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Mapping R&D Investment by the European ICT Business Sector

Sven Lindmark, Geomina Turlea, Martin Ulbrich

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Preface

In today's society growth and jobs are strongly dependent on progress in science and technology. The target of 3% GDP investment in R&D for the EU was included in the Lisbon strategy in 2002. This target is an overall target for all the R&D sectors in Europe, but R&D policies are often sector specific and closely linked to innovation systems. It is therefore of utmost interest to analyse the contribution of the individual sectors, to detect the specific challenges and support evidence-based policy-making. Until now, very little systematic effort has been devoted to gathering and analysing internationally comparable data on R&D expenditures. For ICT, a key sector of the economy, these studies are of crucial importance.

This report presents the results of a study carried out by the Joint Research Centre's (JRC) Institute for Prospective Technological Studies (IPTS) at the request of the European Commission's DG Information Society & Media (DG-INFSO). The study has produced an in-depth analysis of business sector investment in ICT R&D. It has also made a preliminary analysis of the Member States innovation systems related to ICT. The data and the conclusions represent a unique source of information for key stakeholders and analysts in industry, government and academia.

The study has shown that the ICT business sector is the largest R&D investing sector in Europe, ahead of the automotive and pharmaceutical industries, contributing just above 26% of the business R&D investments of all economic sectors combined. Even so, the EU's ICT business sector spends about 50% less on R&D than the US, not only in absolute amounts, but also as share of GDP. Indeed of all economic sectors, the ICT sector is by far the biggest contributor to the R&D gap between the EU (1.19% GDP) and the US (1.88% GDP). These findings underline how essential such study is for European policy-making.

The ICT business sector's R&D gap has two aspects: first, the ICT business sector is a smaller part of the economy in the EU than in the US, and second it shows a lower BERD intensity (business R&D/value added) in the EU as compared to the US.

These observations vary largely when looking at company or country data: the R&D intensity of the individual ICT companies in Europe is fully comparable to the investment of companies that are active in the US. Europe's weakness is to be found in its difficulty to make innovative SMEs in the ICT sector grow and become world leaders. Among EU Member States Finland and Sweden host the highest R&D effort in the ICT sector, relative to the size of their economies. In general, Northern Member States show higher ICT sector R&D intensities than Southern Member States, and the former EU15 Member States have a much higher intensity than the more recently integrated EU10, which display very low absolute levels by contributing only around 1% of the EU total ICT Business Expenditure on R&D.

Establishing a time-series monitoring of the private investment in ICT R&D, remains on the common agenda of DG INFSO and the JRC. This report is the first of a series which will also expand into looking at the EU 27, at the public investment in ICT R&D, at ways to measure outcome and at investments done in competing countries. The successive reports will significantly deepen our understanding of the ICT sector's dynamics and of the role that R&D plays within it.

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Director General
Joint Research Centre

Fabio Colasanti
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Executive Summary

This report sets out the main findings of a study on Business Expenditure on Research and Development (BERD) in the EU Information and Communication Technology (ICT) sector. This study provides the first comprehensive overview of the available data in this respect.

The policy context

Information and Communication Technologies (ICT) are considered to be among **the key enabling technologies of the 21st century** for support to the Lisbon Strategy[1] and sustainable development. However, the data on R&D expenditure in these key technologies are often partial and lack coherence. As a result, policy makers have no detailed factual assessment of sufficient quality on which to base decisions.

Considering this background, and in response to a request from the Directorate General Information Society of the European Commission, the Joint Research Centre (JRC) carried out a study to assess available data and improve their coherence and quality. The study was designed to provide input for reflection on the role of R&D in ICT in the renewed Lisbon Strategy.

The study was conducted between 2006 and 2007, and was led by the Joint Research Centre's Institute for Prospective Technological Studies[2] on behalf of, and in close collaboration with, DG INFSO Directorate C. It focuses on R&D investment in the ICT sector as defined by the OECD, and therefore does not include ICT R&D carried out in other sectors of the economy.

R&D in ICT: EU vs. US

The ICT business sector (i.e. ICT manufacturing and the provision of ICT services) is the largest R&D investing sector in Europe, ahead of the automotive and pharmaceutical industries.[3] It spends €32.8 billion on R&D in the EU, contributing just above 26% of all business R&D investments of all economic sectors combined.

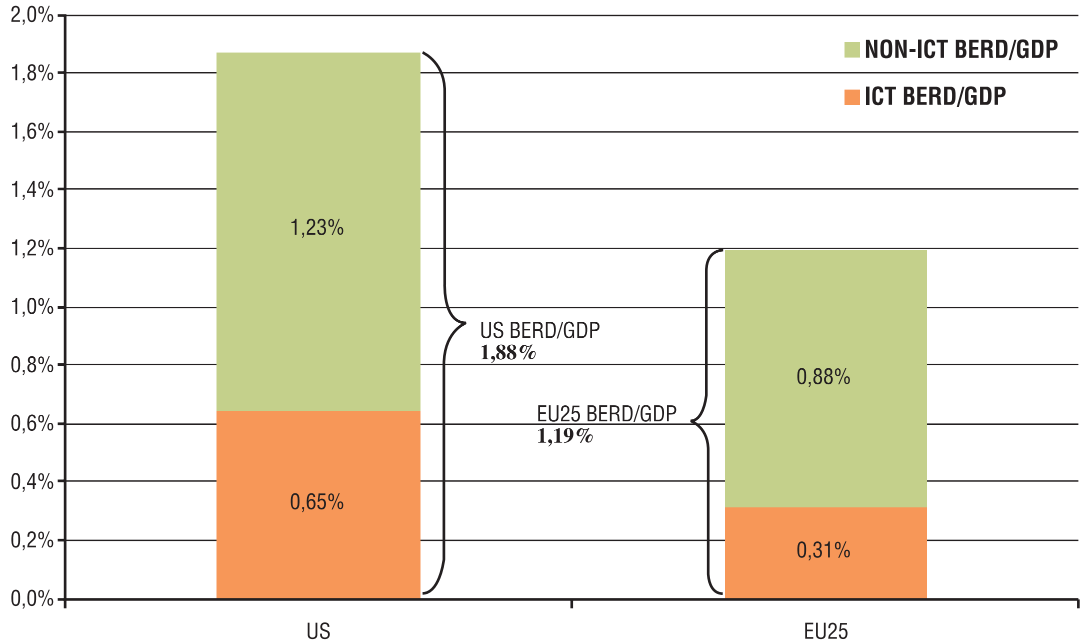
Even so, the EU ICT business sector spends only about half as much on R&D as the US, not only in absolute amounts, but also as share of GDP: whilst the US invests 0.65% of its GDP in ICT BERD, the EU spends only 0.31%. Indeed, **the ICT sector alone is responsible for as much of the economy-wide BERD investment gap between the EU (1.19% of GDP) and the US (1.88% of GDP) as all other sectors combined**. Moreover, during the period 1999-2004, growth rates were generally higher in the US than in the EU, so the ICT business sector R&D investment gap is not closing.

1 European Commission (2000) DOC/00/7: The Lisbon European Council – An agenda of economic and social renewal for Europe. Contribution of the European Commission to the special European Council in Lisbon, 23-24 March 2000; European Commission COM (2005) 24: Communication to the Spring European Council – Working together for growth and jobs – a new start for the Lisbon Strategy.

2 The Institute for Prospective Technological Studies (IPTS) is one of the seven research institutes of the European Commission's Joint Research Centre (JRC).

3 This report covers the period up to 2004, the latest year for which official data was either available from ESTAT, OECD or Member States at the time of writing, or for which it was possible to estimate data with a reasonable degree of confidence. For more, see Box 1.1.

Contribution of ICT and non-ICT sectors to total BERD intensity % of GDP, 2004



Source: JRC-IPTS based on data from Eurostat, OECD, EU KLEMS

This ICT business sector R&D gap reflects two aspects: 36% are accounted for by the fact that the **ICT business sector is a smaller part of the economy in the EU** than in the US, and 64% are accounted for by **a lower BERD intensity (business R&D/value added) of the ICT sector in the EU**. The lower R&D intensity of the sector is, in turn, primarily due to two sub-sectors: Computer Services and Software on the one hand, and Electronic Measurement Instruments on the other hand.

R&D in ICT by Member State

Among EU Member States, **Finland (1.54% of GDP) and Sweden (1.05% of GDP) host the highest R&D effort** in the ICT sector, relative to the size of their economies. In general, Northern Member States show higher ICT sector R&D intensities than Southern Member States, and the Western Member States a much higher intensity than the EU10, which display very low absolute levels by contributing only 0.8% of the EU total ICT Business Expenditure on R&D (BERD).

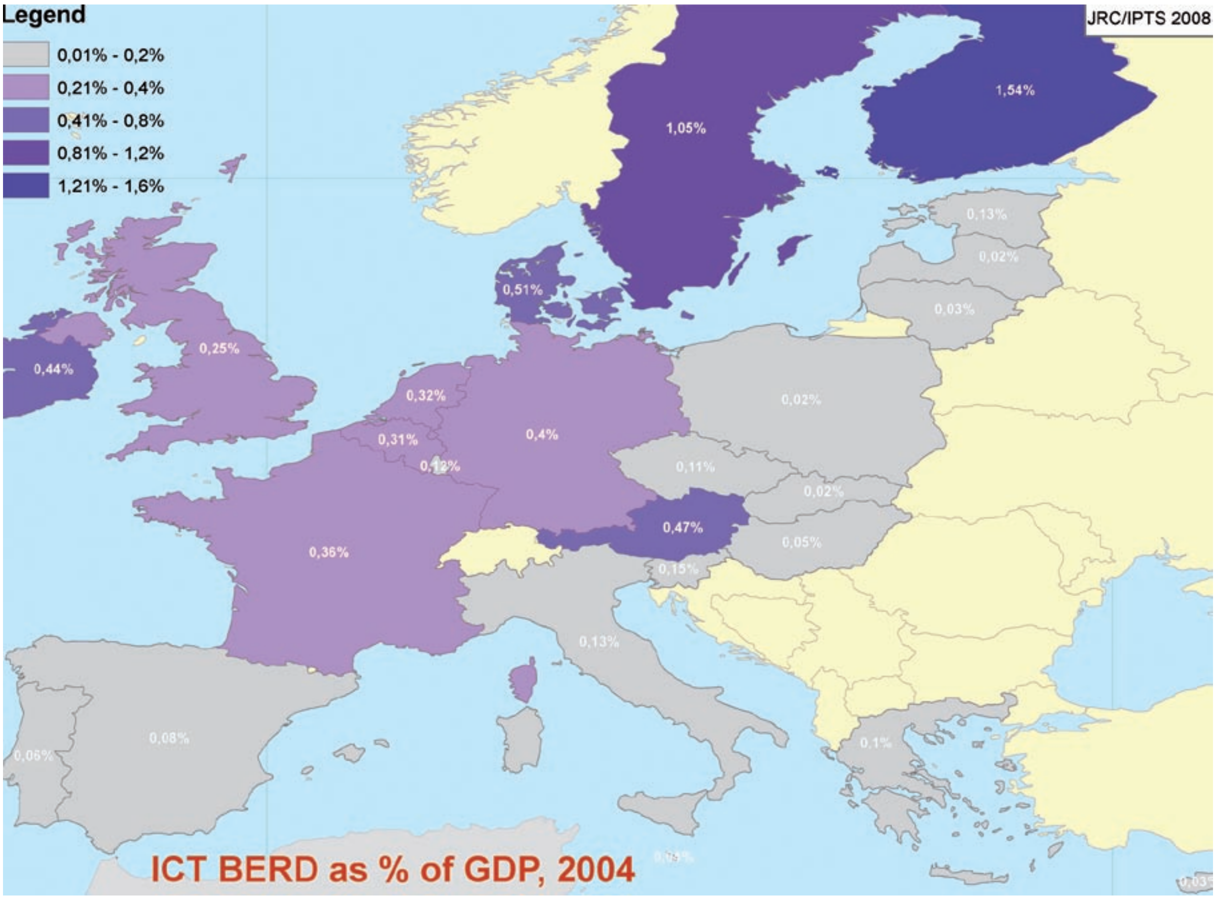
The following map shows business expenditure on ICT R&D divided by GDP in the EU Member States.

R&D in ICT by sub-sector

R&D intensities (BERD divided by Value Added) are highest in Telecom Equipment, followed by IT Components, Electronic Measurement Instruments, IT Equipment, and finally by Multimedia Equipment. The two services sectors, Telecom Services and Computer Services and Software have much lower R&D intensities. However, more than a third of the ICT sector's value added is created in these services sectors, hence the absolute amounts of R&D in these sub-sectors is above several of the manufacturing sub-sectors.

Regarding development over time, it is noteworthy that **most of the growth** in business R&D is taking place in Computer Services and Software and, albeit more slowly, in the Electronic Measurement Instruments sub-sector.

ICT BERD as % of GDP, 2004



Source: JRC-IPTS based on data from Eurostat, OECD, EU KLEMS

Key figures for the ICT sub-sectors (€ billion 2004)

ICT sub-sector	Value Added	Trade balance 2005	BERD	BERD / VA (2004)	BERD average yearly growth 2000-04
IT Equipment	12,1	-40,8	2,3	18.8%	-1.5%
IT Components	17,4	-7,5	4,4	25.2%	
Telecom Equipment	19,9	-5,3	8,5	42.5%	-1.2%
Multimedia Equipment	8,1	-2,5	0,9	11.6%	
El. Measurement Instruments	25,7	6,3*	5,4	*21.4%*	5.5 %*
Telecom Services	*176*	*-0,7*	*3,0*	*1.7%*	*-1.0%*
Computer Services, Software	*185*	*6,3*	*7,1*	*3.8%*	*12.9%*
Total ICT	**444****	**-44,3***	**31,6****	**7.1%**	**2.4%****

Notes: *Includes whole ISIC 33 **Only includes ISIC 33.2/3 and 64.2. BERD is therefore slightly lower than the € 32,8 billion stated before, and BERD/VA slightly higher. See box 2-1 for ISIC groups

Source: JRC-IPTS based on EUROSTAT, OECD ANBERD, national statistics, EU-KLEMS and company annual reports.

The IT Equipment is the sub-sector where the Western Member States' industry is least competitive, at least on the price-sensitive and still growing mass market. This sub-sector has also been strongly hit by relocation. EU R&D intensity in IT Equipment stands at around 19% of value added, but this figure hides a wide variation between EU Member States. R&D intensity in the Western Member States has been growing since 1999 and seems to have reached a higher plateau in the last years while most of the R&D in the Eastern Member States comes from foreign direct investment from third countries.

With an R&D intensity at 25.2%, the IT components industry is characterised by a very high research intensity, which to date has allowed European industry to compete successfully. In other words, thanks to strong R&D efforts, European products have escaped the price competition of the mass market and competed instead on innovation and quality.

The Telecom equipment sector is Europe's traditional ICT strength. This sub-sector is also the most R&D intensive of all ICT sub-sectors. However, after reaching its peak in competitiveness due to the runaway success of the GSM standard, since 2000 its position has been eroded, following the crash of the dotcom bubble. Not only has value added decreased considerably from 2000 to 2004, R&D went down even further, resulting in a decreasing R&D intensity.

The multimedia sector is in quite a different situation. Some European producers are relatively strong in the premium segments, but this strength is overshadowed by the weakness in the mass market. Moreover, R&D by European companies has actually been shrinking rapidly for several years while non-European countries continue to increase their research.

The Electronic Measurement Instruments sub-sector is often overlooked among the ICT manufacturing sectors. However it stands out by being the only one in which EU industry has a consistent trade surplus. Much production, research and design is on demand by customers, and competitiveness advantages obtained by R&D investments are more important than lower production costs.

The R&D intensity of the Telecommunication Services is low, at around 1.7% of value added (BERD/VA) and 0.9% of turnover (BERD/turnover), and it has been declining in recent years. Still, from an international perspective, Telecom Services R&D in Europe remains rather strong, with more than half the world's expenditures, and this share is increasing.

The Computer Services and Software sub-sector is the main ICT R&D growth engine in Europe; in fact most of the BERD growth in the EU in recent years is due to this sub-sector. It can be divided into two main parts: (1) the development and production of software, and (2) the provision of computer services (often labelled IT services), where the former is very R&D intensive and the latter less so. The differences in R&D intensity and total BERD between Western Member States and Eastern Member States are not as large as for the rest of the ICT-sector. In combination with rapid growth rates, this fact suggests that software R&D could be a vehicle to establish more significant R&D capability in these countries and in the EU as a whole.

* * * * *

The present study underlines the importance of the ICT sector, responsible for 26% of business R&D investment in Europe, for the overall level of EU R&D investment, for the success of the Lisbon agenda and, ultimately, for the competitiveness of European industry. It also shows that the EU will not be able to match the US share of ICT RD investment (standing at 35% of total US BERD) unless it significantly increases the R&D effort in its ICT sector. In this context, the fact that the largest part of the gap EU/US is due to the sub-sector with the fastest-growing BERD on both sides of the Atlantic, i.e. Computer Services and Software, is rather worrying, since it implies that the gap is more likely to widen than to close.

A significant part of the ICT BERD gap is due to the smaller overall size of the ICT sector in the EU. Furthermore, most of the gap is accounted for by a lower BERD intensity (business R&D/ value added) of the ICT sector. A positive view is that the structure of the European economy, with a large number of major manufacturers in many different industries, but with a comparatively small specialised ICT-producing sector, might make us underestimate Europe's position in ICT R&D. As R&D research outside the registered ICT sector is not recorded within existing internationally agreed methodologies, the "embedded" ICT R&D might be much more important in Europe than elsewhere, resulting in a statistical undervaluation of Europe's ICT capacity. This will be further investigated by IPTS.

In the meantime, the aim of increasing EU ICT BERD to US levels cannot be only a matter of encouraging existing ICT (or even non-ICT) companies in Europe to spend more on ICT R&D. Addressing the ICT BERD gap implies fostering sufficiently attractive conditions for the establishment, growth and international development of R&D-intensive ICT activities in Europe. This, in turn, needs a wider approach than just research policy. It should also include consideration of labour and product market regulations, education, tax and infrastructure policy, etc. It is only by addressing all of these aspects together, that the economic environment for ICT companies can be improved to the point where more become large, international, R&D-intensive players.

1. Introduction

1.1 Definitions

Since 2005, the Institute for Prospective Technological Studies (IPTS)[4] has been running a research project on Research and Development (R&D) in the Information and Communication Technologies (ICT) sector in Europe. This project was launched at the request of the Directorate General Information Society (INFSO) of the European Commission. It collects and analyses data on R&D spending in the ICT industry (see Box 1-1). So far, the focus of the study has been on macro-economic data regarding Businesses Expenditure on Research and Development (BERD), which accounts for over 80% of the total R&D in the ICT sector.[5] To complement the analysis with company data, the project also uses data from the EU Industrial R&D Investment Scoreboard,[6] which tracks R&D spending by the biggest 1,000 European and non-European R&D spenders. The project covers the 25 Member States, but not, as yet, Bulgaria and Romania. ISIC/NACE data is included up to 2004, company level data up to 2005, which is the latest year for which data of reasonable quality is available.

Box 1-1 Note on data, definitions and abbreviations

R&D is defined in accordance with the OECD (Frascati manual, OECD 2002:30) as "creative work undertaken on a systematic basis in order to increase the stock of knowledge… and the use of this stock of knowledge to devise new applications."

BERD is Business Expenditure on R&D and includes all R&D carried out in the business sector (as opposed to government, higher education and private non-profit sectors) in a given country, regardless of the source of funds. The BERD data are based on data available from OECD, Eurostat and national statistical offices. Where unavailable from these sources, they have been estimated using the methodology set out in the Methodological and Technical Reports of the project, both available from the IPTS Information Society unit. Data on sectoral Value Added (VA) comes from the EU KLEMS project.*

The ICT sector refers to the "operational definition" as specified in the Frascati manual (200:188), i.e. ISIC/NACE 30, 32, 33, 64 & 72. ISIC refers to the International Standard Industrial Classification used by OECD while NACE refers to *Nomenclature générale des Activites économiques dans les Communautés Européennes* and is the European standard used by Eurostat. ICT BERD measures the R&D expenditure of companies registered in the ICT sector in each given country. It thus excludes R&D carried out by companies in other sectors, such as vehicles, even if the R&D concerns ICTs. Whenever possible, further sectoral break-down has been attempted, down to four-digit level subdivisions of the above categories (e.g. 6420 for "Telecom Services" within 64 "Post and Telecom Services")

* See http://www.euklems.net/

4 The Institute for Prospective Technological Studies (IPTS) is one of the seven research institutes of the European Commission's Joint Research Centre (JRC).

5 Part of the data collection has been carried out initially by ETEPS members: ISI-Fraunhofer, TNO, Arc Systems GmbH and Institute of Economics (Hungarian Academy of Sciences), under the REDICT Project

6 European Commission (2007a)

The secondary data set, the R&D scoreboard data, concern only the 1000 largest EU and 1000 largest non-EU R&D investors. In order to have comparable company sizes for the EU and non-EU, the 338 largest R&D investors were selected. A few companies, e.g. AT&T and Verizon were added, because they were missing from the general scoreboard due to reporting issues. The methodology for the data extracted from the EU industrial R&D Investment Scoreboard is available from http://ipts.jrc.ec.europa.eu/publications. In this data set R&D is attributed to the country of the company headquarters, regardless of where the R&D took place. For example, R&D by a Dutch company in China would be included in the figure for European companies. Further information on major companies were extracted from the AMADEUS data base (http://www.bvdep.com/en/AMADEUS.html).

R&D intensity is measured in three different ratios in this report:

1) BERD / Value Added (macro-economic data)
2) BERD / turnover (macro-economic data)
3) R&D / net sales (companies data)

Although high R&D intensity is generally regarded as positive sign of a knowledge-intensive and innovation-producing sector, this indicator should be analyzed with some caution, especially for macro-economic (national accounts) data, where high or rapidly rising R&D intensities could be the result of low or declining Value Added, in turn due to shrinking markets or relocation of value adding activities (such as production).

1.2 The structure of the report

The report is structured as follows. Chapter 2 provides an overview and an analysis of ICT R&D in the EU and compares it to the US. The European ICT R&D deficit (i.e. the fact that the EU as a whole spends relatively less than the US on ICT R&D) is introduced in Section 2.1. This deficit is then analysed in terms of R&D intensity and size of the whole ICT sector as part of the economy, and also in terms of its constituent sub-sectors, using macro-economic data (Section 2.2) and company data (Section 2.3). Section 2.4 provides an intra-European analysis on country-level. The major conclusions are summarized in Section 2.5.

The main body of the report constitutes an overview and analysis of the six ICT sub-sectors. It starts with an overview of the sub-sectors in Chapter 3, before looking at each one in turn: IT Components (Chapter 4); IT Equipment (Chapter 5); Telecom and Multimedia Equipment (Chapter 6); Electronic Measurement Instruments (Chapter 7); Telecom Services (Chapter 8) and Computer Services and Software (Chapter 9). These chapters follow the same structure. First a general economic profile of the sub-sector is presented, followed by an overview of the most important R&D activities by Member State. Each chapter ends with a summary of the main observations. Finally, the report ends in Chapter 10 with a summary of the main conclusions.

2. R&D in ICT in Europe and the US

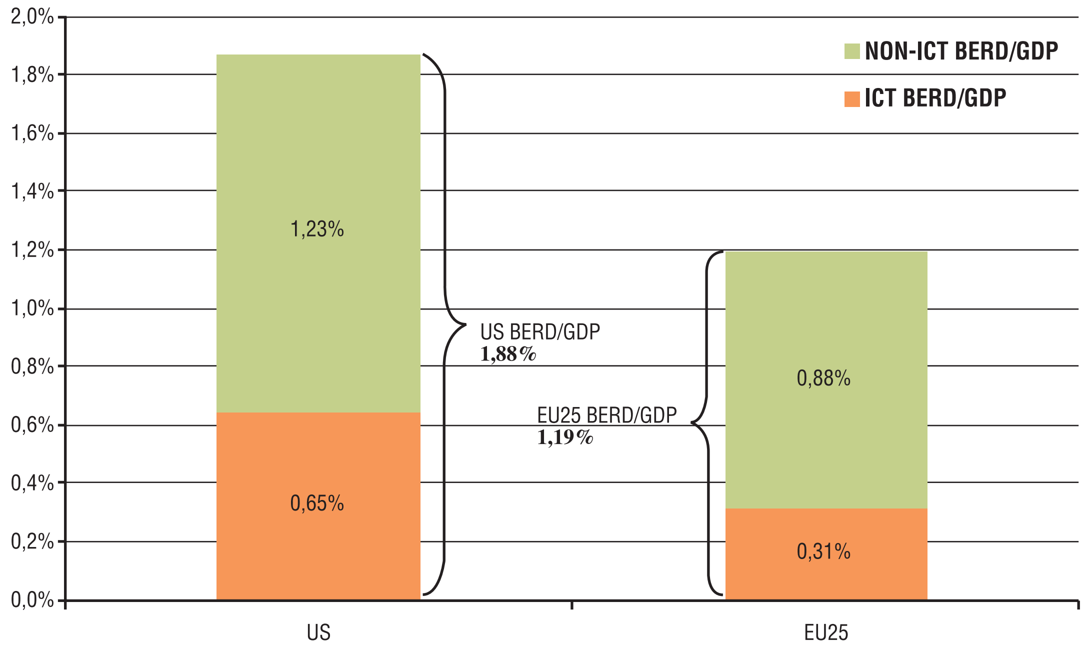
2.1 The European ICT R&D deficit

The **ICT** business sector in the EU spent € 32.8 billion on R&D in 2004. This was far below the US at € 61 billion (in PPP exchange rates[7]). These €32.8 billion invested in ICT research amount to 0.31% of EU Gross Domestic Product (GDP) (which we shall call "the contribution of ICT to total R&D intensity") whilst the € 61 billion spent in the US correspond to 0.65% of US GDP.

In 2004, the business spending on R&D in **all sectors together** amounted to 1.88% of GDP in the US (which we shall call "total R&D intensity") and to 1.19% of GDP in the EU,[8] showing a gap of 0.70%. About half of this gap (0.34%) is accounted for by the lower contribution of the ICT sector (see Chart 2-1). Whilst the contribution of all other sectors is 40% higher in the US than in the EU, the contribution of the ICT sector is more than twice as high in the US.

Recent growth of ICT BERD shows different patterns for the US and for the EU, as illustrated in Chart 2-2. Growth is more volatile in the US than in the EU. In recent years (2001-2004) the growth of the ICT BERD in the EU appears to have stagnated.

Chart 2-1: Contribution of ICT and non-ICT sectors to total BERD intensity (BERD/GDP); expressed as % of GDP (2004)

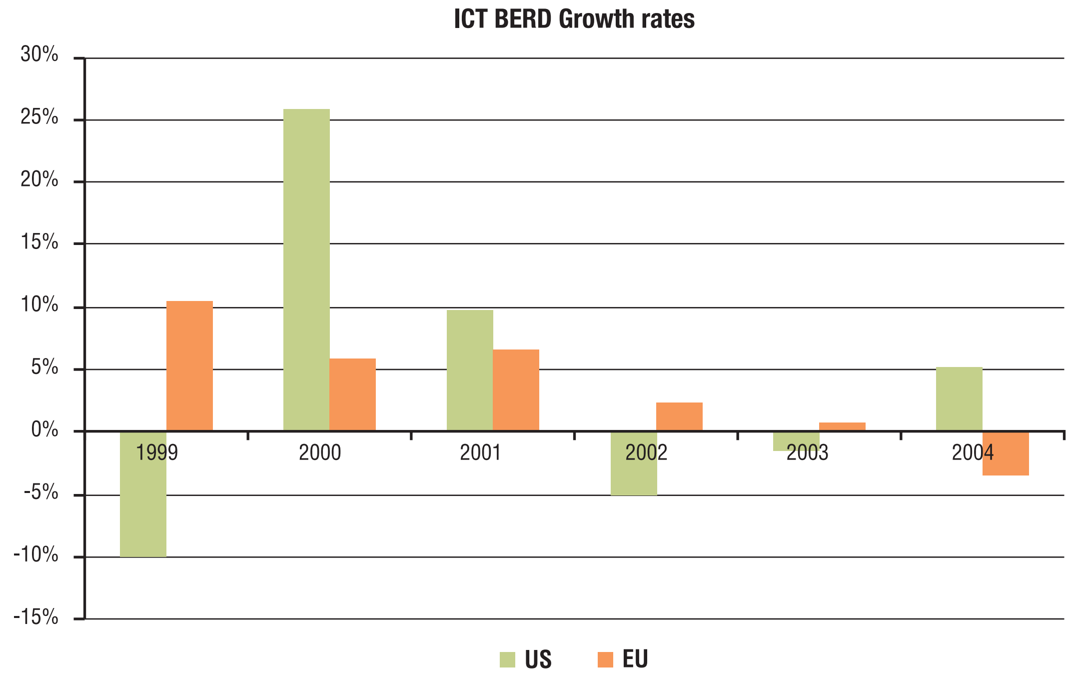


Source: IPTS based on data from Eurostat, OECD, EU KLEMS

7 PPP - Purchasing Power Parity exchange rate are used to equalize the purchasing power of different currencies in their home countries for a given basket of goods.

8 The total R&D business intensity in an economy is the sum of the BERD/GDP ratios of all economic sectors.

Chart 2-2: EU and US: ICT BERD growth trends



Source: IPTS based on data from Eurostat, OECD, EU KLEMS

2.2 The factors determining ICT R&D intensity

2.2.1 Size factor and intensity factor

This contribution of the ICT sector to total business R&D intensity can be broken down into two factors: (1) a size factor and (2) an intensity factor: a large sector will carry out more R&D than a comparable small sector, and an R&D-intensive sector will carry out more R&D than a non R&D intensive sector of the same size. To measure this, the size factor is defined as the proportion of the ICT sector value added to the total value added in the economy (which is roughly equal to GDP[9]), while the intensity factor is defined as the R&D performed in the ICT sector divided by the value added in that sector.

In mathematical terms:

$$R\&D^{ICT}/GDP = (VA^{ICT}/GDP) * (R\&D^{ICT}/VA^{ICT})$$

- $R\&D^{ICT}/GDP$ is the contribution of ICT to total R&D intensity,
- VA^{ICT}/GDP is the size of the ICT sector relative to the overall economy ("size factor"),
- $R\&D^{ICT}/VA^{ICT}$ is the R&D intensity of the ICT sector ("intensity factor").

By applying this calculation to both the EU and the US, we can identify why the ICT contribution to total R&D intensity in the US is higher than in the EU (0.65% vs. 0.31%). Table 2-1 shows that both the weight of the ICT sector and the R&D intensity of the ICT sector are higher in the US. Thus, both factors contribute to the lower ICT R&D share of the economy. However, the difference is much bigger for the ICT R&D intensity (10.4% vs. 6.5%) than for the weight of

9 The difference between GDP and the sum of sectoral value added (GVA) is the net subsidies on products – see http://www.statistics.gov.uk/articles/economic_trends/1416.pdf

Table 2-1: The ICT R&D deficit broken down into size and intensity factors

	ICT BERD in the economy ($R\&D^{ICT}/GDP$)	Size (VA^{ICT}/GDP)	Intensity ($R\&D^{ICT}/VA^{ICT}$)
US	0.65%	6.2%	10.4%
EU 25	0.31%	5.0%	6.2%

Source: IPTS estimates based on data from Eurostat, OECD, EU KLEMS

the ICT sector in the economy (6.2% vs. 5.0%). As a result, the intensity factor accounts for 64% of the gap, and the size factor for 36%.[10]

Having thus explained that the lower contribution of the ICT sector to total R&D intensity is due to both the size factor and the intensity factor, we will now look closer at these two factors. Can the data tell us why the ICT sector has a smaller weight in the economy, and why the ICT R&D intensity is lower?

2.2.2 The weight of the ICT sub-sectors

The ICT sector has a smaller weight in the EU economy than in the US economy. Is this due to any particular sub-sector of the ICT sector? If so, the structure of the ICT sector should be different: those sub-sectors which are responsible for the smaller size of the ICT sector in the EU would have a significantly smaller share in the EU ICT sector than the share of the same sub-sector in the US. If, for example, the IT Equipment sub-sector were smaller in the EU than in the US, but all the other sub-sectors were of the same relative size, then IT Equipment would be a smaller part of the ICT sector as a whole.

Chart 2-3 shows that, in terms of value added, the share of the different sub-sectors is fairly similar for EU and the US. Post and Telecom Services account for some 45% in both regions, followed by computer services at 30-35%. There are but small differences. Computer services have a slightly larger share in Europe, IT Equipment is identical, while the other sub-sectors have slightly larger shares of the US value added. A further breakdown of the Components, Telecom and Multimedia Equipment sub-sector would show (not shown in the chart) that the US has a much larger share of Components, while the EU has a larger share of Telecom- and Multimedia Equipment. Overall, however, the composition of the sector is very similar. No particular sub-sector explains the smaller size of the EU ICT sector relative to the US.

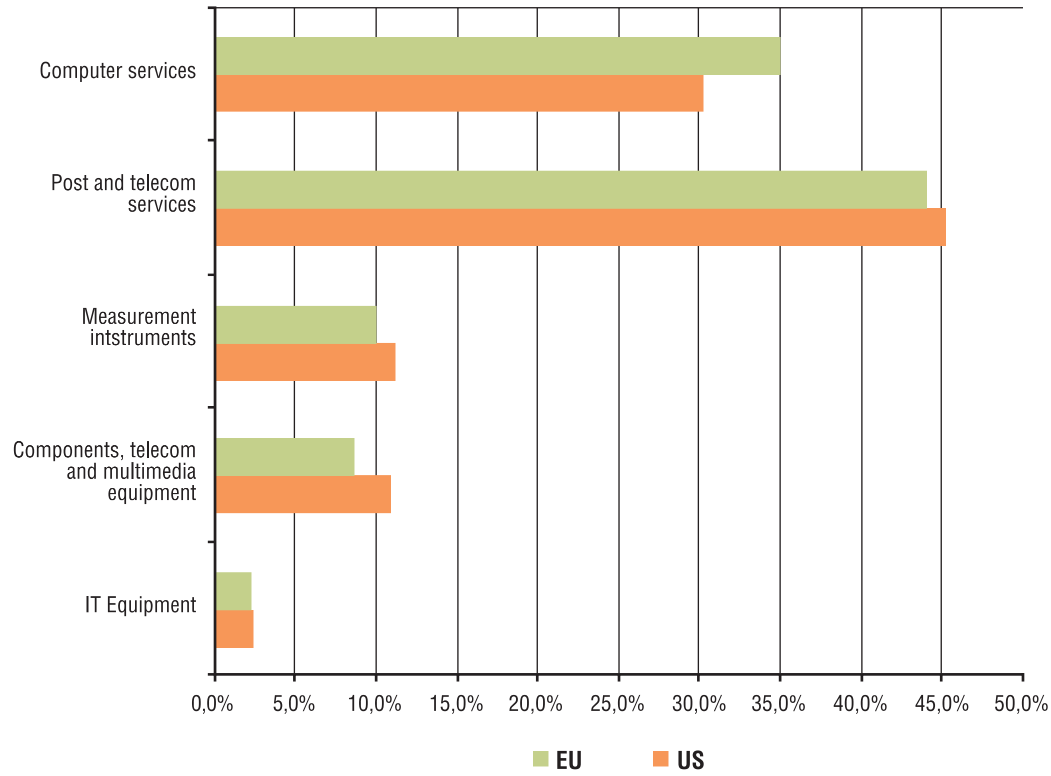
2.2.3 The R&D intensity of the ICT sub-sectors

The ICT sector has a lower R&D intensity in the EU economy than in the US economy. Is this due to any particular sub-sector of the ICT sector? If so, the responsible sub-sector should show a significantly smaller R&D intensity that the same sub-sector in the US. As illustrated in Chart 2-4, the different sub-sectors do indeed show significant differences when it comes to their respective R&D intensities:

- For IT Equipment, US national data show an R&D intensity of over 50% in the US, and lower than 20% in Europe.
- For Measuring Instruments and for Computer Services, the R&D intensity is significantly higher in the US than in the EU.
- For Components, Telecom and Multimedia Equipment, the R&D intensity is virtually the same.

10 The deficit can be calculated as = $R\&D^{ICT\ US}$ / GDPUS – $R\&D^{ICT\ EU}$ / GDP^{EU} = contribution from structural factor + contribution from intensity factor = $VA^{ICT\ US}/GDP^{US}$ ($R\&D^{ICT}$ US/$VA^{ICT\ US}$ – $R\&D^{ICT}$ EU/$VA^{ICT\ EU}$) + $R\&D^{ICT}$ EU/ $VA^{ICT\ EU}$ ($VA^{ICT\ US}/GDP^{US}$ – $VA^{ICT\ EU}/GDP^{EU}$). To calculate the percentage or contribution, these factors are divided by ($R\&D^{ICT\ US}$ / GDP^{US} – $R\&D^{ICT\ EU}$ / GDP^{EU})/100.

Chart 2-3: Sub-sectoral composition of the ICT sectors in the US and EU 25; % of sub-sectors VA in total ICT value added 2004



Source: IPTS based on data from Eurostat, OECD, EU KLEMS

- For Telecom Services, the R&D intensity is significantly higher in Europe (at a low level).

In short, the higher R&D intensity of the US ICT sector can be attributed to IT Equipment, Measurement Instruments and Computer Services and Software.

Therefore, what the macro-economic data can tell us is that no sub-sector is particularly responsible for the smaller size of ICT sector. However, three sub-sectors alone are responsible for the lower R&D intensity in Europe: IT Equipment, Electronic Measurement Instruments and Computer Services and Software. The first is a very small sub-sector with a large difference in R&D intensity, while the latter is a large sub-sector with a small difference in R&D intensity. Electronic Measurement Instruments are in-between. Due to its very small size, IT Equipment accounts for a much smaller part than the other two.

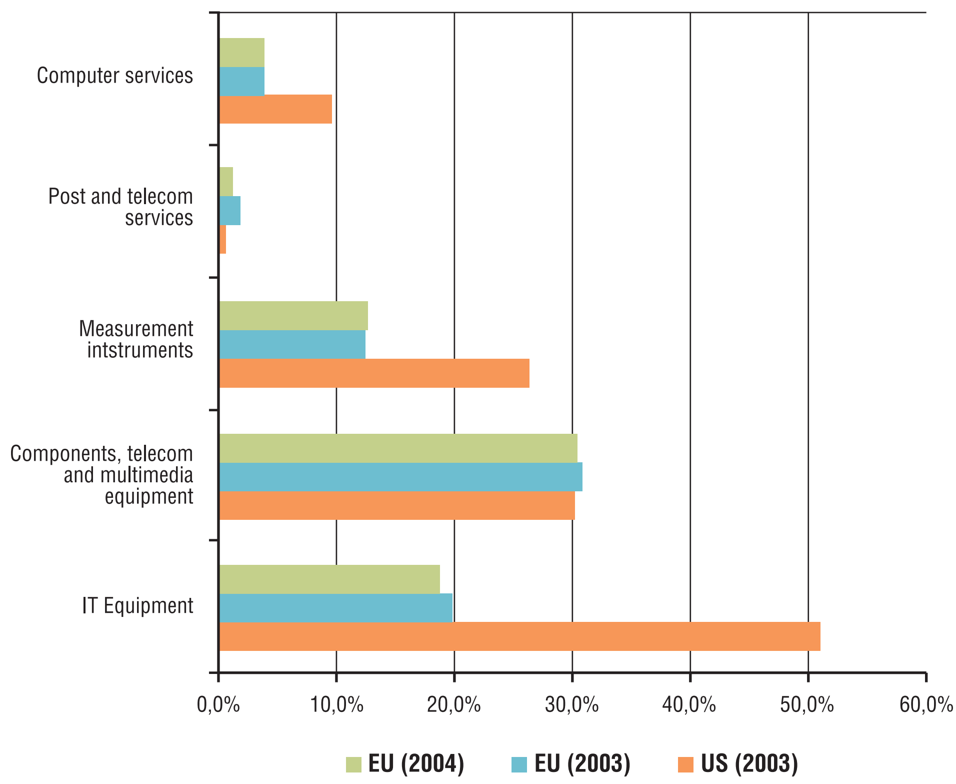
2.3 The R&D intensity of the ICT sector: company data

2.3.1 The weight of the ICT sub-sectors

Let us now have a look at the same elements, i.e. size and structure of the ICT sector and R&D intensities of the sub-sectors, but with data from the secondary data set, i.e. the company data based on the 2006 EU Industrial R&D Investment Scoreboard.[11]

11 European Commission (2007a). Company data and macro-economic data are not directly comparable; for a detailed discussion of the methodological limitations on the company data, see the Methodological Notes in the annex of the Scoreboard.

Chart 2-4: ICT sub-sector R&D intensities (BERD/VA in 2003)



Source: IPTS based on data from Eurostat, OECD, EU KLEMS

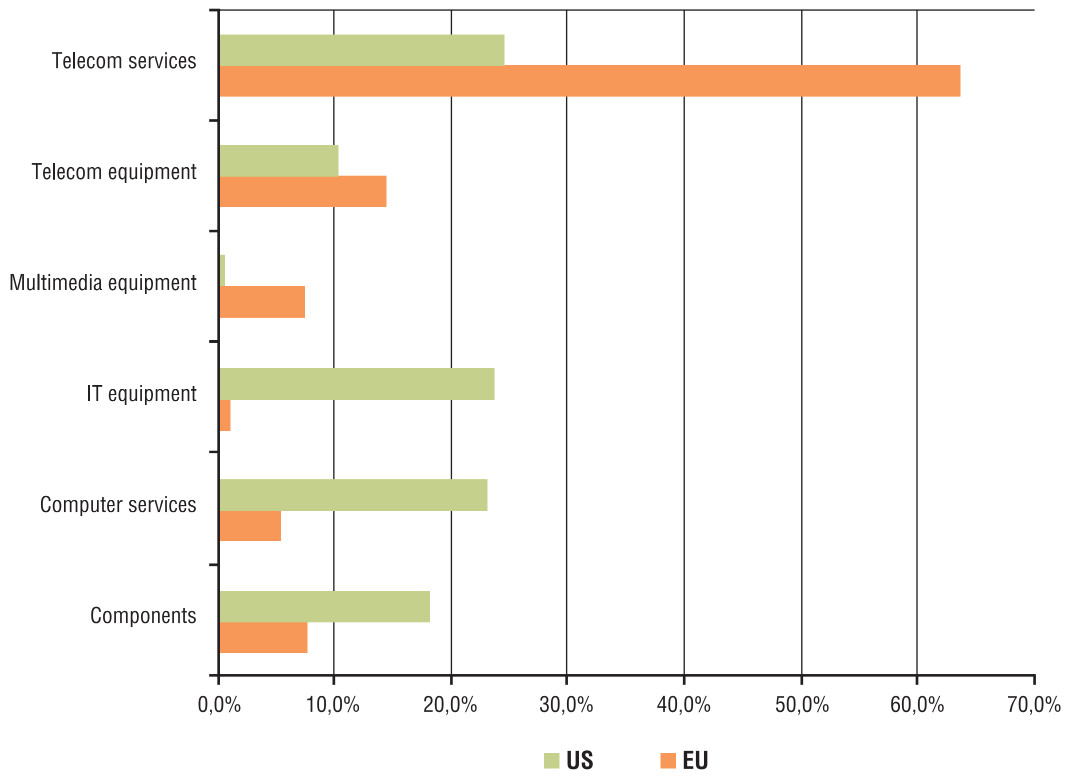
The macro-economic data above indicated that the ICT sector in the EU and the US have very similar structures. However, the company data, measured by sales, show big differences in the structures of the ICT sectors in the EU and the US, as shown in Chart 2-5. The Telecom Services and Multimedia Equipment sectors play a bigger role in the EU, while Computer Services and Software, IT Equipment and Components play a bigger role in the US.[12] The relatively larger size of Telecom Services in the EU is primarily due to two factors: (1) the rest of the ICT-sector is much smaller in the EU, and (2) EU telecom operators have expanded outside the EU to a larger extent than US ones have done outside the US. The relative large share of Multimedia Equipment in the EU is because Philips is registered in this class. Apart from Philips, this sector is marginal in both the EU and the US. While the Telecom Equipment sectors are relatively equal in size, in the remaining sectors the EU is dwarfed by the size and number of US companies. To sum up, company data shows a considerable aggregate size difference as well as weight difference of the sub-sectors.

2.3.2 The R&D intensity of the ICT sub-sectors

The macro-economic data above (2.2.3) indicated a significantly higher R&D intensity in the US than in the EU in several sub-sectors. However, for the company data, the R&D intensities (measured as R&D / net sales) of the sub-sectors are similar for the EU and the

12 It should be noted that the size difference between US and EU companies is even larger for company data than for macroeconomic data. The total turnover of US ICT firms in the secondary data set is € 830 billion compared to less than € 450 billion for a comparable set of EU firms. This means that, for instance, although the share of Telecom Equipment is higher in the EU, the total turnover of US firms is higher. The difference in R&D expenditures is even larger, € 61 billion (US) versus € 22 billion (EU), while R&D intensity difference is relatively smaller at 7.4% (US) versus 5.0% (EU). (All data for 2005)

Chart 2-5: Sub-sectoral composition of US and EU company turnover; net sales 2004



Source: IPTS based on the 2006 EU Industrial R&D Investment Scoreboard (European Commission 2007) complemented with data for major US Telecom Services firms
Note: Data for 2004 is shown here for comparative reasons. 2005 data would display a similar pattern.

US companies, as illustrated in Chart 2-6. EU companies even have a slightly higher R&D intensity in IT Equipment, Telecom Equipment and in Telecom Services, it is virtually the same in Computer Services, and only slightly lower in Multimedia Equipment and in Components. The contrast with the comparative R&D intensities of the sub-sectors according to macro-economic data is stark.[13]

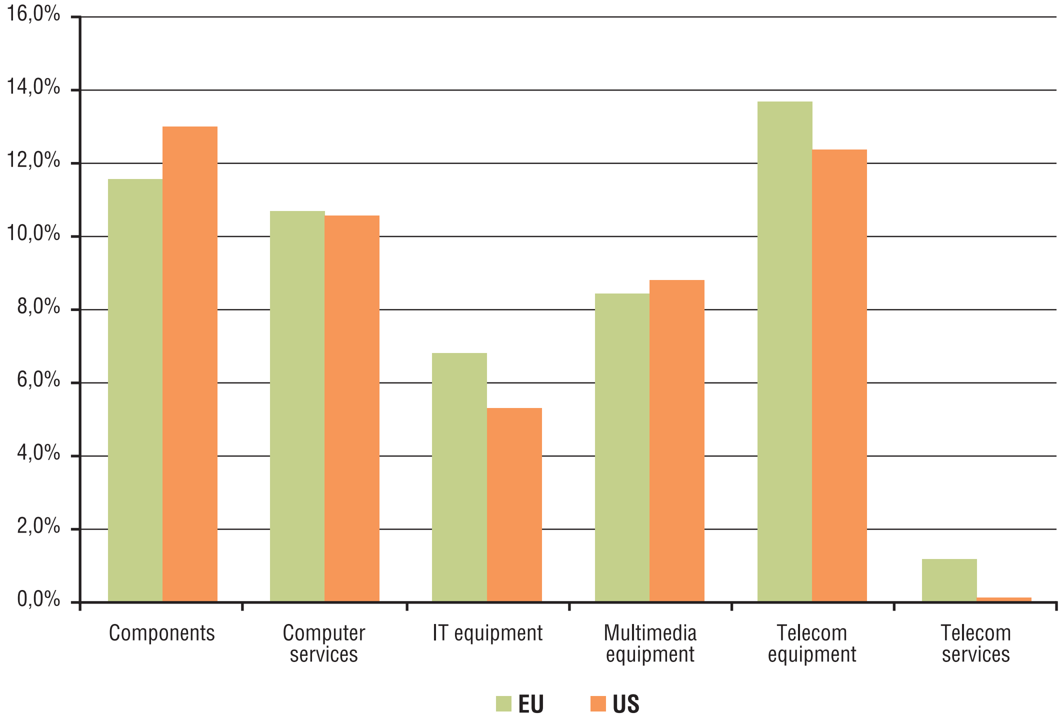
Thus we now have two apparently conflicting interpretations. On the one hand, the macro-economic data shows the ICT sectors in the EU and the US have virtually identical structures in terms of their sub-sectors, but most sub-sectors in the US have higher R&D intensities. On the other hand, the company data show very similar R&D intensities in the sub-sectors, but very different ICT sector structures. In the latter case, the lower overall ICT sector R&D intensity is due to a higher share of low R&D-intensity sub-sectors in the EU (especially Telecom Services) than in the US.

These differences are due to different methodologies. While the macro-economic data is geography-based, taking both R&D and value added into account in so far as it takes place in a given country, the company data is structure-based, taking R&D and sales into account in so far as they are carried out by a given company, regardless of where in the world they occur.[14]

13 No company data for Measurement Instruments; Components, Telecom Equipment and Multimedia Equipment have been separated for company data.

14 The company data is also limited to the biggest R&D investors, and may thus in particular underestimate the size of Computer Services and Software, which includes large numbers of very small firms. For Telecom Services, IT Equipment, Components, Telecom Equipment and Multimedia Equipment, however, most of the economic activity takes place in large companies.

Chart 2-6: ICT sub-sector R&D intensities; R&D / net sales 2004



Note: Data has allowed for disaggregating Components, Telecom- and Multimedia Equipment but a lack of comparable data have prevented us from providing R&D intensities for Measurement instruments. Note also that data available for 2005 show a similar pattern.

Source: IPTS based on the 2006 EU Industrial R&D Investment Scoreboard (European Commission 2007)

The different results, when combined with the different methodologies, offer an intriguing analysis. If US companies have a similar R&D intensity in IT Equipment and Computer Services, but the US as a geographic entity has a higher R&D intensity than the EU, one explanation could be that US companies especially in IT Equipment and Computer Services have a larger part of their production and other value-adding activities abroad. That would also explain why these sub-sectors have a much bigger share of the overall ICT sector in the US according to the company data, but not according to the macro-economic data.

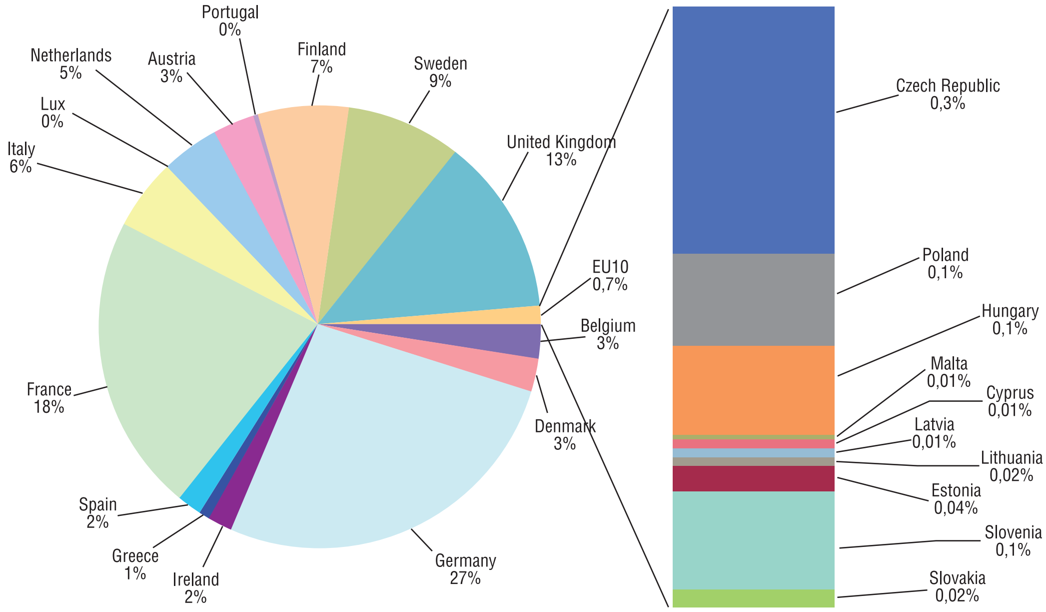
Such an explanation would also correspond to anecdotal evidence indicating that US companies, which are substantially larger in the IT Equipment and Computer Services sub-sectors than their EU counterparts, are more internationalised – companies such as Microsoft, IBM, Hewlett-Packard or Apple have very substantial operations outside the US. However, at this stage, this is but a hypothesis which calls for a deeper investigation of the internationalisation trends of ICT sector activities in the future.

2.4 Intra-European country analysis

2.4.1 Shares in R&D in ICT in the EU

Within the EU, ICT sector BERD is heavily dominated by the largest countries, i.e., Germany, France and the UK, and also Sweden and Finland. Notably, Western Member States contribute more than 99% of the ICT business R&D expenditures while the Eastern Member States contribute less than 1% (see Chart 2-7).

Chart 2-7: Distribution of ICT BERD in EU countries



% of total EU ICT BERD, 2004
Source: IPTS based on data from Eurostat, OECD and national statistics

2.4.2 The contribution of ICT to total R&D intensity

If we instead look at the contribution of ICT BERD to total R&D intensity, a different pattern emerges, as shown in Chart 2-8. This indicator is more useful for the analysis, because it puts ICT R&D investment in relation to the size of the different economies. Here, two countries, Sweden and Finland, have a much higher figure than the rest, and indeed well above the US figure, while a group of countries including France and Germany are above the EU average. The ICT BERD/GDP for Belgium and the UK is slightly below the EU average, and finally there is a large group of countries, including southern and eastern European Member States, which are far behind. The emerging overall picture is one of a decreasing ICT contribution as one moves from North to South and from West to East.

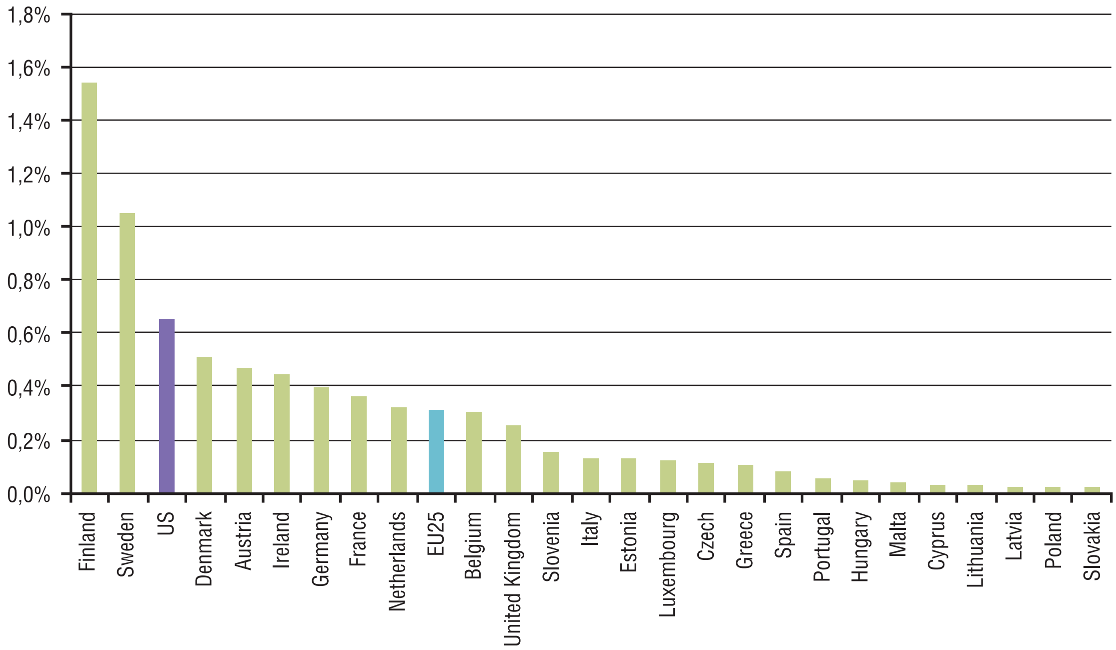
2.4.3 The weight of the ICT sector in the economy

In order to further analyse these results, we may, analogously to the analysis of the whole ICT sector and its sub-sectors, break down this result into a size factor and an intensity factor. The size factor, i.e. the share of the ICT sector in GDP, is shown for the EU Member States as well as for the EU and the US in Chart 2-9.

One observes that the country differences regarding the weight of the ICT sector in the economy are mostly due to differences in the relative share of the manufacturing part of the sector rather than in the services part. Indeed, countries in which the ICT sector is relatively large (such as Finland or Ireland) are mostly those where the ICT manufacturing sector is also relatively large (with some notable exceptions such as Latvia). On the other hand, the share of ICT services appears to be fairly stable across all Member States.[15]

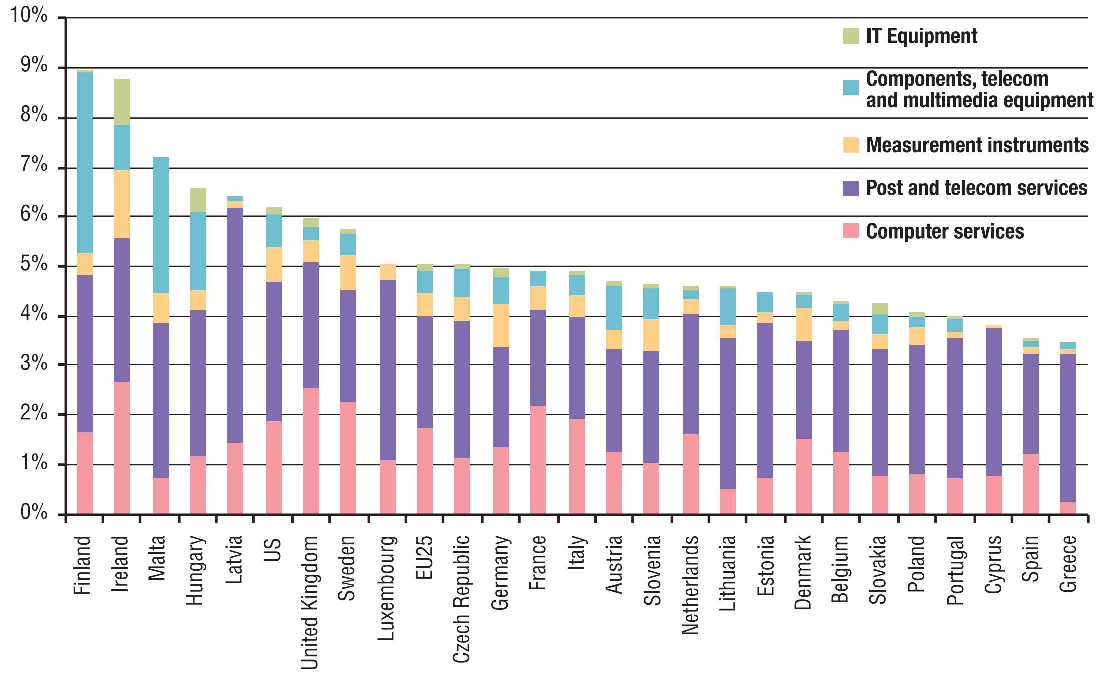
15 Telecom services spending is known to correlate strongly with GDP

Chart 2-8: *Contribution of ICT sector to total R&D intensity – EU and US; ICT BERD/GDP, 2004 or the latest year available*



Source: IPTS based on data from Eurostat, OECD, EU KLEMS national statistics

Chart 2-9: *Weight of the ICT sector in the economy – EU and US; ICT VA / GDP, 2004*



Source: IPTS based on data from EU KLEMS and Eurostat

Taking the two previous charts together, it can be seen that the relative differences between the countries regarding the weight of the ICT sector in the economy (Chart 2-9) are much smaller than the differences in the contribution of ICT to total R&D intensity (Chart 2-8). As a result, it appears that the differences in the weight of the ICT sector in the economy only explain the different levels of the ICT contribution to the total R&D intensity among Member States to a small extent.

2.4.4 The R&D intensity of the ICT sector

If the size factor explains only a small number of the differences, then the intensity factor should explain the overwhelming majority of the differences. Indeed, as shown in Chart 2-10, the R&D intensities of the sector in the Member States show very large differences. The ICT R&D intensity varies from 0.03% (Latvia)) to 18% (Sweden). Again, Sweden and Finland are far ahead, even above the US (as is Denmark this time); Germany, France and a few other western European countries are slightly above the EU average; and the southern and eastern European Member States are below. Interestingly, Estonia and Slovenia have an ICT R&D intensity of more than 2%, which is higher than that of Italy, Spain and Portugal.

It is striking that the order of ICT R&D intensities is extremely similar to the order of the contribution of the ICT sector to total R&D intensity, while the order for the weight of the ICT sector is somewhat different. This underlines that it is really the intensity factor which is the key to explaining the differences in contribution among Member States, rather than the size factor.

2.5 The overall ICT sector: conclusions

This chapter, which introduces a general view of global facts and trends in the ICT-sector R&D, documents three main aspects of the European ICT Sector R&D that can be estimated of high relevance for policy-making.

2.5.1 Mind the R&D gap

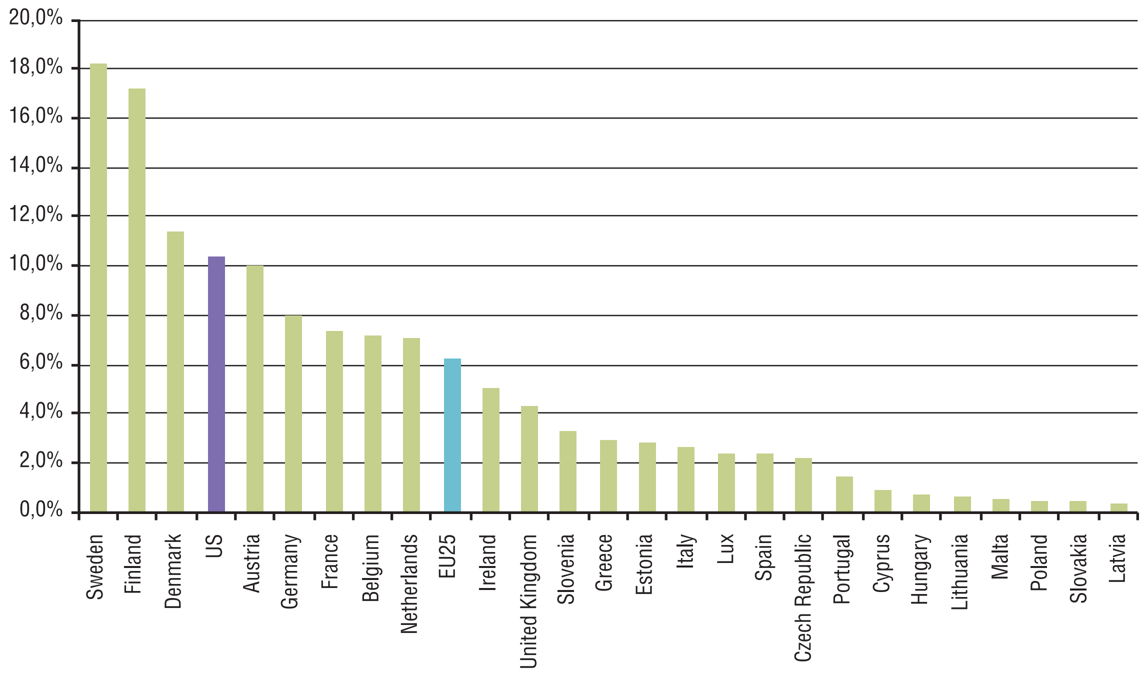
The macro-economic data confirm that the EU ICT BERD amounts to only half the US ICT BERD. This matters not only for the ICT sector, but also for the Barcelona objective of 3% expenditure on R&D in the overall economy. This target is only reachable if the contribution of the ICT sector grows considerably. Currently, its contribution is too small (at 0.31%) for this objective to be reached. Moreover, the data do not show any significant catching-up of EU ICT R&D investments.

2.5.2 An issue of ICT sector size and R&D intensity

The contribution of the ICT sector to the total R&D expenditure is smaller than in the US partly because the ICT sector is a smaller part of the economy. Mostly, however, it is smaller because of its lower R&D intensity. According to macro-economic data, this is due in turn to much lower EU R&D intensity in the sub-sectors IT Equipment (which is however very small and thus contributes little to the overall difference), Computer Services and Software, and Electronic Measurement Instruments. On the other hand, company data shows instead that R&D intensities are very similar inside and outside the EU for companies in each ICT sub-sector. This, combined with a higher share of low R&D-intensity sub-sectors in the EU, provides an alternative explanation for the lower ICT R&D intensity.

These two explanations taken together indicate that the ICT sector in the US is much more internationalised, i.e. it operates a large share of production, but only a small share of R&D abroad, while EU companies operate a similar (and much smaller) share of both production and R&D abroad. As a result of large-scale production offshoring, geographically-based

Chart 2-10: *ICT Business R&D Intensities (BERD / VA) in EU Member States and the US; BERD/VA, 2004 or the latest year available*



Source: IPTS based on data from Eurostat, OECD, EU KLEMS national statistics

macro-economic data show lower value added for the US, and hence a higher R&D intensity. However, at this stage this remains a hypothesis which calls for further investigation.

2.5.3 Geographical divides

Within the EU, there are two geographical ICT R&D divides. Firstly between North and South, with the Nordic countries outperforming the rest and the Southern Member States lagging behind; the excellent performance of the Nordic countries in ICT R&D is sector specific and linked to the presence of a very strong Telecom Equipment industry. Secondly, much more pronounced, there is a gap between East and West, with very low levels of ICT R&D in the Eastern Member States. Yet, the size of the ICT sector relative to the total economy is virtually identical in Eastern and Western Member States. Therefore, the low levels of R&D in the Eastern Member States clearly derive from a dominant share of lower R&D-intensive ICT activities.

* * * * *

These general conclusions treat the ICT sector as a whole, although they already refer to the importance of the variety among the ICT sub-sectors for the analysis. The next chapter will provide a comparative analysis of the sub-sectors, followed by an in-depth look at R&D in each of the sub-sectors which make up the ICT sector. We will move along the value-added chain, starting with IT Components, then progress to finished manufacturing products (IT Equipment, Telecom and Multimedia Equipment, and Electronic Measurement Instruments), and end up with ICT services, first Telecom Services and then Computer Services and Software.

Box 2-1 Classifications

The classification which we use for segmenting the sub-sectors is the "Nomenclature statistique des Activités économiques dans la Communauté Européenne" (NACE) derived from the International Standard Industrial Classification (ISIC). This classification is used by European statisticians to collect industrial data, and is therefore the starting point of the analysis, although sometimes the titles may seem quaint and the categories do not necessarily correspond to current value-chains or industry sectors. The following table gives you an overview of the main contents of the following NACE/ISIC sectors.

Official title		Plain English
30	Manufacture of Office, Accounting and Computing Machinery	Computers, Printers, Scanners, Photocopiers
321	Manufacture of Electronic Valves and Tubes and other Electronic Components	Semiconductors, Printed Circuits (motherboards etc.), LCDs, TV Tubes; Diodes
322	Manufacture of Television and Radio Transmitters and Apparatus for Line Telephony and Line Telegraphy	Telephones, Faxes, Switches, Routers, TV and Radio Emitters
323	Manufacture of Television and Radio Receivers, Sound or Video Recording or Reproducing Apparatus, and Associated Goods	TV, VCR, (digital) Cameras, Radios, Cassette Players, CD and DVD Players
3312	Manufacture of Instruments and Appliances for Measuring, Checking, Testing, Navigating and other purposes, except industrial process control equipment	Measurement Instruments (sensors, readers)
3313	Manufacture of Industrial Process Control Equipment	Industrial Process Control Equipment
642	Telecommunications	Telecom Services
72	Computer and Related Activities	Hardware Consultancy, Software Consultancy and Supply, Database Activities, Internet, Maintenance and Repair

On the other hand, international trade data in goods is collected according to a different classification called SITC (Standard International Trade Classification). The international trade data in services follows EBOPS (Extended Balance of Payments Standard Classification). The correspondences are roughly as follows:

NACE		SITC
30	Office Equipment	75 - Office Machines and Automatic Data-processing Machines
32	Telecom and Multimedia Equipment	76- Telecom and Multimedia Equipment 77- Electrical Machinery, and electrical parts thereof (including non-electrical counterparts of electrical household-type equipment) – partially
3312 3313	Measurement Instruments (sensors, readers) Industrial Process Control Equipment	87- Professional, Scientific and Controlling Instruments – partially
NACE		**EBOPS**
642	Telecommunications	247 – Telecommunication Services
72	Computer and Related Activities	263 – Computer Services 890 – Other Information Provision Services

3. Comparative analysis of the EU ICT sub-sectors

3.1 General economic profile of the ICT sub-sectors

In terms of general economic characteristics, the ICT sub-sectors display very different characteristics (see Table 3-1). Most striking, perhaps, is the very large share which the services sectors (Telecom Services and Computer Services and Software) occupy in terms of turnover and value added. Taken together these two sectors add up to about two thirds of the turnover and an even larger share of the value added of the total ICT-sector. In addition, they have been growing rapidly and persistently for more than a decade. In particular, Computer Services and Software (72) more than doubled its value added between the years 1995-2001, only to experience a slight slowdown in growth rates in the years to follow. In terms of value added growth, Telecom Services (64.2) appear to have been more or less untouched by the crisis years, growing persistently at about 6-7% per year.

The manufacturing sectors are very different from each other. Electronic measurement (33.2/3) instruments show the most positive development, with continuously increasing value added after the year 2000 and, in addition, a trade surplus. IT Equipment (30) is clearly in worse shape: after 2000, turnover and value added started to decline and this sub-sector also has a huge trade deficit, corresponding to more than 90% of the total EU trade deficit in the ICT-sector.

The economic performance of IT Components (32.1), Telecom Equipment (32.2) and Multimedia Equipment (32.3) are mixed. IT Components and Telecom Equipment both grew very rapidly in the 1990s, but were severely hit during the crisis in the early 2000s, especially Telecom Equipment, which lost about one quarter of its value added in the year 2001 alone. Although there were signs of recovery for both sub-sectors in 2004, they still have large trade deficits. In the case of Telecom Equipment, this trade deficit is worsening. The smaller Multimedia Equipment sub-sector (32.3), which also has a trade deficit, grew only slowly until the year 2000 to then decline slowly during the crisis years.

Table 3-1: Turnover, Value-added and trade-balance for the ICT sub-sectors

Sub-sector	Turnover € bn 2004	VA € bn 2004	VA CAGR 95-00	VA CAGR 00-04	Trade-balance € bn 2005
30 IT Equipment	59,2	12,1	1.7%	-4.7%	-40,8
32.1 IT Components	60,0	17,4	15.7%	-4.3%	-7,5
32.2 Telecom Equipment	92,3	20	12.3%	-9.2%	-5,3
32.3 Multimedia Equipment	48,8	8,1	4.0%	-4,7%	-2,5
33.2/3 El. Measurement Instr.	64,3	25,7	7.5%*	1.2%	6,3
64.2 Telecom Services	394	176	6.0%**	7.3%	-0,7
72 Computer Services & SW	312	184,9	16.4%	4.9%	6,3
Total ICT	**1031**	**444**	**9.5%**	**3.7%**	**-44,3**

Source: IPTS based EUROSTAT and EU-KLEMS.
*Notes: Nominal terms. * ISIC 33 ** ISIC 64; CAGR stands for Compound Average Growth Rate*

3.2 Business R&D in the ICT sub-sectors

The R&D dynamics of the ICT sub-sectors also differ, as can be seen in Table 3-2. In contrast to value added and market size, most of the R&D (about 70%) is performed in ICT manufacturing. Telecom Equipment (32.2) stands out with the highest BERD (€ 8.5 billion) and highest R&D intensity (42.5% BERD/VA). This is in stark contrast to Multimedia Equipment (32.3), which has the lowest BERD and lowest R&D intensity of the manufacturing sub-sectors.

IT Components (32.1) is also a relatively R&D intensive sub-sector with 25% BERD/VA. Even so, this sector is probably responsible for a large part of the € 5,3 billion R&D gap with the US for the total Sector 32.[16] Regarding IT Equipment, R&D intensity is also relatively high, but even so the R&D gap with the US stands above € 4 billion. Moreover, most R&D in this sub-sector in the EU is not performed by large EU companies. This suggests that much of the limited R&D taking place in this sector in Europe is either conducted by small firms or (more likely) by foreign controlled ones. Finally, of the manufacturing sub-sectors, Electronic Measurement Instruments is the only sub-sector where R&D investments are persistently increasing in Europe. Even so, the EU attracts far less R&D than the US, which invests almost € 11 billion more than the EU in this sub-sector.

Among the services sectors, the Computer Services and Software sub-sector stands out because of its strong R&D growth. With Telecom Services R&D having remained flat, R&D in Computer Services and Software in fact accounts for most of the business R&D growth in the EU in recent years. While this is a positive trend in itself, the fact that this growth is overshadowed by size and growth of the Computer Services and Software sector in the US is worrying for the EU.

3.3 Company R&D in the ICT sub-sectors

Company data (Table 3-3) show that EU firms have a prominent R&D position in the two telecom sectors. Telecom Services R&D is, with the exception of the Japanese giant operator NTT, largely performed by EU firms. In Telecom

16 Although we have no comparable US BERD data for sub-sector 32.1, company data suggest that much more business R&D is conducted in the US, than in the EU. See also Table 3-3.

Table 3-2: Business R&D profile of the ICT sub-sectors

Sub-sector	BERD (€ bn 2004)	EU-firms world wide R&D (€ bn 2005) company data	BERD / VA (2004)	BERD Growth (CAGR 00-04)	BERD EU-US (€ Purchasing Power Parity bn 2003)
30 IT Equipment	2,3	0,3	18.8%	-1.5%	- 4,1
32.1 IT Components	4,4	4,0	25.2%		
32.2 Telecom Equipment	8,5	9,1	42.5%	-1.2%	- 5,3
32.3 Multimedia Equipment	0,9	2,4	11.6%		
33 Measurement Instruments *(of which 33.2-3)*	6,6 *(5,4)*	N/A	12.6% *(21.4%)*	5.5%	-10,8
64.2 Telecom Services	3,0	3.8	1.7%	-1.0%	1,6
72 Computer Services & SW	7,1	2,6	3.8%	12.9%	- 9,8
Total ICT*	**31,6**	**N/A**	**7.1%**	**2.4%****	**-27,5**

Source: IPTS based on EUROSTAT, OECD ANBERD, national statistics, EU-KLEMS and company annual reports (EU Industrial R&D Investment Scoreboard)
*Notes: * Including sectors 30, 32, 64.2, 33.2-3 and 72. **Including 30, 32, 64.2, 33 and 72.*

Equipment, almost 40% of the worldwide R&D is invested by EU firms. However, this is still below the American R&D investments. In addition, the presence of rapidly growing Chinese companies (e.g. Huawei, ZTE) is becoming noticeable. In addition, some Japanese (e.g. NEC) and Korean (e.g. Samsung, LG) have a presence in Telecom Equipment although they are registered in other classes. Thus, the often quoted strength of Europe in Telecom Equipment needs to be regarded with some caution.

In three other sub-sectors, i.e. IT Components, Multimedia Equipment and Computer Services and Software, EU firms have relatively small but noticeable R&D investment at around 10% of total global R&D.[17] IT Components is dominated by US, Japanese and Korean firms, but also includes a few relatively large EU players (STM and Infineon). The major firms in Computer Services & Software are almost exclusively from the US, with the exception of German SAP. Compared to Asia however, the EU company position is better. R&D in the Multimedia Equipment industry is almost exclusively conducted by East Asian firms, although Philips is also a strong competitor in some segments. One should note however that the Philips product portfolio extends beyond multimedia products (lighting, medical equipment), and the company invests far from all its €2.4 billion in this sub-sector. Finally, IT Equipment appears to be a sub-sector that the EU has more or less lost to US and East Asian firms.

17 Estimated for Multimedia Equipment, see comment below on Philips.

Table 3-3: Company R&D profile of the ICT sub-sectors in the EU, the US and the RoW (2005)

	EU		US		RoW		Total
Sub-sector	**R&D in bn €**	**Top R&D investing companies**	**R&D in bn €**	**Top R&D investing companies**	**R&D in bn €**	**Top R&D investing companies**	**R&D in bn €**
30 IT Equipment	0,3	Oce (0,2) Bull (0,05) Neopost (0,05)	9,9	HP (3,0) Sun (1,5) EMC (1,0)	13,0	Hitachi (J) (2,9) Toshiba (J) (2,5) NEC (J) (2,0)	23,2
32.1 IT Components	4,0	STM (1,3) Infineon (1,2) ASML (0,3)	19,2	Intel (4,4) Texas (1,7) Freescale (1,0)	17,6	Samsung (S-K) (4,6) Canon (J) (2,1) LG (S-K) (1,5)	40,8
32.2 Telecom Equipment	9,0	Nokia (4,0) Ericsson (2,7) Alcatel (1,8)	11,2	Motorola (3,1) Cisco (2,8) Lucent (1,2)	2,7	Nortel (Ca) (1,6) Kyocera (J) (0,4) ZTE (Chi) (0,2)	23,0
32.3 Multimedia Equipment	2,4	Philips (2,3) B&O (0,07) Pace (0,04)	0,2	Harman (0,2) TiVo (0,03)	8,3	Matsushita (J) (4,1) Sony (J) (3,8) Yamaha (J) (0,2)	10,9
64.2 Telecom Services	3,8	BT (UK1,1) FT (F, 0,7) Telefónica (E 0,5)	0,2	AT&T (0,11) Alltel (0,04) Sprint (0,04)	3,5	NTT (J) (2,3) Telstra (Au) (0,3) SKT (S-K) (0,2)	7,4
72 Computer Services & SW	2,7	SAP (1,1) Dassault (0,3) Business Objects (0,1)	20,6	Microsoft (5,6) IBM (4,6) Oracle (1,6)	1,0	Sega (J) (0.3) Nintendo (J) (0,15) Cognos (Ca) (0,09)	24,3
Total ICT	**22,3**		**61,3**		**46,0**		**129,6**

Source: IPTS adapted from European Commission (2007a)
Note: Electronic Measurement Instruments are not included because European Commission (2007a) does classify companies into this sub-sector.

3.4 EU Member State BERD in the ICT sub-sector

Table 3-4 shows the top business R&D-hosting Member States and the most R&D intensive ones. As is to be expected, the "big three" Member States, Germany, France and the UK, host more R&D than the other countries, in most of the sub-sectors. It can be noted that Germany leads in all manufacturing sub-sectors, while the UK tops the services sub-sectors. Smaller Member States, such as Finland, Sweden and the Netherlands are present in sub-sectors in which they have large domestic firms. For instance, Sweden and Finland spend large amounts on R&D in Telecom Equipment, largely because of the presence of Ericsson and Nokia, which both conduct a large share of their R&D in their respective home countries.

The pattern differs considerably if instead of absolute amounts we compare R&D intensities, as measured by BERD/VA. The Nordic countries, which are the most R&D-intensive for the aggregate ICT sector, are also among the most R&D-intensive in several sub-sectors, notably also outside the Telecom Equipment sub-sector. Apparently the presence of large domestic firms is not a necessary condition for a high R&D intensity in a specific sub-sector. The R&D intensity of France is also very high in several sub-sectors. The only Eastern Member State present in the above table is Estonia in Computer Services and Software, with an R&D intensity equal to Ireland's, a country well-known for its software industry. A final remark concerns the interpretation of R&D intensity (BERD /VA) as an R&D performance measure.

Table 3-4: Top 3 BERD and BERD/VA Member States per ICT-sub-sector

Sub-sector		Top 3 EU BERD MS (€ bn 2004)	Top 3 EU BERD/VA MS (2004) *
30	IT Equipment	Germany (0,5) France (0,2) *Netherlands (N/A)*	France (38%) Sweden (27%) Denmark (23%)
32.1	IT Components	Germany (1,35) France (1,3) UK (0,65)	France (39%) Denmark (36%) Austria, UK (34%)
32.2/3	Telecom Equipment	Germany (1,9) Finland (1,7) Sweden (1,5)	Sweden (145%) France (83%) Ireland (47%)
32.3	Multimedia Equipment	*Netherlands (N/A)* Germany (0,3) Sweden (0,2)	
33	Electronic Measurement Instruments	Germany (2,7) France (1,4) UK (0,5)	Finland (25%) Denmark (24%) Sweden (21%)
64.2	Telecom Services	UK (1,0) France (0,7) Germany (0,5)	Sweden (3.2%) Finland (2.3%) France, UK (2.2%)
72	Computer Services & SW	UK (1,6) Germany (1,5) France (0,9)	Denmark (16%) Finland (11%) Estonia, Ireland (10%)
Total ICT		**Germany (8,8)** **France (6,0)** **UK (4,4)**	**Sweden (18.2%)** **Finland (17.2%)** **Denmark (11.4%)**

Note: There are no reliable statistics available for the Netherlands at sub-sector level. However, we have indicated its presence in the sub-sectors we would expect to find it, based on company data.
** Only Member States for which there is reliable data available are included.*
Source: IPTS based on EUROSTAT, OECD ANBERD, national statistics, EU-KLEMS and company annual reports

In the Telecom Equipment sub-sector, some Member States have extreme R&D intensities, not least Sweden with over 100%. These high figures are very much due to rapidly decreasing value added in recent years, rather than any positive R&D dynamics.

3.5 Eastern EU R&D profile for the ICT sub-sectors

Table 3-5 distinguishes the Eastern Member States (i.e. the ones that joined the EU in 2004) from overall EU figures. In doing so, the weak R&D performance of the Eastern Member States becomes noticeable. They contribute less than 0.8% to the total ICT BERD in the EU. This share stays below or around 1% for all the investigated sub-sectors. Most of this limited investment of €0.25 billion takes place in Telecom Equipment (€0.075 billion) and Computer Services and Software (€0.090 billion).

As can be seen in the right hand side of Table 3-5, the discrepancy is not only because the ICT sub-sectors are larger in the Western Member States. The overall EU R&D intensity is in fact higher than the EU-East R&D intensity in all the ICT sub-sectors: in four sub-sectors (IT Equipment, IT Components, Multimedia Equipment and Telecom Services) the R&D intensity of the Eastern Member States is less than 1/10 of that of the EU as whole. In these sub-sectors BERD/VA stays below 1% in the East (or just above, for IT Components). This East-West gap is somewhat less marked for the other sub-sectors, especially Telecom Equipment, which has the highest R&D intensity of all sub-sectors in the East (12.3%), and Computer Services and Software, where the R&D intensity of the EU is only about twice as high as it is in the Eastern Member States.

Table 3-5: BERD and BERD/VA in the EU 25 and Eastern Member States (2004)

Sub-sector	ICT BERD			ICT BERD / ICT VA	
	EU (€ billion)	EU-East (€ billion)	EU-East/EU	EU	EU-East
30 IT Equipment	2,3	0,005	0.2%	18.8%	0.6%
32.1 IT Components	4,4	0,012	0.3%	25.2%	1.2%
32.2 Telecom Equipment	8,5	0,075	0.9%	42.5%	11.9%
32.3 Multimedia Equipment	0,9	0,011	1.2%	11.6%	0.9%
33 Measurement Instr.	6,6	0,040	0.6%	12.6%	2.2%
64.2 Telecom Services	3,0	0,013	0.4%	1.3%*	0.1%*
72 Computer services & SW	7,1	0,090	1.3%	3.8%	1.9%
Total	**32,8**	**0,247**	**0.8%**	**6.2%***	**1.05%**

Notes: EU-East, or EU10 includes the 10 Member States which joined the EU in 2004, i.e. Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia
Note also that the EU East values are less reliable because they are low and susceptible to statistical noise.
**VA includes the entire sector 64, due to a lack of reliable national data for 64.2. Therefore R&D intensity for 64.2 and for the total ICT sector is lower than stated elsewhere.*
Source: IPTS based on EUROSTAT, OECD ANBERD, national statistics, EU-KLEMS and company annual reports

4. IT Components (NACE/ISIC 32.1)

4.1 General economic profile of the components industry

This sector includes all components used for production of IT Equipment, which can be classified into:

1. **active components** (over 75% of components) such as semiconductors, integrated circuits including smart cards, valves and tubes (i.e. cathodic tubes for traditional TV and computer screens – hence its official name "electronic valves and tubes and other electronic components"). Also included are photosensitive semiconductors for solar energy production.

2. **passive components** (less than 25% of components) such as printed circuits, resistors and capacitors.

We will therefore refer to NACE/ISIC sector 32.1 as "IT Components".

IT Components represent less than 6% of the total turnover of the ICT industry and 4% of its value added, but they contribute with more than twice that share to the total R&D expenditures. They have the highest R&D intensity among the ICT sub-sectors (estimated at 25% BERD/VA average in 2002-2004[18]). The sector may be even more important than these figures suggest, see Box 4-1.

Within IT Components, active components contribute on average three quarters of the turnover and production,[19] as well as approximately 80% of EU external trade in the corresponding SITC codes.[20] Active components consist essentially of cathode-ray tubes and valves on the one hand, and semiconductors, ICs and micro-assemblies on the other hand. Valves and tubes are declining sectors: cathodic tubes are strongly affected by the emergence and continuing price improvements of flat screen technologies, and now attract very limited research efforts. From 2005, they have contributed only around 10% of the total output of active components. Semiconductors, ICs and

18 Semiconductor industry is subject of highly cyclical behaviour, therefore a multi-annual average is more relevant to highlight the general trends.
19 Own calculations based on EECA and EUROSTAT data
20 776 (active components) + 772.2 and 772.3 (printed circuits and resistors) + 778.6 (capacitors)

Table 4-1: Main figures for the IT Components sub-sector

2004, or the latest year available	€ bill.	% in total EU ICT	% in total EU ICT (manufacturing sectors only)
EU sales (turnover)	60,0	5.0%	15.5%
EU value added (at current basic prices)	17,4	3.3%	15.8%
EU BERD (*)	4,4	13.4%	19.3%
EU exports (2005)	22,8	16.8%	19.6%
EU imports (2005)	30,2	16.8%	18.2%
EU trade balance (2005)	-7,5	-16.8%	-14.9%
R&D intensity (BERD/VA)	*25.2%*		
R&D intensity (BERD/turnover)	*7.3%*		

** The nominal value of sectoral BERD is an estimation valid within a 95% confidence interval*
Source: IPTS based on OECD, EUROSTAT and EU KLEMS

micro-assemblies contribute almost 90% of the production of active components and 68% of the total production of IT Components. On the country level, their share in total production of IT Components varies from 100% in Malta to below 30% in all Eastern Member States.[21]

Regarding trade, the group consisting of active components (SITC group 776), is one of three main contributors to the overall EU trade deficit in ICT goods. However, between 2000 and 2005 exports grew in volume while imports stagnated, somewhat improving the trade balance, although, due to rapidly decreasing prices in this category, the value of both exports and imports fell. On the other hand, Europe holds an increasing surplus position in the group of products (SITC 772) which includes some of the passive components such as printed circuits and resistors. Since printed circuits rely on semiconductors, the strong export price premium in this product is also related to the presence of high-end semiconductors production. In fact, the EU excellence in printed circuits is connected with its specialisation niches in GSM equipment and smart-cards (both of which contain printed circuits made of semiconductors).[22] In short, the surplus in group 772 and the improvement in group 776 can be attributed to increasingly sophisticated semiconductor products commanding a premium, usually a result of successful R&D investments.

Trade data for the semiconductors should be read keeping in mind that semiconductor manufacturing allows for easy fragmentation into very thin slices of the value chain, which makes partial outsourcing or offshoring easy. Roughly speaking, the semiconductor manufacturing process is composed of a diffusion[23]/pre-test cycle of several months ("front-end") and an assembly/final test cycle of a few weeks ("back-end"). The first part is usually executed in wafer fabs, and the second part in testing and assembly sites. Typically, semiconductor design activities are located in the advanced economies, but wafer fabrication and, in particular, assembly and testing sites have in the last two decades moved to (Far East) Asia. Thus, the search for optimal locations, which have, for example, cheap labour or the availability of skilled labour, can be pursued separately for each step of production.

This fragmentation of the value chain has led to the emergence of three main types of companies in the semiconductor manufacturing industry. Firstly, there are *integrated device manufacturers*, or IDMs, who design, manufacture and sell their own chips. Secondly, *fabless companies* design and sell their chips but outsource the manufacturing to foundry companies. Thirdly, *pure-play foundry companies* manufacture the chips designed and sold by their customers.[24] To these variants and intermediaries can be added, such as Fab-lite companies[25] and IP vendors.[26]

The R&D expenditures of the semiconductor companies represent around 70% of the research carried out in the entire IT Components sector. Due to the described industry structure, however, the distribution of these expenditures does not follow the geographic distribution of production. Both the back-end and front-end operations are moving towards cheap labour locations, but cutting-edge

21 Estimation based on REED (2006) and Xuereb (2004)
22 ESIA (2006)
23 An essential stage of the manufacturing of semiconductors that infuses tiny quantities of impurities into a base material, such as silicon, to change its electrical characteristics (Computer Desktop Encyclopedia, 1998)
24 www.wikipedia.com
25 Traditional semiconductor companies that adopt a combined approach utilising in-house and external capacity. They represent probably the most significant business model trend. Fab-lites (eg Micronas) can best be classified as intermediate players, slotting in between integrated device manufacturers (IDMs) and fabless companies. (http://www.isaonline.org/aboutus-faqs.html)
26 In the semiconductor industry, intellectual property (IP) means the sale of design rights to the companies that develop and manufacture integrated circuits. These designs are sold in two forms: i) Design licensing: The silicon designer has the right to use the development tools to integrate the IP design block with the chip that is currently under development, and ii) Royalties: The IP company receives royalties for every chip that is sold. These are usually a percentage of the final selling price of the silicon (http://www.isaonline.org/aboutus-faqs.html)

research on semiconductors is still taking place in Europe, especially on embedded systems.

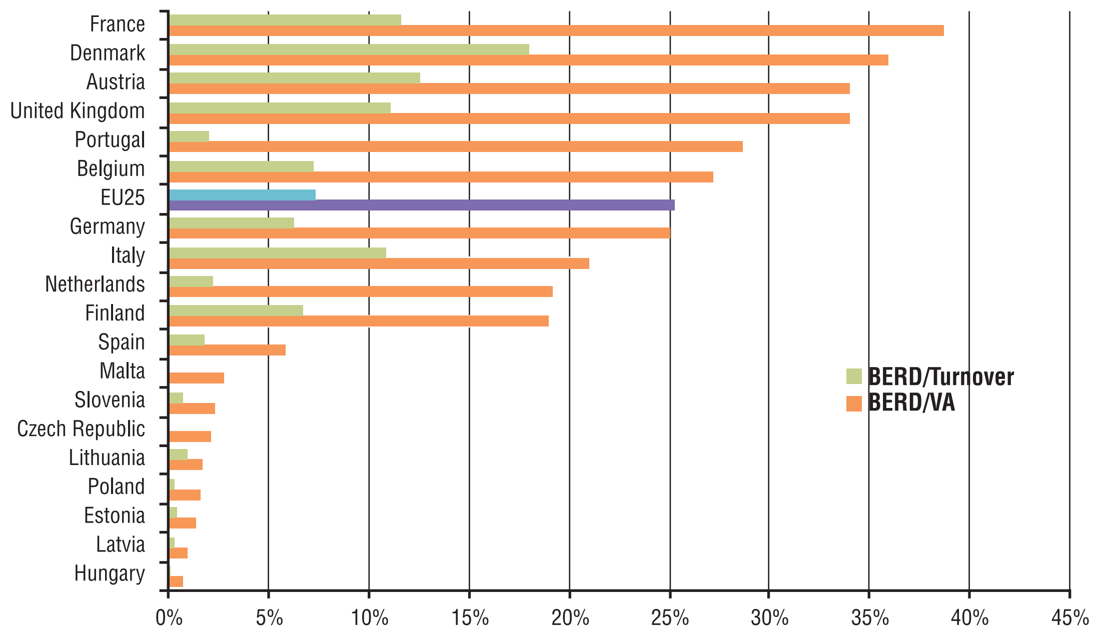
4.2 The most important R&D activities by Member State

The R&D intensity of components remained the highest in the ICT sector after the crisis of the ICT sector in 2001. However, R&D intensities vary substantially between countries. The most intensive R&D countries include Denmark, France, Austria, Finland and the UK, and also Sweden, for which country level data on BERD in the IT Components sector is not available (see Chart 4-1). Nevertheless, R&D expenditures probably place Sweden among the top performers with regard to R&D intensity of the national IT Components industry.

In semiconductor production, quite often “the fab is the lab”, i.e. some of the more applied and design types of R&D are extremely closely linked to production. Indeed, the biggest Integrated Device Manufacturers (IDMs) and fabless companies have set up their research centres close to their main markets and perform their design activities in the wafer fabs. They are often in close cooperation with research platforms, mainly for fundamental research, and much of the research is actually performed in dedicated R&D centres, both public and private. European industries and research institutions (e.g. IMEC/Leuven, CEALeti/Grenoble, Fraunhofer/Dresden) have developed a manufacturing science base that has allowed them so far to remain competitive and capable of transition to mass production. These R&D activities often benefit from EU, national or local research grants or are supported by European Technology Platforms such as the one for European Nanoelectronics (ENIAC) or for embedded intelligent systems (ARTEMIS), or by sectoral initiatives such as MEDEA+.

The proximity of research and manufacturing facilities enables technology transfers and the creation of global centres of excellence like the semiconductor clusters in Dresden, Grenoble

Chart 4-1: Research intensities in IT Components; Selected countries, 2004



Note: Not all countries are shown in the chart. As a general note to this and the similar charts for the other sub-sectors, countries are excluded if (1) data are based on unreliable estimates or (2) if BERD/VA is insignificant or zero. Here, Greece, Luxembourg, Sweden and Ireland are excluded due to lack of reliable data, while Slovakia and Cyprus reports BERD 0 in this class.

Source: IPTS based on Eurostat, OECD, EU KLEMS and national statistics

Box 4-1 The relevance of the semiconductor industry for EU competitiveness

The semiconductor industry is particularly relevant for R&D policy for at least four reasons.

Firstly, its **leverage**: progress in this industry has a tremendous impact on general innovation and growth. ESIA (2006) claims that the semiconductor industry currently enables the production of almost 10% of world GDP. The potential is even bigger: every vision of an information society is built on the widespread use of more powerful semiconductors.

Secondly, its very high **R&D intensity**; it is the ICT sub-sector with the highest R&D intensity, at up to 15% to 20% of total revenues.[3] There is even a whole category of companies which rely entirely on the income from licensing their research results, so called IP vendors. Interestingly, the EU has the world's largest IP vendor, ARM Holdings.[4] There are two reasons for this high research intensity in the semiconductor industry: the race at the technological frontier, which calls for medium- to long-term, mostly fundamental research on the continuous improvement of materials and processes,[5] and the high intensity of design-related activities (classified as R&D) necessary for customisation of the products. As a comparison, the passive components industry spends only 5% of their sales on R&D.

Thirdly, the **investment intensity** of this sector is very high. In the semiconductor industry, a fully equipped production line is seen as a prerequisite for research and innovation, when leading-edge technologies are used. As a consequence of increasing process complexity, the investment required to set up semiconductor production facilities has increased dramatically; the cost for a leading edge fab with front-end production lines has doubled between two technology generations. To set up a new 300mm[6] fab amounts to at least €2,5 billion today, and this investment has to be recouped within five years. This is why IDMs have investment intensities of about 20% of turnover.[7]

Finally, the industry is particularly relevant for the **enhancement of the skill level of human resources**. Semiconductor companies show very high shares of researchers in their overall staff.[8]

1 ESIA(2006) and Cientifica (2005)
2 PriceWaterhouseCoopers (2005)
3 Such as CMOS (complementary metal-oxide semiconductor), or search for materials that would replace silicon. Also, companies like Affymetrix, Agilent, microParts, STMicroelectronics are key players in the emerging field of linking micro-systems and semiconductors research with life sciences (see http://www.yole.fr/pagesAn/products/pdf/LifescienceIC.pdf)
6 The 300mm wafers are the current technology edge. Moving from an 8-inch (or 200 mm) wafer to a 12-inch (or 300mm) wafer increase the number of semiconductor chips by 2.25 times. (GAO 2006)
7 From ICT sector task force reports: http://ec.europa.eu/enterprise/ict/policy/doc/wg3_report.pdf
8 As in 2005, 21% of Infineon staff was involved in R&D activities (www.wikipedia.com). In the same year, ST Microelectronics allocated 19% of the staff to R&D activities, share held constant since 2003 (ST Microelectronics Annual Report, 2005).

and the larger Eindhoven area (from Nijmegen to Leuven), or the development of semiconductor facilities in Ireland, and also Catania and Avezzano in Italy.[27] According to this logic, the increasing offshoring of design and manufacturing towards East Asia, together with the fact that demand for semiconductors comes from industries which are themselves progressively offshored to East Asia, means that those R&D activities risk being moved to countries such as China and Taiwan.[28]

27 From ICT sector task force reports: http://ec.europa.eu/enterprise/ict/policy/doc/wg3_report.pdf

28 http://www.edn.com/article/CA6310922.html?partner=eb&pubdate=3%2F1%2F2006

Indeed, the most advanced production sites are increasingly not in Europe. While 16% of the global fab capacity with wafer sizes of up to 200mm is located in Europe, only 9% of the more advanced 300mm segment is located in Europe. Additionally, while 14 new 300mm fabs are scheduled to launch production globally in 2007, only one of them will be based in Europe.[29]

The European semiconductor business is dominated by giants such as ST Microelectronics, Philips (now NXP) and Infineon. However, smaller companies, mostly fabless or IP companies, hold their own on the market. Hundreds of fabless companies are estimated to be present in EU.[30] They flourish mostly in niche markets, developing specific customised products hard to outsource due to their local relevance. For instance, the German conglomerate Bosch GmbH, the world's third largest manufacturer of microsystems (MEMS - Micro-Electro Mechanical Systems), commands specific application-oriented niche markets, mainly in automotive electronics.[31] The other EU companies in the semiconductors industry, although far smaller in terms of revenues than the US fabless industry,[32] are more specialised and less subject to an easy transfer of operations abroad.

The semiconductor manufacturing industry in Europe is concentrated in a few countries: there are 88 sites in Germany,[33] 50 in the UK,[34] 34 in France and 16 in Italy.[35,36] About 100 of these production facilities consist of front-end manufacturing, as well concentrated in Germany, France, Italy the Netherlands, the U.K. and Ireland.[37] As a result, almost half of the EU overall turnover in semiconductors is accounted for by Germany and the UK.[38]

Although the growth in production between 2002 and 2004 is impressive (over 20% per year in real terms[39]), few changes have occurred in the country distribution. Notably however, production in **Germany** grew faster than in the UK. This reflects to a large extent the performance of German manufacturer Infineon,[40] and to a smaller extent the performance of the smaller German companies such as Elmos Semiconductor. However, as shown before, the German case is special in that Germany has a large and fast-growing photovoltaics sector. Indeed, if the EU production of photosensitive semiconductor devices grew by over €870 million in 2005, reaching a total of € 2,2 billion, 490 millions of this growth came from Germany alone.[41] In 2005, Germany in fact covered 56% of the EU production of photosensitive semiconductor devices. As a result, about 40% of the world's suppliers for photovoltaics are based

29 http://www.eetimes.eu/germany/196603333;jsessionid=JAJ4ZKIEND5AQQSNDLPSKH0CJUNN2JVN
30 http://www.edn.com/article/CA6310922.html?partner=eb&pubdate=3%2F1%2F2006
31 Bosch manufacturing activities are based in Reutlingen, Germany for the front end. Back end manufacturing is carried out in several Bosch plants (Germany, Spain, etc.) but also using external subcontractors. Bosch has as well a subsidiary dedicated to non automotive business, Bosch Sensortec, working as a fabless organization, developing MEMS devices that are manufactured in the Bosch manufacturing facility in Reutlingen; (Yole 2006); however, Bosch as a group is registered under the Telecom Equipment NACE code. We will develop the discourse on the automotive electronics and related research in the respective chapter.
32 http://www.edn.com/article/CA6310922.html?partner=eb&pubdate=3%2F1%2F2006
33 Covering about 5% of the world production of semiconductors (ESIA 2006)
34 Approx 2% of the world production of semiconductors (ESIA 2006)
35 Approx. 4% of the world production of semiconductors is located in France and Italy (ESIA 2006)
36 http://www.eetimes.eu/germany/196603333;jsessionid=JAJ4ZKIEND5AQQSNDLPSKH0CJUNN2JVN
37 ICT sector task force reports: http://ec.europa.eu/enterprise/ict/policy/doc/wg3_report.pdf
38 Estimation and graph based on data on production from REED (2006). Data for Slovakia is estimated as regional share from total active components industry; data from Malta estimated using EUROSTAT and Xuereb (2004); the countries for which data is unavailable (Baltic States, Luxembourg and Cyprus) cover 0,2% of the EU25 turnover in the overall sub-sector NACE/ISIC 32.1 (Valves, tubes and electronic components).
39 The world average was 15% per annum (http://www.icknowledge.com/economics)
40 www.infineon.com
41 PRODCOM figures (EUROSTAT)

in Germany,[42] including major producers such as Conergy, Solarworld, Q-cells and Ersol.

France and Germany have the same share of semiconductor production in total domestic production of electronic components (about 50%), but with a somewhat different structure. ST Microelectronics conducts almost 90% of its R&D activities here, much of which is in France: its advanced R&D centres are located in Crolles (Grenoble), Tours and Rousset (Aix-en-Provence). Crolles has also attracted FDI via the Crolles2 alliance between ST Microelectronics, Philips (now NXP) and US producer Freescale (ex-Motorola), which is meant to jointly develop submicron Complementary Metal Oxide Semiconductors (CMOS) logic processes and to build and operate an advanced 300-mm wafer pilot line.[43] Taiwan's TSMC, the world's largest semiconductor foundry, also participates in process development and alignment. However, NXP announced its withdrawal from the end of 2007. In Toulouse, Freescale runs a key R&D centre together with a production line dedicated to automotive and telecommunication devices. Moreover, France has developed a significant cluster of smart card companies doing research, including Gemalto, Ingenico and Oberthur.

Following the sale of Marconi, the **UK** semiconductor industry is dominated by Foreign Direct Investment, particularly from US and Japanese manufacturers (similarly, the **Irish** semiconductor industry is dominated by Intel, with a 300 mm wafer plant in Leixlip and a research centre in Shannon). However, home-grown UK companies excel in semiconductor design and hold leading positions among the most research-intense EU companies; indeed, among the 24 second-tier (behind the giants Infineon, STM and Philips) semiconductor research investors, no less than 11 are from the UK, including fairly large ones such as ARM and CSR. Also, Cambridge-based Plastic Logic is building in Dresden the world's first plant for semiconductors made of plastic, rather than silicon.

Italy is another major R&D location for the semiconductor industry. Advanced R&D centres of ST Microelectronics are located in Italy (Castelletto/Catania and Agrate Brianza). Micron Technology[44] has an R&D centre for leading edge memory devices in Italy, while the Infineon development centre in Padova[45] concentrates on automotive embedded systems (i.e. computing systems integrated into the cars, such as electronic driving aids) and industrial drivers and controllers.

The **Netherlands** owe their relatively strong position in semiconductor research to the above-mentioned larger Eindhoven area, with Philips Semiconductor (now NXP) in Eindhoven, ASML in Veldhoven and ASM International in Bilthoven. Philips, one of the three semiconductor front-end production giants in Europe, has facilities in 20 countries across the world, including 24 research centres,[46] and allocates over 20% of the sales to R&D. ASML has R&D centres in the Netherlands, Asia and the US, but not in other EU countries. ASM International, specialised like ASML in equipment for semiconductor manufacturing, has similarly spread its R&D facilities around Asia, the US and Europe. Both ASML and ASM International had a somewhat lower R&D intensity at 13-14% in 2005, with their R&D investment also growing at comparable rates.

Portugal and **Malta** host mainly assembly and testing sites, with a much lower emphasis on R&D but still high skill requirements. Infineon[47] started operating in Portugal in 1996, with back-

42 SEMI Europe, http://wps2a.semi.org/wps/portal/_pagr/140
43 ST Microelectronics Annual Report 2005
44 www.micron.com
45 www.infineon.com
46 www.NXP.com
47 Since the data is for 2005 or earlier, Infineon includes what later became Quimonda

end operations[48] such as assembling and carrying final tests for memory chips. In 2003, it decided to expand the production capacity in the assembly factory in Porto,[49] which boosted the country's production and explains the important growth of the country share in total EU production (from around 2.4% in 2002 to almost 4% in 2004). Given the level of skills demanded even for back-end operations, Infineon has collaborated with Portuguese universities for developments of the production lines that resulted in the creation of a post-graduate semiconductor-oriented course by the Universities of Porto, Aveiro and Lisbon.[50] From the New Member States, Malta is a particular case, due to the presence of the ST Microelectronics assembly plant in Kirlop. This single semiconductor plant produces 40% of total domestic manufactured output and accounts for over 50% of Malta's manufactured exports.[51] Here, around 25% of the workforce has advanced technical and engineering qualifications.[52]

The presence of the semiconductor industry is very limited in the Eastern Member States, with the rest of the Eastern Member States providing less than 3% of the total production. Even so, these countries offer an attractive mixture of relatively cheap R&D staff with good technical skills and proximity to the main EU markets, leading semiconductor companies to open research centres in Eastern Member States where production facilities exist,[53] e.g. in Prague (ST Microtechnologies) or even where no production takes place, e.g. Riga and Bucharest (Infineon).

Like the active components analysed so far**, passive components**[54] are present in virtually all electric and electronics equipment and are generally produced and assembled in conjunction with semiconductors. R&D expenditure on passive components is estimated world-wide at € 2 billion, of which the European share is around 15%.[55] The research intensity of passive components is much lower than that of active components, and Europe is not strongly represented in this category, as from the 15 leading suppliers in the world only one, the German company EPCOS, is European,[56] whilst the main world players are Japanese companies that carry on most of the research in Japan. However, there is a cluster of fairly significant research investors in the field of printed circuit boards and machines for producing them, mostly based in Germany, and consisting of Schweizer Electronics, Vogt Electronic, LPKF, and Mania Technologie, as well as Austria's AT&S and Finland's Aspocomp.

4.3 Conclusions

IT Components, and in particular semiconductors, are an important market in themselves. In addition, they are also key ingredients for office equipment (see chapter on NACE 30), telecom and Multimedia Equipment (see chapter on NACE 32.2/3) and Electronic Measurement Instruments (see chapter on NACE

48 The back-end operation refers to creation of interconnecting wires between transistors on a wafer. For a description of the process of semiconductor fabrication see http://en.wikipedia.org/wiki/Semiconductor_fabrication
49 The Infineon investment have been backed up by an EU non-reimbursable grant and of an income tax exemption for profits deriving from the investment corresponding to 29.4% of the overall investment costs of the project located in Vila do Conde (Grande Porto), an assisted area under the EC Treaty; http://europa.eu/rapid/pressReleasesAction.do?reference=IP/04/352&format=HTML&aged=1&language=EN&guiLanguage=en.
50 http://www.investinportugal.pt/MCMSAPI/HomePage/BusinessActivities/ElectricAndElectronic/Infineon/
51 Xuereb (2004); the company plays more than a significant role in the country economics. Malta is the first location in which ST has started implementing a programme to contribute effectively towards bridging the digital divide. Among other initiatives, ST in Malta is providing free Internet courses for 1,000 Maltese citizens by the end of 2003 (ibid).
52 http://jobs.st.com/HROnline/HROnlineContent.nsf/vhomeeng/Malta?opendocument
53 The main existing production facility in Czech Republic belongs nevertheless to US-based company ON Semiconductor, and it was established following the company decision to relocate production from France and US. (REED 2006)
54 Passive components are components that offer resistance to an electric current (EECA (2006))
55 *Source: http://www.eeca.org/pdf/WhiteBook.pdf*
56 EPCOS spends 4-5% of the annual sales for R&D projects (www.usa.epcos.com)

33.2/3) – basically for the entire ICT manufacturing and also other manufacturing sectors. Indeed, the value chain of semiconductors, from producing wafers, via cutting the wafers into raw chips, designing circuits for these chips, printing the circuits, assembling chips into larger ensembles, and finally integrating them into finished products, is considered by many to be the heart of the ICT industry.

The semiconductor industry is characterised by a very high research intensity, which to date has allowed European industry to compete successfully by focusing on a number of economically significant specialties, such as GSM and smart card components, and photovoltaics. In other words, thanks to strong R&D efforts, European products escape the price competition of the mass market and compete instead on innovation and quality.

The research efforts are dominated in expenditure terms by the giants of the sector, i.e. Infineon, NXP and STM, but there are also a large number of second-tier companies in Europe investing heavily in R&D and niche markets. Those R&D efforts by smaller companies are geographically concentrated (clusters) and located only in a few countries (Germany, UK, France, Italy, Netherlands and Ireland), often in proximity to research establishments of the above-mentioned big three. This probably reflects the technical interaction between the various stages of the value-added chain and would tend to indicate that in terms of research, contrary to production, fragmentation is sometimes not very efficient in this sector. The presence of the semiconductor industry is very limited in the EU10.

At a global level, while the back-end operations (mainly foundries) are moving towards cheaper locations than the EU, cutting-edge research on semiconductors is to a large extent taking place inside Europe, particularly in promising fields such as nanotechnology[57] and photovoltaics.[58] Still, the semiconductor industry is dependent on its key markets, mainly the ICT sector, consumer electronics, process automation and car industries - all manufacturing sectors which can be potentially offshored. As a result, not only does semiconductor manufacturing risk following this trend, but so does the part of the R&D activities that is closest to the market, i.e. the customised design of the wafers.

57 Three of the world's leading research clusters in nanotechnology are located in Europe: IMEC in Belgium, Center for Nanotechnology (CNT) in Dresden and CEA LETI in Grenoble and Crolles.

58 In this segment, Europe dominates the equipment world market with a market share of about 80 percent and the production of equipment with a share of 60% (ESIA (2006))

5. IT Equipment (NACE/ISIC 30)

5.1 General economic profile of the IT Equipment industry

We will refer to NACE/ISIC30 sub-sector as "IT Equipment". This sector includes the typical IT Equipment such as computers, printers, scanners, photocopiers, and also more traditional office equipment such as typewriters and cash registers, which are however less than 4% of the production of the sub-sector.

IT Equipment is a global industry; in fact, it is the sub-sector which most people have in mind when they think about ICT goods being produced in Asia and imported into Europe. There are indeed few big European competitors in this industry, and IT Equipment was responsible for more than 80% of the total EU trade deficit in ICT goods in 2005. Moreover, with a growing EU market and a declining turnover of EU producers, the trade deficit in IT Equipment continues to increase rapidly. As a consequence, the market share of EU producers on the EU market declined sharply from 49% in 2000 to 33% in 2004. 36% of the IT Equipment trade deficit is due to the import of automatic data processing machines (essentially computers) from China. This has risen from only 13% in 2001.

Overall, the markets for IT Equipment are characterised by declining prices and cost-based competition, which implies that volumes will grow faster than values, be they for trade or for production and value added. However, there are also niche markets, such as bar-code readers and price readers, where quality competition prevails. These are accompanied by high R&D investments. For example Italy's Datalogic and Sweden's Pricer remain competitive with rapidly increasing R&D budgets. Section 5.2 offers a more detailed view on these topics.

R&D intensity in the Western Member States has been growing since 1999 and seems to have reached a plateau in the last two years (2003-2004) for which data is available. At the same time, the share of value added in turnover has increased sharply recently (by more than 10 points between 1999 and 2004), and productivity has increased, too. This combination of trends might signal a tendency to producing higher value added and more technology intensive goods to gain the competitive edge.

Table 5-1: Main figures for the IT Equipment sub-sector

2004, or the latest year available	€ bill.	% in total EU ICT	% in total EU ICT (manufacturing sectors only)
EU turnover	59,2	5.0%	15.3%
EU value added	12,1	2.3%9	11.0%
EU BERD (*)	2,3	7.0%	10.0%
EU exports (2005)	29,6	21.7%	25.4%
EU imports (2005)	70,4	39.1%	42.4%
EU trade balance (2005)	-40,8	-92.2%	-81.9%
R&D intensity (BERD/VA)		*18.8%*	
R&D intensity (BERD/turnover)		*3.9%*	

** Steady declining from 4% in 1999*
Source: IPTS based on OECD, EUROSTAT and EU KLEMS data

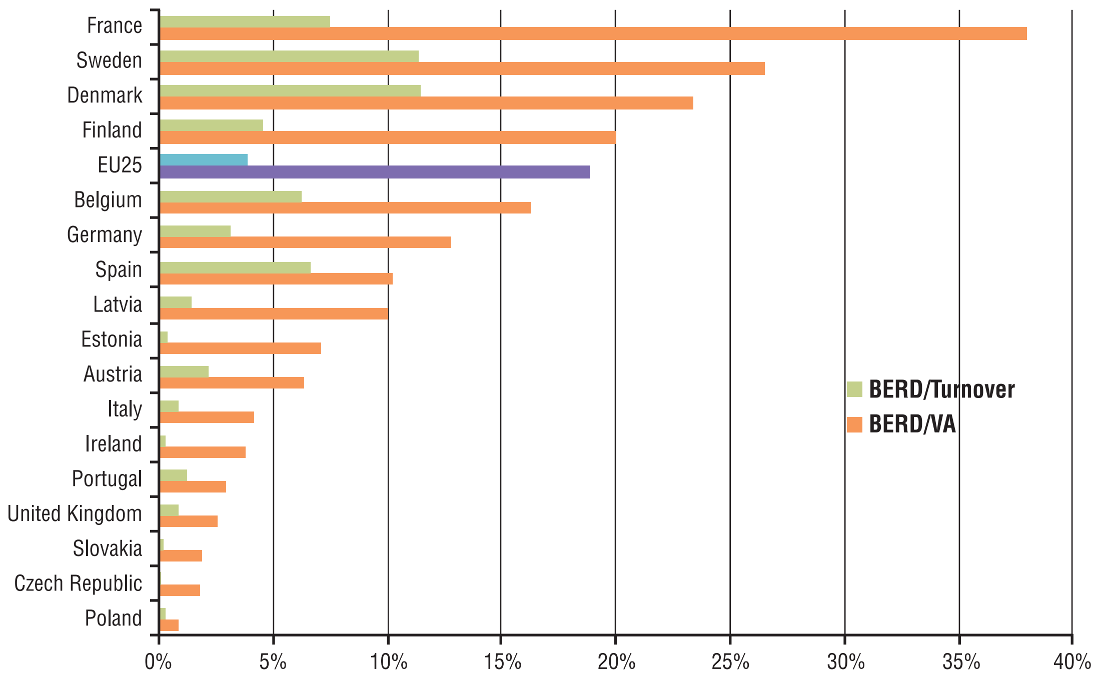
5.2 The most important R&D activities by Member State

The research intensity of the IT Equipment industry increased over the period 2000-2004, but this was essentially the statistical effect of a sharper decline of turnover and value added than of BERD, which might imply that highly R&D intensive activities were less likely to be off shored than more basic activities.

France shows a fairly high R&D intensity ratio. This country is also home to two big (for Europe) IT Equipment companies, i.e. Bull, specialised in servers, and Neopost, which produces mail sorting equipment. France could be contrasted with the relatively low R&D intensity in the **UK**. In both countries, a high productivity level is maintained by a strong decline in total employment in IT Equipment, indicating a relocation of less productive activities abroad. UK R&D employment in IT Equipment declined in 2004 to nearly half its 2002 level, the most significant drop in R&D personnel amongst the EU countries. This drop is also indicated by company data. For example, R&D at handheld devices manufacturer Psion and at data storage specialist Plasmon decreased from 2002 to 2005. In contrast, over the same time period, R&D employment in IT Equipment in France grew by 3%. One possible explanation could be that UK production *and* research tend to relocate more easily to other English speaking regions, which are relatively technologically advanced. In contrast, French companies have set up operations in North-Africa driven by historical links and cost reduction objectives,[59] while keeping more qualified activities such as R&D within the country. These trends may explain the high R&D intensities in France in relation to low ones in the UK.

59 REED (2005). Several of the arguments below draw on the same source.

Chart 5-1: Research intensities in IT Equipment; selected countries, 2004



Note: Greece, Lithuania and Luxembourg could not be estimated with sufficient reliability, while Cyprus, Malta and Slovenia reports BERD 0 for this sector. Netherlands appears in published statistical data as one of the top EU countries R&D spenders in this sector – nevertheless the data published by both OECD and EUROSTAT are supported neither by business statistics data nor by the actual spending of the top companies in the field. This issue is currently subject to further clarification

Source: IPTS based on Eurostat, OECD, EU KLEMS and national statistics

Unlike France and the UK, **Germany's** industry structure in electronics is more oriented towards innovative small and medium-sized companies. Although research intensity decreased between 2002 and 2004, the number of R&D employees, the share of R&D employees in total employment, value added and productivity increased during this time. This suggests a strong and successful innovation and niche building activity in IT and office equipment in this country.

In most Western Member States,[60] the share of R&D staff in total IT Equipment employment increased between 2002 and 2004. In Belgium, Netherlands, Ireland, Sweden, and Denmark, where sectoral productivity levels are high and value added is constant or increasing, niches of technological specialisation within the IT Equipment sector are very likely to be found or are currently forming. For example, **Sweden** has several medium-sized companies in areas such as video surveillance (Axis) or disc testers (AudioDev), which have either extremely high or rapidly increasing R&D/sales intensities.

These niches are often developed by foreign affiliates of multinationals that are moving their production lines to lower labour cost countries, but are maintaining and even expanding their R&D activities in the Western Member States where they previously also had production facilities (typically the case in Belgium and Ireland). At the same time, European companies, such as OCE, a leading manufacturer of copiers and printers from the **Netherlands**, apply similar strategies.[61] **Denmark** is a different case: its electronics industry is basically structured around numerous small local companies excelling in niche markets that are too specialised and limited to attract multinational giants. In the case of Denmark, this strong niche orientation explains the very high share of R&D employees in total ICT employment (approximately 34% in 2004[62]).

Very high growth of R&D personnel in IT Equipment is also evident in **Portugal** and **Spain.** However, R&D intensity decreased while productivity remained constant at rather low levels in both countries. In Spain, key products in the sector are the notebooks produced by foreign affiliates of HP, IBM or Fujitsu. The technology is easily transferable, and a low share of technologies used is home-based. Portugal could become an important node for electronics industry generally[63] in Europe, given the active government effort to move to higher-quality production by promoting investment, research and development, and staff training.[64] However, in the sectors producing IT Equipment, the growth appears to remain cost-based, and therefore vulnerable to low-cost country competition (typically East Asia).

The **Eastern Member States** would appear as the most likely destinations for relocated activities in IT Equipment manufacturing and R&D. This was indeed the case in the 1990s, but in general it happened less than expected,[65] and quite often through Foreign Direct Investment from third countries rather than from the Western Member States.

In comparison with the Western Member States, all the relevant indicators are much lower for the Eastern Member States. As of 2004:

- only 0.2% of the EU BERD in IT Equipment was performed in Eastern Member States, compared to almost 6% of the value added,

60 With the exception of Germany, Greece and UK
61 For a detailed case analysis see Dachs et al. (2007)

62 As compared with the EU25 average of 24%
63 The definition of the electronics industry as in REED (2005) is different from the ICT sector defined here and includes for instance electric and electronic medical and industrial instruments as well as electric and electronic households appliances
64 REED (2005)
65 It is worth noticing that from the beginning of transition to after the integration the inter EU25 trade in office equipment did not increase very much at least in a relative sense: from 46% of total imports in 1993, to 47% in 2003 Dachs et al. (2007)

- the R&D intensity of IT Equipment manufacturing stood at 0.6% in Eastern Member States, compared to 19.9% in Western Member States,

- the share of R&D personnel in total personnel was on average 25 times lower in the Eastern Member States, than in the EU.

Within the group, there are very large differences not only between countries, but also over time. One of the reasons that create this volatility is that the BERD includes all the expenses for fixed assets, including building and land, in the year of their acquisition. As many of the available funds, including structural funds, were spent on upgrading the technical infrastructure and research facilities, the data can significantly increase or decrease from one year to the next because a major building site was started or finished. This is particularly visible in the case of **Poland**. However, the activity of the domestic IT industry in the country continues to be mostly the assembly of imported components for the domestic market. Giving the strong price competition from no-brand computers, the sales of big international investors in Poland as Compaq, Dell and IBM have actually decreased in Poland.

The **Czech Republic, Hungary** and **Poland** cover ca 84% of the value added, 70% of the R&D expenditures and 70% of research staff for IT Equipment among the Eastern Member States, but the **Baltic States** and **Slovakia** are leading in terms of R&D intensity. The development in all those countries is driven mainly by FDI. Only in very few cases has FDI spilled over into domestic business developments.

R&D personnel and R&D intensities grew quickly in the Czech Republic and Poland between 2002 and 2004.[66] The Czech Republic appears to be a very special case, since R&D investments grew from less than €0.15 million in 2002 to more than € 1.2 million in 2004, accompanying a growth of only 12% of the real gross output.[67] This growth is mostly due to investment by international companies such as FOXCONN and Taiwanese First International Computers. In 2004 alone, the value of R&D performed in the Czech Republic almost doubled. Despite this growth, at 18%, the actual R&D intensity remains very low.

Hungary saw a surge in the value added in 2003, following a continuous decline since 1999, due in turn to the impact of the sharp downturn in the global demand for peripherals (printers, screens, mice), where earlier the country had had a strong specialisation. Growth in 2003 was centred in the segment of computer systems. This growth in value added was not paralleled by growth in employment or R&D indicators, so it was most likely due to the opening of new markets for existing products or rises in prices due to branding/purchasing of existing companies by FDI. Although big international companies as HP, IBM and Fujitsu-Siemens have operations in Hungary, the share of no-name computers on the market is ca. 50%, as in Poland. This sets the competition for the domestic market on price, leaving few resources available for R&D investments.

Overall, although the Eastern Member States were expected to accommodate relocated production and research activities from Western Member States, this does not seem to be an extensive phenomenon in IT Equipment. This is probably due to two main factors. Firstly,

66 Faggio (2003) shows that in Poland positive FDI wage and technology spillovers from foreign- to domestic-owned firms are concentrated in two high-tech industries, office machinery and communication equipment (NACE 30 and 32). The growth in wages due to FDI might explain the significant growth of R&D expenditures and R&D employment after 2003

67 EU KLEMS

the assembly industry is responding to low purchasing power, which limits the potential revenues on the domestic markets. Secondly, wages in these countries are no longer low enough to be a sufficiently strong incentive for locating production and R&D to the Eastern Member States. As a result, FDI has arrived on a smaller scale than anticipated.

5.3 Conclusions

IT Equipment is the sub-sector where the Western Member States' industry is least competitive, at least on the price-sensitive and still growing mass market. This sub-sector has also been strongly hit by relocation, with ICT goods being produced in Asia and imported to Europe. Consequently, the trade deficit in this sub-sector increases year-on-year and is responsible for more than 80% of the total EU trade deficit in ICT goods.

EU R&D intensity in IT Equipment stands at around 19% of value added, but this figure hides a wide variation between EU Member States. R&D intensity in the Western Member States has been growing since 1999 and seems to have reached a higher plateau in the last two years (2003-2004) where data is available, though this is often due more to decreasing value added than to increasing R&D. There are no significant relocated research activities from Western Member States to the Eastern Member States in this sector. Instead most of the R&D in the Eastern Member States comes from foreign direct investment from third countries.

There are however a number of niche markets in IT Equipment in which EU (mostly Western Member States) producers compete on the basis of quality, based in turn on strong R&D. High productivity and R&D intensity are then often associated with a relocation of lower productivity activities abroad.

6. Telecom and Multimedia Equipment (NACE/ISIC 32.2/3)

6.1 General economic profile of the sub-sector

This section covers TV and Radio Transmitters and Telecom Equipment (NACE/ISIC 32.2) and TV and Radio Sets, CD, DVD, MP3 Players and Similar Machines (NACE/ISIC 32.3). In terms of trade statistics this corresponds almost completely to telecom and sound equipment (SITC group 76). The lack of available detailed BERD data (at country level, mostly due to confidentiality issues) prevented us from making a meaningful separation of NACE 32.2 from NACE 32.3 on a country level. We will refer to this sub-sector as Telecom and Multimedia Equipment.

The valued added of Telecom and Multimedia Equipment declined strongly in 2001, followed by a very slow recent revival. Despite this, the industry carried out R&D of over € 9 billion in 2004, or 30% of the total R&D in ICT. The sub-sector was responsible in 2005 for 15% of the total trade deficit in ICT goods, with a deficit contribution constantly increasing from 2002, when the previous surplus turned into deficit. Clearly, something is amiss in this sub-sector. It is worth mentioning, however, that during the period

Table 6-1: Main figures for the telecom and Multimedia Equipment sub-sector

2004, or the latest year available	€ bill.	% in total EU ICT	% in total EU ICT (manufacturing sectors only)
EU turnover, from which:	141,1	11.8%	36.4%
- Telecommunication Equipment	*92,3*	*7.7%*	*23.8%*
- Multimedia Equipment	*48,8*	*4.1%*	*12.6%*
EU value added, from which:	28,1	5.3%	25.5%
- Telecommunication Equipment	*20,0*	*3.8%*	*18.1%*
- Multimedia Equipment	*8,1*	*1.5%*	*7.4%*
EU BERD (*)	9,4	28.8%	41.6%
- Telecommunication Equipment	*8,5*	*25.9%*	*37.4%*
- Multimedia Equipment	*0,9*	*2.8%*	*4.2%*
EU exports (*2005*), from which:	42,1	31.0%	36.2%
- Telecommunication Equipment	*30,6*	*22.5%*	*26.3%*
- Multimedia Equipment	*11,5*	*8.6%*	*9.9%*
EU imports (*2005*), from which:	49,9	27.8%	30.1%
- Telecommunication Equipment	*35,9*	*20.0%*	*21.6%*
- Multimedia Equipment	*14,0*	*7.8%*	*8,5%*
EU trade balance (*2005*), from which:	-7,8	-17.7%	-15.7%
- Telecommunication Equipment	*-5,3*	*-12.0%*	*-10.7%*
- Multimedia Equipment	*-2,5*	*-5.7%*	*-5.0%*
R&D intensity (BERD/VA)		*33.7%*	
- Telecommunication Equipment		*42.5%*	
- Multimedia Equipment		*11.6%*	
R&D intensity (BERD/turnover)		*6.7%*	
- Telecommunication Equipment		*9.2%*	
- Multimedia Equipment		*1.9%*	

** The nominal value of sectoral BERD for the total of NACE 322 and NACE 323 is an estimation, valid within a 95% confidence interval; however the breakdown on NACE 322 and NACE 323 employs further estimations and should be regarded with caution. Data for the countries with the most significant contribution to the BERD especially in Telecom Equipment (Finland, Sweden and UK) are particularly scarce.*
Source: IPTS based on OECD, EUROSTAT and EU KLEMS data

between 2000 and 2004 the share of value added in turnover and the productivity did not decline.

Telecom Equipment (in particular for 3G mobile networks) is responsible for the bulk of both production and trade in the sector. Half of the EU output in radio transmission apparatus is produced in Finland (19.5%), France (17.9%) and Hungary (14.2%).[68] Since 2000, in Telecom Equipment, the EU has recorded a switch from a trade surplus to a continuously increasing trade deficit, simultaneously with worsening terms of trade.

The R&D intensity of Telecom Equipment is very high; with BERD/VA standing at over 40%, this ration is the highest of all ICT sub-sectors.[69] Company data show very high R&D intensity for this sub-sector, too. A large part of R&D activities in Telecom Equipment sector nurture technological convergence: a considerable segment of devices could also be (and increasingly are) considered as Multimedia Equipment. As a result, the sectoral distinctions for statistical purposes are blurring, calling for more careful product and company level analysis.

There is a small group of Multimedia Equipment products where European producers are very competitive on quality, with exports (in volume) larger than imports despite higher prices: switching equipment, loudspeakers (mounted) and electric sound amplifier sets. In 2005, they represented about 8% of the total EU Telecom and Multimedia Equipment sub-sector production[70] and 9% of the EU exports from this sub-sector.[71] Almost 40% of the production of switching equipment originates in France and Germany. Denmark alone produces 23% of total EU production of mounted loudspeakers, mostly due to Bang and Olufsen, while almost 60% of electric sound amplifier sets are produced in Germany.[72]

68 PRODCOM database

69 While the R&D intensity for Multimedia Equipment is lower, at about average for ICT manufacturing.

70 Calculated using PRODCOM database

71 EUROSTAT data

72 Calculated using PRODCOM database

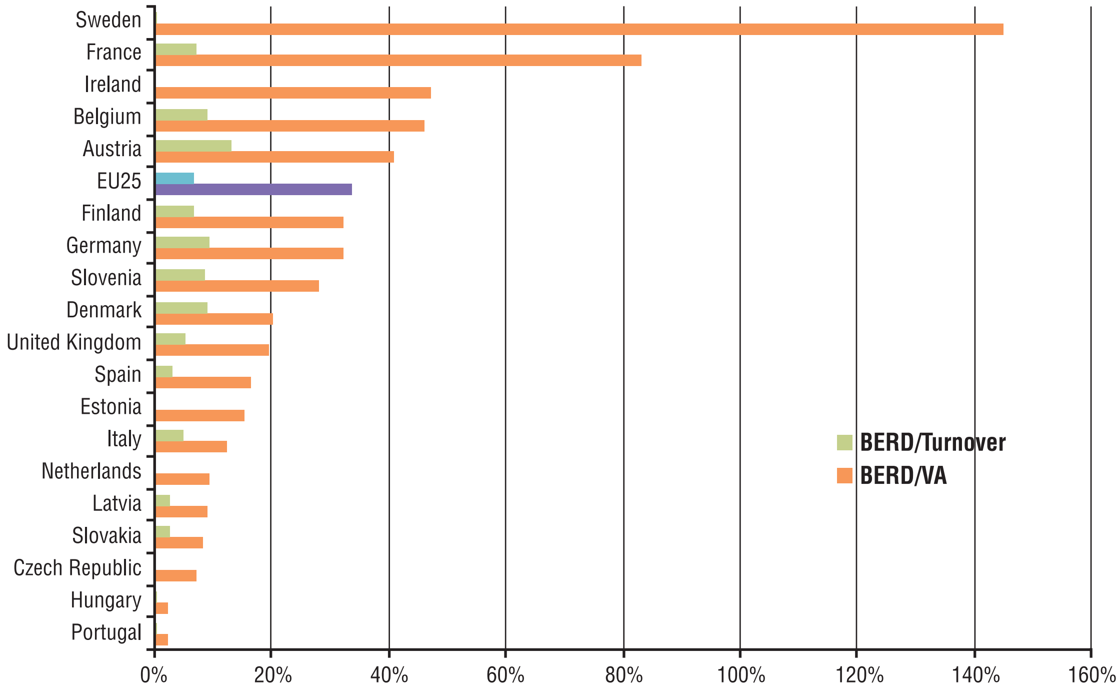
6.2 The most important R&D activities by Member State

Only 1% of the Telecom and Multimedia Equipment R&D is carried out in the Eastern Member States, and the difference in R&D intensity (BERD/VA) between the Western Member States and the Eastern Member States has increased during the last few years, to a factor of 9 (4.4% in Eastern Member States as compared with 35% in Western Member States). One should note that the gap for Telecom Equipment is much lower, at a factor of about 4, than for multimedia, at a factor of about 20, although the absolute levels are very small.

The deterioration of the Eastern Member States' relative R&D intensity is the result of the combined dynamics of value added and BERD. In the Western Member States, both declined, but value added declined faster than BERD, resulting in an increase of R&D intensity. In the Eastern Member States, both grew, but value added grew faster than BERD, resulting in a decline of the R&D intensity. However, several Eastern Member States such as Slovenia, Estonia and Slovakia, have performed notably well.

As can be seen immediately, the **Swedish** data is particularly interesting. Telecom and Multimedia Equipment is dominated by Ericsson. Although it has operations worldwide, almost half the staff is employed in Sweden. This company's R&D intensity is particularly high, with 17% of sales invested in R&D in 2004 and 16% in 2005. Nearly one-third of employees work in R&D and over 20,000 patents have been registered worldwide. Ericsson's strengths are in GSM and WCDMA technologies, and the company also develops and licenses technology platforms,

Chart 6-1: Research intensities in Telecom and Multimedia Equipment; selected countries, 2004



Note: Greece, Lithuania, Luxembourg, Malta, Poland and Slovakia could not be estimated with sufficient reliability using available data, while Cyprus report 0 BERD in this sub-sector.
Source: IPTS based on Eurostat, OECD, EU KLEMS and national statistics

as well as the chip design and software that are inside many of the world's most advanced GPRS and WCDMA handsets.[73] Ericsson has also been active in several projects of the EU framework programmes. A large part of Ericsson's R&D is conducted in Kista outside Stockholm, an area which has also attracted R&D of several smaller domestic companies as well as foreign ones. SonyEricsson Mobile, the mobile phone producer, has a large R&D development activity at its HQ premises in Lund in the south of Sweden.

The statistical data nevertheless describe a contrast between very high research intensity when calculated relative to the value added and a rather low one when compared with total sales. This has three explanations. First, the telecom crisis hit the Swedish Telecom Equipment industry particularly strongly – EU KLEMS reported a decline in value added by a factor of 10 between 2000 and 2002 alone, and a negative value in 2001. Since then the value added has grown, but, as in 2004, it stood at barely a third of what it was back in 2000. The sales show a decline as well, but much less. Second, a disproportionate share of Ericsson's sales may be reported by its Swedish subsidiaries. Third, the particularities of R&D data collection for Sweden add further uncertainty to the calculations.[74]

Finland is a world leader in fixed and especially wireless products. A wide range of products originate in Finland, including digital transmission systems, exchanges, mobile phones,

73 http://www.ericsson.com/ericsson/investors/financial_reports/2005/annual05/summary_downloads/summary2005_en.pdf

74 Beginning with the 2003 data sent to Eurostat and OECD, Sweden has included all of ISIC/NACE 30-33 in ISIC/NACE 30 (with a note stating that it includes other classes) and provides no breakdown for ISIC 32. EUROSTAT reports the data as such, while OECD estimates the sub-sectoral distribution based on 2001 data when a breakdown for all 3 of 30, 32 and 33 was available in the country submission. Since the OECD approach correspond better to received information on R&D, we use OECD data for Sweden.

subsets, antennas and amplifiers. The sector output followed the global downturn in 2001 and 2002 after a period of previously extremely high growth. In 2002 and 2003, the decline in the production of both fixed and wireline infrastructure equipment was compensated by the production of mobile handsets, although this is a fragile segment, because it is easily subject to offshoring.[75]

Nokia, which had 36% of the world mobile phone market in 2006,[76] is dominating the Finnish telecom and Multimedia Equipment industry. It is a research intensive company, which had a share of R&D investment in sales of 12% in 2004 and 11% in 2005.[77] Nokia Research Center, the corporations's industrial research laboratories, has sites in nine different locations around the world, three of which are in Finland (Helsinki, Tampere and Toihala). The research pursued by Nokia covers mostly various areas of handset developments as well as wireless networks, including projects of technological convergence.

The **Danish** performance reflects the presence of Bang & Olufsen, an important producer of LCD television sets and other high-tier home entertainment systems. In addition to Bang & Olufsen, it should be mentioned that Nokia has an R&D centre in Copenhagen, and that Aalborg/North Jutland is known for its large number of firms active in wireless communications R&D. Bang & Olufsen is one of the top EU R&D investors, with an R&D intensity in 2005 of 13.4% of turnover. They also have an interesting R&D strategy, with a rather limited core R&D department oriented towards blue-sky research, called Idealand/Idealab, and they collaborate extensively with external product designers and even customers. The bulk of the R&D expenditures go towards financing PhD students and programmes through partnerships with American and European Universities. At Aalborg University in Denmark, the company is involved in the Sound Quality Research Unit under a four–year centre contract.[78] It is noticeable that the R&D intensity of the company group is below the corresponding ICT sector R&D intensity for Denmark. This has two explanations. On one hand, Bang and Olufsen's R&D activities are concentrated in Denmark, while manufacturing operations are dispersed in other sites around the world (in the Czech Republic in particular). On the other hand, the national figure is the statistical consequence of a sharp decline of production in other sub-sectors included in the telecom and Multimedia Equipment industries in 2004, in particular in transmission equipment (where the Danish turnover declined from € 712 million in 2003 to € 233 million in 2004[79]), mainly as a result of the decision by Flextronics International to close its facility in Denmark.[80]

The very same reason boosted the R&D intensity of **Ireland** in 2004: a very sharp decline in turnover in Telecom Equipment (from € 840 million in 2003 to € 80 million in 2004[81]), combined with a high and fairly constant BERD mostly in radio and TV sets. This high BERD reflects the activity of the national market leader O'heocha Design, the R&D and production competencies of which are focused on wireless audio streaming. The presence of Bell Labs Research Centre, Ireland, established in 2004 as part of Alcatel-Lucent's telecom research should also be mentioned.[82]

Germany offers a completely different picture. It hosted headquarters or essential branches of the biggest mobile telephone producers, including Motorola (with the production site in Flensburg), Nokia (with the production site in Bochum now closed) and Siemens (with the production site in

75 REED (2006)
76 www.nokia.com Q3 2006 Press Release
77 Calculated based on http://www.nokia.com/link?cid=EDITORIAL_4636
78 http://www.bang-olufsen.com/graphics/bogo/reports/annualreport_2005-06_uk.pdf
79 EUROSTAT data
80 REED Electronic Yearbook 2005/2006
81 EUROSTAT data. At this point we don't know the reasons for this drop.
82 http://www.alcatel-lucent.com/wps/portal/

Bocholt, sold to BenQ in 2005 and since closed). Nokia and Motorola operations in Germany alone covered half of the country's turnover in Telecom Equipment (excluding Siemens[83]) and more than a third of the total telecom and Multimedia Equipment production in 2004.[84] Nokia had an R&D centre on the production site in Bochum, taking advantage of the nearby concentration of technical universities in the Ruhr area.[85] In Taunusstein, Motorola is developing research on intelligent systems that integrate wireless devices, sensing systems and active displays with intelligent decision-management software.[86] A Bell Labs team is located in Nuremberg and has its roots in wireless advanced technologies system engineering, global wireless system research, and wireless advanced technologies.[87] Alcatel's R&D innovation centre in Stuttgart focuses on radio networks and technologies, such as UMTS evolutions, WiMAX, multi-standard and multi-band radio base stations, and on high-speed optical transmission, optical access and advanced electronic technologies.[88] Finally, Philips has two R&D laboratories in Hamburg and Aachen.

The rest of the German Telecom and Multimedia Equipment industry is dominated by German companies, which also carry out significant R&D. In particular, the Bosch–Blaupunkt Group stands out, covering 9% of the German telecom and Multimedia Equipment turnover in 2004. Bosch concentrates its R&D activities in Germany, where it has five specialised centres in: Frankfurt (sensor systems and systems based on ultrasound technology); Hildesheim (automotive hi-fi and navigation systems); Schwieberdingen (production engineering and systems); Waiblingen (development and processing of plastic materials) and Schillerhöhe (applied automotive and industrial research).[89]

The **UK** Telecom and Multimedia Equipment industry is strongly dominated by foreign investors, a rather unique feature among the Western Member States. Among the top ten, only Telent, a company providing integrated network solutions, is a domestic company.[90] Regarding inward R&D investment, Asian multimedia (especially flat screen) producers have set up dedicated R&D and design centre subsidiaries in the UK, including the Pioneer Digital Design Centre (PDD), the Samsung Research Institute or Fujitsu Laboratories of Europe, with a view to adapting their products to the local demand, and to participating in standardisation activities. Among the EU R&D investors, one should mention the Philips Research Laboratoire at Redhill for content developers and publishers to develop their ambient intelligence-enabled offerings.[91]

In **France,** Philips had no less than 17% of the total turnover in this sub-sector as of 2004.[92] The presence of Philips in France was boosted by the cooperation with France Telecom towards developing the market for broadband, wireless home networks, connected devices, and value-added broadband-connected entertainment and communication services, and also by the presence of Philips Semiconductors in Crolles2.[93] Other international suppliers of consumer audio and video systems have established research centres in France, too. In particular, one should

83 Siemens Germany is not classified as a Telecom Equipment manufacturer and is therefore not included in the official statistics for this category
84 Calculation based on EUROSTAT data.
85 http://research.nokia.com/locations/bochum/index.html
86 http://www.motorola.com/content.jsp?globalObjectId=6677-9298-9301
87 http://www.alcatel-lucent.com/wps/portal/
88 http://www.alcatel-lucent.com/wps/portal/
89 http://researchinfo.bosch.com
90 Excluding Vodafone, which is registered under Telecom Equipment in the UK (according to the Amadeus database). Since the company provides telecoms services, it will be discussed in Chapter 8 instead.
91 http://www.ambx.com/site/about/philips
92 Calculation based on Amadeus and EUROSTAT data
93 In the Amadeus database, the main parts of Philips activities are registered in this class in France. After 2004 Philips institutionally separated the semiconductors production units (now NXP) and sold some of its operations in the telecom areas, so we expect that the presence of Philips in France will be lower in subsequent years. For major R&D activities located in Grenoble, see the chapter on IT components.

mention the Pioneer Speaker Design Centre's main headquarters located in Paris. Its explicit mission is to remaining permanent touch with the most fashionable design trends in European interior design.[94]

Home-grown producers Alcatel (now Alcatel-Lucent) and Thales Communications together cover 10% of the total Telecom and Multimedia Equipment turnover in France.[95] Alcatel's Marcoussis Research & Innovation Centre specialises in the fields of optical transmission and networks, packet transport infrastructure, mobile networks, converging applications, user profiling, security and multimedia expansion.[96] Thales International Group invests approximately 18% of consolidated revenues in research and development[97] and is present in all major competitiveness clusters in France, the most relevant of which are in the field of complex industrial systems and specific equipment for air and maritime transport safety and security. Thales Research France employs 220 full-time staff, around 40 doctoral students and 50 outside researchers from CNRS, the École Polytechnique, IOTA,[98] etc.

In the **Netherlands,** Philips overwhelmingly dominates[99] the domestic turnover of the telecom and Multimedia Equipment sector,[100] although the aggregate R&D intensity of Philips is not particularly high at 7.7% of turnover. Its research increasingly evolves around emerging e-health concepts and equipment, and it has developed a European niche in this area. The Philips' High Tech campus, located in Eindhoven, remains the centre of the company's global R&D activities. In general, Philips is widely connected on the global market and participates in numerous EU financed projects.[101] Regarding Telecom Equipment, it is worth noting that production in the Netherlands is dominated by foreign (European) investors; the five biggest players are all subsidiaries of other EU companies (Alenia Marconi, Thales, Bose, Ericsson and Bosch)

Slovenia's performance in R&D intensity is mainly due to its strong telecom and radio communication equipment industry. The main player is the Iskratel group, established in partnership with Siemens. In 2005, the Iskratel group invested 18% of sales in R&D and almost 30% of company personnel work in R&D-related activities.[102]

Developments in **the Czech Republic** are equally dominated by a local Siemens branch, Siemens S.R.O., which covers no less than 40%[103] of the total telecom and Multimedia Equipment sector in the country.[104] Other important global players such as Panasonic and Bang and Olufsen have established operations in the Czech Republic, too, but mostly as manufacturing sites. The Czech Republic also stands out as a producer

94 http://www.pioneer.co.uk/eur/content/company/speaker_design_centre.html
95 Calculation based on Amadeus and EUROSTAT data
96 http://www.alcatel-lucent.com/wps/portal
97 Thales Research and Technologies comprises four research centres in France, the UK, the Netherlands and Singapore, located on the premises of the partner Universities École Polytechnique, Delft University and Nanyang Technological University. The Group also has various laboratories managed jointly by corporate research and Group subsidiaries and a network of research departments directly assisting operational units (http://www.thalesgroup.com/all/pdf/Thales_uk_2005.pdf).
98 http://www.thalesgroup.com/all/pdf/Thales_uk_2005.pdf
99 Data for turnover in NACE 32.2-3 for Netherlands is not available due to confidentiality issues and it is estimated based on company info from the Amadeus Database. Although Philips does not primarily register in this sub-sector, it is clear that the company's main ICT-related business area is consumer electronics. It could therefore be assumed that Philips registers a large parts of its R&D activities in this sub-sector NACE 32.3.

100 It is not clear in which sector Philips registers its R&D activities
101 E.g. Ambience, Ozone, Amigo, IceCream (www.philips.com)
102 http://www.iskratel.si/sites/INTERNET_en/doc/o_podjetju/profil_podjetja/CP_0806_ENG.pdf
103 Own calculation based on EUROSTAT turnover data in NACE 322 and NACE 323 for Czech Republic and turnover data for Siemens S.R.O from Amadeus database.
104 However, the statistical registration is misleading: Siemens S.R.O. is registered under the NACE group 322, but produces goods that cover a very wide range of industrial ICT. In particular, Siemens is a renowned producer of medical equipment.

of mobile telephones, through branches of Flextronics, Panasonic and Celestica. However, the firm level information publicly available does not allow a precise definition of the R&D activities performed in these establishments. There are also Czech producers of Telecom Equipment, such as STROM Telecom, TTC Telecommunikace Praha, TESLA Praga and TSE. These companies invest mostly in development activities for the domestic market, and their size and R&D investment is smaller.

Slovakia has its niche in TV and, since 2002, in DVD production, a market segment dominated by foreign investors (in particular, by Samsung of South Korea) which develop related R&D activities within the country.

6.3 Conclusions

Telecom Equipment and Multimedia follow two very different trajectories. Of the two, the Telecom Equipment sector is in much better shape R&D-wise, but even so its position has been deteriorating recently.

Telecom Equipment is Europe's traditional ICT strength, including major international players in infrastructure equipment (Alcatel-Lucent, Ericsson, Nokia-Siemens) and in handsets (Nokia, SonyEricsson). This sub-sector is also the most R&D intensive of all ICT sub-sectors. It is a geographically less concentrated industry than the rest of the ICT manufacturing sector, in the sense that, in addition to the usual dominant countries, Germany, France and the UK, the Nordic producers also have very strong R&D presence in this sub-sector. However, after reaching its peak in competitiveness due to the runaway success of the GSM standard, since 2000 its position has been eroded, following the crash of the dotcom bubble. Not only has value added decreased considerably from 2000 to 2004, R&D went down even further, resulting in a decreasing R&D intensity. Although company data indicate a strong R&D rebound in 2005, and despite the fact that its competitors had suffered a similar crisis, European industry has clearly lost ground, and has switched from a trade surplus to a continuously increasing trade deficit.

The multimedia sector is in quite a different situation. European producers are relatively strong in the premium segments (Bang and Olufsen, Philips), but this strength is overshadowed by the weakness in the mass market. Moreover, R&D by European companies has actually been shrinking rapidly for several years while non-European countries continue to increase their research. Despite the notable presence of a number of Japanese-owned research centres, particularly in the UK, in order to be connected to trend-setting networks, this is a worrying trend for an industry based on premium products.

7. Electronic Measurement Instruments (NACE/ISIC 33.2/3)

7.1 General economic profile of the sector

The NACE sector 33 covers measuring equipment in general. The part that mostly interest ICT R&D is restricted to the subgroups 33.2 and 33.3, sub-sectors that cover electronic instruments for measuring (such as sensors) and controlling (such as dispensers). It also contains electronic navigation systems, radars, radio remote controlled devices, etc. We shall refer to it as *Electronic Measurement Instruments*. The trade data in Table 7-1 will refer to the NACE 33 total only, mainly due to aggregate data availability issues. The rest of the chapter will exclusively concentrate on Electronic Measurement Instruments.

Since 2000, Electronic Measurement Instruments is the only manufacturing subgroup in the ICT sector that has shown a trade surplus, and even a steadily increasing one. There is a surplus in all product groups except radar and navigation systems, which might be cause for concern, given the market potential for car navigation systems. Contrary to the general argument that the EU tends to be more competitive in higher R&D intensity sectors, the trade surplus in Electronic Measurement Instruments has been achieved despite the fact that R&D intensity is around average for ICT manufacturing.[105]

105 It is worth mentioning that the statistical classification used to categorize the ICT related part of NACE 33 into Electronic Measurement Instruments (NACE 3320+3330), is imperfect. Around 8% of the total output of *Electronic Measurement Instruments* consists in non-electronic devices, while for a large part of the other both electronic and non-electronic solutions are available. Moreover, some of the medical equipment statistically included in the NACE 3310 is actually ICT based, in particular the *electro-diagnostic apparatus for medical, surgical, dental or veterinary purposes*. Nevertheless, as a result of the blurring borders between the sub-sectors, some of the producers of the electro-medical instruments will be found among the market and R&D leaders within the Electronic Measurement Instruments sub-sector.

Table 7-1: Main figures for the Electronic Measurement sub-sector

2004, or the latest year available	€ bill.	% in total EU ICT	% in total EU ICT (manufacturing sectors only)
EU turnover measurement instruments, from which Electronic Measurement Instruments:	127,3 64,3	10.7% 5.5%	32.8% 16.6%
EU value added, measurement instruments,(*) from which Electronic Measurement Instruments:	52,4 25,7	9.9% 4.9%	47.7% 23.4%
EU BERD, measurement instruments,(**) from which Electronic Measurement Instruments	6,6 5,4	20.2% 16.4%	29.1% 23.7%
EU exports, Electronic Measurement Instruments (2005)	21,8	16.0%	18.7%
EU imports, Electronic Measurement Instruments (2005)	15,5	8.6%	9.3%
EU trade balance, Electronic Measurement Instruments (2005)	+6,3	+14.15%	+12.56%
R&D intensity (BERD/VA), measurement instruments, from which Electronic Measurement Instruments		*12.6%* *21.4%*	
R&D intensity (BERD/turnover) measurement instruments, from which Electronic Measurement Instruments:		*5.2%* *8.4%*	

* *Data for NACE 33 and for Electronic Measurement Instruments are not fully compatibleNote Exports, imports and trade balance refer to whole NACE 33 sub-sector.*
** *The nominal value of sectoral BERD is an estimation valid within a 95% confidence interval; data for Electronic Measurement Instruments implies nevertheless extensive estimations and should be regarded only as indicative figure*
Source: IPTS based on OECD, EUROSTAT and EU KLEMS data

Despite its external competitiveness, Electronic Measurement Instruments seem to be an industry heavily oriented towards the internal EU market. This is firstly due to the very nature of many of these instruments, which are often customized for integration into other devices such as automation production lines, which makes them less tradable. The share of such customized activities represented 22% of the total output in Electronic Measurement Instruments in 2005.[106] Secondly, many of the instruments needed in the defense industry or other strategic areas, like aeronautical and space navigation, and therefore produced on demand by EU Member States, are included into this group.

Thirdly, the high priority given by the EU policy to health and safety, energy saving and environmental protection issues has boosted the development of this sector. The main impact of these policies is an increase in precision, as higher and higher accuracy is required. For instance, the increasing use of natural gas for household appliances under conditions of very high safety and maximized energy efficiency requires very precise gas meters, safe gauges, instruments for measuring, analyzing and monitoring pressure and other specific variables – these alone cover almost 7% of the total output of Electronic Measurement Instruments.

Finally, this industry provides essential instruments and appliances for key sub-sectors within the ICT sector. For example, 3% of the total output of electronic measuring instruments consists of instruments for telecommunications, and another 1% of instruments for checking semiconductor wafer or devices. Nearly all of the instruments used for measuring electricity variables (about 6% of the total output of electrical measurement instruments) have a use in the electronics and ICT sectors themselves.

106 This and the following paragraphs draw on Eurostat PRODCOM data.

7.2 The most important R&D activities by Member State

R&D in Electronic Measurements Instruments is geographically concentrated. France, Germany and Italy produce approx. 60% of the total value of the sector and perform 70% of its total BERD.[107] For comparison, the same three countries are responsible for about 50% of both value added and BERD in the rest of the ICT sectors. It is worth noting that the presence of the Eastern Member States within the industry is extremely low: 3.5% of the VA of the EU Electronic Measurement Instruments originates in the Eastern Member States, and an estimated less than 0.6% of the EU BERD.

The products contained in the Electronic Measurement Instruments sector are very diverse, and country data generally reflect company specialization in very narrow and specific niche markets in the most high-tech products, or companies having secondary activities where the main business is in a different sector (or a in a different ICT sub-sector). Therefore, one additional difficulty to the analysis is that, in certain sub-sectors, the discrepancy between the information provided by product level data and by company level data can be very significant.[108]

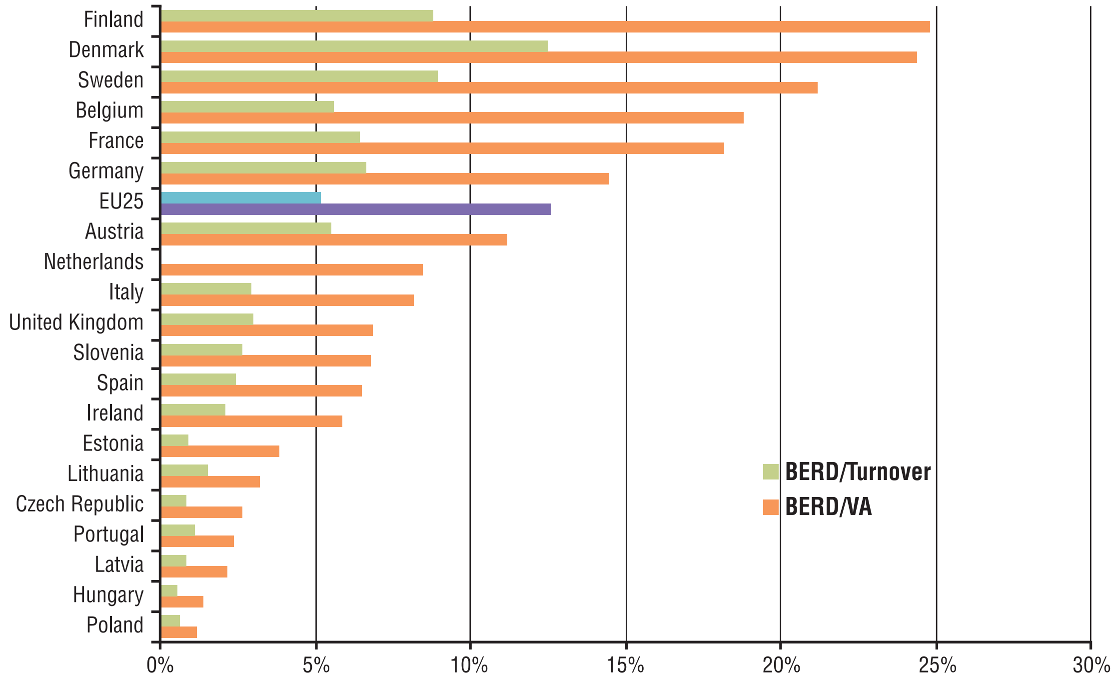
France shows strong a specialisation in defense-related instruments and electronics, mostly the *radio navigational* and *remote control devices,* which account for about 10% of EU production.[109] These are used for naval, aeronautical and space navigation, pilotless aircraft, rockets, missiles, toys and model ships or aircraft, machines, and the detonation of mines, etc. In France, Sagem Defense (Safran Group) and three Thales affiliates cover about 36% of total turnover. Thales and Sagem are also the main

107 BERD data in 3320 and 3330 is published by only 11 out of 25 Member States.

108 For these reasons, we describe only a few selected countries below.

109 Estimated using PRODCOM database

Chart 7-1: Research intensities in Measurement Instruments; selected countries, 2004



Note: Greece, Luxembourg and Malta are excluded because of lack of reliable data. Cyprus reports 0 BERD while Slovakia's BERD in this sector is insignificant. Note also that graph include the whole NACE 33 sector.
Source: IPTS based on Eurostat, OECD, EU KLEMS and national statistics

manufacturers of radar systems, where France is home to almost half the EU production. Both the Safran Group and the Thales Group are very large R&D investors (Thales ranks 43rd and Safran 48th in the EU), [110] which explains to a large extent why France is the leader in R&D intensity of this sector in Europe.

Germany covers approximately 30% of both EU value added and BERD in Electronic Measurement Instruments and offers a much larger range of specialization than France. The German Electronic Measurement Instruments industry is to a larger extent than other countries based on small and medium companies.[111] The country leader, Carl Zeiss SMT, covers 15% of the total country sub-sector turnover. With R&D expenditures of 10.5% of the sales, the company is also one of the larger EU R&D investors in this sub-sector. Its main activity is in healthcare systems, but its main R&D activities are concentrated in microscopy and medical imaging, rather than in pure instrumentation.[112]

Italy, together with France and Germany, is strong in the production of instruments for checking semiconductor wafers or devices. However, the sector is dominated by the US

110 See "European Commission (2007a) available at www.jrc.es. Although their affiliates and country branches show up in various ICT subsectors, the industrial groups are registered elsewhere (Safran Group in NACE 35.3 - *Manufacture of aircraft and spacecraft* and Thales Group in NACE 75.2 - *Defence activities*), therefore they do not appear in the analysis based on company data.

111 For instance, almost 40% of the test benches produced in EU25 are manufactured in Germany, mainly serving the strong domestic car industry – nevertheless www.industrystock.com lists 22 different producers of test benches registered in Germany, all manufacturers of measurement instruments in general, from which the first listed, Stahl GmbH, has less than 50 employees.

112 http://www.zeiss.de/C12567A100537AB9/Contents-Frame/8A0034620211F35341256A780049C66A

process control and automation systems leader Emerson Electric, followed by two providers of defence-related equipment, Galileo Avionica and Alcatel Alenia Space Italia. These last two companies cover 16% of the total Italian sectoral turnover,[113] and have very high research intensity. Galileo Avionica specializes in land, air, naval and space systems.[114] Finmeccanica, the owner of Galileo Avionica, is the 18th biggest R&D spender company in the EU, with over 15% of the sales reinvested in R&D.[115] Alcatel Alenia Space's portofolio includes rocket launchers and telecommunication and observation satellites for both civilian and military purposes. Research is being carried out in the field of nano-ceramics, and in preparation for nano-metallic materials, nanosensors for exploration purposes, and health monitoring.[116]

Denmark is an important producer of electro-medical equipment, especially in electro-diagnostic equipment and hearing aids.[117] Denmark's performance in this sector R&D reflects the results of Radiomedical APS, a leading provider of blood gas analyzers, which covers around 10% of the total turnover in this sector, because the company is registered in this NACE sector, although these products are not part of the ICT sector according to the most detailed OECD definition. Denmark retains another important niche, measuring equipment for noise and vibration, a segment in which the Danish company Bruel & Kjaer is the world leader.[118],[119]

7.3 Conclusions

The Electronic Measurement Instruments sub-sector is often overlooked among the ICT manufacturing sectors. However it stands out by being the only one in which EU industry has a consistent trade surplus, while R&D intensity is only about average. This state of affairs can be explained by the composition of the sector, which includes a large number of small and very diverse categories of companies and products. Therefore, there is not much large scale production which could take advantage of offshored production. Much production, research and design is on demand by customers, and competitiveness advantages obtained by R&D investments are more important than lower production costs. This could nevertheless change if navigational systems grow into a larger market.

The R&D intensity of this sub-sector is average for ICT manufacturing. At the same time, as much of the output is directed towards industrial equipment, producers and R&D are more concentrated around the manufacturing centres, i.e. Germany, France and Italy, than in the ICT sector as a whole.

113 Based on AMADEUS and EUROSTAT data
114 For Galileo Avionica's product portfolio see http://www.selex-sas.com/about_ga.html.
115 European Commission (2007a)
116 http://www.nsti.org/Nanotech2006/exhibitors.html?id=234
117 REED (2006)
118 REED (2006)
119 Bruel & Kjaer is a subsidiary of UK Spectris plc, the precision instrumentation and controls company, with a corporate R&D expenditure of 7.1% of sales in 2004 (36,7% of the operating profit in 2003) (European Commission 2007)

8. Telecom Services (NACE/ISIC 64.2)

8.1 General economic profile of the sub-sector

This chapter covers ISIC/NACE 6420/64.20 'telecommunications', henceforth labelled "Telecom Services". It includes telephone, cable and satellite network services, maintenance of the network, broadcasting services and Internet access provision, but not Internet publishing (included in ISIC 7240) or production of radio and television programmes (see instead ISIC 9213).[120] Some main figures for the sector are presented in Table 8-1.

Telecom Services represent a substantial share (almost 40%) of the value added and turnover of the ICT sector. Its share of BERD is much lower, but still important at almost 10%. The very high value added and turnover, combined with modest R&D expenditures, lead to low R&D intensities (1.7% BERD/VA in 2004), in fact the lowest of all ICT sub-sectors. The shares of imports and exports are relatively marginal at € 5-6 billion, and comprise 3-4% of total ICT imports/exports, suggesting that Telecom Services are mostly produced and consumed domestically. Consequently, the share of domestic suppliers on the EU market is very high.

While the Telecom Services market as a whole has grown persistently for several decades, the fixed voice telephony market has recently started to decline. The main growth markets in the last few years have been mobile telephony and fixed data communications. Broadband data communication still has substantial growth potential in Europe, but mobile telephony, which has been the main growth engine of Telecom Services since the 1990s, is now slowing down,

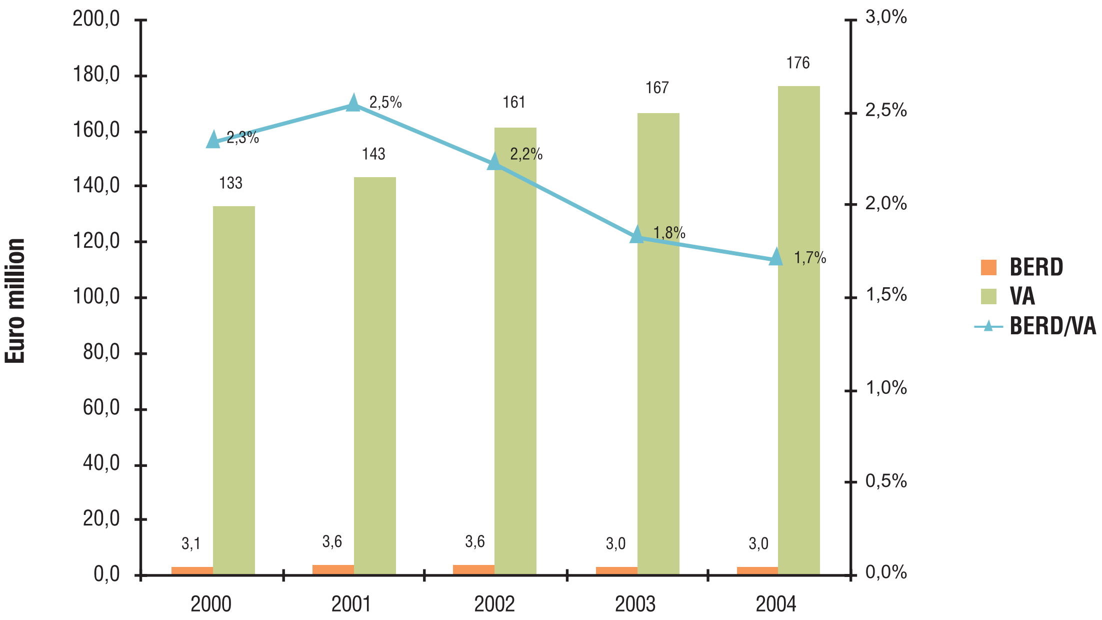
120 See e.g. http://unstats.un.org/ for ISIC and NACE definitions of the sector.

Table 8-1: Main figures for the Telecom Services sub-sector

2004, or the latest year available	€ bill.	% in total EU ICT	% in total EU ICT (service sectors only)
EU turnover post and telecommunications, from which: Telecom Services	492,3 394	41.3% 33.0%	61.2% 49.1%
EU value added, post and telecommunications, from which: Telecom Services (*)	232 176	44.1% 33.3%	55.6% 42.4%
EU BERD, Telecom Services	3,0	9.1%	30%
EU exports (2005)	5.2	3.8%	26.3%
EU imports (2005)	5,9	3.3%	41.7%
EU trade balance (2005)	-0,7	1.6%	-12.5%
R&D intensity (BERD/VA), relative to: *- total VA in 64* *- estimated VA in 642*		*1.28%* *1.70%*	
R&D intensity (BERD/turnover), relative to: *- turnover in 64* *-turnover in 642*		*0.60%* *0.70%*	

** Estimated based on EUROSTAT data*
Source: IPTS based on OECD, EU KLEMS and EUROSTAT data

Chart 8-1: EU 25 BERD, value added (VA) and R&D intensity (BERD/VA) in Telecom Services (2000-2004)



Source IPTS based on OECD, EU KLEMS and EUROSTAT data

as penetration levels are approaching 100%. Value added mobile services, may still constitute an important growth market in the future.[121]

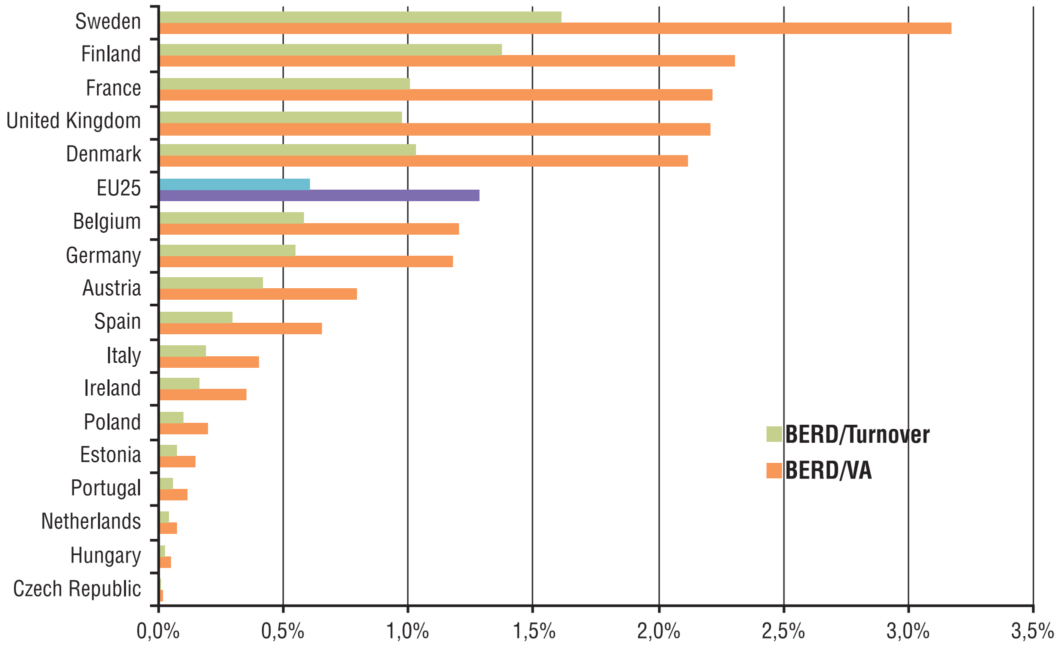
The Telecom Services sector is still very much a legacy of the former regime dominated by (mostly) state-owned national telecom monopolies. Indeed, as late as 2005, national regulation still required telecommunication carriers to conduct R&D in some countries. For instance, in France, government regulation required France Telecom to spend a fixed share of its revenue on R&D.[122]

Following a long-term shift from R&D conducted by the telecom monopolies to R&D mostly conducted by equipment suppliers, in recent years Telecom Services have also shown a decline in R&D intensity (BERD/VA), which has dropped from 2.5% in 2001 to 1.7% in 2004, as can be seen in Chart 8-1. This decline can largely be explained by the rapid growth in value added. BERD, on the other hand, stayed between € 3.0 and 3.6 billion, with the higher values for 2003-2004.[123]

European R&D in the Telecom Services sector is relatively high compared to the US, but low compared to Japan, for example. Company data shows that the total R&D investments of the top 25 R&D investors in this sub-sector globally was around 7.4 billion of which 3.8 billion was invested by EU companies and 3.6 billion by non-EU companies. While the EU companies increased their aggregate R&D investment by €0.5 billion between 2002 and 2005, the non-EU companies decreased their investment by a similar amount. On aggregate, R&D intensity on sales of EU firms was higher (1.2%) than that of non-EU firms (0.9%). The company data are very much influenced by NTT of Japan, which accounts for some 2/3 of the total non-EU R&D investment, having an R&D intensity of around 3%, which is higher than that of the typical EU telecom

121 See e.g. Salanave & Kalmus (2007:28-40)
122 4% according to OECD (2005:75) and France Telecom Form 20-F files. According to OECD (2007:NTT in Japan and Korean telecom carriers have such obligations). (*Ibid*)
123 It may be worthwhile pointing out that there are no signs of telecom service providers drastically reducing their R&D investments after burst of the telecom and IT bubble in 2000.

Chart 8-2: *Research intensities in Telecom Services; selected countries, 2004*



Note: For reasons of data availability, VA and turnover cover the aggregated post and telecommunications, while BERD relate to Telecom Services only. Greece, Latvia, Lithuania, Luxembourg and Malta are not shown in the chart because of a lack of reliable data. Cyprus, Slovenia and Slovakia report BERD 0 in this class.

Source: IPTS based on Eurostat, OECD, EU KLEMS, national statistics and annual reports of major telecom operators

operator. However, NTT's R&D has declined in recent years, which explains most of the decline among non-EU firms. The non-EU company data are also very influenced by US firms, in the sense that they disclose very low R&D figures (AT&T) or none at all (Verizon). According to company data, the total R&D among major US Company amounted only to € 190 millions in 2005.[124],[125] In conclusion, company data indicate that EU firms hold an increasingly strong position as regards R&D in this sub-sector.

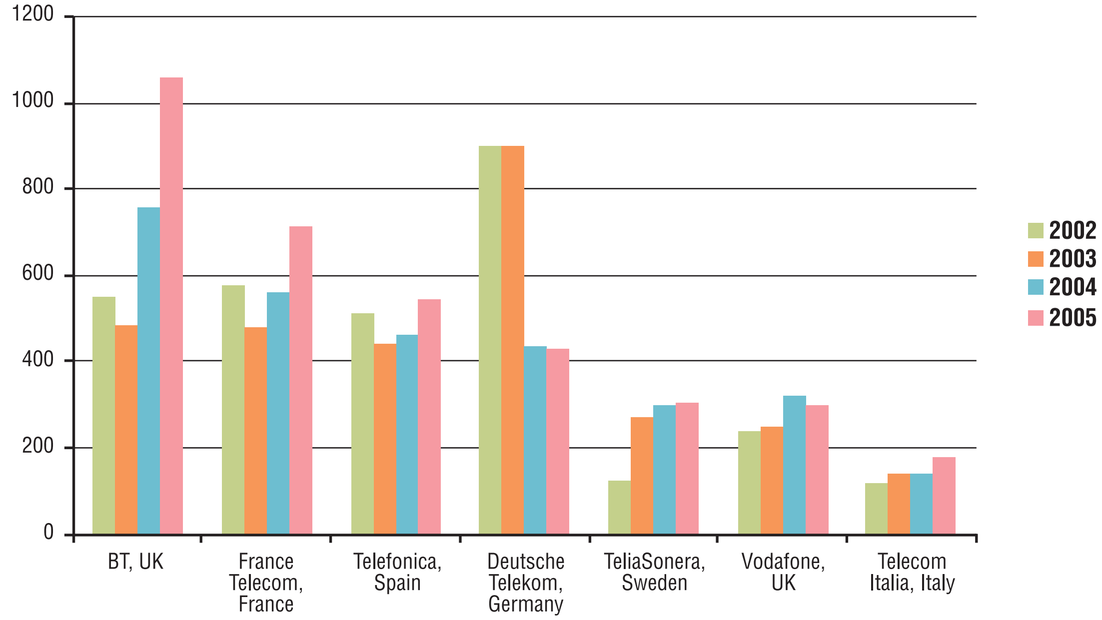
124 These low R&D expenditures could be compared with OECD data, which states some € 1400 million BERD in ISIC 6420 in the US for 2003. Thus, US BERD is much higher than the R&D investments reported in Annual Reports and other filings. The reason for this is not clear at this point. Nevertheless even the higher figure, € 1400, is much lower than the corresponding figures in this sub-sector.

125 The data in this paragraph is based on 2006 EU Industrial R&D Investment Scoreboard (EC, 2007) including complementary information collected primarily from annual and other financial reports of the major telecom operators (AT&T, Verizon etc.)

8.2 The most important R&D activities by Member State

Telecom Services R&D intensities as measured by BERD/VA differ significantly between EU Member States. Chart 8-2 illustrates the high R&D intensities of Northern and Western countries, the lower intensities of Southern countries such as Italy and Spain, and very low intensities of Eastern Member States. The Western Member States' Telecom Services are over 10 times more R&D intensive than the Eastern Member States; less than 0.3% (of which three quarters in Poland) of the BERD in this sub-sector is performed in the Eastern Member States. Although several Western European operators have substantial interests in operators in the Eastern Member States, according to available information, France Telecom is the sole large operator to have established an R&D centre in any of these countries (in Poland). The UK, France and Germany together account for some ¾ of all BERD in the sector in the EU.

Chart 8-3: R&D investments for the Top-7 R&D investing telcos 2002-2005 (€ millions)



Source: IPTS based on the EU 2006 R&D Investment Scoreboard (European Commission 2007)

We will now use company data to illustrate the most important business R&D activities in Telecom Services as R&D in this sector is largely performed by a few major firms. In 2005, seven large EU telecom companies invested in total €3,6 billion in R&D, which amounted to more than 90% of the total sub-sector R&D of EU-firms (€3,8 million according to the EU 2006 R&D Investment Scoreboard[126]) and which is higher than the total BERD in the EU in Telecom Services in 2004. The dominance of these seven companies in the EU Telecom Services R&D landscape motivates a closer inspection of their R&D activities. Chart 8-3 therefore shows their R&D investments for the years 2002-2005. It can be seen that, except for Deutsche Telecom, which reports a cut of their R&D by more than half in 2004 probably as a result of a change in accounting principles, all other telcos increased their R&D investments between 2003 and 2005, and particularly in 2005.[127] A brief analysis of the R&D activities of those seven telcos, in the context of their home countries, follows.

BT ranks highest among the European telcos in terms of R&D spending, in spite of not having as large a presence outside its home country as its major European counterparts (such as DT, FT and Telefónica). Together with Vodafone, it accounts for some 97-98% of the R&D expenditures of **UK** Telecom Services providers.[128] Much of BT's R&D is carried out at the laboratories of Adastral Park (which used to be Martlesham labs) near Ipswich (UK). By 2001, the labs employed some 3,600 R&D engineers, of which 3,500 served the

126 European Commission (2007a)

127 This increase may be compared with a corresponding decrease in BERD from 2002 to 2004 (compare 5-2). There are several possible explanations for those differing patterns, since BERD measures R&D performed in Europe as reported to statistics offices, while R&D expenditure in annual reports measures R&D financed by companies. An increase in company data and simultaneous decrease in national BERD data may for instance signify that the telco-financed R&D is increasingly performed by other actors outside the telecommunications services business sector or outside Europe.

128 Data from the DTI R&D Scoreboard (DTI, 2006)

business divisions, and less than 100 engaged in longer term research.[129] BT also ran R&D centres in London, Cardiff, Belfast and Glasgow. In 2001, BT launched BT Exact Technologies, which was comprised of its engineering and R&D activities. The same year two other labs were opened in Boston (US) and in Malaysia.[130] In recent years, BT Exact has developed into an IT consultancy division rather than an R&D division.[131] Now, from Chart 8-3, it is clear that BT has dramatically increased its R&D expenditures in recent years. This increase is very much due to a rapid increase in capitalized software development costs, rather than an increase in R&D operating costs.[132]

The second important UK-based Telecom Services R&D investor is the **Vodafone** group.[133] Although Vodafone increased their R&D spending continuously until 2000, the group still viewed itself primarily as a user rather than a developer of technology.[134] However, during the 2001 financial year,[135] Vodafone created a new R&D function "to increase its influence on the development of the technology it will use in the future and as a centre of excellence in applied research in mobile communications and its applications".[136] This R&D function initially consisted of four centres in the UK, the Netherlands, Germany and the US, with two new centres added in Italy and Spain during the 2002 financial year.[137] In addition, R&D of the Japanese mobile operator J-Phone was absorbed into Vodafone's R&D, when Vodafone took control of the company, but later dismantled when J-Phone was divested. An associate centre in Paris (France) belongs to Vodafone's associated undertaking in France - SFR.[138]

The R&D function of Vodafone typically consists of applied research on technology that will be used in the business in three years and beyond. In 2006, the main themes being researched were the evolution of 3G, new application areas for mobile communications and convergence with the Internet. Much of the work of the R&D function is done in collaboration with other companies, both within the group and externally.[139] The group appears to be spread out among its main operating companies in Germany, Italy, the Netherlands, Spain, the UK and US.

Most of the Telecom Services R&D in **France** is conducted by **France Telecom (FT)**, although Vivendi (primarily a media company which owns 56% of SFR) and Bouygues (a conglomerate which controls Bouygues Télécom) also conduct R&D related to Telecom Services. In the 1990s, France Telecom's well-known research lab CNET was replaced by FT R&D, which abandoned several costly areas of research such as switching, electronics and optical devices in order to focus on the needs of FT business units. Partly as a consequence, the R&D intensity of FT dropped rapidly from 3.7% in 1995, to 1.3% in 2000. This drop was in spite of the fact that by 2001, FT still held a regulatory obligation to spend (including expenses and capital expenditures) no less than 4% of its gross revenues on R&D (not including revenues from subsidiaries).[140]

129 Fransman (2002:225-228, 230).
130 BT Annual Report and Form 20-F 2001
131 BT Annual Report and Form 20-F 2005
132 BT (as several other companies) reports two components of R&D expenditure (1) capitalized software development costs and (2) R&D operating costs. (See e.g. BT Annual Report and Form 20-F 2005). It could also be mentioned that BT's increases in R&D expenditures are not matched by similar increases in BERD in the UK for 2003, and 2004. Therefore, at this point, there is some doubt regarding if this increase by BT in R&D expenditures actually signifies an increased R&D effort.
133 Observe that according to the AMADEUS database Vodafone is classified in NACE as a manufacturing firm. In the following, some observations on Vodafone's R&D activities will be made anyway, because, no matter the NACE classification, Vodafone should be considered a telecom services firm.
134 Vodafone Annual Reports 2000 and 2001
135 Vodafone's financial years ends in March.
136 Vodafone Annual Report 2001
137 It could also be mentioned here that the group holds a stake in China Mobile company tasked with R&D in mobile data
138 Vodafone Annual Report 2006
139 Vodafone Annual Report 2006
140 France Telecom Form 20-F 2002

In 2001, the downward trend of R&D expenditures was reversed. Initially the increase mainly came from growth in external subcontracting. Since 2000, R&D expenditures have almost doubled to € 856 million in 2006. The R&D labour force has risen to some 4,200 employees (including support). In addition to its previous locations in France and Silicon Valley (US), FT also opened laboratories, research and innovation centres in Tokyo (Japan), London (UK), Warsaw (Poland), Boston (US), Beijing and Guangzhou (China) and Seoul (Korea) in 2001-2005.[141] Since January 2007, the groups R&D activities have been integrated in the Orange Labs Network.[142] In conclusion, FT appears strategically committed (as expressed in its strategic initiative of 2005 "NexT"[143]) to R&D and innovation, and this commitment is reflected in rising R&D expenditures in recent years.

Telefónica is **Spain's** leading R&D investor in this sub-sector, and in fact in the Spanish ICT sector as a whole. As of 2006, the group's R&D expenses were € 588 million. Approximately 35% of R&D activity is carried out directly by the research division Telefónica I+D (Telefónica R&D).[144] Of the group's R&D expenses, € 334 million were carried out in Spain.[145],[146] Telefónica I+D develops new future-oriented services and identifies emerging technological options. In 2006, it employed a staff of 1,186 professionals employed directly and 1,378 people employed indirectly. It currently has offices in Spain (Barcelona, Granada, Huesca, Madrid and Valladolid), Sao Paulo (Brazil) and Mexico and is working on the extension and specialisation of these centres.[147]

The Telecom Services R&D in **Germany** is dominated by **Deutsche Telekom (DT)**, although for instance Vodafone and NTT DoCoMo have established R&D facilities in Germany.[148] Almost half of Deutsche Telekom's revenues (47.1%) come from its ownership of operations in third countries, fairly equally split between the rest of Europe and North America.[149] As of 1999, DT reported R&D spending of some € 700 million and a 2% R&D intensity on sales. In that year, DT established T-Nova with a view to bringing together its various units involved in R&D.[150] In the following years (2000-2001), R&D expenditures and employees increased to € 900 million and the number of employees peaked at 7,500 employees.[151] Further changes were made in 2002 and 2003, shifting the focus from R&D to innovation.[152] In 2004, R&D accounting principles appear to have changed, so R&D

141 It is unclear how much of FTs R&D was spent outside France. However, it could be noted that, the annual report of 2005 it mentioned that the number of employees in Beijing rose to 100 that year. Given (a not trivial) assumption that there is a similar level of employees, in the other countries where FT had R&D centres, 800 of 4200 R&D employees are outside France.

142 This paragraph draws on France Telecom Forms 20-F 2001 - 2005, and the France Telecom document de référence 2006

143 One of the main operational and financial objectives of the "NExT" program is accelerate innovation by allocating up to 2% of revenues on Research and Development (France Telecom Form 20 F 2005)

144 Telefónica I+D is classified in NACE 731, as a research and development company.

145 http://www.telefonica.es/index/tid.html (Accessed, June 15 2007). In 2004, this figure was € 311 million, which is much higher than the total BERD (€ 110 million) in Spain in NACE 642, according to EUROSTAT. This is due to the fact that some BERD is reported in other NACE classes, and possibly because R&D has actually been performed by other actors. Still, it should be recalled Spain's total ICT BERD in 2004 was some € 640 million, and accordingly Telefónica, plays a very important role in ICT R&D system of Spain.

146 It should also be noted that in 2003, the company changed its methodology for accounting for R&D expenses, and provide comparable figures back to 2001. Before that Telefónica's R&D expenses are not comparable. See Telefónica Form 20-F 2003

147 http://www.telefonica.es/index/tid.html (Accessed, June 15 2007), and Telefónica Annual Report 2006 and Form 20-F 2006

148 NTT DoCoMo's R&D in Germany is however, classified outside the telecom services sector.

149 Deutsche Telekom Annual Report 2006.

150 Fransman (2002:148-149)

151 Deutsche Telekom Annual Reports 2000 and 2001

152 Deutsche Telekom Annual Reports 2002 and 2003

investment dropped to some € 400 millions that year.[153] As of 2006, DT R&D comprised two areas: the Innovation Development Labs was the Group's general contractor for R&D, and the Strategic Research Labs was in charge of more long term research. Most of DT's R&D appears from annual reports to be carried out in Germany, although the company has recently established an R&D subsidiary in Israel.

In **Italy**, Telecom Italia conducts most of the R&D in this sub-sector, although a sizeable part (€ 94 million in 2005) is invested by Fastweb.[154] Vodafone also has an R&D presence in the country. **Telecom Italia (TI)** is fairly concentrated on the home market, with some broadband and ISP interests in Europe, and mobile interests in Brasil through TIM, its partly divested mobile arm.[155] In 2001, Telecom Italia consolidated its R&D activities into the TILab unit, situated in Rome and Turin, including activities of the former R&D labs (CSELT). The R&D activities amouned to € 138 million and were conducted by 1,080 engineers.[156] From 2006, "technological innovation" has been carried out by various specific laboratories, some Operating and Business Units, and Olivetti,[157] and in collaboration with external parties. Although R&D investment increased from 2002 to 2005, in 2006 it was back to below the levels of 2001.[158]

In general, the R&D investments of the **Nordic** Telecom Services sectors are relatively high. **TeliaSonera** is the largest R&D investor in Telecom Services in **Sweden** and the Nordic countries as a whole. It focuses its R&D efforts on machine-to-machine wireless communication, services for the home and family, new content services and customer terminals as carriers for new services. Its R&D activities are built on cooperation with partners, customers, universities, colleges and research institutions. In 2005, TeliaSonera incurred R&D expenses of € 306 million, decreasing somewhat in 2006.[159] A substantial share of this amount was spent in **Finland**, possibly in the range of 40%.[160]

8.3 Conclusions

Telecommunication Services, domestic in supply and demand, stand for a large and increasing share of the value added in the ICT-sector. The main growth in Europe is to be found in broadband data communications, while mobile voice communications is now maturing. Business R&D expenditures, measured as BERD, remain relatively stable at between €3-3.6 billion per year in the EU. As a result the R&D intensity is low, at around 1.7% of value added (BERD/VA) and 0.9% of turnover (BERD/turnover), and it has been declining in recent years.

Almost all BERD in the sector is performed in the Western Member States of the EU, and most of it in Germany, the UK and France, while the Nordic countries have the highest R&D intensities. Company data show that some 90% of the corporate R&D is invested by seven firms: BT, FT, Telefónica, DT, TeliaSonera, Vodafone and Telecom Italia. These operators have actually increased their R&D spending in recent years (with the exception of DT, probably due to a change in accounting). Few numbers are available, but it seems that a large part of the R&D is still performed in the operators' respective home countries, although Vodafone

153 Deutsche Telekom Annual Report 2005
154 REDICT Country Report Italy and European Commission (2007a)
155 http://www.telecomitalia.com (accessed 15 June, 2007)
156 Telecom Italia Annual Report 2001 and Pouillot & Puissochet (2002)
157 Olivetti holds a stake in Telecom Italia.
158 Telecom Italia Annual Report 2006
159 TeliaSonera Annual Report 2006
160 From Sonera Annual Report 2000, it is clear that Sonera before the merger had a high R&D intensity as well a strong growth in terms of absolute numbers, at a level of some €70 million. Telia on the other showed a downward trend at around €150 million. (Telia Annual Report 2000). It is therefore reasonable to assume that the Finnish part of company has kept at least 1/3 of its R&D activity in Finland.

is very internationalised R&D-wise, and France Telecom and Telefónica, for example, have substantial R&D activities outside the EU. Apart from NTT DoCoMo's labs in Germany, we found little evidence of the opposite, i.e. foreign telcos setting up R&D facilities in Europe.

Finally, from an international perspective, Telecom Services R&D in Europe remains rather strong, with more than half the world's expenditures, and this share is increasing. European operators invest much more than their US counterparts, but relatively less than some countries in the Asia-Pacific region, notably Japan.

9. Computer Services and Software (NACE/ISIC 72)

9.1 General economic profile of the sub-sector

This chapter covers ISIC/NACE 72 'computer and related activities', henceforth labelled "Computer Services and Software" (CSS).[161] This sub-sector can be divided into two major parts: (1) the development and production of software and (2) the provision of computer services (often labelled IT-services).[162] Software can in turn be divided into customized software and packaged software, where the latter may be conceptually regarded as a good rather than a service. The provision of customized software can sometimes be difficult to distinguish from consulting and implementation services. In addition, companies often have both kinds of activities in their portfolio, which makes it difficult to classify them in one activity or the other. Some main figures for the sector are presented in Table 9-1.

CSS represents a substantial share of the value added (more than 40%) and turnover (more than 30%) generated in the ICT sector. Its share of BERD is somewhat less, but very important at more than 20%; together with the very high value added and revenues, it leads to medium R&D intensities, lower than for the manufacturing sector, but higher than for Telecom Services. The share of imports is relatively low at 4.6% while the share of exports is much higher at 14.5%, thus creating a positive trade balance of 6.3 billion.[163]

These figures underestimate, however, the importance of CSS since products and services dependent on software are becoming increasingly prevalent (cf. embedded systems). As a result,

161 In official classification systems it includes activities related to: design, set-up, operation and maintenance of computer systems and networks; custom software development and software publishing; data-processing activities and storage and online distribution of electronic content. See e.g. http://unstats.un.org/ for ISIC and NACE definitions of the sector.

162 Note that in addition there are some activities, such as web portals and search engines provision, which do not fall into either one of these two categories.

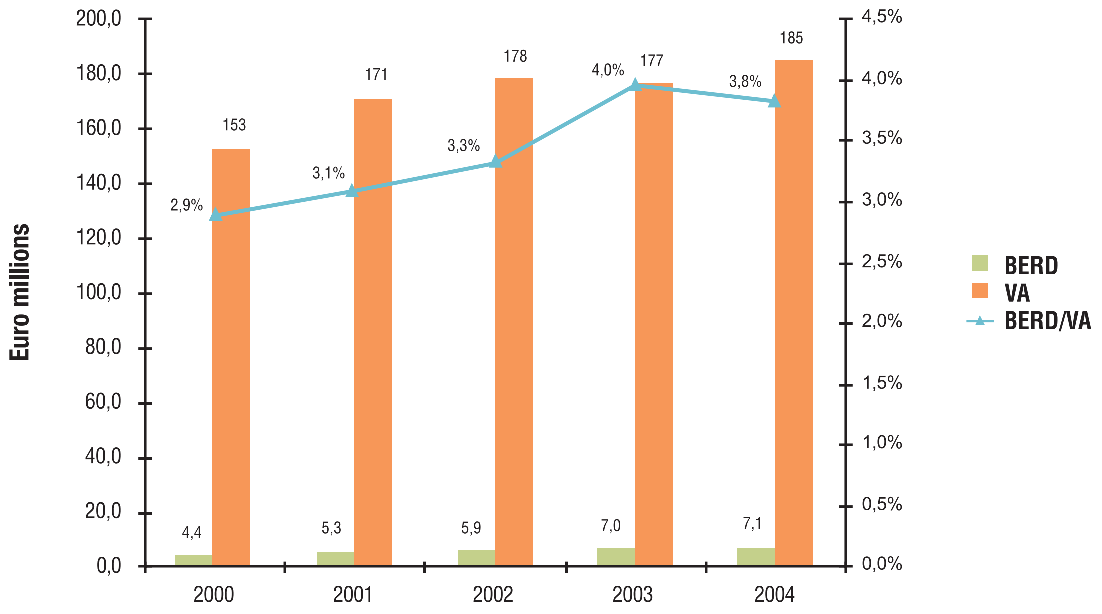
163 This positive trade balance is due to the specialization of few countries, Ireland in particular, but also Belgium, Germany, Sweden, and the UK. (See Dachs et al. 2007)

Table 9-1: Main figures for the Computer Services and Software sector

2004, or the latest year available	bill. Euro	% in total EU ICT	% in total EU ICT (service sectors only)
EU turnover	312,0	30.3%	44.1%
EU value added	184,9	41.6% a.)	51.2% a.)
EU BERD	7,1	21.6%	70.3%
EU exports (2005)	14.5	10.7%	73.7%
EU imports (2005)	8,2	4.6%	58.3%
EU trade balance (2005)	6,3	14.2%	113%
R&D intensity (BERD/VA)		*3.8%*	
R&D intensity (BERD/turnover)		*2.2%*	
Share on the EU 25 market		*97.5%*	

Note: a) Shares of value added is calculated against a ICT sector total based on estimations of Telecom Services (64.2).
Source: IPTS based on OECD, EU KLEMS and EUROSTAT data

Chart 9-1: EU 25 BERD, VA and R&D intensity (BERD/VA) in Computer Services and Software (2000-2004)



Source: IPTS based on OECD, EU KLEMS and EUROSTAT data

software is to a substantial degree developed outside the CSS sector.[164] Also, computer services are to a large and increasing extent provided by hardware/manufacturing firms.[165]

Software and services differ markedly in R&D intensity. Company data shows that the sector has an average R&D intensity worldwide of 10% on sales, with services companies at about 5% and the software companies at about 15%. This makes software one of the most R&D-intensive sub-sectors of all. Thus, there seem to be a fundamental difference in the importance of R&D between these two parts of the sector.

Chart 9-1 illustrates the development of value added (VA), BERD and BERD/VA intensity, which show (almost) persistent growth throughout the time-period 2000-2005.[166] In fact, it is remarkable that almost all BERD growth in the EU ICT sector is due to Computer Services and Software!

The R&D in the EU is however dwarfed by the R&D reported in the US. In 2003, the US BERD was almost €17 billion (PPP adjusted), compared to €7 billion in the EU. BERD/VA intensity was also much higher at 9.6%, compared to 4.0% in EU.

9.2 The most important R&D activities by Member State

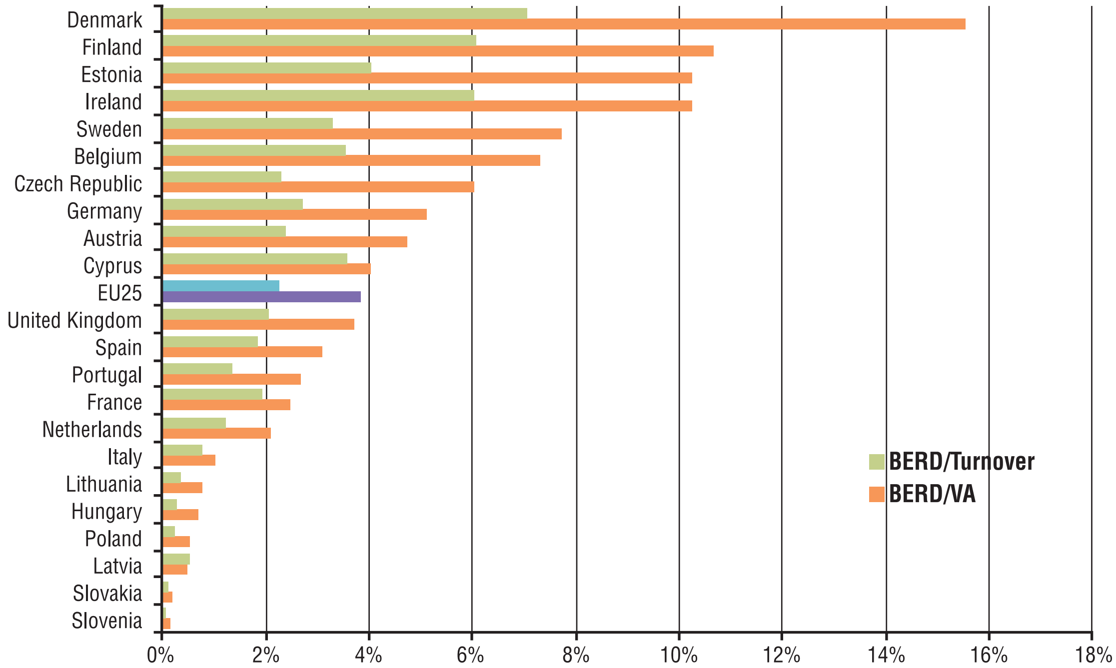
Computer Services and Software BERD in the EU is to a very great extent (45%) conducted in the UK and Germany; Denmark, Ireland and Sweden also have comparably high shares. Only some 2.5% of BERD (€90 million) is conducted in the Eastern Member States, of which some two

164 Hawkings & Puissochet (2005) It has been estimated that while the CSS-sector itself had software development expenses of € 39 billion in 2002, six other sectors (Telecom Equipment, Consumer electronics, Aerospace, Automotive, Medical Equipment and Automation) together had software development expenses of € 58 billion (of a EU total economy R&D of € 187 billion) (IDATE, 2006b)

165 IBM may serve as an illustration. In 1992 11% (USD 7.4 billion) of IBM's revenues came from services a figure which increased to 48% in 2004 (USD 46,2 billion) (OECD, 2006:52). This trend has been seen in other industries as well (See e.g. Davies 2004)

166 There is a break in the trend for VA in 2003 and for BERD/VA in 2004.

Chart 9-2: *Research intensities in Computer Services and Software*



Note: Greece, Luxembourg and Malta and not shown in chart due to lack of data for one or more of the variables.
Source: IPTS based on Eurostat, OECD, EU KLEMS, national statistics

thirds are performed in the Czech Republic (€60 million).

Concerning R&D intensities (Chart 9-2) Denmark, Finland, Estonia and Ireland stand out, with BERD/VA at more than 10% (higher than in the US). Sweden, Belgium and the Czech Republic are also well above EU average. The UK is slightly below the EU average, largely due to a high value added in this sector. France displays relative low R&D intensities, as do several of the Eastern Member States. However, on average, in R&D intensity Eastern Member States (2%) are not that far behind the Western Member States (4%). This relatively small gap suggests that the barriers to establishing an R&D capability in a country are lower in CSS than in other ICT sectors.

The **UK** has the largest CSS sector of the EU Member States, both in terms of value added and BERD, with a BERD at over €1.6 billion in 2004. Although the UK has a relatively high share of activity performed by foreign-owned firms in this sector, there is also substantial domestic R&D. The UK is also home to the largest number of CSS firms in the EU according to the EU 2006 Industrial R&D Investment Scoreboard.[167] These firms invested almost €1 billion in R&D in 2005 with a focus on financial services and manufacturing sectors. Nevertheless, UK firms are also known to off-shore much of their software development activity, particularly to India.[168] Software R&D is regionally clustered, particularly around London and the east of England. R&D investments of foreign firms include IBM's software development facility in Hursley, (1,500 employees)[169] and Microsoft's first non-US research centre.[170] The largest domestic R&D investor in this sub-sector is Misys (€131 million), an application software and services provider which focuses on financial markets. The leading software company in UK in terms of sales is Sage, supplier of accounting, payroll, CRM and business management software.

167 European Commission (2007a)
168 http://www.ukinvest.gov.uk/10145/en_GB/0.pdf
169 http://www-05.ibm.com/employment/uk/hursley/index.html
170 http://research.microsoft.com/cambridge/

The largest domestic company in the sector (albeit with rather low R&D expenditures) is however LogicaCMG, a consultancy company which focuses on IT and telecom. Like most consultancy firms, it reports rather low R&D expenditures.

Germany has the second highest BERD in Europe, at about € 1.5 billion. Historically, over 90% of that BERD has been in software (i.e. group 72.2). This country is home for Europe's largest software company by far, SAP. We estimate that slightly more than half of SAP's R&D (i.e. more than € 0.5 billion in 2004 with some 5,000 employees) takes place in Germany.[171]. SAP's German R&D is concentrated at its headquarter facilities in Waldorf, but they also have engineering centres in Darmstadt, Dresden and Karlsruhe and SAP labs in a number of other German locations.[172] The second largest German software firm is Software AG, which develops and offers system software and services for data integration and data management. IBM's largest development centre outside the U.S is situated in Böblingen (1,800 employees).[173],[174]

In terms of R&D intensity, **Austria** is positioned between Germany and the EU average, with a BERD/VA at 4.7%. The sector consists mostly of subsidiaries of large MNCs (IBM, Microsoft etc.) which often develop specific software solutions, provide consultancy services and adapt ICTs to the specific demand of Austrian customers. In addition, this sub-sector benefited from the enlargement process in particular and some ICT service firms established their Eastern Europe headquarters in Vienna. However, unlike the rest of the ICT sector in the country, and in spite of the strong presence of MNCs, much of the software R&D is conducted by domestic SMEs (e.g. Fabasoft, Update Software).[175]

Relative to the UK and Germany, **France** displays low BERD (€908 million) as well as low BERD/VA (2.5%). The major domestic company in this sector is Cap Gemini, one of the world's largest IT services companies, with a staff of 75,000 operating in 30 countries. However, the company reports no R&D expenditures.[176] Other large services companies operating in France are IBM, Sopra, Alten and Unilog (Logica), albeit with modest R&D spending, apart from IBM, whose R&D has been estimated at €237 million.[177] Microsoft and Amadeus (the airline reservation system provider located in Sofia Antipolis) have been mentioned as the most important software companies with development centres in France.[178] This country has a relatively large number of domestic software firms, concentrated primarily in the Ile-de-France (Paris) region, followed by the Rhone-Alpes region.[179] Most of the R&D of French firms, €588 of €801 million, is spent by

171 The estimation is based on the fact that in 2006, approximately 51.8% of the R&D personnel were located in Germany. (SAP 20-F Report 2006).

172 SAP 20-F Report and Annual Report 2006

173 REDICT Country Report Germany. IBM Germany currently employs about 21,000 persons at 40 locations. Its headquarters are in Stuttgart-Vaihingen. Main activities in Germany are sales and distribution, services and development activities (*ibid*). It is unclear how many of those work with software or computer services related R&D.

174 The largest software R&D investor in Germany may in fact be Siemens, possibly in the range of € 1 billion. It is unclear however, how much of this investment is reported in the CSS-sector. Siemens had R&D expenditures of € 5.7 billion in 2006. The company claims that more half of this investment is in software, and that some 43% was in Germany (http://www.siemens.com/innovation).

175 The section on Austria draws heavily on the REDICT Country Report Austria. Interesting to note is that PSE Siemens in Vienna is the largest Software development department of Siemens world-wide with more than 1,000 employees. It could also be noted that, Austria provide statistics on the thematic aims of R&D, from which it is clear that the whole Austrian industry invested € 136.8 million R&D related to software development (72.2), which is much more as the official sectoral value of €75.9 million. Thus, clearly the strength in Austrian Software R&D lies in embedded software rather than packaged ditto. (*ibid*)

176 It is also registered in another class according to the Amadeus database (74)

177 REDICT Country Report France

178 The best French software development teams, Take IT easy, September 12, 2006, available online at http://techiteasy.org/2006/09/12/the-best-french-software-development-teams/ (accessed 11 July 2006)

179 Truffle (2006b) 61 of the 100 largest French firms are headquartered in Ile-de-France, including the two largest ones (Dassault and Business Objects) while 16 firms are situated in the Rhone-Alpes region (*ibid*)

four firms:[180] Dassault Systemes (€259 million),[181] Business Objects (€138 million), Ubisoft (€103 million) and Infogrames Entertainment (€86 million). According to the Truffle Report (2006b), only 15% of the French software companies have outsourced R&D.

All three Nordic countries have high R&D intensities. **Denmark** has the highest R&D intensity of all Member States, with almost half of its total ICT BERD in CSS. Foreign firms play a major role. Microsoft, IBM and Oracle are present in the Copenhagen region and Nokia has a software development centre there, too (registered in class 72). In addition to Copenhagen, Aarhus is also distinguished for software development, including object technology, user interface, IT security, clinical information systems, 3D visualisation and interaction and pervasive healthcare. Major companies in the Aarhus area include IBM and Oracle.[182] The largest Danish R&D investor in this sub-sector is Simcorp, which develops integrated investment and treasury management systems.

As in many other countries, **Sweden's** computer software services sector is characterized by (1) a large number of firms, (2) a strong presence of the global players (the largest being IBM), (3) a number of domestic suppliers and (4) subsidiaries from companies in other sectors, such as Volvo IT (responsible for serving Volvo with IT services). Software development is concentrated in Stockholm and the other larger cities.

In **Finland** the major, partly home-grown, computer services company is TietoEnator, which has its headquarters in Esboo. It provides IT services to commercial and government organizations, in telecoms and other selected verticals.[183] IBM also has a research centre in the country.[184]

Ireland's R&D system is highly and increasingly dependent on Computer Services and Software. Some 25% of all BERD and almost 60% of ICT BERD in Ireland takes place in this rapidly growing sector. This country is particularly strong in software development, design and supply chain management, and is the second largest worldwide exporter of software goods after the US. Many leading international software firms including Microsoft have significant operations in Ireland, including R&D activities. However, the size of the domestic Irish industry is still relatively small compared to the foreign controlled one.[185]

In 2003, **Greece** had a surprisingly high BERD/VA intensity (13.5%) in this sector, which was second only to Denmark. However, this is mostly due to a very small value added rather than high R&D. Still, several major global ICT companies (e.g. Microsoft, IBM, Oracle, SAP) have regional operational centres for the Balkan region in Greece.[186]

In spite of a large market and much value added in this sector, **Italy** underperforms in terms of BERD, with BERD/VA intensity at only 1.0%. This is well below the other Western Member States and the Eastern Member States average, and is declining. The firms are very much concentrated in Northern Italy (and Lazio/Rome), in particular Lombardy, which hosts the only Italian software company in the R&D Scoreboard – TXT E-Solutions.[187] Several of the large international computer services are present in Italy including IBM, which carries out applied software research in its Rome Tivoli Laboratory

180 The information on these four companies draws on their Annual reports and websites.
181 The company employs 3,100 engineers in research laboratories in France, the US, Canada, Germany, the United Kingdom, Israel and India. (Dassault Systemes 20-F form 2006.
182 The section on Denmark draws (albeit not exclusively) on the REDICT country report for Denmark.
183 www.tietoenator.com
184 According to the REDICT country Report on Finland
185 REDICT country report Ireland
186 REDICT country report Greece
187 European Commission (2007)

(with 400 researchers) as well as in five other competence centres.[188]

Spain and Portugal are just below the EU average in terms of R&D intensity. In **Spain,** the sector is regionally clustered around Madrid and Barcelona,[189] and is growing very fast. BERD has more than quadrupled between 1998 and 2004, reaching a level of over 50% of Spain's total ICT BERD. The major domestic R&D investor is Indra Sistemas with €86 million in R&D in 2005.[190] Indra is active in IT-services, simulation and testing software and defence electronics. IBM plans to open a new Innovation Centre in Barcelona, Spain. The new centre will help start-up companies, software developers and independent software vendors create new software applications and services.[191]

Together with components (32.1), CSS has the largest share of ICT BERD in **Portugal**. This country has a few well known software houses (e.g. Altitude Software, Critical Software, Software Multimedia e Industrial, ATX Software, EASYSOFT). The most important R&D spenders are Soneacom (telecom, media and also IT services and software); Novabase (Engineering Solutions and IS consulting) and the Aitec group (controlling a large number of companies in the ICT field).[192]

The BERD and R&D intensities in this sector in **Belgium** are relatively high. However, growth is slower than in many other countries. The CSS sector is concentrated in Brussels and Flanders, while the software part is especially prevalent in Flanders. In spite of the rather high BERD, we have not found any major R&D investing companies in this sector in Belgium (i.e. with R&D spending above €10 million).

The Netherlands has lower R&D intensity than the EU average, and are one of the few countries where CSS BERD has declined in recent years.[193] The sector includes a mix of US and EU services firms (e.g. IBM, Atos, CapGemini) as well as national champions (Getronics). The major domestic software firms which reports R&D are Unit 4 Agresso and Exact (both in business software).

Although **Luxembourg** is home to more 1,000 firms in this sector with a total of more than 4,000 employees, we have not been able to explicitly identify any R&D activity in this sector. However, given the structural characteristics, there should be some €10 million of BERD in this country.

Among the Eastern Member States, the Czech Republic and Estonia stand out with R&D intensities much above the EU average. The **Czech Republic** has the highest BERD of all Eastern Member States by far (€60 of €90 millions in the Eastern Member States) and is growing rapidly. A number of international firms already have their services and development centres there (e.g. IBM in Brno), and others (e.g. Logica) were considering opening new development and services centres. There is also a relatively large number of SMEs active and internationally competitive in software, E-security and mobile applications areas.[194] **Estonia**'s Computer Services and Software is small, but very R&D intensive (at 10.2%), placing the country at a level similar to

188 REDICT Country Report Italy
189 Company search in Amadeus database
190 Amadeus, provider of technology and distribution solutions to the travel and tourism industry, is also important software developer, but its development is essentially in France (see France).
191 Evertiq, Several companies expanding R&D facilities in Spain, http://www.evertiq.com/newsx/read_news.aspx?newsid=7270&cat=6, April 16 2007, 1:39 PM (accessed 12 July, 2007)
192 REDICT Country Report Portugal, which can also be consulted for original sources.
193 The reasons for this decline are not clear at this stage.
194 REDICT Country Report Czech Republic. A list of the most successful of those SMEs, 14 in total, with a total of 844 employees, is provided by CzechInvest and Tuesday Business Network: Czech ICT market in 2004 http://www.evertiq.com/newsx/read_news.aspx?newsid=7270&cat=6. Assuming that they have a similar R&D/ employee ratio as the average as the EU software firms in EC (2007) € 23000, we can estimate their total R&D investment to circa € 20 million.

Finland and Ireland.[195] The number of companies in the sector is very high, but production volumes and exports are low and specialization is still not established. Although Estonia enjoys the presence of firms representing major Western software companies, such as Oracle, Microsoft, etc., these mainly limit themselves to selling and servicing software, and, to some extent, to adapting to the domestic market.[196] Instead, stimulated by governmental structures and the banking sector, a domestic software sector has developed, primarily in the region around Tallinn, the capital city.[197]

Among the remaining Eastern Member States, Cyprus, Poland and Hungary stand out with BERD between €4-10 million. The rest of these states have marginal BERD (below €1 million) and will therefore not be discussed in this report. **Cyprus** has the highest BERD/VA at 4.0%, almost equal to the EU average. In fact software services accounts for 97% of all ICT BERD expenditures in Cyprus. Much of this can be attributed to the software firms A.Th.Loizou & Son Ltd. and AEC Soft.[198] In **Poland**, BERD was below €10 million in 2004, but is rising rapidly. In spite of the presence of several foreign Computer Services and Software firms (e.g. IBM, Oracle, Microsoft), it appears that leading domestic firms in this sector, such as Comarch (€3,4 million), Prokom (€5.0 million) and Computerland, invest most in R&D.[199] Finally, **Hungary's** Computer Services and Software sector is a mix of large foreign multinationals (IBM, EDS and SAP) and domestic ones such as Synergon (the largest, active in services) and Graphisoft (the only company whose R&D expenditures were known in 2005, recently acquired by German Nemetschek). SAP has also established R&D centres in Budapest to act as a hub in the region.

195 However, this high figure is based on one observation, BERD as provided by Eurostat in 2004. Since BERD for previous years are much lower (three times lower), we should treat this data with caution.
196 REDICT Country report Estonia
197 See Kalmet (2004)
198 REDICT Country Report Cyprus
199 The section on Poland draws on the REDICT Country Report Poland.

9.3 Conclusions

The Computer Services and Software sub-sector is the main ICT R&D growth engine in Europe; in fact most of the BERD growth in the EU in recent years is due to this sub-sector. It can be divided into two main parts: (1) the development and production of software, and (2) the provision of computer services (often labelled IT services), where the former is very R&D intensive and the latter less so. In addition to the R&D activity taking place inside the sector, there is evidence that even more software development is taking place outside the sector.

In spite of the dynamism shown in this sector in the EU, it seriously lags behind the US in almost every R&D related measure – BERD is much lower, as is BERD intensity. The CSS sector is very much dominated by US firms (e.g. IBM, EDS, Microsoft, Oracle), which are also present in most EU Member States, competing with a few large European ones (SAP, LogicaCMG, CapGemini) and a large number of smaller domestic ones. Although some of those US multinationals have established R&D facilities in Europe, notably IBM, most R&D seems still to be taking place in the US.

The UK and Germany have the highest Computer Services and Software BERD. In the case of Germany, this is largely due to SAP, which is the largest European software company and software R&D investor by far. Countries with relatively high BERD intensities are the Nordic countries, Ireland, Estonia, Greece, Belgium and the Czech Republic, while the low figures for Italy are notable. The differences in R&D intensity and total BERD between Western Member States and Eastern Member States are not as large as for the rest of the ICT-sector. In combination with rapid growth rates, this fact suggests that software R&D could be a vehicle to establish more significant R&D capability in these countries and in the EU as a whole.

10. Conclusions

The ICT sector is a key component of European industry. Like most other sectors, it is currently facing the impact of globalisation. As a consequence, it is generally assumed that European ICT firms can ensure their competitiveness only by investing heavily in research and development, which would allow them to develop innovative products and services, thus staying ahead of lower cost producers. Though R&D is not the only factor of competitiveness, it is, nevertheless, a key factor. Therefore, this report has looked at the European R&D landscape in the ICT sector, trying to identify the strengths, the weaknesses, and the overall situation of Europe.

10.1 There is an ICT sector R&D gap between the EU and the US

Business expenditure on R&D in the EU, i.e. the amount that the EU ICT business sector invests in R&D within the EU, is lower than the comparable figure for the US, both in absolute terms and relative to GDP. In fact, **the ICT sector contributes only about half as much to overall business expenditure on R&D as a percentage of GDP as it does in the US.** It is thus one of the main "culprits" of the fact that the overall R&D intensity in Europe is still far from achieving the Barcelona objective of an R&D investment of 3% of GDP.

There are two reasons why the contribution of the ICT sector to total economy R&D intensity is smaller than in the US. One is that the ICT sector is smaller in the economy. However, this accounts for only about a third of the difference. The second more important reason is that **the R&D intensity of the ICT sector is lower in the EU** and this accounts for two thirds of the difference. The R&D intensity differential is, in turn, mostly due to much lower R&D intensity in the IT Equipment and Measurement Instruments manufacturing, and the Computer Services and Software sub-sectors.

Interestingly, the secondary data set we used, i.e. company data from the biggest R&D investors, shows a somewhat different picture. **For companies, R&D intensities, as measured by R&D investment relative to sales, are very similar in the EU and the US for each ICT sub-sector**. However, on the aggregate ICT-sector level, there is still a sizeable difference in R&D intensity between EU and US companies. This can be explained by the fact that the industrial structure as reflected in company data is very different. On the one hand, there are proportionally more large companies in the EU Telecom Services sector than elsewhere, and Telecom Services is a sub-sector which has a low R&D intensity. On the other hand, with the exception of the Telecom and Multimedia Equipment sub-sector, there are relatively few large EU companies in the other sub-sectors which have higher R&D intensities than Telecom Services. In other words, the company data indicate there is no significant R&D intensity difference at sub-sector level. However, there is a difference at the aggregate ICT sector level due to the relatively weaker presence of EU firms in R&D-intensive sub-sectors.

Taking these two results together suggests that the ICT sector in the US, which is composed of bigger companies, operates a large share of production abroad, but only a small share of its R&D. Large US companies have typically outsourced manufacturing to East Asian production sites, whilst overwhelmingly retaining their R&D at home. As a result, a large US company may for example produce two thirds of its products abroad, but carry out only one third of its research overseas. In this case, the low level of production (as measured by value added) retained at home would drive up the R&D intensity (as measured by R&D/VA). By contrast, EU companies operate a similar (and much smaller) share of both production and R&D abroad. This would explain why R&D intensity is different at the geographic level (US vs. EU), but not at the company level (US companies vs. EU companies). It would also be coherent with the fact that there is a clear difference between IT Equipment and Computer and Software Services (generally considered to be very globalised) and Telecom Services (where EU operators have mostly expanded into other EU countries rather than worldwide and where US operators have ventured very little abroad and are less affected). All the same, at this stage it is essentially a working hypothesis which calls for a deeper investigation of the internationalisation trends of ICT sector activities.

This hypothesis raises the question of the usability of R&D intensities for policy making. After all, R&D intensity (BERD/VA) can increase either due to higher R&D or to lower Value Added. In other words, if offshoring of production increased, so would R&D intensity - at least, mathematically, since Value Added in the EU would decrease. Yet, fostering the offshoring of ICT production is clearly not the intention of policy makers.

However, one should note that, even with major outsourcing of production, the ICT sector still represents a larger share of the US economy than of the EU economy. In other words, US ICT companies are so much bigger than European ICT companies that, even without a major part of their production, they still produce more value added at home. **The ICT R&D gap between the US and the EU reflects, more than anything, the lack of a sufficiently large European presence in the ICT sector**.

While **R&D investment in the European ICT sector** continues to grow slowly in nominal terms, it **pretty much stagnated in real terms** (i.e. after accounting for inflation) **from 2001 to 2004**. For 2005, only company-level data is available, and this shows real growth both for the US and the EU, with the US figure growing faster. In any case, current growth rates are a far cry from the policy objective of catching up with US R&D intensity, since that would require considerably faster growth of ICT R&D spending in the EU than in the US for a prolonged period of time.

Given the tentative diagnosis above, i.e. that the lower ICT R&D intensity in the EU than in the US is not necessarily an indicator of insufficient investment in R&D by EU firms, but rather the result of an absence of large internationalised EU companies in certain ICT sub-sectors, especially IT Equipment, Electronic Measurement Instruments and Computer and Software Services, it stands to reason that R&D policy in itself is unable to address the issue effectively. It certainly has an important role to play; R&D support for small companies, which hopefully will become large companies on the back of their R&D results, would appear highly effective. However, company creation and growth depends on many circumstances, including labour and product market regulations, education, tax and infrastructure policy, etc. It is only by addressing all of these aspects that the economic environment for ICT companies can be improved to the point where more of them become large international players. **Conversely, it is wrong to blame R&D policy alone for lower levels of R&D investment in the EU than elsewhere**.

Moreover, the tentative diagnosis implies that policy needs a much longer time horizon. If the problem were simply one of insufficient funding or of wrong policy incentives, policy could be improved and results could be expected in two or three years. However, if policy needs to be changed to enable the growth of a larger number of big companies in those ICT sub-sectors where the EU is currently lacking sufficient presence, the time horizon expands dramatically. Most of the large companies of today, including those in the computing sector, have been around for 30 years; and even the brand new Internet giants (Amazon, eBay, Yahoo, Google) have already been around for ten years, before they have become significant investors in R&D. **In short, European R&D in ICT**

cannot be boosted overnight; the best one can hope for is a gradual improvement which would show first results after about ten years, with the real impact showing after 20 or 30 years.

Alternatively, ICT R&D in Europe could increase much more quickly by attracting more R&D from existing large foreign companies. Again, the attractiveness of the EU as an R&D location for foreign ICT investors depends on many policy areas, in particular education and skills, and not just on R&D policy. However, while increased R&D by foreign ICT companies would certainly be welcome, provide highly-paid jobs and create positive spill-overs, it would not really improve the competitiveness of the EU ICT industry.

At this point, a caveat is necessary. This study is about the business ICT sector research, not about research in ICT. Indeed, there are many ICT products and applications developed by companies outside the ICT sector – ICT is a general purpose technology, and, as such, not limited to those companies specialised in this sector. The structure of the European economy, with a large number of major manufacturers in many different industries, but with a comparatively small specialised ICT-producing sector, might make us underestimate Europe's position in ICT R&D. **In other words, while R&D research outside the registered ICT sector is not recorded in this study, this "embedded" R&D might be much more important in Europe than elsewhere, resulting in a statistical undervaluation of Europe's ICT capacity.**

10.2 Different Member States and ICT sub-sectors perform differently

It is generally assumed that most R&D in ICT takes place close to company headquarters. Indeed, our data indicates that, within the EU, R&D is concentrated in those countries where large ICT companies are based. This means R&D is conducted mostly in the largest economies such as Germany, France and the UK, and also in some smaller countries with large ICT players such as Sweden (Ericsson), Finland (Nokia) and the Netherlands (Philips). It is striking how small the R&D investments of the large Southern countries, Italy and Spain, are in this sector. Even more striking are the very low levels of R&D in the Eastern Member States. Since a large part of the Eastern Member States' ICT industry is based on Foreign Direct Investment in production, distribution and sales, but not in R&D, their R&D intensity is very low. Moreover, it appears that until now few foreign investors, including investors from the Western Member States, have taken advantage of the supply of fairly cheap but well qualified researchers in the Eastern Member States. **If this trend is confirmed, it would raise the question as to why the Western Member States' companies do not take advantage of this potential, particularly when faced with the much debated ICT skills gap at home. However, national accounts data is only available until 2004, the year of EU enlargement, so it is too early to come to any definite conclusions on this question**.

Regarding the ICT manufacturing sub-sectors, Telecom Equipment remains Europe's strength with a few leading firms (e.g. Nokia and Ericsson) with very high R&D investments, whilst the IT Components industry is strong in a number of niche markets, despite being far smaller than its foreign competitors. It is interesting to note that, of the ICT sub-sectors, these two are the most R&D intensive, which is why EU industry is able to retain a strong presence there. On the other hand, Multimedia Equipment and IT Equipment are weak points in the EU (in terms of trade, presence of large EU players and R&D investments). The Electronic Measurement Instruments sub-sector falls somewhere in the middle.

The value-added chain of **IT Components** (mostly semiconductors) is characterised by very high research intensity. This has allowed European industry (Infineon, NXP and STM, and also a large number of smaller companies) to compete successfully so far by focusing on a number of economically significant specialties, such as GSM and smart card components. In other words, thanks to strong R&D efforts, European products escape the price competition of the mass market and compete instead on innovation and quality. However, it is striking that most semiconductor research is taking place close to production facilities, which would indicate that a possible relocation of production would equally endanger the location for R&D.

The **Telecom Equipment** sub-sector is Europe's traditional strong point. It has a number of very large players and is geographically less concentrated, due to the Nordic producers. Europe still has a strong presence both in handsets (Nokia, Sony Ericsson) and in transmission equipment (Alcatel-Lucent, Ericsson, Nokia-Siemens), but its position has been eroded following the crisis in 2000/2001, after which the trade balance has begun to worsen. However, Telecom Equipment has the highest R&D intensity of the entire ICT sector, higher even than semiconductors, which should allow EU industry to remain competitive despite high costs.

In the somewhat less R&D-intensive **Multimedia Equipment** sector, European producers (Bang and Olufsen, Philips) are relatively strong in the premium segments, but this strength is overshadowed by the weakness in the mass market. There is also a notable presence of a number of Japanese-owned research centres in the EU, particularly in the UK, which are there in order to be connected to European trend-setting networks.

IT Equipment is the sub-sector where Western Member States' industry is least competitive, mainly for cost-related reasons. EU industry has opted for developing a number of niche products where significant R&D investment allows it to escape from price competition by focusing instead on quality. This results statistically in a fairly high R&D intensity, but should not be confused with strong investment in R&D. Besides, even this R&D intensity is less than half that of the US. IT Equipment is also where Western Member States' industry has most failed to profit from the science skills in the Eastern Member States. Much of the R&D investment in the Eastern Member States comes instead from foreign direct investment from countries outside the EU. Finally, the impact of IT Equipment heavily skews the analysis of overall ICT external competitiveness, as 80% of the trade deficit is caused by this group of products alone.

Electronic Measurement Instruments is often overlooked among the ICT manufacturing sub-sectors. However, it is in fact one of the larger sub-sectors, and a competitive one, as shown by a consistent trade surplus. This competitiveness exists despite an only average R&D intensity which is also much lower than in the US. This is due to the fragmentation of the sub-sector in many niches, a number of which have been occupied by European producers on the back of strong R&D efforts.

The two ICT services sub-sectors are completely different from one another. **Telecom Services** are dominated by a handful of very large companies, both in value added and in R&D. The R&D intensity in Telecom Services is by far the lowest in the entire ICT sector and has been declining in recent years. As a very large and relatively mature sector, R&D expenditure tends to be stable rather than growing fast. It should be noted, however, that the business R&D expenditures in the EU are much higher than in the US in this sub-sector.

At the other end of the spectrum, the EU **Computer Services and Software** sub-sector is mostly composed of small and medium size enterprises (with the notable exception of SAP). The absence of large companies is particularly notable with respect to the US. This sub-sector has been responsible for most of the BERD growth in the ICT sector in recent years, yet it continues to be dominated by US firms. The EU R&D intensity in this sub-sector remains far below the comparable US figure, which points to either a strategic problem or a huge potential for improvement, depending on the point of view. However, much R&D in software is taking place outside the Computer Services and Software sub-sector, on "embedded systems" in other sectors. Thus our current figures may understate the real size of EU software R&D.

Glossary

BERD - Business Expenditure on Research and Development

EBOPS -Extended Balance of Payments Standard Classification

ESTAT - Eurostat, European Commission

EU – The 25 member States that were part of the European Union, at the time of data collection (2004-2005)

EU10 – the 10 Member States which joined the EU in 2004, i.e. Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia

FDI – Foreign Direct Investment

GDP - Gross Domestic Product

ICT – Information and Communication Technology

IDM - Integrated device manufacturers

INFSO -Directorate General Information Society and Media, European Commission

IP – Intellectual Property

IPTS - Institute for Prospective Technological Studies

ISIC - International Standard Industrial Classification

IT - Information Technology

JRC - Joint Research Centre, European Commission

NACE - Nomenclature générale des Activites économiques dans les Communautés Européennes

R&D - Research and Development

RDI - R&D intensity is measured in three different ratios in this report:
1) BERD / Value Added (macro-economic data)
2) BERD / turnover (macro-economic data)
3) R&D / net sales (companies data)

PPP - Purchasing Power Parity exchange rate

SITC - Standard International Trade Classification

VA – Value Added

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Abstract

The report shows that the ICT sector alone is responsible for about half the R&D investment gap between the EU and the US, i.e. the fact that EU invests a much smaller share of its GDP in R&D. It argues that this is partly because the ICT sector is a smaller part of the economy in the EU than it is in the US. More important, however, is the lower R&D intensity (business R&D / value added) of the ICT sector in the EU. This is mainly due to lower R&D intensity in two sub-sectors: Computer Services and Software, and Electronic Measurement Instruments. Current data analysis gives no indication that the ICT R&D gap is closing. The analysis further finds that among EU Member States, Northern Member States show higher ICT R&D intensity than Southern Member States, and the Western Member States a much higher intensity than the Eastern Member States. The bulk of the paper then takes a closer look at each of the ICT sub-sectors, mapping out the R&D effort in each of them.

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