estimates are not consistent.

Table V.B

Generalised Method of Moments Estimation

(standard errors in parentheses)

Factor inputs	**SYS GMM**			
	EU-15	EU-3	USA	JAPAN
Total				
Constant	3.074* (0.367)	3.177 (0.437)	3.691* (0.274)	4.597* (0.358)
N	0.491* (0.130)	0.494* (0.152)	0.719* (0.065)	0.797* (0.109)
K	0.356* (0.077)	0.328* (0.086)	0.207* (0.065)	0.339* (0.070)
R&D	0.096 (0.085)	0.151† (0.091)	0.151* (0.053)	-0.118† (0.061)
Sargan	97.22* (0.043)	117.8 (0.751)	127.0** (0.000)	196.1** (0.000)
AR(1)	-1.212 (0.225)	-0.603 (0.546)	-3.943** (0.000)	-1.848 (0.065)
AR(2)	-2.49* (0.012)	-2.394* (0.017)	-1.807 (0.071)	0.093 (0.925)
Manufacturing				
Constant	2.846* (0.510)	2.987* (0.642)	3.519* (0.315)	3.624* (0.379)
N	0.441* (0.174)	0.427* (0.181)	0.639* (0.075)	0.468* (0.095)
K	0.252† (0.144)	0.383* (0.160)	0.286* (0.079)	0.300* (0.075)
R&D	0.316* (0.122)	0.159* (0.075)	0.114† (0.059)	0.216* (0.060)
Sargan	124.4 (0.598)	130.6** (0.000)	178.2** (0.002)	83.24 (0.241)
AR(1)	0.138* (0.890)	0.086 (0.931)	-3.489** (0.000)	-0.543 (0.587)
AR(2)	-2.113* (0.035)	-1.917 (0.055)	-0.960 (0.337)	-2.967** (0.003)

Table V.B continued…

Generalised Method of Moments Estimation

(standard errors in parentheses)

Factor inputs	**SYS GMM**			
	EU-15	EU-3	USA	JAPAN
Services				
Constant	4.037*	3.410*	3.845*	4.826*
	(0.305)	(0.324)	(0.248)	(0.402)
N	0.872*	0.644*	0.724*	0.944*
	(0.109)	(0.099)	(0.072)	(0.155)
K	0.157*	0.251*	0.167*	0.267*
	(0.071)	(0.057)	(0.074)	(0.095)
R&D	-0.038	0.123†	0.182*	-0.094
	(0.071)	(0.065)	(0.056)	(0.093)
Sargan	61.30	64.48	121.7**	66.40
	(0.873)	(1.000)	(0.001)	(1.000)
AR(1)	-1.249	-1.754	-1.119	-1.142
	(0.212)	(0.080)	(0.263)	(0.253)
AR(2)	-0.645	-0.618	-1.678	0.863
	(0.519)	(0.536)	(0.093)	(0.388)

(*) = Coefficient significant at 95% level.

(†) = Coefficient significant at 90% level.

Chapter VI:

The Policy Framework: Does the EU Need a Productivity Agenda?

Geoff Mason, Mary O'Mahony and Bart van Ark

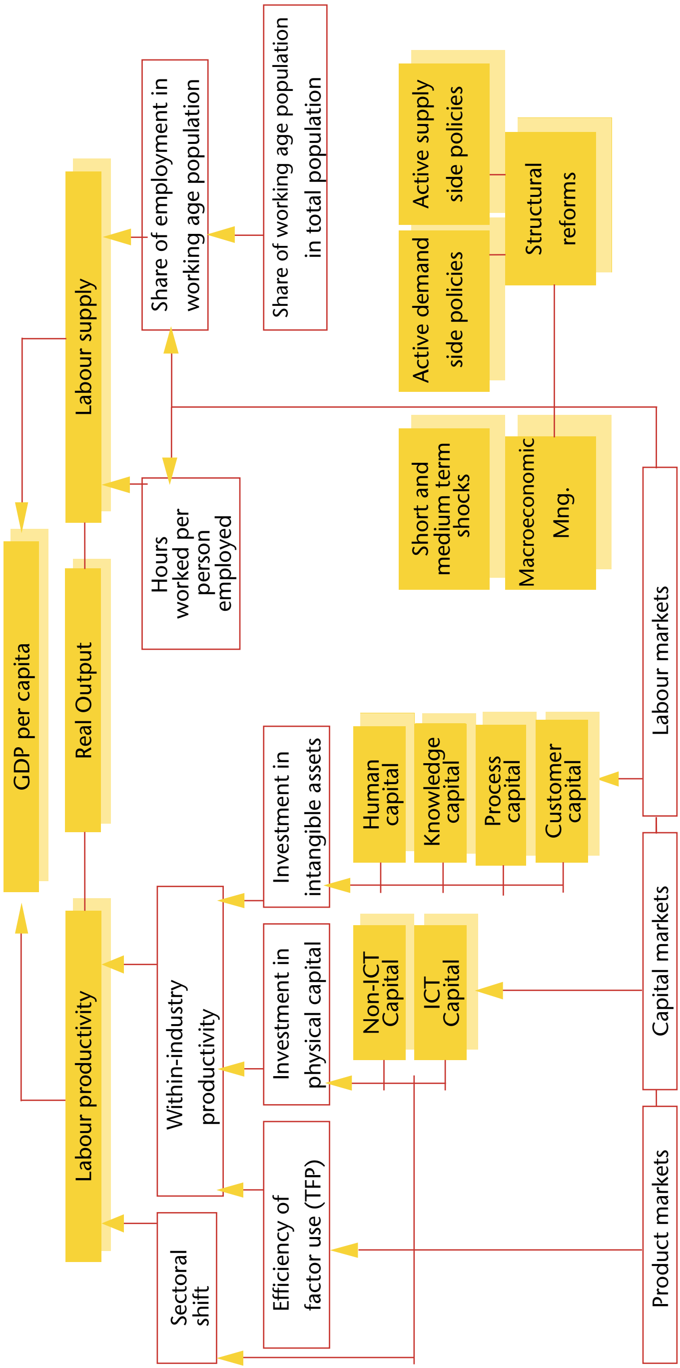
VI.1 Background

The results reviewed in Chapter I confirm that, with some exceptions, average labour productivity growth rates in EU countries have fallen short of those in the US since the mid-1990s. Chapter IV also shows that the recent economic downturn does not significantly alter the viewpoint that the faster growth of US productivity since the mid 1990s is of a structural and not primarily cyclical nature. For the EU there are no signs as yet that productivity will set onto a catch-up path relative to the US. These findings suggest a need for the EU to develop a concerted set of policies designed to improve its relative productivity performance.

The statistical findings also reveal a marked pattern of cross-country differences within the EU in terms of factor endowments, patterns of industrial specialisation and the extent (and apparent causes) of productivity growth differentials relative to the US. These differences often relate to 'proximate' sources of growth, that is, variation in the quantity and quality of production inputs. But in many cases they are also associated with cross-country differences in 'ultimate' sources of growth such as the institutional arrangements that shape the workings of capital, labour and product markets, policies towards education and knowledge creation and their influence on the speed of diffusion of new technology (see Figure VI.1). Thus, while the principal aim of this chapter is to consider productivity-related policy issues which have a general relevance across the EU, attention will also be drawn to some influences which are necessarily more country-specific in nature.

The chapter is ordered as follows: firstly a theoretical framework is presented for assessment of different kinds of public policy intervention which are designed to influence enterprise behaviour. The main findings on the sources of the relatively slow growth in EU productivity in recent years are summarised and the policy implications of these findings are assessed. These may be roughly divided into policy issues that are directly related to investments in ICT and their impacts on relative productivity performance, and policy issues that more generally address the causes of slower productivity growth in the European Union.

Figure VI.1
Analytical framework of sources of growth



VI.2 Theoretical perspectives on productivity-enhancing policies

In a market economy the main ways available to public policy makers to promote and support faster productivity growth are to try and encourage private enterprises to move in a productivity-enhancing direction by

(1) direct modification of the costs and benefits of alternative investment decisions (e.g., through taxes, subsidies or legislation of different kinds), and/or

(2) changes to the institutions that condition private sector decision making, for instance, the extent of competition in different product markets; the levels and types of skill produced by national education and training systems; the levels and institutional forms of support for basic and strategic research; investment in transport infrastructure; legislation governing labour and financial markets, etc.

The most well established theoretical perspective relating to enterprise behaviour, and government policies attempting to influence that behaviour, derives from neo-classical theories of economic growth. As is well known, in neo-classical models enterprises are seen as profit maximising entities which make decisions about production, employment and investment in response to price signals in perfectly competitive markets where all risks relating to unknown future outcomes are essentially quantifiable.

From this theoretical perspective the argument in favour of policy interventions is to seek to correct different kinds of market failures, externalities, spillovers, etc., that inhibit an optimal allocation of resources. It is further argued that policies should be so designed as to minimise distortions to market signals, for example, that as far as possible they should be generally applicable in nature rather than intended to encourage particular kinds of economic activity (as would be the case with sector-specific or technology-specific policies). In practice many neo-classical economists would not go as far as to advocate positive policy interventions to correct perceived failures on the grounds that the policy makers do not have sufficient information to correct these without inducing other distortions. On the other hand, neo-classical economists tend to be strongly in favour of negative interventions, i.e. those that remove government influence in the market place such as deregulation of product or labour markets.

As early neo-classical models treated technical change and innovation as exogenous to the growth process, they took no account of the ways in which knowledge creation and utilisation depend on decisions taken by enterprises. During the 1980s this problem was addressed by the development of endogenous growth theory, in particular those models that focused on the importance of investments in human capital and research and development (Romer, 1990, 1994; Lucas, 1988). Due to the public good characteristics of knowledge creation, enterprises are unable to appropriate all the external benefits of their investments and therefore private rates of investment in research and innovation will be lower than would be socially optimal. In principle, this is another form of market failure that provides a rationale for government policies designed to encourage higher levels of private investment in knowledge production.

Later versions of endogenous growth models concentrated more on the dynamic process linking innovation and growth within a Schumpeterian framework of creative destruction, (e.g. Aghion and Howitt, 1992; Grossman and Helpman, 1991). These models have implications for the design of competition policies. Since innovation involves fixed costs, imperfect competition is required to enable these to be recovered by successful innovators. Thus, the initial formulation of these models allowed greater market power to raise the profitability of research and the growth rate in line with a Schumpeterian view of innovation. Recent extensions of this model yield a more complicated picture in terms of the impact of the degree of competition on innovative behaviour, resulting in a hump-shaped relationship (Aghion and Howitt, 1998, Aghion et al. 2001). In effect there may be a trade-off between the positive effects of competition on innovation and growth (e.g., firms' fear of falling behind rivals if they do not invest in R&D) and the potentially negative effects of strong competition on firms' ability to appropriate adequate returns to their investments in R&D. For example, Baumol (2002) emphasises the strength of oligopolistic competition to support innovation as firms are forced to be just as innovative as their competitors. At the same time, to reduce the cost of innovation such firms aim to share and license their new knowledge among competitors, which supports technology diffusion.

A different focus on productivity-enhancing policies has come from evolutionary theories of economic growth in which enterprises are seen as profit seeking (rather than profit maximising) and operating in conditions of unquantifiable uncertainty rather than quantifiable risk. Technological change is viewed as a key driver of economic growth and is endogenous to the model – that is, it is heavily influenced by decisions taken by profit seeking enterprises (Nelson and Winter, 1982). From this perspective the central aim of policy is not so much (or not just) to remove market imperfections, but rather to provide conditions that support inventions and innovations. There is increasing agreement that this needs to be done, not just by encouraging the production of new economic knowledge, but also by taking steps to facilitate and speed up the distribution of knowledge within national economies (David and Foray, 1995). This approach provides a rationale for public policies and programmes intended to influence the behaviour of enterprises in terms of, for example, external knowledge search and exchange, and R&D collaboration with universities, research institutes and other enterprises (see, for example, Dosi et al., 1988; OECD 1999).

Another feature of the evolutionary perspective on enterprise behaviour is that it emphasises 'a much more complex set of spillovers than is found in neoclassical theory' (Lipsey and Carlaw, 1998, p49). Examples are sector-specific improvements in technologies with wide applications in other industries, and two-way knowledge flows along product supply-chains in the course of new product development. Insights of this kind suggest that policies targeted at particular sectors and/or categories of enterprise may be effective tools in meeting public policy objectives.

However, the design of alternative policies intended to speed up the rate of technological change typically requires a strong element of judgement, regardless of whether the policies are sector-specific or horizontal in nature, and therefore there is considerable scope for government error in formulating and implementing such policies, just as there is in efforts to correct market imperfections. Hence there is widespread agreement about the need for caution in efforts to improve productivity and growth through public policy interventions. Indeed, many evolutionary economists caution against any hint of policy makers returning to previous efforts to 'pick winners', rather the aim should be to 'encourage winners to emerge by strengthening the innovation process in general' (Metcalfe and Georghiou, 1998).

In the light of these different perspectives on enterprise behaviour and public policy interventions, this chapter considers both actions that EU governments can take to improve the operations of markets *and* actions which in principle may help to strengthen innovation processes and speed up technological change. Thus, mindful of the scope for wastage of public resources in efforts to directly influence enterprise behaviour, the main emphasis will be on evaluating changes in public policies which help shape the social-institutional context for private sector decision-making. Examples relate to education and training, infrastructure of different kinds and institutional arrangements concerning basic scientific research and technology diffusion and utilisation.

VI.3 Scope for improving productivity growth rates

VI.3.1 Improvements through better use of ICT

The first results from this project point to a key role for ICT in explaining the superior productivity growth performance of the US since 1995 compared to most EU countries. Firstly, ICT-producing sectors and intensive ICT-using sectors represent substantially larger shares of total value added in the US economy than they do in the EU as a whole (see Table II.8). The only EU countries with larger ICT-production shares of value added than the US are Finland, Ireland and, to a lesser extent, Sweden. Secondly, the US has recently benefited from much higher labour productivity growth in intensive ICT-using industries such as distribution and financial securities than has been seen in the EU (Table III.1).

As a consequence of these developments, and widespread evidence of positive returns to ICT investments at enterprise level, earlier concerns about the so-called 'ICT productivity paradox' in the US have now dissipated. It is now generally recognised that much of the impatience at the apparent lack of productivity pay-off to ICT investments was due to an initial lack of awareness of the lengthy timescales under which earlier technological revolutions had unfolded.

There are two main issues to consider. The first relates to the *scale* of ICT investment. Triplett (1999) points out that, even though investments in ICT grew very rapidly in the US throughout the 1980s and 1990s, computer equipment still accounted for only about 2% of the physical capital stock in 1994 when concerns about the productivity paradox were still strong. Real ICT investment and capital service flows in the European Union have grown almost as rapidly as in the United States, but the level of ICT investment either as a share of total equipment or as a percentage of total GDP has remained well below that of the US and it has not shown any catch-up during recent years (van Ark et al., 2002b; Timmer et al., 2003). This raises the possibility that it is only when the scale of ICT investments reaches a certain threshold level that an economy is likely to start to benefit from network effects.

The second issue concerns the *timing* of any pay-off to ICT investments. At the outset of the ICT diffusion period, there was very little understanding of the fact that any new skill-intensive general-purpose technology is likely to require a substantial period of time before its full potential can be realised (David, 1990; Caselli, 1999). Thus, returns to new investments in ICT hardware are likely to be delayed until complementary investments in new software and ICT skills training have been made along with appropriate changes in work organisation and incentive structures designed to maximise the benefits to be gained from ICT (Bresnahan, Brynjolfsson and Hitt, 2002).

On this basis, it can be argued that the now-visible pay-offs to widespread ICT investments in the US economy reflect the head-start that many US enterprises had relative to many of their EU counterparts, in engaging with ICT. The reasons why the US was the leader in developing and diffusing this new technology have not been fully documented but are likely to be related in part to its strong focus on defence-related research during the 1950s, 1960s and 1970s. In addition a larger endowment of highly skilled labour in the initial adoption phase may have assisted rapid diffusion. This initial lead allowed US firms to develop the complementary assets (skills, patterns of work organisation, new processes and products) that enabled them to maximise returns from ICT investments. For example, in a comparison of banks engaged in business lending in the US, Britain and Germany, several US banks had benefited from relatively early use of time- and labour-saving PC's and had adopted new forms of work organisation which speeded up the evaluation of credit requests at the lower end of the business lending market and economised on the use of support staff such as credit analysts (Mason, et al., 2000). Moreover in many industries, for example in retailing, ICT has also contributed to the exploitation of potential economies of scale through the rise of the so-called 'big-box' retail formats, such as Walmart, Home Depot, etc.

A possible implication of this line of thinking is that it is just a matter of time for the majority of EU-based enterprises to catch-up with US rivals as ICT diffuses more widely. Evaluating whether this is likely to occur, however, requires an examination of the institutional environment in which EU enterprises operate. Thus it is pertinent to ask whether the markets and social institutions in the EU provide as strong support and incentives for the diffusion of ICT and the development of complementary assets as is found in the US. Alternatively, has there been sufficient support for enterprises to adapt ICT to suit the workings of EU member-country markets and institutions? These issues need to be assessed in the light of other developments apart from ICT that have implications for productivity improvements, including possible conflicts between different policy objectives.

VI.3.2 Non-ICT impacts on growth

Although less intensive ICT use provides an important explanation for Europe's slower productivity growth relative to the US since the mid 1990s, this does not tell the whole story. Indeed the slowdown in productivity growth in Europe is at least as strongly related to a decline in the contribution of non-ICT capital and TFP as to a smaller contribution of ICT investment to labour productivity growth. Table VI.1 shows that in the latter half of the 1990s, EU labour productivity growth slumped from 2.43 to 1.37 percentage points, whereas US growth accelerated from 1.19 to 1.85 percentage points. This turnaround in the growth differential, i.e., from faster to slower labour productivity growth in Europe *vis-à-vis* the US, adding up to 1.73 percentage points, is only partly related to bigger effects from ICT technology in the US. For example, the rapid decline in the contribution from non-IT capital deepening in the EU compared to a slight acceleration in the US accounted for over a third of the 1.73 percentage points. Even more importantly, TFP growth declined even more strongly in the EU whereas it accelerated in the US, accounting for half (0.87 percentage points) of the change in the labour productivity growth differential.

The decline in non-ICT capital deepening needs to be seen in the light of EU labour market policies towards raising the employment rate, one of the important goals in the Lisbon Agenda. Some EU countries have developed active labour market policies or realised long spells of wage moderation to increase labour supply (see the discussion in Chapter I). Thus there has been a process of substitution of labour for capital, by definition lowering labour productivity growth. In addition if the increased employment is concentrated among relatively low skilled workers, often those previously on benefits or altogether outside the labour force, then this may further lower labour productivity growth. Thus raising both employment and labour productivity growth may be conflicting objectives, at least in the short run. The short-term impact of active labour market policies in EU countries, which has led to increasing availability of low cost labour, may have contributed to a lower concentration of production in high technology industries where the use of unskilled labour is minimal. In this context the challenge for policy makers is to address the trade-off between employment and productivity objectives by measures which will retrain and up-skill low skilled workers entering (or re-entering) the labour market to levels which will make them more employable in capital-intensive high-tech industries.

Table VI.1

Sources of annual labour productivity growth

	1980-1990	1990-1995	1995-2001	1995-2001 over 1990-1995	1995-2001 over 1980-1990
European Union					
Average labor productivity	2.28	2.43	1.37	-1.07	-0.92
Contribution of capital deepening	1.16	1.30	0.90	-0.40	-0.26
Information technology	0.34	0.29	0.42	0.13	0.08
Noninformation technology	0.82	1.01	0.48	-0.53	-0.34
Total factor productivity	1.12	1.14	0.46	-0.67	-0.66
United States					
Average labor productivity	1.46	1.19	1.85	0.66	0.39
Contribution of capital deepening	0.71	0.58	1.05	0.46	0.33
Information technology	0.52	0.40	0.72	0.33	0.20
Noninformation technology	0.19	0.19	0.32	0.13	0.13
Total factor productivity	0.75	0.61	0.80	0.20	0.05
US-EU difference					
Average labor productivity	-0.82	-1.24	0.48	1.73	1.30
Contribution of capital deepening	-0.45	-0.71	0.14	0.86	0.60
Information technology	0.18	0.11	0.30	0.20	0.12
Noninformation technology	-0.63	-0.82	-0.16	0.66	0.47
Total factor productivity	-0.37	-0.53	0.34	0.87	0.71

Note: Average annual percentage rates of growth. Contributions are defined in equation (6).

The contribution of total factor productivity includes contribution of labor quality.

Source: Timmer, Ypma and van Ark (2003)

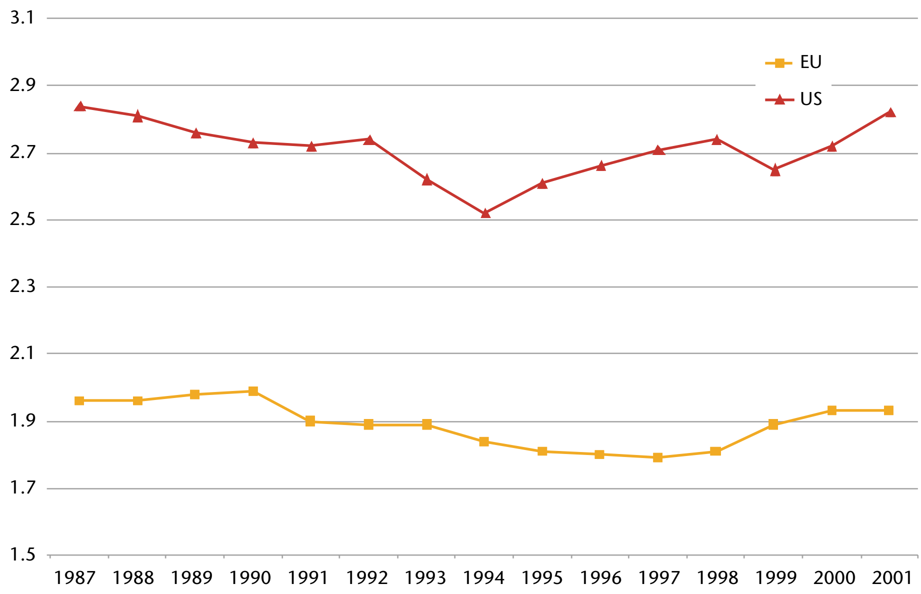
Finally Table VI.1 above highlighted the decline in EU TFP growth rates in the second half of the 1990s, both an absolute decline and relative to the US. Increases in measured TFP can arise for a number of reasons including investment in innovation-inducing activities such as R&D expenditures, measurement issues including cyclical influences and pure TFP or costless increases in output arising from network externalities or spillovers. The latter encompasses activities that indirectly raise productivity but are not directly remunerated in the market.

Arguably one of the most important omitted inputs in Table VI.1 is labour quality, dominated by the use of skilled labour. The influence of labour force skills was discussed in the growth accounting estimates presented in Chapter III where it was shown that investment in human capital has a significant impact on labour productivity growth. Organisational changes require expenditures, e.g. consultancy fees and developing managerial skills, and so is a second omitted input that ideally should also be included in a growth accounting calculation. Data on expenditures related to organisational changes are not readily available but the indirect evidence from US-European comparisons at establishment level referred to above suggest that this type of unmeasured (or badly measured) input may help to explain the faster TFP growth in the US in the second half of the 1990s.

OECD data on gross expenditure on R&D as a proportion of GDP are available for the 1990s and presented in Figure VI.2 (data prior to 1987 are collected for individual countries and not for the EU as a whole). US levels of R&D investment relative to output exceed those in the EU and over the past decade, there has been a noticeable divergence in the R&D ratio between the EU and the US. The US has seen significant increases in the R&D to output ratio, in particular since the mid-1990s, whereas the EU appears to have a relatively static level of R&D intensity, showing much less variation than the US.

Figure VI.2

Gross expenditure on R&D to GDP ratio, 1987-2001



(Source: Main Science and Technology Indicators, OECD, various years)

The existence and/or importance of spillovers in raising TFP growth has been the subject of academic debate for decades. The presence of spillovers provides an explanation of aggregate increasing returns to scale without abandoning the assumption of perfect competition and constant returns to scale at the firm level. There are various interpretations of how externalities originate. New knowledge can be generated from growth in activity, e.g. with increasing investment and production (Arrow 1962), with the accumulation of human capital (Uzawa 1965) or via the acquisition of quality-improved inputs (Goto and Suzuki 1989)[63]. Much of the discussion has been in terms of possible external benefits from R&D expenditures. Exchange of ideas within research teams of different firms and within industries that operate in similar fields is another way of diffusing knowledge and generating externalities (Griliches, 1992). In terms of empirical results the consensus seems to be that external benefits from R&D activity are present but there is a wide variation in empirical methods and hence in estimates of the magnitude of these effects (see Griliches, 1998 for an overview of methods, while a summary of estimates can be found in Jones and Williams, 1998).

Recently the focus has moved to discussion of possible external benefits from ICT adoption. There is little by way of hard evidence that significant spillovers from ICT lead to increased TFP growth, although O'Mahony and Vecchi (2003) present some econometric evidence for an ICT impact on TFP, at least for the US. Much of the research on productivity impacts from ICT is consistent with the notion that this new technology raises productivity growth over and above the impact attributable to the direct ICT capital deepening channel (e.g. the industry analysis in Stiroh, 2002, or firm level analysis in Bresnahan, Brynjolfsson and Hitt, 2002). Further support is presented in this report. Thus the TFP growth estimates comparing ICT using to non-ICT industries in Chapter III are compatible with ICT spillovers and the analysis in Chapter IV suggests that accelerating growth in ICT using sectors is not primarily due to cyclical influences. Accordingly, at least part of the faster US growth in TFP during the second half of the 1990s may reflect a more widespread impact of network effects in the US than has occurred so far in most EU countries.

VI.4 The regulatory and institutional environment

The regulatory environment in which firms operate is likely to impact on their ability to instigate productivity improvements, either through the optimal allocation of inputs, technology transfer or ability to generate spillovers. In many studies a distinction is made between product and labour market regulations. Economic theory suggests that, all else being equal, a greater degree of product market competition creates greater opportunities for comparing performance and increases incentives to search for and implement cost-reducing investments in new technology and changes in work organisation (Nickell, 1996; Nickell, et al, 1997). Similar expectations about incentives apply to firms operating in a context of relatively low costs in terms of adjusting labour quantities and qualities in ways that harmonise with the adoption of new technologies and new modes of work organisation.

[63] For example, the growth of the airline industry was made possible by the introduction of excellent aircraft by the aircraft manufacturing industry (Goto and Suzuki 1989).

A number of recent studies highlight the effects on growth and innovation performance of inter-country differences in product and labour market regulations. For example, estimates reported in OECD (2003), based on industry-level data for 18 countries between 1984 and 1998, suggest that TFP growth is significantly negatively associated with an index of the stringency of product market regulation (PMR). The PMR measure comprises a mix of indicators of direct state control of industries, barriers to entrepreneurship (such as legal barriers to competition and administrative burdens on start-up firms) and legal and other barriers to international trade and investment (Nicoletti, Scarpetta and Boylaud, 1999). A similar index of employment protection legislation (EPL), designed to capture the costs of adjusting labour inputs, is also found to be negatively associated with TFP growth in countries where adjustment costs cannot be offset by reducing wages or stepping up internal training. Using the same OECD measures of EPL but different measures of PMR for 13 industrial countries, 1992-99, Gust and Marquez (2002) also find that ICT adoption and productivity growth are significantly negatively associated with restrictive regulatory practices.[64]

In a review of the earlier OECD studies, Nicoletti and Scarpetta (2003) consider the impact of product market regulations on underlying productivity in the context of a dynamic model of productivity growth and technology transfer. They estimate TFP,[65] using a range of OECD data, covering over 23 two-digit industries in manufacturing and business services in 18 OECD countries between 1984 and 1998. The basic model used is derived from the endogenous growth model of Aghion and Howitt (1998) where industry level TFP is a function of knowledge and other influences which include industry and country characteristics and a term to capture technology transfer from the country that is the technological leader. The PMR indexes, calculated in the earlier studies, are included to capture regulatory impacts on the product market. This study concludes that the long run costs of anti-competitive regulation, in terms of foregone productivity improvements, are higher in countries that are further away from the technological frontier. At the same time, by increasing competitive pressures, entry liberalisation has a generalised effect on productivity in all countries, regardless of their position with respect to the technology frontier.

From an EU sectoral perspective, as adopted in this study, the policy implications of such findings warrant a great deal of discussion and scrutiny before any specific recommendations can be formulated. Just as the findings in Chapters II and III above reveal a marked diversity between EU countries in respect of factor endowments, patterns of industrial specialisation and the extent of productivity growth differentials relative to the US, so too is there a considerable variation between EU countries on the OECD measures of product and labour market regulation.

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[64] Gust and Marquez's measures of regulatory burdens on start-up firms and regulatory burdens in general are derived from surveys of business managers reported in the World Competitiveness Report 1993 and Global Competitiveness Report 1998. For full details of the OECD measures of product and labour market regulation, see Nicoletti et al (1999).

[65] Multi-factor productivity (MFP) in their terminology.

On the overall PMR measure, the relatively light degree of regulation in the US compares favourably with most EU member countries and particularly with Italy, France, Belgium and Greece. However, two EU states – the UK and Ireland – have more in common with the US than with other European countries. And examination of some of the more specific measures of PMR, for example, administrative barriers, shows that while Italy, France, Belgium, Germany, Spain, Finland, Greece and Sweden are ranked well above the US, two EU states, the UK and Denmark, are ranked at a lower level. Four other EU members, Ireland, the Netherlands, Austria and Portugal, are at much the same level as the US. In the case of barriers to international trade and investment, only three EU member states, Portugal, France and Greece, are ranked as having greater barriers than the US (Nicoletti et al, 1999, Figure 7).

For a limited number of industries it was possible to precisely match the OECD PMR measures with the sectoral productivity estimates in this report. For example, in the case of retailing, less regulation overall is related to higher labour productivity growth (more output growth with no effect on employment growth). Looking at specific types of regulation however suggests lower barriers to entry appear not to have much effect on labour productivity growth, but do raise employment. In air transport, countries with lower degrees of overall regulation show both higher output and employment growth. In this case less international regulation leads to higher productivity growth.

With regard to the strictness of EPL, the US is ranked below all EU member states and, with the exception of the UK and Ireland, the margin between the US and EU states is substantial (Nicoletti et al, 1999, Figure 11). However, the analysis in OECD (2003) makes clear that the economic impact of strict EPL in a given country varies greatly depending on the nature of that country's wage bargaining and training institutions, its pattern of industrial specialisation and the types of market structure that predominate. For example, strict EPL has a relatively small impact on productivity and R&D intensity in countries such as Germany and Austria with centralised wage bargaining procedures and well-established apprenticeship and continuing training systems which provide support for firms to upgrade the skills of their existing employees in response to technological change. Conversely, OECD (2003) suggests that the negative effects of EPL on productivity may be strongest in countries such as Belgium, France or Portugal 'where the adjustment costs associated to EPL are not offset by the possibility of adjusting wages or use of internal training' (ibid, p.112).

Further to these observations, in order to evaluate the effects of strict EPL, a wider view of predominant labour market institutions in a given country needs to be taken than just to focus on the nature of wage bargaining procedures and national training systems. For example, in France many large enterprises still operate internal labour markets (ILMs) which are characterised by a longstanding preference for external recruitment to be confined to a range of entry-level jobs and for the bulk of more senior positions to be filled through internal promotion (Eyraud, Marsden and Silvestre, 1990). In recent years there have been some signs of French ILMs being destabilised but Beret (2000) reports their continued dominance in engineering sectors (if not in service sectors). Common rationales for employers to maintain ILMs centre on the benefits to employee motivation, the cost savings from lower labour turnover and firms' efforts to maximise returns from job-specific and company-specific training (Wachter and Wright, 1990). Hence, to the extent that ILMs are in operation in a particular industry or country, it is likely that the effects of strict EPL will be reduced.

At industry level strict EPL is likely to have strong negative effects on productivity in low-technology industries if employers are restricted in their capacity to shed labour following the introduction of labour-saving technologies. Strict EPL is also likely to depress productivity growth and R&D intensity in high technology industries with relatively low levels of market concentration where technologies tend to evolve and/or be replaced very quickly. By contrast, the negative impact of strict EPL on R&D intensity is likely to be less in high- or medium-technology industries with relatively high levels of market concentration. OECD (2003) cites the examples of electronic components and aircraft as industries of this kind which are characterised by cumulative innovation processes rather than rapidly changing technologies, and thus stand to benefit from progressive development of existing employees' skills.

VI.5 Policy implications

The many examples of diversity among EU countries in the extent and impact of regulatory practices serve as reminders that policy inferences in the area of de-regulation need to be similarly diverse and attuned to the specific nature of each country's institutional and market structures and the patterns of industrial specialisation and comparative advantage which are associated with those structures. For example, in countries where strict EPL is closely associated with industrial relations practices and vocational training institutions that have many positive outcomes (for example, in skills development), there is a case for caution in efforts to reform arrangements for employment protection.

That said, the growing evidence of the recent benefits to the US economy of its relatively light degree of product market regulation, suggests that most EU member states need to subject their existing market regulations to detailed scrutiny with a view to identifying and cutting out unnecessary administrative burdens and barriers to competition.

Haltiwanger, Jarmin and Schank (2002) report evidence that US manufacturing enterprises engage in more market experimentation than do their German counterparts, taking greater risks in adopting new technologies and the development of new products, which shows up in a much wider dispersion of productivity levels in the US than is found in Germany. In this context overall US productivity performance is enhanced by more rapid exit of less productive enterprises and more rapid growth of surviving new entrants. Such findings are consistent with an argument that many EU countries would benefit from greater competition in at least some of their product markets in order to be better able to match the US in benefiting from investments in ICTs.

In terms of industrial policy in general, these findings on the high level of inter-industry variation in ICT-intensity, exposure to foreign trade and other key characteristics suggest that the evolutionary emphasis on the specificity of sectors and their core technologies needs to be taken into account in policy design. Hence horizontal policies such as market de-regulation and tax relief on R&D spending may need to be complemented by sector-specific policies as well, and particularly if it is hoped to speed up the distribution of knowledge and foster innovation processes within EU economies. In a recent study on the service sector, van Ark, Broersma and den Hertog (2003), argue that deepening and broadening of innovation policies to cover not only manufacturing but also service industries may be as much needed as the use of horizontal policies to support productivity and innovation in services.

Many public policies and programmes are already in place at EU and member state levels which seek to promote two-way knowledge transfer between enterprises and academic science-base institutions and to encourage enterprises to build up collaborative R&D networks in conjunction with supply-chain partners as well as universities and research institutes. Policy design in this area can benefit greatly from taking account of sector-specificities.

For example, on the basis of a series of comparisons of matched samples of production and research establishments in Germany and Britain, Mason and Wagner (1999) conclude that bridging institutions such as the Fraunhofer institutes perform their role of intermediating between the academic science base and industry with notable success in mature industries such as mechanical engineering. However, there seems to be much less scope for bridging institutions to play an effective role in fast changing R&D-intensive areas of electronics where both small and medium-sized enterprises and larger firms are well capable of making direct contacts with university based researchers. In this type of high-tech industry, policy might be better directed to specific, targeted programmes which support partnerships between companies, universities and specialist research organisations and/or help to ensure that large proportions of PhD students in engineering and science subjects have access to industrial training during their studies.

At the same time industrial policy in the US and in individual EU member states needs to work with the grain of revealed comparative advantage which has developed in the context of nation-specific institutional structures. For example, in the case of the US, much of technology policy of the 20th century was focused on defence related research with a large spillover to innovation in the civil sector of the economy. Indeed the US advantage in ICT is strongly related to the US defence programme. More recently, US technology policies appear to move in the direction of research and development activities that are focused on strengthening of security against terrorism. This redirection of technology policies will likely have a large impact on the civil sector again, for example through supporting the development of computerised sensory interfaces, and increasing the ability to analyse vast amounts of data (Trajtenberg, 2003).

Similar nation-specific features of technology and innovation policies can be observed within the European Union. For example, Mason, Beltramo and Paul (2003) find that

British-French differences in higher education structures and highly qualified labour markets have contributed to very different types of innovation networks in the two countries' optoelectronics industries. In the case of supply-chain research linkages, their research suggests that there is a faster rate of *new* external relationship building in Britain which is stimulated to a considerable extent by steady flows of individual engineers and scientists moving from jobs in one company to another and bringing new personal networks of external contacts with them. These individual level connections provide the basis for British-based establishments to widen the range of external knowledge sources available to them and to regularly embark on new collaborative relationships with current or prospective supply-chain partners while disengaging from some of their other relationships. At the same time the majority of British establishments actively seek to diversify their relationships with universities as well in order to gain access to a range of expertise, and this tendency is encouraged by the establishments being regularly approached by different university departments in search of industrial funding.

By contrast, external research relationships and knowledge sourcing patterns in French optoelectronics establishments tend to be characterised by a high degree of stability. In the case of inter-enterprise interactions. This partly reflects the lingering effects of previous French state involvement in supply-chain planning. However, relationships with public laboratories and universities are also remarkably stable, in part because of the relatively low labour mobility in the French market for engineers and scientists. Thus French establishments have limited opportunities to recruit experienced engineers and scientists who might bring with them the personal contacts needed to cultivate new knowledge sources and potential new collaborators outside the firms' existing relationships.

Both types of innovation network have advantages and disadvantages. Many researchers have highlighted the time, effort and resources that are needed to develop innovation networks, typically requiring a progressive build-up of trust and recognition of mutual self-interest on the part of key technical personnel on all sides (Powell, 1990; Grandori and Soda, 1995; Lazaric and Lorenz, 1998). In this respect French enterprises may well derive benefits from the greater stability of their external research relationships.

However, in a rapidly changing industry, constituent members of networks also need to be open to new sources of knowledge and ideas which lie outside those networks (Granovetter, 1983, 1985; Cooke and Wills, 1999). Here there seem to be clear advantages to British establishments from the greater fluidity of their collaborative relationships, often in the process of change and reformation, and higher levels of labour mobility, with experienced engineers and scientists adding new ideas and personal contacts to enterprise knowledge bases whenever they moved between employers.

In the specific cases of Britain and France, therefore, the implications for policy designed to promote network formation and knowledge transfer are rather different. In Britain, programmes supporting the development of innovation partnerships between enterprises, supply-chain partners and universities may need to include incentives for the various partners to pursue more research projects of a medium-term strategic nature than they might otherwise be inclined to do. Conversely, in France greater priority arguably needs to be given to incentives for enterprises to seek new partners outside their existing networks.

Research on the development of innovation networks in other EU countries might well reveal other country-specific characteristics which need to inform policy design. More generally the high degree of institutional variation among EU member-states suggests that industrial policies aimed at promoting knowledge transfer and fostering innovation should try to build on accumulated institutional strengths within each country at the same time as seeking to improve the functioning of markets and to rectify weaknesses in labour market, education and training and other institutions.

VI.6 Conclusions

This chapter has outlined the main forces driving EU productivity growth and their policy implications. The cautious assessment of prospective policy recommendations in this chapter reflects the nature of the political reality that all public policy interventions are likely to involve costs as well as benefits. More generally, there is always a possibility of market failure being compounded by government failure, something that is emphasised in both the neo-classical and evolutionary perspectives on enterprise behaviour.

Particular attention has been drawn to two kinds of policy trade-off that need to be borne in mind. One concerns the potential conflict between employment and productivity objectives which can be ameliorated if simultaneous efforts are made to upgrade the skills of new entrants and re-entrants to the labour force in particular in the light of new opportunities for innovation in technology using industries. Another potential trade-off concerns the possibility that policy designed to intensify product market competition may have a negative impact on incentives to innovate. This suggests that the weight of empirical evidence favours a continued emphasis on competitive markets, although the relationship between innovation and competition is not linear and can be industry specific. As described by Porter (2002), the intensity of competition in national product markets is likely to have direct effects on innovation and productivity growth even in industries that are dominated by multinational enterprises competing in world markets. Examples include positive externalities such as specialised labour pools and knowledge spillovers which are fostered by geographic proximity of competing firms.

In contrast to product markets, there is less consensus on the implications for productivity growth of deregulating labour markets. As with product markets, the issue is the trade off between static gains in efficiency and the more dynamic implications for investment, in this case in human capital. In this respect the effects of strict employment protection legislation may need to be evaluated on a country-specific basis rather than seek to draw policy inferences for the EU as a whole. The labour market institutions that evolved in several EU countries in the post-war period served them well in building up a strong human capital base and aided the process of convergence to US productivity levels. If labour market deregulation serves in any way to undermine incentives for individuals to accumulate human capital or firms to engage in on the job training, then this could have a negative impact on long run growth.

Due concern for national specificities within the EU should also help avoid any kind of reflex 'policy borrowing' reaction to the fact that the US has enjoyed substantially faster productivity growth than the EU since the mid-1990s. For example, strong arguments in favour of general support for innovative networks have been outlined but these need to be considered in the context of countries' institutions that have been built up over many years. Any attempts to replicate innovation support programmes that have been successful in the US may prove ineffectual if they are not appropriate to conditions in EU member countries. Another risk of policy borrowing is that insufficient thought may be given to questions of timing. For example, the earlier adoption of ICT in the US is likely to have been facilitated by its relatively large stock of graduates in the workforce. Certainly the vast literature on skill biased technical change seems to support a link between ICT and the use of graduates (see e.g. Autor, Katz and Krueger, 1998, and Chennells and van Reenen (1999) for a review). However the wage premium to highly skilled workers in the US has diminished in recent years (Beaudry and Green, 2002), suggesting high level skills may be more important in the initial adoption phase rather than subsequent use phase (Chun, 2003; O'Mahony, Robinson and Vecchi, 2003). Thus policies focusing primarily on high level skills may be less appropriate now in the face of a more developed information technology than in the past. Improvements in human capital formation undoubtedly remain central to future EU productivity performance but new policy initiatives will need to be grounded in hard empirical evidence on the types and levels of skills which are most sought after by employers in different EU member countries.

Chapter VII

Data Sources and Methodology

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VII.1 General Introduction on Performance Measurement Issues

Over the past decades there have been increasing concerns about whether the macroeconomic statistics correctly trace output, employment and productivity changes in the knowledge economy. Most famous is of course the Solow quip that 'you can see computers everywhere, except in the statistics' (Solow, 1987). Also Griliches (1994) shows a striking difference between the acceleration of labour productivity growth in 'measurable' sectors of the US economy (agriculture, mining, manufacturing, transport and communication, and public utilities) and the slowdown in 'unmeasurable' sectors (like construction, trade, the financial sector, 'other' market services and government). Apart from this rise in measurement error at the aggregate level due to a shift towards the unmeasurable sectors of the economy, one may also observe an increase in measurement problems in the 'unmeasurable' sector itself. This component of the rise in measurement problems may – at least in part – be related to the increased use of ICT.

For a comprehensive view of measurement problems concerning output, value added and productivity, one needs to make a distinction between the various sources of measurement problems. These can be divided into four categories, namely measurement problems with regard to output in manufacturing (which is the major industry of the 'measurable' sector of the economy) and output in services (which dominate the 'unmeasurable' sector) vis-à-vis measurement problems concerning the inputs (production factors and intermediate inputs) in manufacturing and services. The diagram below presents a summary of the major issues in each quadrant as well as the most desirable and feasible solutions (van Ark, 2002).

For manufacturing output the problems are relatively straightforward. Nominal output and prices of industrial products are relatively easy to measure. The measurement problems in the northwest quadrant of the diagram are therefore largely confined to measuring ICT output in constant prices. It is well known that the capabilities of semiconductors and computers have improved tremendously over the past few decades.[66] Since

[66] See Nordhaus (2001) for a long-term perspective on the increase in computing power.

	Manufacturing	Services
Output	Primarily computers and other ICT, Solution primarily through use of hedonic price indices Feasible provided data availability	Most services with 'customised' production, and non-market services (education, health, etc.) Solutions through detailed surveys on multiple dimensions of output for each industry Difficult in methodological terms as well as in terms of data availability
Input	Primarily semiconductors and software Solution primarily through use of hedonic price indices Feasible given availability of data and use of input-output matrices	Primarily ICT input including software Solution through use of real input series adjusted with hedonic price deflators Feasible provided availability of capital-flow matrices

consumers can buy computers with vastly more computing power at comparable prices, the price of computing power has declined continuously. However, traditional methods of sampling and calculating price indices for these goods will almost certainly underestimate the rate of price decline and, as a result, the rate of productivity growth. At present there are only a few countries, like the US and Canada, that have a comprehensive system in place for measuring prices of computers and semiconductors.

An adequate implementation of hedonic deflators, however, requires some further considerations. Apart from adjusting the deflator for computer output, it is also necessary to make an adjustment for the most important ICT inputs in industry (the southwest quadrant of the diagram above). For example, Triplett (1996) shows that between 1974 and 1994 the prices of semiconductors declined almost 3000 times compared to only 20 times for computers over the same period.[67]

To ensure international comparability of ICT deflators, a harmonised procedure has been applied in the industry databases for this report. Thus value added deflators for ICT-producing industries (derived with a double deflation procedure) and ICT investment in the US are applied to all other countries, after adjusting for differences in general inflation (see section VII.2).

In contrast to manufacturing, measurement problems in the service sector are perhaps easier to deal with for inputs (the southeast quadrant of the diagram) than for output (the northeast quadrant of the diagram). The most important technological inputs in the service sector are ICT products, which give rise to the same measurement issues as for ICT output. The share of computers and other high tech equipment in the inputs in market services has strongly increased in most OECD countries. A major problem here is the measurement of own-account software which makes up a substantial part of investment. They create the greatest problems in terms of international comparability (Lequiller et al. 2003).

[67] See also Jorgenson (2001) for updated series.

The largest measurement problems, however, relate to the measurement of output in the service sector. There are only few possible ways to resolve this without re-estimation by the national statistical offices. The current methodology of splitting the change in output value into a quantity component and a price component is difficult to apply to many service activities, as often no clear quantity component can be distinguished. Moreover, possible changes in the quality of services are also difficult to measure. These problems are not new, and improvement in the measurement of service output has been a topic on the agenda of statisticians and academics for a long time.[68] In many service industries information on inputs (such as labour income) was and still is used as a proxy for output.

The increased importance of ICT may have accelerated quality changes in services. For example, improved inventory management in the distribution sector makes it possible to differentiate the supply of goods in terms of time, place and type of product. The application of ICT has supported the customization of financial products or combinations of products (like an insurance, an investment fund and a mortgage). Services in the public sector, such as health care, are also increasingly characterised by diversity and differentiation in time, place and type of treatment. Even though such changes have not exclusively led to upward adjustments of real output, on balance the bias is probably towards an understatement of the growth in real service output (Triplett and Bosworth, 2000).

It should be emphasised that statistical offices are doing much to improve measurement methods. In the United States, the US Bureau of Labor Statistics (which is responsible for the development of price indices) and the Bureau of Economic Analysis (which produces the National Income and Product Accounts) have introduced various improvements in measurement methods (Dean, 1999; Gullickson and Harper, 1999; Landefeld and Fraumeni, 2001). In a series of reports, Eurostat recently evaluated measurement practices in various service activities, such as financial services and public services, and 'difficult to measure' goods industries, such as computers and large equipment (Eurostat, 2001).

In conclusion, measurement error at macroeconomic level has partly increased because of the greater share of 'difficult to measure' industries in the economy. In addition, there are indications that within these industries, in particular in services, measurement errors get bigger because of the increased use of ICT. It is not clear, however, whether these problems have systematically led to biases which differ across countries or over time. As discussed above in Chapters I and III it appears that non-market services add more to overall productivity growth in the European Union than is the case for the US. In several countries important adjustments to national accounts measurement are being implemented or considered, for example, for the measure of output in the finance sector in several countries. It also appears that the use of hedonic price indices, which is applied or experimented with by many statistical offices, is a promising avenue to improve the measurement of real output of and inputs for computers. The biggest problem area, however, remains the measurement of real output in many service industries.

68 See, for example, Griliches (1992) and the statistical work of the Voorburg Group on Service Statistics (http://www4.statcan.ca/english/voorburg/).

VII.2 Databases for this project

Specifically for the purpose of this report, three new databases have been created. Most importantly, an industry database on labour productivity has been constructed including series on value added and labour input covering 56 industries for all 15 EU member states and the US allowing output and labour productivity growth comparisons.[69] Secondly, an industry growth accounting database was constructed for four European countries (France, Germany, Netherlands and UK) and the US allowing calculation of the contribution to growth from ICT-capital and total factor productivity. Finally a database was developed on relative measures of levels of productivity and unit labour cost in manufacturing, with relative levels being derived on the basis of unit value ratios (UVRs). The latter database is part of the International Comparisons of Output and Productivity (ICOP) programme at the University of Groningen.[70]

The databases are described in more detail below, and are available in electronic format in a CD-ROM with this report. Updates and extensions can be downloaded from the websites of the Groningen Growth and Development Centre and the National Institute of Economic and Social Research.[71] The Industry Labour Productivity Database are time series in spreadsheets for each variable in individual country files. For each variable there is also an underlying spreadsheet describing sources and methods. The industry growth accounting database has a similar format, with sources and methods described in more detail below (sub-section B). The database on labour productivity and unit labour costs is available in one file, with spreadsheets for individual countries. Sources and methods are described in sub-section C.

A. Industry labour productivity database for the European Union and the US

Introduction

The Industry Labour Productivity Database provides a comprehensive internationally comparable dataset on industrial performance at a detailed industry level for the 15 EU countries and the US. It enables the user to design indicators such as shares of output and employment by industry and to analyse trends in value added and labour productivity. Variables covered include current value added, value added deflators, persons engaged, number of employees, hours worked and labour compensation for 56 industries for the period 1979-2001.

The Industry Labour Productivity Database updates and extends previous work at the Groningen Growth and Development Centre (GGDC) and the National Institute on

[69] At present the database covers 56 industries.

[70] See http://www.eco.rug.nl/dseries/icop.html

[71] See http://www.ggdc.net/dseries/ and http://www.niesr.ac.uk/

Economic and Social Research (NIESR) recently described in, for example, van Ark, Inklaar and McGuckin (2002) and O'Mahony and de Boer (2002). For most variables and countries, the OECD STructural ANalysis (STAN) database is taken as the point of departure, which in turn is largely based on recent national accounts of individual OECD member states.[72] The STAN data is complemented, updated and backdated and further disaggregated by the use of information from industry surveys and additional information from (historical) national accounts of individual countries to provide a complete and up-to-date data set for the period 1979-2001. In general the method employed was to use STAN aggregates as control totals and the other data to divide these totals into sub-industries.[73] In a limited number of cases STAN also includes working hours per person employed (or per job), but for many countries alternative sources had to be employed to obtain these estimates.

Country Coverage

Table VII.1 provides a list of countries covered in the database. All 15 EU countries are covered as well as the United States. Aggregate estimates for the EU as a whole are also provided.

Table VII.1

List of countries in databases

Belgium	BE	**Luxembourg**	LU
Denmark	DK	**Netherlands**	NL
Germany*	DE	**Austria**	AT
Greece	GR	**Portugal**	PT
Spain	ES	**Finland**	FI
France	FR	**Sweden**	SW
Ireland	IR	**United Kingdom**	UK
Italy	IT	**United States**	US

* separate series are provided for West Germany for 1979-1991 and for unified Germany from 1991-2001

Industry coverage

Data are provided for 56 industries in total. The industries are classified according to the International Standard Industrial Classification (ISIC) revision 3. This classification is very close to the European NACE rev 1 classification system. Table VII.2 provides a listing of the industries. The industry division is more detailed than in STAN which allows a focus

[72] See http://www.oecd.org/document/15/0,2340,en_2649_33703_1895503_119656_1_1_1,00.html

[73] Approximately 50 per cent of individual cells in the Industry Labour Productivity Database is directly derived from OECD STAN, whereas the other 50 per cent represents extensions.

on industries which are characterised by high ICT-investment shares and/or ICT-goods production. For example, additional entries were included for five of the six ICT producing industries (semiconductors, ISIC 321; communication equipment, 322, fiber optics, 313; radio and TV equipment, 323; and instruments, 331). Separate entries are also included for motor vehicle trade and repairs, wholesale and retail trade (ISIC 50, 51 and 52) and professional and 'other' business services (ISIC 741-743 and 749).

Variables

The following variables are covered:

Value added is current gross value added measured at producer prices or at basic prices, depending on the valuation used in the national accounts. It represents the contribution of each industry to total GDP.

Deflator is the change in the value added deflator. It can be combined with current value added to derive quantity indices of real value added at industry level.

Persons engaged comprises number of workers engaged in production, including employees as well as self-employed, working proprietors and unpaid family workers.

Employees is the number of employees.

Hours refers to average annual hours worked per employee or per person engaged.

Labour compensation is current price labour costs borne by the employer. It includes wages as well as the costs of supplements such as employer's compulsory pension or medical payments. It refers to compensation of employees only.[74] Labour costs can exceed value added in cases where an industry incurs losses, or when an industry receives significant net subsidies.

Sources and Methods

The construction of the Industry Labour Productivity Database was done in a two-step procedure to ensure national accounts compatibility. Basic point of departure is the STAN database. STAN provides data which is generally based on the latest official national accounts data of individual OECD member states. Due to changes in industrial classifications and the introduction of the new 1993 System of National Accounts (SNA) and the 1995 European System of Accounts (ESA), official series often lack industry detail, especially for the period before the 1990s. In some cases, STAN goes beyond the official published data and provides data at more detailed levels based on additional sources, but important gaps still remain.

[74] In some cases the variable employees and labour compensation are replaced by one variable: compensation per employee, depending on data availability.

Table VII.2

Industries in the labour productivity database

	Industry Name	ISIC rev 3
	TOTAL ALL INDUSTRIES	**01-99**
1	**Agriculture**	01
2	**Forestry**	02
3	**Fishing**	05
4	**Mining and quarrying**	10-14
5	**Food, drink & tobacco**	15-16
6	**Textiles**	17
7	**Clothing**	18
8	**Leather and footwear**	19
9	**Wood & products of wood and cork**	20
10	**Pulp, paper & paper products**	21
11	**Printing & publishing**	22
12	**Mineral oil refining, coke & nuclear fuel**	23
13	**Chemicals**	24
14	**Rubber & plastics**	25
15	**Non-metallic mineral products**	26
16	**Basic metals**	27
17	**Fabricated metal products**	28
18	**Mechanical engineering**	29
19	**Office machinery**	30
20	**Insulated wire**	313
21	**Other electrical machinery and aparatus nec**	31ex313
22	**Electronic valves and tubes**	321
23	**Telecommunication equipment**	322
24	**Radio and television receivers**	323
25	**Scientific instruments**	331
26	**Other instruments**	33ex331
27	**Motor vehicles**	34
28	**Building and repairing of ships and boats**	351
29	**Aircraft and spacecraft**	353
30	**Railroad equipment and transport equipment nec**	352+359
31	**Furniture, miscellaneous manufacturing; recycling**	36-37
32	**Electricity, gas and water supply**	40-41
33	**Construction**	45
34	**Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel**	50

Table VII.2 continued…

Industries in the labour productivity database

	Industry Name	ISIC rev 3
35	**Wholesale trade and commission trade, except of motor vehicles and motorcycles**	51
36	**Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods**	52
37	**Hotels & catering**	55
38	**Inland transport**	60
39	**Water transport**	61
40	**Air transport**	62
41	**Supporting and auxiliary transport activities; activities of travel agencies**	63
42	**Communications**	64
43	**Financial intermediation, except insurance and pension funding**	65
44	**Insurance and pension funding, except compulsory social security**	66
45	**Activities auxiliary to financial intermediation**	67
46	**Real estate activities**	70
47	**Renting of machinery and equipment**	71
48	**Computer and related activities**	72
49	**Research and development**	73
50	**Legal, technical and advertising**	741-3
51	**Other business activities, nec**	749
52	**Public administration and defence; compulsory social security**	75
53	**Education**	80
54	**Health and social work**	85
55	**Other community, social and personal services**	90-93
56	**Private households with employed persons**	95

As a second step STAN data were complemented with information from detailed industry and services statistics and additional (historical) national accounts data for individual countries. Use was made of international statistics such as the *OECD Structural Statistics for Industry and Services*, the *OECD Services Statistics on Value Added and Employment* and the *Eurostat Labour Force Survey*. Furthermore national sources have been used including national accounts and economic census and survey material. The spreadsheets associated with each of the country files provide a full account of the sources used for each country, each year and each variable.

Filling procedure

In case of missing data there are basically two procedures for estimating value added, employment and compensation data by industry: (1) applying shares from additional data to higher level national accounts aggregates or (2) applying higher-level growth rates to more detailed levels. The first is most useful when for a particular sub-sector there is no data available for any year from the national accounts. In that case, the share of the sub-sector in some higher level aggregate is derived from additional secondary data sources and applied to the aggregate in the basic source. In case data is available in the basic source for some years, secondary data shares are used for missing years provided they correspond closely to the basic source. If not, growth rates from secondary data are applied to the original basic data for missing years. To maintain national accounts compatibility a normalisation procedure is used so that subsectors add to the corresponding higher-level industry aggregates provided in the national accounts. If there is a summation discrepancy, the subsectors absorb the residual. Each sub-sector does so in proportion to its weight in the parent industry. This procedure ensures that output and employment measures are national accounts compatible and, importantly, have the same economy-wide coverage.[75]

For series on hours worked per person and deflators for value added, gaps in the basic source (STAN) are filled in a simpler way. If no additional data could be found, higher level aggregates have been used. For example, in case no separate figure on hours worked per person for sub-sector 351 could be found, the figure for 35 (when available) is used instead. The same was done for deflators where necessary.

The source descriptions in each of the country files provide a detailed account of the filling procedures used for each country, year and variable.

Alternative deflators for ICT production

At present there are only a few countries that have an adequate system in place for measuring prices of computers and semiconductors which take into account the fast increase in quality of these goods. To achieve international comparability, harmonised US deflators are applied for six ICT-producing manufacturing industries (ISIC 30, 313, 31ex313, 321, 322, 323, 331 and 33ex331) in all countries. US value added deflators are corrected for differences in overall inflation between each country and the US. Inflation is measured as the change in the deflator of all industries, excluding the ICT-producing manufacturing industries.[76] Since the ICT-producing industries are not separately distinguished in the US National Income and Product Accounts, these deflators were constructed using price changes in output and intermediate inputs of ICT goods as follows:

1) Value of shipments deflators for manufacturing industries and gross output deflators for non-manufacturing industries were obtained from the BEA data sets on ‘Gross Output by Detailed Industry’ and ‘Shipments of Manufacturing Industries’. A Törnqvist index was applied to obtain gross output (value of shipments) deflators for each of the industries.

[75] Often additional data is taken from surveys. Sampling coverage and definitions in survey data can differ within and across countries.

[76] This procedure is based on Schreyer (2000, 2002).

2) The Input/Output (I/O) tables from the Bureau of Labor Statistics (BLS)[77] for 1983-2001 are then used to calculate an intermediate input deflator for each ISIC industry.[78] For each of the 190 I/O industries a gross output deflator series was calculated.[79] These deflators are used to calculate an intermediate input price index for each industry. For industry *i* this is done in the following way:

$$\Delta \ln P_i^M = \sum_j \bar{s}_{i,j}^M \Delta \ln P_{i,j}^M \qquad \text{(VII.1)}$$

In equation (VII.1) $P_{i,j}^M$ is the price of the j^{th} intermediate input used in industry *i*. The price change for this input is weighted by the average share of input *j* in total intermediate inputs in current prices of the industry over the two periods:

$$\bar{s}_{i,j}^M = \frac{1}{2}\left(\frac{P_{i,j}^{M,t} M_{i,j}^t}{\sum_j P_{i,j}^{M,t} M_{i,j}^t} + \frac{P_{i,j}^{M,t-1} M_{i,j}^{t-1}}{\sum_j P_{i,j}^{M,t-1} M_{i,j}^{t-1}} \right) \qquad \text{(VII.2)}$$

3) Using the deflators for gross output and intermediate inputs, gross output and intermediate inputs at constant prices was calculated. These are combined to calculate real value added growth:

$$\Delta \ln V_i = \frac{1}{\bar{s}_i^V}\left(\Delta \ln Q_i - \bar{s}_i^M \Delta \ln M_i \right) \qquad \text{(VII.3)}$$

Here, V_i, Q_i and M_i are the quantity indices of value added, gross output and intermediate inputs respectively. Furthermore:

$$s_i^V = 1 - s_i^M = \frac{P_i^t Q_i^t - P_i^{M,t} Q_i^{M,t}}{P_i^t Q_i^t} \qquad \text{(VII.4)}$$

s_i^V is the share of current value added in current gross output. The average over the two periods is taken and used in equation (VII.3). Finally, the value added deflator is derived as the difference between the growth rate of current and real value added.

[77] Specifically from the Office of Occupational Statistics and Employment Projections (http://www.bls.gov/emp/). These tables are used since they are available for each year in the sample and because the industry detail is much greater (190 versus 96 industries).

[78] For the period 1979-1983 intermediate input shares are estimated for some industries such as the computer industry based on the 1977 BEA benchmark I/O table. For others such as machinery the intermediate input deflator for the most closely corresponding industry from the BEA GDP by Industry dataset.

[79] If there is a many-to-one correspondence, a Törnqvist index is used to aggregate to the level of aggregation of the I/O table.

While this procedure does not exactly replicate the BEA procedure, it serves as a good approximation since the aggregate deflators are close to the original value added deflator from the national accounts.[80]

Aggregation

Many countries at present still use fixed-weight (Laspeyres) indices to calculate aggregate value added at constant prices. This can lead to serious substitution bias if the structure of the economy is changing over time. For example, when fixed weights are used the price decline for computers will be overstated because of the relatively large weight in the base year compared to successive years (Landefeld and Grimm, 2000). To correct for this problem, chain-weighted indices like Fisher or Törnqvist indexes are needed.

In (re)calculating real value added aggregates for industry groups and for the aggregate economy chain-weighted (Törnqvist) deflators for value added were used. For industry *i* this is done in the following way. Let P_i^V the deflator for value added in industry *i* and P^V the aggregate deflator, then the change of the deflator in period t is given by:

$$\Delta \ln P^{V,t} = \sum_i \bar{s}_i^{V,t} \Delta \ln P_i^{V,t} \qquad \text{(VII.5)}$$

The price change in industry *i* is weighted by the average share of industry *i* in total value added over the two periods defined as:

$$\bar{s}_i^{V,t} = \frac{1}{2}\left(\frac{P_i^{V,t} V_i^t}{\sum_i P_i^{V,t} V_i^t} + \frac{P_i^{V,t-1} V_i^{t-1}}{\sum_i P_i^{V,t-1} V_i^{t-1}} \right) \qquad \text{(VII.6)}$$

Finally, real aggregate value added growth is calculated as the growth rate of aggregate current value added[81] minus the growth rate of the deflator as follows:

$$\Delta \ln V^t = \Delta \ln V^t P^{V,t} - \Delta \ln P^{V,t} \qquad \text{(VII.7)}$$

The use of chain-weighted deflators means that the estimates for the total economy here will generally not conform to the official real GDP series from national and international statistical agencies. However, with this procedure more consistency across countries is achieved.

[80] Differences occur for a number of reasons: the BEA uses the detailed source material of the I/O tables, which is more disaggregated than the 190-industry table used here. Furthermore a single deflator was used for all inputs from a certain commodity category, while the BEA distinguishes between domestically produced and imported goods. Also, the price deflators used here correspond to the value of shipments of an *industry* not of the *commodities* that are used as inputs. Finally, the BEA uses Fisher aggregation instead of Törnqvist.

[81] Aggregate current value added is the sum of industry current value added.

It should also be stressed that the use of Törnqvist aggregation diverts from simply adding up value added estimates at constant prices from the lowest industry level to higher aggregates. In particular when underlying industries show strongly different growth rates (such as ICT-producing industries relative to non-ICT industries), a summed result may deviate from a Törnqvist weighted result. Hence intermediate aggregates, such as a series for say total manufacturing, can only be obtained by again applying the Törnqvist aggregation procedure.

European Union aggregation

In order to arrive at totals for the European Union, current price measures in national currencies are converted into euro's using, as much as possible, sector specific purchasing power parities (PPPs).[82] For agriculture and manufacturing, these sector specific PPPs are obtained from industry-of-origin UVRs (see Rao, Ypma and van Ark (2003), forthcoming, on agriculture; and the description of the productivity level database for manufacturing in sub-section C). For for mining and public utilities estimates were obtained on the basis of matching product quantity details of individual items in both industries with gross output values from industry surveys and national accounts. For a limited number of countries, industry-specific UVRs could be obtained for two service sectors (distribution and transport/communication). For most services industries, however, PPPs were obtained from specific expenditure PPPs from the Eurostat/OECD International Comparisons Project (ICP), which were adjusted for transport and distribution margins on the basis of I/O tables for individual countries (OECD, 2002b). In a small number of cases of large outlier PPPs for individual industries, aggregate GDP PPPs were used instead. The industry PPPs were all converted to a 1997 basis, and were then applied to obtain value added shares by industry and by country in the total EU aggregate for the whole period 1979-2001. These were then used to Törnqvist aggregate the PPPs for individual industries to an EU aggregate.

German unification

In order to deal with German unification in 1990 two data sets have been constructed: one for Western Germany (covering the period 1979-1991) and one for unified Germany (covering the period 1991-2001). Growth rates for Western Germany are linked to 1991 data for unified Germany.

US reclassifications

As the US Standard Industrial Classification (SIC) differs considerably from the ISIC rev 3 (and NACE Rev.1) classification at more detailed industry levels, several major adjustments were made to the US National Income and Product Accounts. The main reclassifi-

[82] See van Ark and Timmer (2001) for a discussion of approaches to obtain sector-specific PPPs. See also the discussion on the Productivity and Unit Labour Cost Database under C below.

cations were carried out for motor vehicle trade and repairs (ISIC 50), retail trade (ISIC 52), hotels and restaurants (ISIC 55), post and telecommunications (ISIC 64), all industries in business services (ISIC 71-74) and Other community, social and personal services (ISIC 90-93). See the sources and methods description in the US file for more details. Price deflators for these industries have been developed in a similar way as for ICT producing industries using a double deflation procedure (see above).

B. Industry growth accounting database for the European Union and the US

Introduction

In addition to the Industry Labour Productivity Database, data on labour skills and investment have been collected for the US and 4 European countries (France, Germany, The Netherlands and the UK). This allows for a decomposition of output growth into into the contributions of quantity and quality of labour and capital, and total factor productivity using the growth accounting methodology outlined in Jorgenson *et al.* (1987).

Growth Accounting Methodology

The growth accounting approach to total factor productivity estimation has been used to estimate the impact of ICT on productivity by amongst others Jorgenson and Stiroh (2000) and Oliner and Sichel (2000). It allows for the decomposition of output growth into contributions from factor inputs and underlying productivity growth. Assume the production function of an industry in country (j) may be written:

$$Q^j_t = A^j_t f_{jt} \, (L^j_t, K^j_t) \qquad \text{(VII.8)}$$

Where Q is real output (here measured as real value added), K and L are the capital and labour inputs, respectively, and A is technical progress or multi-factor productivity (hereafter, MFP). Assuming perfectly functioning markets and constant returns to scale, MFP can be calculated as an index. Assuming a translog production function, the Törnqvist index is the appropriate approximation of the Divisia index (Jorgenson *et al.*, 1987). Then output growth can be decomposed into its various components in the following way:

$$\ln(Q^j_t/Q_{t-1}) = \alpha^j(t,t\text{-}1)\ln(L^j_t/L^j_{t-1})+(1- \alpha^j(t,t\text{-}1))[\ln(K^j_t/K^j_{t-1})]+\ln(A^j_t/A^j_{t-1}) \qquad \text{(VII.9)}$$

Where $\alpha(t,t\text{-}1)$ is the share of labour in value added averaged over the two time periods.

The need for a quality adjustment to factors of production stems from the work of Denison (1967) and Jorgenson and Griliches (1967). In studies on the impact of ICT on productivity, this has involved quality adjustment of capital, accounting for substitution between ICT capital and non-ICT capital (Oliner and Sichel, 2000, Jorgenson, 2001). In addition this analysis includes a labour quality adjustment using information on skill shares and relative wage levels of skill categories. Following Jorgenson *et al.* (1987) the growth in aggregate labour and aggregate capital can be estimated as Törnqvist indexes of their components. Suppose there are *i* types of labour and *s* types of capital. Then these indexes are given by:

$$\ln(L^J_t / L^J_{t-1}) = \sum_i \alpha_i^J(t,t-1)\ln(L^J_{i\,t} / L^J_{i\,t-1}) \qquad \text{(VII.10a)}$$

$$\ln(K^J_t / K^J_{t-1}) = \sum_s \alpha_s^J(t,t-1)\ln(K^J_{s\,t} / K^J_{s\,t-1}) \qquad \text{(VII.10b)}$$

where $\alpha_l^J(t,t-1)$ is the share of type l labour in the total wage bill and $\alpha_s^J(t,t-1)$ is the share of type s capital in the value of capital.

Capital is composed of six asset types of which three are ICT-related assets, defined here (and elsewhere) as computing, software and communications. Investment series at constant prices are converted into estimates of productive capital stocks using the perpetual inventory method with geometric depreciation rates. Depreciation rates vary between asset types and industries. Further details on capital services estimation are provided in O'Mahony and Timmer (2002).

Coverage

The dataset covers 26 industries and the period 1979-2001.[83] The list of industries is given in Table VII.3. This database is an extension and update of the work described in O'Mahony (1999) and O'Mahony and de Boer (2002).

Labour Skills

Estimating labour quality requires total labour input to be divided into a number of skills categories. Unfortunately skills classifications differ across countries, but these disparities are not a major issue for examining the growth contribution, since the contribution from each skill group is weighted by its wage share (with the implicit assumption that wages equal marginal products). As long as the number of skill groups does not vary too much across the countries and the divisions are roughly equivalent, then the relative wage shares pick up differences across countries in the growth in labour quality.[84] There are additional complications if the calculations do not control for other impacts on wages such as gender, age, min-

[83] Investment series for most asset types cover longer periods.

[84] No attempt is made to match the categories across countries (but see Table III.13 in Chapter III for a comparison of high skill levels).

Table VII.3

Industries in growth-accounting database

	Industry Name	ISIC rev 3
1	**Agriculture, Forestry and Fishing**	01-05
2	**Mining and Quarrying**	10-14
3	**Food, Drink & Tobacco**	15-16
4	**Textiles, Leather, Footwear & Clothing**	17-19
5	**Wood & Products of Wood and Cork**	20
6	**Pulp, Paper & Paper Products; Printing & Publishing**	21-22
7	**Mineral Oil Refining, Coke & Nuclear Fuel**	23
8	**Chemicals**	24
9	**Rubber & Plastics**	25
10	**Non-Metallic Mineral Products**	26
11	**Basic Metals & Fabricated Metal Products**	27-28
12	**Mechanical Engineering**	29
13	**Electrical and Electronic Equipment; Instruments**	30-33
14	**Transport Equipment**	34-35
15	**Furniture, Miscellaneous Manufacturing; Recycling**	36-37
16	**Electricity, Gas and Water Supply**	40-41
17	**Construction**	45
18	**Motor Vehicles & Wholesale Trade**	50-51
19	**Retail Trade & Repairs**	52
20	**Hotels & Catering**	55
21	**Transport**	60-63
22	**Communications**	64
23	**Financial Intermediation**	65-67
24	**Real Estate Activities and Business Services**	70-74
25	**Other Services**	90-99
26	**Non-Market Services**	75-85

imum wages and the impact of collective bargaining. The sample size in the survey data used in this study precludes the division of workers by age and gender – in addition to skills – by industry group. Similarly there is no information to take account of other influences which may cause deviations of wages from marginal products.

The number of labour skill types (based on educational attainment or qualifications) varies from three in Germany to seven in the Netherlands. Table VII.4 summarises the categories included for each country but some further explanation is required.

The most transparent case is the US where the division at the post-secondary level depends on the number of years of college attendance and/or whether a degree was awarded. First degrees and above in the US are awarded after 3-4 years of study and tend to be dominated by academic subjects. Associate degrees are shorter, 2–3 years, and are dominated by vocational subjects areas. The final two categories distinguish those who have graduated from high school from others and so is more an attendance than an attainment measure.

The categories in the UK are somewhat different at the intermediate/lower end, although degrees and higher level below degree (other NVQ4) are roughly equivalent to the US first degree and above and associate categories, respectively. The category NVQ3 includes school leavers who have achieved at least one pass at A-level and equivalent vocational qualifications. NVQ12 includes school leavers with passes in the main examinations taken at age 16 (GCSE) plus lower level vocational qualifications.

For France, the categories Bachelor degrees and Baccalaureate plus two years are again broadly equivalent to the US university degrees and associate degrees. Baccalaureate is similar to the UK A levels whereas the vocational qualifications can be achieved at a number of different levels. BEPC is similar to the UK GCSE.

In the case of the Netherlands, there are seven levels of educational attainment. The higher level categories are less comparable to other countries in that most students in academic subject areas complete a masters degree or above. The next level down (HBO) is tertiary education, but more of a vocational type. MAVO/HAVO/VWO is general education which normally leads to entry into a higher level, taking up 4 to 6 years of study after primary school. LBO/VBO and MBO are vocational schooling, taking up a maximum of 4 to 6 years after primary school. Primary schooling (the lowest category) ends at age 12. People in the final category have the lowest educational attainment which is completed primary schooling or below.

The German skill categories are the least satisfactory, as they only show a three way division into higher education, vocational and other. Although a finer classification is available for employment, dividing in particular the two lowest groups, corresponding wage data are not available.

Series on number of persons engaged by type of education are benchmarked on total employment in each industry to maintain consistency with the Industry Labour Productivity Database. Therefore, education shares derived from sources described below are used to subdivide series on total persons engaged from the industry database. In general, education shares are based on data for employees and refer to the distribution of number of employees, rather than hours worked.[85]

[85] In the case of France it refers to hours worked by employees.

Table VII.4

Skills categories employed in the analysis

France	The Netherlands
1. Bachelor degrees and above	1. Master degree and above
2. Baccalaureate plus 2 years college	2. HBO
3. Baccalaureate	3. HAVO/VWO
4. Vocational (CAP, BEP ou autre de ce niveau CAP,BEP ou autre de ce niveau)	4. MAVO
5. General Educational (BEPC)	5. MBO
6. No formal qualifications (Aucun diplôme ou CEP)	6. LBO/VBO
	7. Primary education or below

US	UK
1. Bachelor degrees and above	1. First degrees and above
2. Associate degrees	2. Other NVQ4
3. Some college, no degree	3. NVQ3
4. High school graduate	4. NVQ2 and NVQ1
5. Did not complete high school	5. No formal qualifications

Germany	
1. Higher education (16-17 years education or above)	
2. Vocational degree	
3. No degree	

Capital input

In total six asset types are distinguished, including computing equipment, communication equipment, software, transport equipment, other non-ICT equipment, and non-residential structures and buildings (see Table VII.5). Residential buildings are not taken into account which allows a sharper focus on the productivity contribution of business-related assets and facilitate the analysis of effects of ICT on capital and productivity growth. Consequently in the analysis of contributions of factor inputs to aggregate economic growth, the real estate sector (in which the imputed rents of residential buildings is recorded as part of output) is left out from output and inputs.

Table VII.5

Asset types employed in the analysis

Non-ICT assets	ICT assets
1. Non-residential buildings and Structures	4. Computing equipment
2. Transport equipment	5. Software
3. Other non-ICT equipment	6. Communication equipment

Harmonised ICT deflators

Generally there is support for the adoption of hedonic deflators in particular for the measurement of real ICT output and investment but there is still some discussion as to how these should be calculated (Triplett, 1996). The US approach leads to significantly higher rates of computer price declines than other industrial countries. Deflators based on the US hedonic price index, adjusted for international price or exchange rate movements, have been employed in many international or individual country studies of the impact of ICT capital on growth, primarily because a viable alternative is generally not available for other countries countries (for example, Colecchia and Schreyer, 2001; Oulton, 2001; van Ark *et al.*, 2002a). This is also the approach adopted in the current analysis. Deflators for IT-equipment, communication equipment and software are based on US deflators, adjusted for differences in non-ICT and non-software investment deflators, by industry (see also above under sub-section A).

Compensation shares to weight factor inputs

The inputs of labour and capital are weighted according to their compensation in total value added. The share of labour in value added includes an adjustment for compensation for self-employed and family workers. The standard approach is to impute compensation for self-employed on the basis of compensation for employees. The simplest assumption is to assume that both types of workers earn a similar compensation. However, a closer look at the figures for the US provided by Jorgenson, Ho and Stiroh (2002) show that this assumption is not valid. On the basis of detailed data for the US it appears that compensation for self-employed is generally lower than for employees due to its particular characteristics (for example in general educational attainment of self-employed is lower than for employees). On the basis of this information it was assumed that the compensation of self-employed was 70% of compensation for employees.[86]

In a few cases labour compensation was still higher than total value added. This is possible in cases where an industry incurs lossess, or when an industry receives significant net subsidies. In either case, MFP calculations become impossible as shares need to be positive. Therefore, the labour share was constrained to a maximum of 95%. In some cases rental prices become negative due to large swings in investment deflators, for example in non-residential buildings. To avoid these cases, a lower bound has been put to the rental price of 0.05.

[86] In the case of household services in the Netherlands, compensation of self-employed is assumed to be 35%. This is due to the way Statistics Netherlands estimates labour in this industry. A large part of the workers in this industry consist of informal small-job labourers whose earnings are well below formal employees.

Data sources for skills and investment

France

Investment series, hours worked by skill type and wage bills by skill type were unpublished data provided by the CEPII in Paris (and obtained from INSEE) under the EC 5th framework project 'Employment Prospects in the Knowledge Economy'.

Germany

INVESTMENT SERIES

Investment series on the six asset types by industry in both current and constant prices were constructed for 1970 to 2001. The main problems relate to the linking of investment series for West Germany and unified Germany and the estimation of series for software and ICT-equipment. The starting point were unpublished investment series by asset type at the aggregate level for West Germany (1970-1991) and for Germany as a whole (1991-2001) from the Statistisches Bundesamt (see Timmer, Ypma and van Ark, 2003). These contained information for eight asset types, but not separately for software (which was included in 'intangible investment') and for IT-equipment (which was included in 'office, computing and accounting equipment'). Software was split off from total intangible investment by using the average corresponding share for France, Finland and Italy. To split off office machinery from IT-equipment the US ratio by industry of IT-equipment to IT-equipment plus office equipment (IOT) were applied.

Investment by industry is available for West Germany (1970-1991) and for unified Germany (1991-2001) from the Statistisches Bundesamt. These datasets contain a breakdown into only two asset types, namely investment in structures and investment in equipment and other assets. For Germany as a whole, the industry detail was sufficient to distinguish the 26 industries until 2000. For 2001 it was necessary to extrapolate some industries using share development for previous years. For the pre-1991 series for West Germany the distribution sector and the transport and communications sector were not split up into more disaggregated industries. To distinguish wholesale from retail trade and transport from communications, investment data were used from the West German National Accounts for 1990. This means that, for example, wholesale trade and retail trade are separately distinguished, but trade and repair of motor vehicles are not.

To further disaggregate industry investment into asset types, the following procedures were used:

- Investment in transport equipment was derived using the average share of transport investment in total non-structures investment by industry for France, Netherlands, UK and US
- Industry shares in aggregate communication equipment investment were derived using industry shares from the *Ifo Investitionenrechnung*, which covers 1970-1994 for

West-Germany and 1995-1998 for Germany as a whole. Series for unified Germany from 1991-1994 were estimated by assuming industry shares in 1994 to be the same as in 1995 and then link with West-German shares in the period 1991-1994.

- A similar procedure as for communication equipment was used for Office, computing and accounting machinery (IOT), which includes IT-equipment. To split off IT-equipment, industry-specific ratios of IT to IOT for the US were applied (see below for US sources).

- Investment in software was derived using the average ratio of software investment to IT-equipment investment by industry for France, Netherlands, and the US

- Investment in non-ICT equipment was calculated as a residual.[87]

To derive complete series for the period 1970-2001, growth rates for West Germany were linked to those for unified Germany in 1991. Historical investment data were derived from *Volkswirtschaftliche Gesamtrechnungen, 1950-1990* (Statistiches Bundesamt) and Kirner (1968). Initial capital stocks in 1970 were estimated for structures and equipment using historical information back to 1870 (structures) and 1960 (equipment).

Labour quality

Data on wage bills and employment for the three categories were from unpublished data received from Statistiches Bundesamt, originally from the German Employment Statistics and Wage and Salary Statistics.

Netherlands

Investment series

Investment series for 50 sectors and 20 asset types for the period 1949-2001 were obtained from unpublished data from Statisics Netherlands (March 2003). Investment has been aggregated to 26 industries and 6 asset types using summation. For initialisation of the PIM in the start year 1948 an estimate of the gross stock from the same data set was used

Labour quality

For employment shares by educational attainment for the period 1990-2000 use has been made of the CBS, *Enquête Beroepsbevolking*, annual issues. Wages by educational type are provided by the CBS, *Loonstructuuronderzoek* for the years 1995, 1997 and 1998. For about 10 broad sectors reliable estimates could be derived. Due to small sample sizes a finer disaggregation was not possible. Consequently it is assumed that sub-sectors have the same educational attainment shares and relative wage structure as higher level aggregates.

[87] This led to balancing problems in the case of the communication industry between 1970 and 1991 (i.e. investment in Non-IT equipment was negative for most years). This was resolved by constraining Non-IT equipment investment to zero.

UK

Investment series

Data series on the six asset types in both current and constant 1995 prices were constructed by industry from 1948 to 2000. Investment in computing equipment and software were assumed to begin in 1959, otherwise series were constructed for the entire sample period. The starting point were unpublished series by industry from the Office of National Statistics (ONS) which underlie their PIM estimates, and which contain data for three asset types: structures, plant & machinery and vehicles. Plant & machinery includes computing equipment and communications equipment but not software.

Industry estimates of investment in all three ICT components were based on information on capital formation from input-output tables for selected years, with linear interpolation used to complete any missing years. This started with series for nominal investment in ICT for the total economy showing separately computers, software and communications equipment, and aggregate series on investment by industry from 1948 to 1999. The nominal aggregate series for computers and communications equipment were those reported in Oulton (2001) from 1974 onwards. Software is also based on Oulton's time series but the level in 1999 was derived in a different way using data on software sales from *The Computer Services Survey (SERVCOM feasibility Survey) - data for 2000* (ONS, 2001), and adjusting for net exports and consumer spending on software. These three series were backdated to 1960 employing data on production and trade.

For each industry its share of total aggregate investment in ICT assets was estimated using 1992-1998 input output tables and data from investment surveys for 1999 and 2000. For prior years ICT shares were calculated by interpolating between periodic input output tables. Industry shares of investment in the three ICT assets were then applied to the aggregate series for the three types of ICT to yield industry nominal investment series. Full details of the method and additional sources are given in O'Mahony and de Boer (2001).

Labour quality

The UK's labour force survey (LFS) contains matched information on wages and skill categories for labour force groups from 1992 onwards. Before 1992 wage data were not available so the LFS employment series were linked to wage trends from the General Household Survey. Further details on the construction of this dataset are available in Mason *et al.* (2003).

US

Investment series

Data series on the six asset types in both current and constant prices were constructed by industry from 1901 to 2001. A two-stage procedure is used in which first total investment series for 57 industries are constructed, which subsequently are broken down into the six asset types. To derive total investment series by private industry, data is used from the National Income and Product Accounts (NIPA) on gross fixed capital formation (which contains data from 1901 onwards for 62 industries). This information was supplemented with investment data from the *NBER Manufacturing Industry Database* (data available from 1958 onwards), the *Annual Survey of Manufacturers 2001* and the *BEA Capital Flow Tables* for 1982 and 1992. The additional information was needed to match the 62 NIPA industries with the industries used in the 56-industry database.[88]

The BEA also provides a dataset on private investment by industry and type which covers the 1901-2001 period. Total investment both by industry and by asset type is consistent with the more aggregated NIPA tables. The BEA distinguishes 62 asset types for 62 industries. The first step aggregates the 62 asset types to six types.[89] Since the BEA table contains more detail in some industries than required for this purpose, the 62 industries were aggregated to 40. For each of the 56 industries, the asset investment composition of the appropriate BEA 40-industry classification was used. So, for example, the computer industry gets the same asset composition as other industrial machinery.

Government investment is contained in separate NIPA tables. Although the NIPA classify a wide range of defense purchases as investment, most were excluded to ensure consistency with national accounts in other countries and the SNA93. This means ‘destructive’ assets such as planes and tanks are excluded while ‘dual-use’ assets like military hospitals are included. The asset composition of government investment is less extensive than for other industries so one can only separately distinguish non-residential and other investment. The asset composition from other non-market services (health and education) is applied to break the ‘other’ investment down into non-IT equipment, transport equipment, IT-equipment, communication equipment and software.

The final step is to aggregate across the 56 industries to arrive at the 26-industry classification. In all aggregation steps current investment was summed and Törnquist aggregation was used to obtain the investment deflators.

Labour quality

Skill shares in total employment by industry and relative wage levels are derived from the US Current Population Survey (CPS). Crucially for the purposes of this report, the CPS contains matched information on wages and skill categories for labour skill groups. The

88 Additional data is used to reallocate the computer industry from machinery to electrical and electronics, to move restaurants out of retail trade and combine it with hotels and to reallocate radio and TV broadcasting from communications to community, social and personal services. This does not resolve all classification problems but it solves the most pressing ones. For some industries not separately identified in NIPA, extrapolations had to be made for the period before 1958. However, these extrapolations will not generally have a large impact as they mostly involve the pre-1958 period and industries like computers, which were marginal before that data.

89 Ideally the 62 assets should be aggregated using capital stocks and type-specific rental prices. For the moment, however, current investments were simply summed and Törnqvist aggregate the investment deflators across asset types.

CPS data set extends back to 1976, although adjustments were required to yield series based on consistent definitions throughout. For example, years of education was replaced in 1992 by variables that were a mixture of attainment and qualifications. So use was made of a matrix that had both series for an overlapping survey. Further details on the construction of this dataset are available in Mason *et al.* (2003).

Other sources

Output at constant prices, labour input and labour compensation are derived from the 56-Industry Labour Productivity Database.

EU aggregation

EU aggregates are all made using Törnqvist aggregation across countries

C. Manufacturing Productivity and Unit Labour Cost database for the European Union and the US

Introduction

This database consists of unit value ratios for 20 manufacturing industries for 14 countries in the European Union and the US for 1997 to allow for comparisons of output, productivity and unit labour cost across countries. They have been derived using the industry-of-origin approach developed in the International Comparisons of Output and Productivity (ICOP) project at the University of Groningen since 1983.[90] Unit value ratios are industry-specific conversion factors derived on the basis of relative producer prices and as such have important advantages over alternatives like the use of exchange rates or PPPs derived from the expenditure side in the International Comparisons Project (ICP).[91] The list of manufacturing industries covered is provided in Table VII.6.

Sources

To derive unit values for 14 European countries use is made of the data for 1997 from Eurostat PRODCOM database.[92] The use of this database has significant advantages over earlier ICOP comparisons between European countries, as products are now recorded on

[90] See http://www.ggdc.net/dseries/icop.html

[91] As expenditure represents not only the production value of the industry in question but also the added value of industries further down the chain, these PPPs require adjustment for taxes and trade and transport margins. While these margins can be 'peeled off', this does not solve all problems. Firstly, at industry level, expenditure PPPs also need to be adjusted to exclude the relative prices of imported goods and include the relative prices of exported goods. Secondly, and most importantly, expenditure PPPs exclude price ratios for intermediate products, which account for a substantial part of output in manufacturing. See van Ark and Timmer (2003) for an elaborate discussion.

[92] Due to the small number of observations, Luxembourg has been excluded in the analysis.

Table VII.6

Manufacturing Industries covered in UVR database

	Industry Name	ISIC rev 3
1	**Food, drink & tobacco**	15-16
2	**Textiles**	17
3	**Clothing**	18
4	**Leather and footwear**	19
5	**Wood & products of wood and cork**	20
6	**Pulp, paper & paper products**	21
7	**Printing & publishing**	22
8	**Chemicals**	24
9	**Rubber & plastics**	25
10	**Non-metallic mineral products**	26
11	**Basic metals**	27
12	**Fabricated metal products**	28
13	**Mechanical engineering**	29
14	**Office machinery**	30
15	**Electrical machinery nec**	31
16	**Radio, television and communication equipment**	32
17	**Instruments**	33
18	**Motor vehicles**	34
19	**Other transport equipment**	35
20	**Furniture, miscellaneous manufacturing; recycling**	36-37

the basis of a common classification. This significantly increased the number of product matches that can be made between countries. The physical volume and value of production are recorded in the PRODCOM list for more than 4,000 detailed products. The products are classified using the same coding as for the NACE Rev. 1 classification of economic activities. The first six digits of the product code are the CPA code (Community Classification of Products by Activity), while the last two digits show the classification of a heading within this CPA heading. The first four digits of the code correspond to the classes of NACE Rev. 1. The value of production sold is calculated on the basis of the 'ex-works selling price' obtained during the reporting period. It also includes packaging costs, even if they are charged separated. Turnover taxes, consumer taxes, separately charged freight costs and any discounts granted to customers are not included in the value of production. The PRODOCM statistics normally cover all undertakings/local units, which manufacture products contained in the PRODCOM list. The list does not include the products of manufacture of coke and refined petroleum products and recycling (Divisions 23 and 37 of NACE Rev. 1).

The PRODCOM database needed to be somewhat cleaned up before starting computations. By comparing quantities and unit values across countries outliers have been removed, or obvious mistakes in the original dataset corrected. Also products with output-quantity observations for only one country have been removed. In the final data set, in total 2,408 products had an output and quantity observation for at least two countries. The distribution of these observations across industries is rather uneven. While the coverage of output in sectors like food and chemical products is very high (frequently more than 50 products covering more than 30% of produced output), coverage for sectors producing machinery and electronics is much less for most countries (see Table VII.7).

In contrast to earlier ICOP studies, that are usually done on a binary basis between two countries, PRODCOM allows the construction of multilateral unit value ratios (UVRs) for the European Union (see below). To allow for comparisons with the United States, a binary comparison between Germany and the US has been made for 1997. Comparisons of EU countries with the US are made through Germany as the link country. This binary comparison is based on data from the manufacturing census in both countries. In total data for 516 manufacturing products have been used for the binary match with the US covering about 25% of total manufacturing output in both countries (see Table VII.8).

Methodology

By dividing value of production by quantities, unit values are derived. These unit values can be considered as an average price, i.e., averaged throughout the year for all producers and across a group of nearly similar products. Subsequently products with similar product codes are matched. For each matched product, the ratio of the unit values in both countries is taken. This unit value ratio (UVR) indicates the relative producer price of the matched product in the two countries. Product UVRs are used to derive an aggregate UVR for industries (see also van Ark and Timmer, 2001).

For the European countries multilateral UVRs are derived using the Elteto-Koves-Szulc (EKS) method. This method is designed to construct transitive multilateral comparisons from a matrix of binary/pairwise comparisons which have been derived using a formula which does not satisfy the transitivity property. The EKS method in its original form uses the binary Fisher PPPs between country j and k (F_{jk}: j,k=1,..M) as the starting point. The computational form for the EKS index is given by

$$EKS_{jk} = \prod_{l=1}^{M} [F_{jl} \cdot F_{lk}]^{1/M} \qquad \text{(VII.11)}$$

The formula defines the EKS index as an unweighted geometric average of the linked (or chained) comparisons between countries j and k using each of the countries in the comparisons as a link. The EKS method in (VII.11) produces comparisons which are transitive, that is a direct comparison I_{jk} should result in the same measure as an indirect comparison between j and k through a link country ℓ. Since the Fisher index is considered to be ideal and possesses a number of desirable properties, the EKS method has a certain appeal since it preserves the Fisher indices to the extent possible, while constructing multilateral index numbers.

The Germany-US UVRs are of a bilateral nature and are constructed according to the standard ICOP-methodology (see van Ark and Timmer 2003). The results are given in Table VII.8.

Results

In Table VII.9 the multilateral unit value ratios for the 14 European countries are given for the year 1997. Prices of all countries have first been converted to euros using conversion rates given in Table VII.10. Germany is taken as the benchmark country which means that the UVRs of all other countries are expressed relative to Germany.[93] If for a particular sector a country has a lower UVR than another country this means that prices in this sector are lower. For example, the lowest producer prices for food are found in Spain (0.90), while the highest prices for food are found in Greece (1.22, which is about 35% higher).

Unit labour costs

Estimates of unit labour cost trends are regularly published by statistical agencies such as the BLS for a large number of industrialised countries and by Eurostat for the EU member states. Comparisons of unit labour costs levels across countries are much less frequently made, primarily because suitable conversion factors for sectoral output are often not available. The manufacturing unit value ratios derived in this study can be used to overcome this problem.[94] Unit labour cost in country U in national prices ($ULC^{U(U)}$) can be written as

$$ULC^{U(U)} = \frac{LC^{U(U)}}{Y^{U(U)}} \qquad \text{(VII.12)}$$

where $LC^{U(U)}$ is the labour cost per employee in country U in domestic prices, $Y^{U(U)}$ is output per person employed in country U at domestic prices.[95] Using the UVRs, unit labour cost of country X can be expressed in prices of country U ($ULC^{X(U)}$) as follows:

$$ULC^{X(U)} = \frac{LC^{X(X)}/ER^{XU}}{Y^{X(X)}/UVR^{XU}} \qquad \text{(VII.13)}$$

where $LC^{X(X)}$ is the labour cost per employee in country U in domestic prices, $Y^{X(X)}$ is output per person employed in country U at domestic prices, ER^{XU} is the exchange rate between country X and U and UVR^{XU} is the unit value ratio between country X and U. By

93 Note that due to the multilateral nature of the dataset, this choice does not affect the results. Any other country can be used as benchmark as well.

94 See, for example, van Ark (1996).

95 Alternatively one can divide the numerator and denominator by hours worked. In that case unit labour cost is written as a ratio of labour cost per hour worked and labour productivity (output per hour worked).

dividing through the unit labour costs in country U at country U prices ($ULC^{U(U)}$), relative unit labour costs between country X and U ($RULC^{XU}$) for a particular benchmark year can be derived:

$$RULC^{X(U)} = \frac{ULC^{X(U)}}{ULC^{U(U)}} \qquad \text{(VII.14)}$$

This benchmark is extrapolated through time using national trends in unit labour costs.

Hedonic UVRs for motor vehicles

It is well known that characteristics and quality of cars differ across countries. The product classification in PRODCOM is not detailed enough to pick up these differences. Therefore use is made of UVRs for car production derived by van Mulligen (2003) who uses a hedonic approach in which various car characteristics are taken into account. The hedonic unit values are available for France, Germany, Italy and UK.

Table VII.7

Descriptive statistics of multilateral dataset based on PRODCOM, 1997.

	Maximum Coverage rate													
	Belgique/ België	Danmark	Deutsch-land	Ellada	España	France	Ireland	Italia	Neder-land	Österreich	Portugal	Suomi/ Finland	Sverige	United Kingdom
15-16	0.36	0.69	0.58	0.36	0.49	0.67	0.56	0.63	0.51	0.46	0.53	0.51	0.59	0.67
17	0.10	0.38	0.35	0.20	0.41	0.13	0.31		0.35	0.13	0.28	0.40	0.20	0.60
18	0.12	0.99	0.28	0.29	0.75	0.19	0.41		0.30	0.62	0.48	0.52	0.15	0.72
19		0.98	0.33	0.33	0.26	0.49	0.15	0.23	0.37	0.64	0.49	0.39	0.19	0.53
20	0.36	0.07	0.33	0.11	0.18	0.40	0.11	0.34	0.08	0.49	0.42	0.42	0.69	0.13
21	0.16	0.15	0.42	0.42	0.31	0.32	0.17	0.37	0.20	0.20	0.26	0.37	0.50	0.29
22	0.26	0.00	0.37	0.03	0.35	0.46	0.10	0.22	0.39	0.29	0.17	0.24	0.44	0.49
24	0.21	0.18	0.16	0.33	0.26	0.20	0.01	0.23	0.12	0.12	0.22	0.10	0.11	0.25
25	0.12	0.04	0.37	0.13	0.27	0.47	0.15	0.26	0.03	0.26	0.18	0.00	0.10	0.14
26	0.33	0.34	0.43	0.45	0.48	0.39	0.44	0.43	0.40	0.37	0.50	0.06	0.29	0.51
27	0.08	0.07	0.40	0.33	0.30	0.26	0.05	0.34	0.11	0.15	0.37	0.08	0.06	0.29
28	0.26	0.03	0.34	0.16	0.28	0.08	0.29	0.21	0.05	0.34	0.29	0.07	0.08	0.22
29	0.04	0.09	0.17	0.12	0.24	0.05	0.06	0.19	0.04	0.08	0.10	0.07	0.08	0.15
30		0.02	0.17				0.38	0.00				0.44	0.04	0.16
31	0.04	0.03	0.22	0.44	0.26	0.00	0.17	0.12	0.08	0.23	0.63	0.13	0.18	0.16
32	0.04	0.33	0.26	0.00	0.21			0.11	0.01	0.01		0.08	0.01	0.12
33		0.21	0.13	0.00	0.21	0.06	0.35	0.14	0.01	0.09	0.27	0.02	0.02	0.14
34	0.50	0.36	0.15	0.05	0.47	0.45	0.08	0.12	0.07	0.10	0.02	0.33	0.04	0.55
35	0.03	0.07	0.03	0.00	0.06	0.01	0.00	0.09	0.09		0.03	0.02	0.04	0.02
36	0.35	0.26	0.47	0.24	0.31	0.04	0.13	0.27	0.12	0.13	0.31	0.23	0.26	0.23

Table VII.7 continued…

Descriptive statistics of multilateral dataset based on PRODCOM, 1997.

Maximum Number of Matches

	Belgique/ België	Danmark	Deutsch-land	Ellada	España	France	Ireland	Italia	Neder-land	Österreich	Portugal	Suomi/ Finland	Sverige	United Kingdom
15-16	96	155	174	117	172	173	75	174	117	101	122	103	82	139
17	25	19	84	33	84	37	12	0	19	21	54	25	5	82
18	38	99	82	108	114	30	34	0	24	63	114	67	8	108
19	0	13	17	20	16	23	2	17	4	6	23	4	2	21
20	16	8	30	17	31	29	6	26	2	25	31	12	17	16
21	6	19	39	11	32	33	2	39	8	6	17	20	19	24
22	9	3	15	6	16	14	10	16	9	10	16	11	6	14
24	49	66	89	44	109	101	13	109	42	24	51	25	25	105
25	13	11	43	8	43	39	8	39	4	15	19	1	9	26
26	16	21	50	12	52	42	7	52	11	22	33	11	12	40
27	13	8	74	14	41	56	2	74	10	15	14	6	9	60
28	24	7	86	27	86	34	14	66	6	39	48	7	12	35
29	7	48	130	30	112	32	11	130	11	14	43	14	12	97
30	0	1	3	0	0	0	3	1	0	0	0	1	1	3
31	4	9	44	12	44	2	5	27	10	15	11	8	7	31
32	2	9	10	1	11	0	0	12	1	1	0	2	1	12
33	0	12	31	1	15	11	3	24	1	1	5	3	3	31
34	2	6	14	3	14	8	3	14	3	4	4	3	5	11
35	1	4	6	1	5	1	1	6	2	0	6	2	3	6
36	17	19	41	17	39	11	10	41	13	18	30	12	12	32

Note: maximum coverage ratio for a country indicates the highest coverage ratio in binary comparisons with other countries. Idem for maximum number of matches.

Source: Eurostat, Prodcom 1997.

Table VII.8

Binary comparison US and Germany, manufacturing industries for 1997.

	Number of UVRs (%)	Cover Ratio US (%)	Cover Ratio German	US$/Euro Laspeyres UVR	US$/Euro Paasche UVR	US$/Euro Fisher UVR
Food And Kindred Products	132	61.9	65.4	1.09	1.36	1.22
Textile Mill Products	25	53.8	49.5	0.69	0.83	0.76
Wearing Apparel	39	73.4	40.5	0.54	0.60	0.57
Leather Products And Footwear	12	61.7	31.2	0.88	0.92	0.90
Wood Products	13	30.8	51.8	0.93	1.08	1.00
Paper Products	18	47.9	61.4	1.14	1.22	1.18
Printing & Publishing	1	1.1	0.2	2.12	2.12	2.12
Chemicals & Allied Products	59	17.5	12.9	1.10	1.04	1.07
Rubber And Plastic Products	4	22.9	7.4	0.98	1.11	1.04
Non-Metallic Mineral Products	23	28.5	22.0	1.26	1.42	1.34
Basic Metal Products	43	69.6	71.3	1.12	1.25	1.18
Fabricated Metal Products	11	3.7	6.5	1.24	1.35	1.30
Machinery & Equipment	53	14.8	13.9	0.95	1.04	0.99
Automotive	5	28.8	39.4	0.87	0.90	0.88
Other transport	1	2.8	6.4	1.88	1.88	1.88
Office and computing machinery	6	44.0	38.3	1.09	1.24	1.16
Electric apparatus, nec	18	41.5	15.1	0.78	1.22	0.98
Radio, TV and communication equipment	17	9.3	16.9	0.84	0.96	0.90
Professional goods	16	3.2	14.0	1.52	1.72	1.62
Furniture And Fixtures and Miscellaneous	20	16.2	23.6	1.01	1.14	1.08
Total manufacturing	516	27.6	27.9	1.09	1.13	1.11

Source: based on German and US census of manufacturing

Table VII.9

Unit value ratios for manufacturing industries in EU countries and US, Germany = 1, 1997

	Belgique/ België	Danmark	Deutsch-land	Ellada	España	France	Ireland	Italia	Neder-land	Österreich	Portugal	Suomi/ Finland	Sverige	United Kingdom	US
15-16	0.97	1.04	1.00	1.22	0.90	1.13	1.06	0.99	0.94	1.12	1.01	1.08	1.13	1.20	1.22
17	0.86	0.85	1.00	0.75	0.70	0.96	0.81	*0.54*	0.91	1.04	0.67	0.86	0.99	0.92	0.76
18	0.85	0.82	1.00	0.74	0.62	1.05	0.79	*0.54*	0.68	1.03	0.66	1.00	1.10	0.85	0.57
19	*0.85*	0.86	1.00	0.83	0.51	0.75	0.93	0.54	1.33	1.04	0.55	1.07	0.88	0.76	0.90
20	0.91	0.99	1.00	0.79	0.69	0.80	1.03	0.71	0.91	1.04	0.71	0.83	0.88	1.05	1.00
21	1.04	0.89	1.00	1.18	0.87	1.02	0.91	0.94	0.97	0.97	0.91	0.92	0.85	1.18	1.18
22	0.88	0.84	1.00	0.69	0.73	1.05	1.46	0.79	1.07	0.96	0.74	0.81	1.25	0.87	*1.18*
24	0.90	1.02	1.00	0.95	0.75	0.96	1.08	0.84	0.86	1.08	0.89	0.97	0.95	1.03	1.07
25	0.72	0.81	1.00	0.66	0.67	0.88	0.91	0.59	0.70	0.88	0.66	0.89	0.90	0.79	1.04
26	0.80	1.12	1.00	0.71	0.67	0.94	0.91	0.68	0.88	1.07	0.73	0.92	1.27	0.95	1.34
27	1.11	1.02	1.00	0.91	0.83	1.01	1.07	0.77	0.99	1.05	0.80	1.02	1.14	1.13	1.18
28	0.83	1.27	1.00	0.68	0.74	0.82	0.64	0.71	0.80	1.13	0.73	0.89	0.96	0.87	1.30
29	0.79	1.02	1.00	0.81	0.85	0.95	0.86	0.83	0.75	1.44	0.76	0.91	0.97	1.01	0.99
30	*0.79*	1.21	1.00	*0.81*	*0.85*	*0.95*	1.33	1.06	*0.75*	*1.44*	*0.76*	1.15	0.94	1.01	1.16
31	0.95	0.75	1.00	0.78	0.80	0.86	*0.84*	0.70	1.19	0.93	0.85	0.82	1.03	0.92	0.98
32	1.44	1.63	1.00	1.27	1.35	*0.86*	*0.84*	1.19	1.31	1.22	*0.85*	1.38	1.41	1.44	0.90
33	*0.95*	1.02	1.00	1.06	0.83	0.88	0.96	0.91	1.24	1.18	0.88	0.92	0.83	0.85	1.03
34	0.93	0.91	1.00	0.96	0.71	1.06	1.01	0.78	0.83	1.14	0.79	0.98	1.31	1.13	0.68
35	0.70	1.06	1.00	0.83	0.74	0.88	0.77	0.70	0.92	*1.14*	0.90	0.85	1.13	0.47	*0.68*
36	0.87	0.69	1.00	0.89	0.67	1.15	0.99	0.75	1.08	1.18	0.81	0.72	0.83	0.73	1.08

Note: Figures in italics are entries for which no reliable estimates could be made. Instead a unit value ratio of a closely related industry is taken.

Source: EU unit value ratios are multilateral ones (EKS) derived from Eurostat, PRODCOM database. US is based on binary comparison with Germany on basis of manufacturing censuses. US/Germany PPP for industry 33 based on 1999 EKS ICP PPP for instruments from OECD.

Table VII.10

Conversion exchange rates (national currency per Euro) as of 1999

Austria	13.76
France	6.56
Germany	1.96
Ireland	0.79
Italy	1,936.27
Netherlands	2.20
Spain	166.39
Finland	5.95
Sweden	8.81
Denmark	7.44
Belgium	40.34
Portugal	200.48
Greece	340.75
UK	0.66
Luxemburg	40.34

Note: For Denmark, Sweden and the UK the Euro conversion rates are the 1999 yearly average exchange rates between the national currency and the Euro, for the other countries the official conversion rate is given.

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