

ISSN: 1576-0162

INDUSTRIAL R&D INVESTMENT: A COMPARATIVE ANALYSIS OF THE TOP EU AND NON-EU COMPANIES BASED ON THE EU 2004 R&D SCOREBOARD

*LA INVERSIÓN EN I + D DEL SECTOR PRIVADO EN LA UE Y EN OTROS
PAÍSES: UN ANÁLISIS COMPARATIVO BASADO EN UNA CLASIFICACIÓN DEL
2004 DE LA COMISIÓN EUROPEA*

Constantin Ciupagea

European Commission and Institute for World Economy Bucharest
constantin.ciupagea@ec.europa.eu

Pietro Moncada-Paternò-Castello

European Commission
pietro.moncada-paterno-castello@ec.europa.eu

Recibido: enero de 2006; aceptado: septiembre de 2006.

ABSTRACT

This paper presents the main results from the 2004 EU Industrial R&D Investment Scoreboard, which lists the top 500 EU companies and the top 500 non-EU companies ranked by their R&D investment. After a short description of the definitions and objectives of the exercise, its content and main findings are shown together with results from other analyses performed within The European Common Directorate General, Joint Research (JRC) – Seville, showing the impact of the degree of concentration at the company's level on the overall industrial R&D stance. There seems to be a correlation between R&D intensity growth and net sales growth. Despite a competitive total amount of R&D investment, the average overall R&D intensity of the sampled European Union companies is much smaller than for their non-EU counterparts. This is related to a smaller proportion of output from sectors with high intrinsic R&D intensity, which is particularly noticeable in IT Hardware and Software and Computer Services. Although R&D investment amounts are comparable for the biggest firms, the share of R&D performers at the middle and the bottom of the EU-500 Scoreboard is much smaller in the EU than in the non-EU. The analysis indicates that national, regional and sectoral patterns deviate considerably from the overall picture of the EU. An entire section of the paper is dedicated to an inter-sector comparison of R&D-related indicators. The issue of concentration of R&D investment among top companies investing

in research is investigated in more detail, in large companies, by sector of activity and by location. It is also proved that the sample of top R&D investing companies is statistically characterised by heteroscedasticity.

Keywords: Industrial R&D; EU Scoreboard; Concentration.

RESUMEN

Este artículo presenta los principales resultados del primer “EU Industrial R&D Investment Scoreboard”, que muestra las primeras 500 compañías pertenecientes a la Unión Europea (UE) y las primeras 500 compañías no pertenecientes a la UE según su inversión en I+D. Después de una corta explicación de la definición y objetivos de este ejercicio, su contenido y sus principales conclusiones vienen junto con los resultados de otros análisis realizados dentro de La Comisión Europea, Dirección General, Centro Común de Investigación (CCI) Sevilla, mostrando la importancia del grado de concentración a nivel de compañía para la situación industrial de la I+D en general.

Parece que hay una correlación entre la intensidad del crecimiento de I+D y el crecimiento de las ventas (netas) de las empresas. A pesar de una impresionante cantidad de inversión en I+D, la media general de la inversión en I+D de la muestra perteneciente a la UE es mucho menor que la de sus equivalentes. Esto está relacionado a una proporción menor de producción procedente de sectores con intensidad en I+D intrínseca alta, lo que se puede observar especialmente en compañías especializadas en IT hardware y también en servicios de software y para ordenadores.

A pesar de que las cantidades de inversión en I+D son comparables para las grandes empresas, la proporción para empresas que están en medio y al final de la lista de “top-500 Scoreboard” es mucho menor en la UE que fuera de ella. Este análisis indica que los modelos y estructuras nacionales, regionales y sectoriales se desvían considerablemente de los de la media europea. Una sección entera del artículo esta dedicada a la comparación entre sectores de los indicadores de I+D.

El problema de la concentración de la inversión en I+D entre compañías muy importantes que invierten en I+D viene investigada en mayor detalle, entre las empresas grandes, según el sector de actividad y según la localización. También se ha demostrado que la muestra de las compañías inversoras en I+D más importantes se puede caracterizar estadísticamente por heterocedasticidad.

Palabras clave: Investigación y desarrollo de las empresas; EU Scoreboard; Concentración.

JEL Classification: O32.



1. INTRODUCTION

As part of its Lisbon strategy the European Council of March 2002 in Barcelona decided to make R&D and innovation the main route through which economic growth and competitiveness in the EU should be increased, even if it would be difficult to raise employment rates to the targeted levels. The “Lisbon Strategy” was agreed by EU leaders at the Lisbon European Council in 2000 with the aim of making the EU “the most competitive knowledge-based economy”. It was recognised that this requires an increase in productivity and that productivity is increased by focusing on the drivers of productivity such as R&D and skills. Consequently, in Barcelona, the European Council set an overall goal of 3 % for R&D as a proportion of GDP, with two-thirds of this financed from private sources. At present, R&D in the EU is at almost 2 % of GDP of which about 64 % is performed in¹ and 55-56 % is financed by industry². This means that overall R&D spending by industry in the EU would need to rise by more than 10 % per annum by 2010 to meet the Barcelona target.

In its Action Plan “Investing in research” (*COM(2003)226final*) the European Commission announced its intention to set up an industrial research monitoring activity, including scoreboards, to analyse trends and facilitate benchmarking of research investment and research management practices between firms. The EU Scoreboard of top R&D-investing companies is particularly valuable in assessing towards the higher level obtaining elsewhere, particularly in the USA and Japan. However, whilst this Scoreboard enables changes in larger companies’ worldwide R&D investments to be monitored, it does not permit assessment of the progress being made by EU companies against the Barcelona goal of increasing the intensity of business R&D investment in the EU since it does not measure the amount of industrial R&D carried out within

¹ As an institutional sector in which R&D is actually spent.

² The latest figures released by Eurostat – *Statistics in Focus, Science & Technology, 2/2005* - show that in 2002 the overall R&D expenditure of the EU-25 as a percentage of their overall GDP was 1.93%, while the share of R&D expenditure financed by business sector in total was, in 2001, 55.4 % (latest estimation for EU-25).

the EU as a proportion of EU GDP. The EU R&D Scoreboard is nonetheless very instructive and relevant to the broader remit of the *3% Action Plan* as a means of monitoring global R&D trends of firms on a sectoral and country by country or world-region basis, which is complementary to, but by no means comparable to the “territorially specific” data collected by official statistics offices (BERD).

A company’s R&D investment enables it to develop new products, processes and services to maintain and enhance its value added. In a world where more and more countries are industrialising, Europe needs to lead in R&D for those sectors where it is a key enabler of added value. This is because the newly industrialising countries in Asia have lower labour costs which will remain well below European levels for the foreseeable future. Successful European companies will therefore compete by offering an edge in new products, processes and services which, combined with marketing skills, operational excellence and sound strategic choices, will enable them to grow value added consistently and continue to provide skilled jobs. The EU R&D Scoreboard allows inputs to this process to be monitored by sector and by company for comparison with equivalent companies headquartered in the USA, Japan or/and the rest of the world.

This paper raises some questions based on the observation of economic reality at company level. What are the most striking features of R&D investment among the major players on world markets (often multinationals)? Why are major European companies among the most important players on the world market while overall average European R&D intensity (ratio of R&D investment to sales) lags behind the one registered in US or Japan? Are economic structural issues and patterns responsible for this difference and at what consequences? The paper also suggests possible further implications that may be derived from the analysis.

A hint addressing the first question comes from the distribution of corporate R&D, which is concentrated in companies, sectors and countries. This paper will try to focus in more detail on the concentration issue, especially when related to the size of firms and to the sector of declared main activity. Comparative issues between the EU and non-EU worlds are also highlighted. These observations lead over to the identification of structural issues and patterns highlighted by question number two. From this, implications as addressed in the third question are derived.

2. SCOREBOARD APPROACHES AND INDICATORS OF INDUSTRIAL R&D

In what concerns quantitative information on industrial R&D, a mapping of country-based sources revealed that the main sources of data are the official R&D, innovation, and some occasional country-specific statistics³. Private

³ See the results of the European Science and Technology Observatory (ESTO) study : “Mapping Surveys and other data sources on Industrial R&D in the EU-25 countries”, Seville, June 2004.

sources of information on industrial (business, corporate) R&D exist but are published only in very few cases.

The (first) European Union (EU) 2004 Industrial R&D Investment Scoreboard is a unique source of information on the R&D investments made by each company included in the 500 top companies registered in the EU ranked by their investment in R&D. It also lists the 500 largest non-EU companies by R&D. The aim is to provide an in-depth assessment of the investments in the future (*R&D and Capital Expenditure*) being made by EU companies for comparison with those of the larger R&D-active companies outside EU. As well as R&D and capital expenditure, a range of financial performance data is included such as sales, operating profits and market capitalisation. The EU 2004 R&D Scoreboard thus provides a detailed perspective on EU companies' R&D compared to the rest of the world in the same way that the existing UK and USA Scoreboards do for these countries⁴. As an analytical tool, a scoreboard permits to compare its members because it applies the same criteria and units of measurement for each of them. Scoreboards are therefore popular tools for benchmarking.

The Scoreboard is intended for four main audiences: *Companies* - to help them benchmark their own R&D investments and performance against international and European competitors in their sectors. Benchmarking coupled with more effective investment and performance improvement programmes is the way in which companies can close any gaps in performance which may exist with their best international competitors; *Investors* - to help them assess the prospects of companies that are in or might be added to their portfolios. Large investors can have a major influence on a chief executive's decisions about the size of his company's R&D investment and the adequacy of its new product pipeline; *Business Organisations* - these include organisations representing businesses (or employees) in each country, and sectoral organisations. Some of these organise best practice programmes which help companies to learn from each other; *Government and Academia Organisations* at regional, national and European level - sector mix, R&D intensity and the business environment for key sectors are examples of important policy issues that arise from Scoreboard-based comparisons of one economy with another. The R&D Scoreboard provides the basis for evidence-based policy development in the areas of R&D investment and the business environment for R&D-active companies in the EU.

The EU Scoreboard analysis section aims to identify and discuss important points and trends taken out from the substantial body of data collected for the 1000 companies and is organised in three main levels as follows:

⁴ DTI: "The 2004 R&D Scoreboard", UK Department for Trade and Industry, London, 2004, http://www.innovation.gov.uk/projects/rd_scoreboard/introfr.html, and Industrial Research Institute: "Industrial Research Institute's 6th Annual R&D Leaderboard", *Research and Technology Management*, 6, 2004, 20-24.

- An overview of the whole set of R&D companies both by world region and by major economy (*EU, Japan, USA, Rest of non-EU Europe, Rest of the World*). It also refers to the performance of companies by the location of their registered office in various EU Member States. This overview addresses top-level measures such as total R&D investment, R&D intensity (*R&D as % sales*) and business performance (*sales growth, profitability, market capitalisation, etc.*).
- The second level of analysis is concerned with sectors and the way in which differences in sector size, sector mix and sector R&D intensity lead to big differences between the overall total of R&D and the overall R&D intensity for companies headquartered in different countries and economies.
- Thirdly, it is essential to understand the strengths and weaknesses of the companies making up the main R&D performing sectors. This is done by looking at major EU companies compared to those headquartered in other economies, by identifying the concentration of R&D by sector and comparing company distributions of R&D intensity which reflect the overall investment intensity of a large sample of companies rather than being biased by the small number of very large R&D-investing companies. An in-depth comparison of distributions can only be made for the EU vs. the USA (*which has a similar R&D Scoreboard*) and is useful for comparing 'strength in depth' outside the largest companies. Finally, there is a discussion of the links that exist between company input investments like R&D and capital expenditures and company performance (outputs).

The *EU R&D Scoreboard* is publicly available⁵. R&D investment in the Scoreboard is taken from the companies' financial reports, which are based on the accounting standards for private companies. Although the accounting standards lead to a certain standardisation in the data reported, companies still have a choice of what to declare as R&D and what not. Thus, in all the cases where the data disclosed by the company do not reveal more detail, the figures in the *EU R&D Scoreboard* are only as homogeneous as the accounting standards⁶. The approach is different from that of OECD or Eurostat, which report Business Expenditure on R&D (BERD) figures, including all expenditures (capital and current) for R&D performed within the business enterprises whether funded by the businesses themselves, from overseas or by government. The Scoreboard figure is the cash world-wide investment in R&D which is funded by the companies themselves. It excludes R&D undertaken under contract for customers such as governments or other companies. It also

⁵ See European Commission 2004 Industrial R&D Investment Scoreboard - <http://EU-IRIScoreboard.jrc.es>

⁶ However, there is on-going convergence in accounting standards. According to EC regulation 1606/2002, publicly traded companies governed by the law of the EU Member States have to prepare their consolidated accounts in conformity with International Financial Reporting Standards (IFRS) by 1 January 2005. For companies whose securities are traded only on a regulated market or who have been using internationally accepted standards before 2002, the deadline is 1 January 2007.

excludes the companies' share of any associated company or joint venture R&D investment⁷.

There are other specificities that may explain the important differences between the data in the EU R&D Scoreboard and those on BERD as collected by national statistical offices. Scoreboard is fundamentally different and the data contained can complement information provided by BERD. It is important to stress that the EU R&D Scoreboard and BERD data have been originally set for different audiences. The Scoreboard is primarily used at micro level by companies, business associations and investors for benchmarking whereas the BERD data is primarily used by economists, governments and international organisations (macro level).

The Scoreboard shows the consolidated world-wide R&D investment for companies and includes R&D wherever in the world it is carried out, i.e. Scoreboard doesn't tell where R&D is performed. The BERD data presents R&D by country and any country's data contains only R&D carried out within the country by those parts of companies located within that country (including foreign subsidiaries). When the Scoreboard mentions a country it always means the location chosen for their registered office by the ultimate parents of the companies listed in the Scoreboard and it does not mean country in the BERD sense.

The Scoreboard and BERD data-sets should not be compared and there is not enough information available to check one against the other, as the samples sizes are different. The BERD data is derived from the data collected by each country on R&D investment by companies operating in that country using questionnaires (*and often a sampling process*). The result gives R&D by sector only for those parts of a company that fall within the geographical boundary of the country concerned. This means that R&D can be related to the country but not to company performance since only part of the company is included (*unless the company has no activities outside the country*); there are also confidentiality constraints that require that no data be disclosed in such a way that it could be related to a specific company - only sector aggregates are published so that R&D/performance relationships are not available in BERD even for individual companies wholly based in the country concerned.

R&D intensities are defined in a different way within the Scoreboard using R&D as a ratio to net sales as opposed to BERD using R&D as a ratio to value added. The reason for this is that value added data are not always publicly available (e.g. for US or Japanese companies, because of the limitation of US GAAP) so that comparisons of EU companies with non-EU (US, Japanese, etc.) companies can only be made using R&D/sales ratios.

One additional element that makes not possible to compare data from the two approaches is that BERD information follows NACE (is the European Statistical

⁷ Where part or all of R&D costs have been capitalised, the additions to the appropriate intangible assets are included to calculate the cash investment and any amortisation eliminated.

Classification- Nomenclature - of Economic Activities⁸⁾ sector classification, while the Scoreboard classifies companies' economic activities according to FTSE (Financial Times Stock Exchange index) classification.

Concluding, it is not possible to compare BERD data for a country or sector with the EU Industrial R&D Investment Scoreboard data. In order to show the difficulty in such check, but also to provide illustration of possible consistency and complementarities, the following information is provided as an example.

a) The totals of both Scoreboard and BERD data-sets for all countries should be equal in principle, provided both were fully comprehensive which they are not. If we are going to verify it, we see that the latest available figure of BERD for EU25 is 116 billion current euro in 2001⁹, while the total volume of EU Industrial R&D Investment by the top 500 companies (and only 500 companies in EU) in the financial year 2003/04 is of 101 billion current euro¹⁰. Considering that i) BERD figure contains also¹¹ the R&D expenditures in EU from abroad organisations, and that ii) the analysis of the flows of companies' R&D expenditures between US, Japan and EU15 reveals that the net outflow from EU15 to US (mainly) and Japan is (in 2000 € PPS) of about €5 billion¹², it can be concluded that, with the limit of the available information and the assumptions taken, the order of magnitude of both R&D volumes in the Scoreboard and BERD are of a similar size.

b) Bearing in mind that sector classifications in BERD and Scoreboard are different, the Scoreboard can provide *complementary* information because refers to industrial R&D made world-wide by top spenders which have a legal location in the EU countries. This is, for example the case when Swiss data - Scoreboard information on pharmaceutical companies Novartis, Roche and Serono *versus* Swiss BERD - are taken into consideration. Only the three Swiss pharmaceutical companies, mentioned above, in 2000 invested world-wide in R&D €5725 million, current prices, while the overall Swiss Business (privately financed) R&D expenditure reported for 2000, by Eurostat, was €4735 million¹³. Similarly, BERD figure for Finland in 2003 is around €3.5 billion (current prices), while the Scoreboard reveals that only one Finnish company invested worldwide in R&D almost €4 billion in the fiscal year 2003.

⁸ NACE stands for "Nomenclature générale des Activités économiques dans les Communautés Européennes".

⁹ European Commission (2003) – *Key Figures 2003-2004* – ISBN 92-894-5814-3

¹⁰ And €102 billion current investment figures in 2001/02, respectively, but for the same sample of companies that are in the TOP500 of EU R&D investors in 2003 (not for the TOP500 companies in 2001).

¹¹ The BERD figure includes all expenditures (capital and current) for R&D performed within the business enterprises whether funded by the businesses themselves, from overseas or by government.

¹² European Commission (2003) – *Key Figures 2003-2004* – ISBN 92-894-5814-3

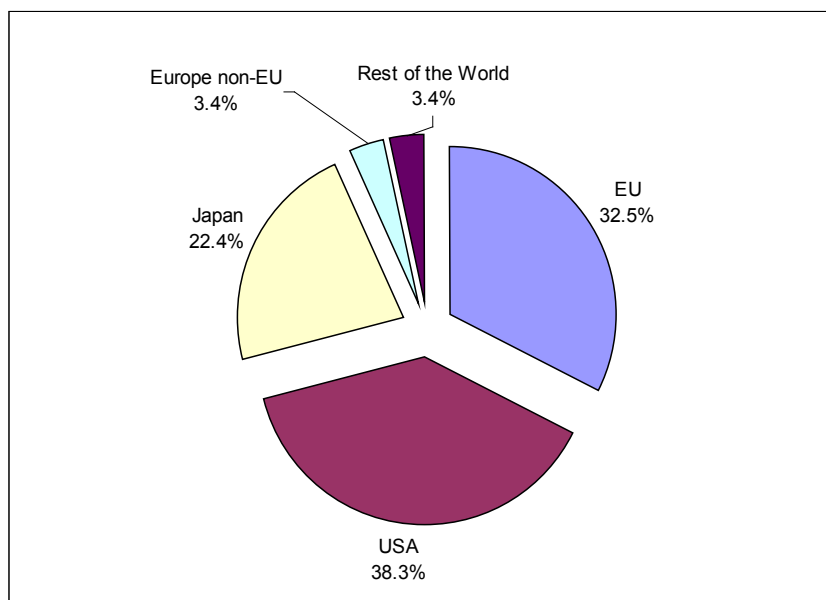
¹³ Eurostat, Statistics in Focus – Science and Technology 2/2005, *R&D Expenditure in the European Union*.

3. THE MAIN FINDINGS OF THE EU 2004 R&D SCOREBOARD ANALYSIS

1. In 2003, the aggregate R&D investment of the top 500 EU companies - as they are listed in the Scoreboard - reached € 100.8m¹⁴. The aggregate R&D investment of the top 500 non-EU companies listed in the Scoreboard was in the same year an equivalent of € 195.6m¹⁵.

The annual growth rates for the R&D investment of the two sets of companies, in 2003 as compared to 2002, were -2% for the EU top 500 companies and 3.9%, respectively. The compound annual growth rates, over the period 2000-2003, were 1.2% and 3.7% respectively, the difference between the EU and non-EU companies being mainly caused by the evolution in 2003.

FIGURE 1: THE R&D INVESTMENT SHARE OF TOP 685 SCOREBOARD COMPANIES, BY REGION OF OFFICE REGISTRATION, IN 2003



Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

¹⁴ Current prices of the year 2003.

¹⁵ In order to convert the non-EURO currencies the end-of-year exchange rate was used, as reported at 31 December 2003. This applies also to the historical comparative data. The principal rates used are: Sweden: 9.08 (Swedish Kronor); Japan: 135.18 (Yen); Switzerland: 1.56 (Swiss Franc); UK: 0.70 (£ Sterling); USA: 1.26 (US\$).

Using comparable sets of EU and non-EU Scoreboard companies¹⁶, the share of EU companies in total top R&D-active companies was 32.5% in 2003 (see Figure 1), showing a decrease as compared to the maximum registered in 2001 (34.2% computed at 2003 exchange rate equivalents).

- The historical data covering the 2000-2003 period allow for several remarks. It should be pointed out that business climate on global markets, for R&D-active companies that are included in the Scoreboard, has improved in 2003 over the previous years (particularly 2001-2002). However, the recovery was faster for the non-EU companies. Whereas 2003 was particularly unfavourable for EU companies, the evolution over the past four years shows similar figures for both sets of companies in terms of their R&D investment indicators (see Table 1).

TABLE 1: DISTRIBUTION OF SCOREBOARD COMPANIES BY CHANGES IN THEIR R&D INVESTMENT IN 2000-2003

	Changes in R&D Investment by Companies, 2003 over the previous year (percentage of all companies)		
	R&D Increase \geq 5 %	R&D Increase 0-5 %	R&D Decrease
EU Top 500	38	16	46
Non-EU Top 500	47	16	37
	Changes in R&D Investment by Companies, 2000-03 (% of total companies)		
	R&D Increase \geq 5 % p.a.	R&D Increase 0-5 % p.a.	R&D Decrease p.a.
EU Top 500	51	18	31
Non-EU Top 500	52	19	29

Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

A small number of top companies are responsible for a large fraction of the aggregate R&D investment summed over all the other companies listed in the Scoreboard. If only 2003 is referred, the top 40 non-EU companies contain 20 companies with R&D investment increases of more than 5% over the previous year and with only 10 companies showing decreases; the EU top 40 have 11 companies with R&D investment increased over the previous year, but 16 companies with decreases.

¹⁶ The 500 top non-EU companies, all of which have R&D of over €51.4million. There are 185 EU companies with R&D over €51.4million giving a world top 685 companies within which valid comparisons can be made between countries since the 685 companies are all in the same R&D size range having R&D over €51m. A difference between the global 685 and the EU 315 (i.e. the 500 less the 185) is that the EU 315 contains many more companies with small sales that are in an earlier stage process of building their businesses and are more likely to compete in national or regional rather than global markets.

TABLE 2: OVERALL BUSINESS PERFORMANCE OF R&D SCOREBOARDS COMPANIES BASED ON 2003 FINANCIAL YEAR DATA

Factor	EU 500	EU 185	Non-EU 500
R&D Investment (€ bn)	100.8	93.9	195.6
R&D Investment /Company (€ bn)	0.20	0.51	0.39
Change in R&D Investment Over Previous Year (%)	-2.0	-1.9	3.9
R&D Investment CAGR for Last 3 Years (%)	1.2	1.1	3.7
Net Sales (€ bn)	3139.3	2614.7	4342.4
Change in Net Sales Over Previous Year (%)	-0.6	-0.7	6.8
Net Sales CAGR for Last 3 Years (%)	0.9	0.8	2.9
Employees (millions)	12.0	9.7	15.6
Change in Number of Employees Over Previous Year (%)	-3.4	-2.9	-1.0
Sales/Employee (€ k)	261.6	270.3	266.6
R&D Investment per Employee (€)	8394	9706	12094
R&D / Sales Ratio (%)	3.2	3.6	4.5
Operating Profit/Net Sales (%)	7.0	6.8	9.1

Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

Note: The growth rates are computed for the 2003 financial year compared with the 2002 financial year. For comparability reasons, the annual growth rates are adjusted according to the available sample of companies in each year (i.e. if there are no data for one company in one year, impeding the computation of growth rate, that particular company is excluded from the aggregate growth rate calculation).

All companies (regardless the regions in which their registered offices are located) showed a reduction of their profitability (operating profit as a percentage of net sales) in 2001 as compared to 2000, which was further deepened in 2002. In 2003, they registered an upturn (see Table 2).

Finally, the EU top R&D-active companies didn't recover in 2003, in terms of their net sales and R&D investment, like the companies located in the non-EU regions (see Table 3). Net sales increased in 2003 for the US companies (by 11.2 % in current prices) and Japanese companies (by 2 %) but showed a small decrease of 0.6 % for EU companies. Overall R&D investment also increased for the US (by 4.7 % in current prices) and Japanese companies (by 2.8 %) listed in the Scoreboard but decreased slightly for the 185 EU companies in the same size range as the non-EU 500.

TABLE 3: R&D INDICATORS OF TOP SCOREBOARD COMPANIES BY REGION OF OFFICE REGISTRATION, IN 2003

	EU-500	EU-185	Europe non-EU	US	Japan	Rest of the World	Non-EU 500
Total R&D investment €bn	100.8	93.9	9.9	110.8	64.9	9.9	195.6
R&D/Sales ratio (intensity %)	3.2	3.6	4.8	4.9	4.2	2.9	4.5

Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

3. The concentration of R&D investment among EU companies is quite high, as the top 20 accounted in 2003 for more than 55 % of the total R&D investment by the full top EU-500 Scoreboard list. The same finding applies to non-EU registered companies, but at a lesser extent. Nevertheless, from 2000-2003 one may observe a declining trend in the share for top 20 EU companies, from 57.5 % in 2000 to 55.3 % in 2003, which means that more and more EU-registered companies from the lower part of the TOP500 were increasing their R&D investment at a higher pace than the very large EU R&D-investing companies.

There is also a significant concentration of R&D investment in each of the ten main sectors wherein the Scoreboard companies have declared their main activity to be. The share of these ten main sectors in total research investment made by the top EU 500 R&D-investing companies, in 2003, was 89.3 %, of the remaining 10.7 % covering 21 other FTSE sectors which are represented in the Scoreboard.

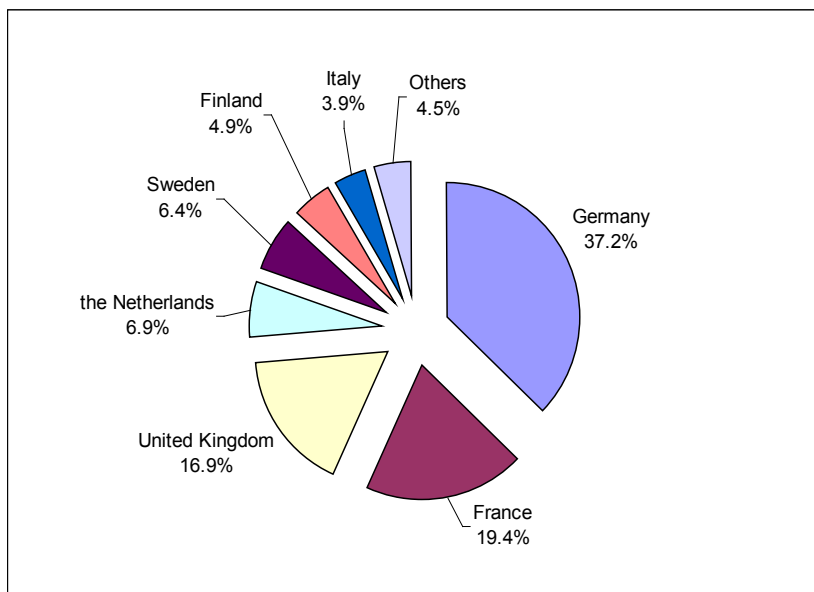
The top company (in each sector of activity) invested in R&D in 2003 a proportion ranging between 15-35 % of the aggregate R&D investment of all the Scoreboard companies declaring themselves as mainly active in the respective sector, regardless the region of office registration (EU or non-EU), with few exceptions (non-EU companies active in IT Hardware show less concentration, so do EU companies in health). The top 2 companies account for 14 - 36 % of sector R&D investment of all companies that are present in the Scoreboard top500 in the 4 main sectors mentioned above. The concentration for the EU-185¹⁷ is higher ranging from 41 – 43 % for automotive and pharmaceuticals to 60 % for IT hardware and 83 % for electronics & electrical equipment (where there are only two large EU companies). More on the issue of concentration will be analysed in the following section of this paper.

4. Among the Scoreboard EU companies there is high concentration by country of office registration and by sector of declared activity. There are three major EU Member States in which EU Top 500 R&D-investing

¹⁷ The group of top 185 companies registered in EU of comparable size with the top 500 companies with registered office outside EU (included in the Scoreboard).

companies have registered their office, who in 2003 accounted for 73.5 % of the aggregate R&D investment of EU top 500 Scoreboard companies: Germany, France and United Kingdom (see Figure 2).

FIGURE 2: SHARE OF R&D INVESTMENT AMONG EU TOP500 SCOREBOARD COMPANIES IN 2003, BY COUNTRY OF OFFICE REGISTRATION

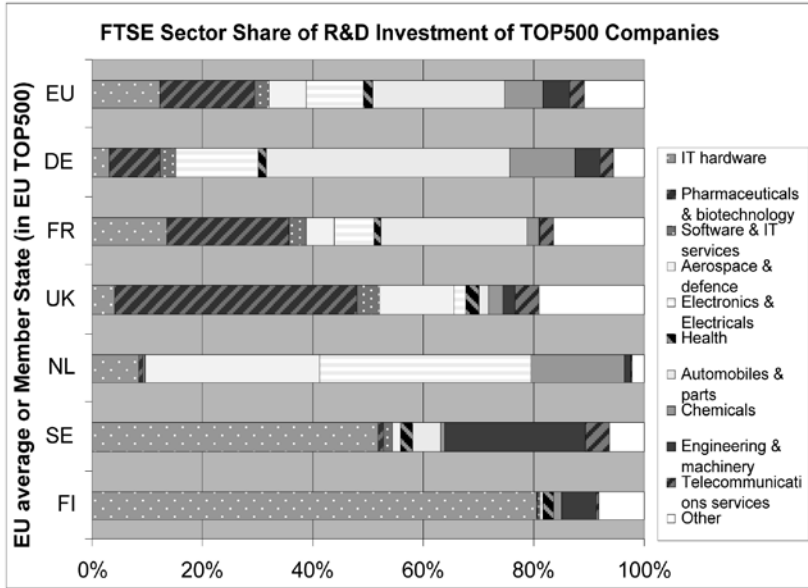


Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

The main three sectors (automobiles & parts, pharmaceuticals & biotechnology and IT hardware, as they were declared by companies as main sector of activity according to FTSE classification index), ranked by their share in the overall R&D investment of EU top 500 companies, accounted for 53.2% of total in 2003. Not all these sectors are characterised – worldwide or within EU – by an intrinsically high R&D/Sales ratio.

With one important exception, that is the case of French companies, EU companies grouped by Member States of registration show at least one strong specialisation in terms of R&D investment, when compared to the average for all top 500 EU companies (higher share than twice the EU average – see Figure 3).

FIGURE 3: THE SHARES (%) ACCOUNTED FOR BY THE MAIN FTSE SECTORS IN TOTAL R&D INVESTMENT OF THE EU TOP 500 SCOREBOARD COMPANIES, BY MEMBER STATES, IN 2003



Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

German top R&D-investing companies are particularly strong in automobiles & parts, which is one of the Europe’s most important sectors investing in research. Finnish companies have more than 80 % of their R&D investment concentrated in IT hardware. Swedish companies show R&D strength and specialisation in IT hardware and its traditional engineering & machinery sector. The Dutch companies make an interesting case with three clear sector specialisations: aerospace, chemicals and electronics & electrical equipment. United Kingdom’s companies have specialised in the pharmaceuticals & biotechnology sector, but are also well above the EU average in aerospace & defence.

- The top 10 EU, US and Japanese companies by R&D investment reflect the strengths of top companies from these three economies. For example, the EU and USA have three pharmaceutical companies each in their top 10 but Japan has none. Japan, which is strong in electronics & electrical equipment and IT Hardware, has six such companies in its top 10 compared to five in the USA and four in the EU. The remaining top 10 companies in each case are active in the automobiles & parts sector, where EU companies show more strength than their non-EU competitors.

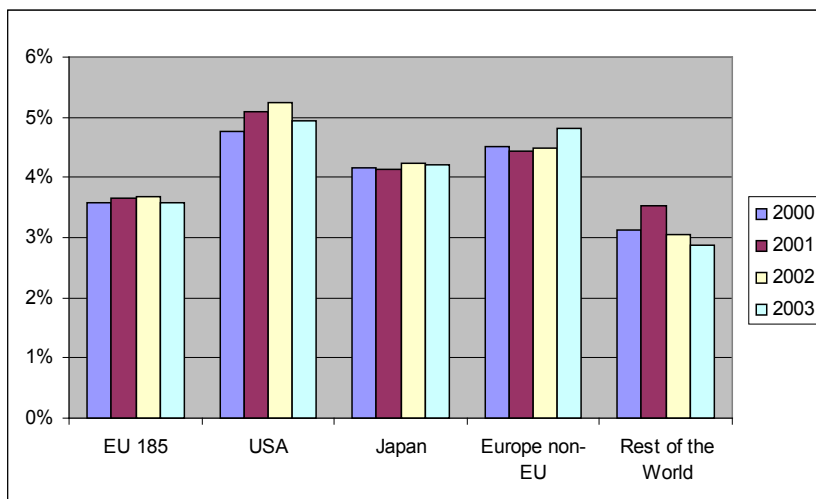
Within the FT Global 500 list of the world’s largest companies by market capitalisation, there are 55 in the Scoreboard EU top 185 and a further 145



in the non-EU Top 500. The other FT Global 500 companies are, of course, not that much R&D-active.

6. An overall decrease in R&D/Sales ratio (R&D intensity) was observed in 2003, as compared to 2002, at the overall Scoreboard companies level (from 3.31 % to 3.21 % in the case of EU Scoreboard TOP500 companies and from 4.66 % to 4.51 % in the case of non-EU Scoreboard TOP500 companies). The R&D intensities remained – nonetheless – unchanged over the period 2000-2003 for EU companies and increased slightly (from 4.44 % in 2000) for non-EU companies (see Figure 4).

FIGURE 4: TRENDS IN R&D INTENSITIES, BY REGION OF OFFICE REGISTRATION (2000-2003)



Source: The 2004 EU Industrial R&D Investment Scoreboard, p.36.

7. The four largest sectors¹⁸ by their weight in the aggregate R&D investment of the top 685 companies¹⁹, which are listed in both sets of the *2004 EU Industrial R&D Investment Scoreboard* are IT hardware (19.6 %), pharmaceuticals & biotechnology (18.8 %), automobiles & parts (18.1 %) and electronics & electrical (10.8 %).

The following Table 4 allows for a closer examination of the sectoral structure by detailing the proportion of total R&D investment for the twelve biggest of the 31 FTSE sectors and providing their respective R&D intensities.

¹⁸ As declared by companies - when registering on recognised stock exchanges or within Annual Reports - as their main activity (FTSE classification).

¹⁹ Top companies selected by criterion of similar size in both Scoreboard's lists.

TABLE 4: R&D INVESTMENT AND INTENSITIES FOR SCOREBOARD COMPANIES, BY SECTOR OF DECLARED MAIN ACTIVITY

FTSE Sector	EU-500		Non-EU 500	
	Sectoral R&D Investment (as a percentage of all sectors)	R&D intensity	Sectoral R&D Investment (as a percentage of all sectors)	R&D intensity
Automobiles & Parts	23.8	4.6	(3) [†] 15.7	4.1
Pharmaceuticals & Biotechnology	17.0	15.2	(2) 18.5	15.1
IT Hardware	12.4	15.6	(1) 22.9	8.6
Electronic & Electrical Equipment	10.3	6.5	(4) 10.9	5.7
Chemicals	7.2	4.2	(6) 4.2	3.8
Aerospace & Defence	6.8	8.0	(10) 2.1	2.7
Engineering & Machinery	4.6	2.5	(7) 2.5	2.8
Telecommunication Services	2.8	1.0	(11) 2.0	2.5
Software & Computer Services	2.6	12.8	(5) 7.8	10.0
Oil & Gas	1.9	0.3	(14) 1.2	0.5
Health	(11) 1.7 *	5.1	(9) 2.2	8.4
Diversified industrials	(13) 1.1 *	3.3	(8) 2.4	2.3
Others (19 sectors)	7.8	0.5	7.6	0.2
Total (31 sectors)	100.0	3.2	100.0	4.5

* Not in the EU-500 top 10 sectors but are in the non-EU 500 top 10; in brackets their ranking in TOP EU.

[†] The numbers in brackets are the order of sector size for the non-EU 500.

Source: The 2004 EU Industrial R&D Investment Scoreboard, p.6.

It can be seen that in seven of the ten biggest and all of the five biggest in the EU R&D-performing sectors, the EU companies have equivalent or higher R&D intensities than the non-EU companies. Even so, overall industrial R&D intensity for the entire group of companies is lower in the EU-500 than in the non-EU 500. The value for the EU is 3.2 %, significantly less than that for non-EU firms at 4.5%. The R&D intensity of US companies (4.9 %) and non-EU European companies (4.8 % overall and 6.5 % for Switzerland) was higher than that of the comparable set of 185 EU companies (3.6 %). Japanese companies had an aggregate R&D intensity somewhere in between (4.2%). Why is the

overall ratio lower, when the sectoral comparison is so favourable? The main reason is that the mix of industrial sectors in the EU differs from that of the non-EU world.

The EU-500 has a smaller proportion of output flowing from sectors with a high intrinsic R&D intensity. This is particularly noticeable in IT hardware and software & computer services. Together, IT hardware and software & computer services represent only 3.2 % of the sales of the EU firms in this Scoreboard, compared to 15.5 % for the non-EU firms. Because these two sectors together have a high R&D intensity relative to other sectors, their larger size in the non-EU raises the average R&D intensity for the whole group of non-EU companies. At the same time, the EU-500 has a larger proportion of output flowing from sectors with a very low intrinsic R&D intensity, such as telecommunications services or oil & gas, than the grouping of non-EU 500 companies.

If one takes out the companies declared to be active in the two afore-mentioned sectors from the two lists of companies²⁰, then the new comparative table will look certainly different if firms were grouped by the location of their registered head office (see Table 5).

TABLE 5: AVERAGE R&D INTENSITIES FOR ALL COMPANIES (EXCEPT THOSE IN TELECOM SERVICES AND OIL & GAS INDUSTRIES), BY REGION OF REGISTERED OFFICE

Indicator\Region	EU	EU-comp	Japan	US	nonEU
No. of companies	500	185	153	288	500
No. of companies (less 2)	475	172	151	280	480
<i>R&D intensity total (%)</i>	3.2	3.6	4.2	4.9	4.5
<i>R&D intensity (less 2) (%)</i>	4.2	4.9	4.3	5.8	5.1

(less 2) - for all companies excluding those declared to be active in Oil & Gas and Telecom Services.

Again the differences between the EU and non-EU are the smaller the bigger R&D investors the companies are. The large companies in the EU-185 group have a similar proportion of their R&D investment outside the four largest sectors like the non-EU companies (34 % compared to 32 %). However, this share rises to 36.5 % in the case where all the EU-500 companies are considered.

8. A comparison of US and EU companies in the same size range using the US 1000²¹ and EU 500 Scoreboards shows very different distributions of companies by R&D/Sales ratio, with the EU having twice the US proportion of companies with low R&D/Sales ratio (between 0 and 2 %) and the US having more than twice the EU proportion (43 % vs. 17 %) of companies

²⁰ This operation will leave aside not more than 5% of previous overall R&D investment of all companies, in the case of EU and Japanese firms, and less than 2% in the case of US companies.

²¹ See "2003 US IRI R&D Scoreboard", Industrial Research Institute, USA, Nov. 2003.

with a high R&D/Sales ratio of over 10 %. The reason for this difference is that there are many more large and middle-large US companies than EU companies in the IT hardware and software services sectors and a large proportion of these show high R&D/Sales ratio. Table 6 presents R&D indicators of the above-referred two sectors for the EU group of companies versus the non-EU group (including the US companies as the main contributor).

TABLE 6: R&D INDICATORS FOR SCOREBOARD COMPANIES IN IT HARDWARE AND SOFTWARE SERVICES

Factor	EU-500	Non-EU 500
R&D Investment (€ million)	15130	60126
R&D Investment (% of Top 500)	15.0%	30.7%
Number of companies	87	152
R&D Investment /Company (€ million)	174	396
Net Sales (€ million)	100758	671966
Net Sales (% of Top 500)	3.2%	15.5%
Employees (thousands)	458	2710
Sales/Employee (k€)	220	248
R&D Investment per Employee (k€)	33	22
R&D / Sales Ratio (%)	15.0%	8.9%

Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

4. CONCENTRATION OF R&D AMONG TOP SCOREBOARD COMPANIES

It was already pointed out that the degree of concentration is high among the top companies²² investing in R&D, at global level as well as in many of the sectors with weight in total world R&D investment. We are detailing now the analysis on the concentration issue, using a comparative approach for EU companies versus the non-EU companies.

We first look at the shares of selected samples of top companies in the available overall R&D investment of the EU and non-EU Top 500 Scoreboard companies. By analysing the share of cumulated R&D investment of the top 20, top 50 and top 100 up to top 400 companies in the total R&D investment made during the same period by all the companies from the 2004 Industrial R&D Investment Scoreboard (TOP500) in any of the main regions, one may have an image (statistical distribution) of the overall concentration of investment in research and development activities for the overall sample of companies.

²² As they appear listed in the EU 2004 Industrial R&D Investment Scoreboard.

High proportions (close to one) for the ratio between the R&D investment sum of the top 20 companies (TOP20), for example, and the investment of TOP500 companies, will mean that most of the R&D is made by the 20 biggest R&D investors with the rest of 480 companies being responsible for the remaining share. Table 7 shows the above-mentioned shares for different samples of companies (the top 20, 50, 100, 200, 300 and 400 companies), in a comparative approach companies registered in EU vs. non-EU registered companies. It also shows the evolution of these shares during the period of analysis, 2000 to 2003.

TABLE 7: THE SHARE OF R&D INVESTMENT OF TOP "N" COMPANIES IN OVERALL TOP500 R&D INVESTMENT IN EU VS. NON-EU REGIONS, 2000-2003 (%)

	EU companies				non-EU companies			
	2000	2001	2002	2003	2000	2001	2002	2003
Top 20	57.5	57.1	55.5	55.3	37.4	35.6	35.7	36.7
Top 50	76.1	75.3	75.2	75.2	61.2	59.6	58.4	58.7
Top 100	87.3	86.4	85.7	86.2	73.4	72.5	71.9	72.5
Top 200	94.7	94.2	93.9	93.9	85.6	85.2	84.9	85.3
Top 300	97.4	97.1	97.0	97.1	92.2	92.1	92.1	92.4
Top 400	99.0	98.9	98.9	98.9	97.0	96.9	96.8	96.9

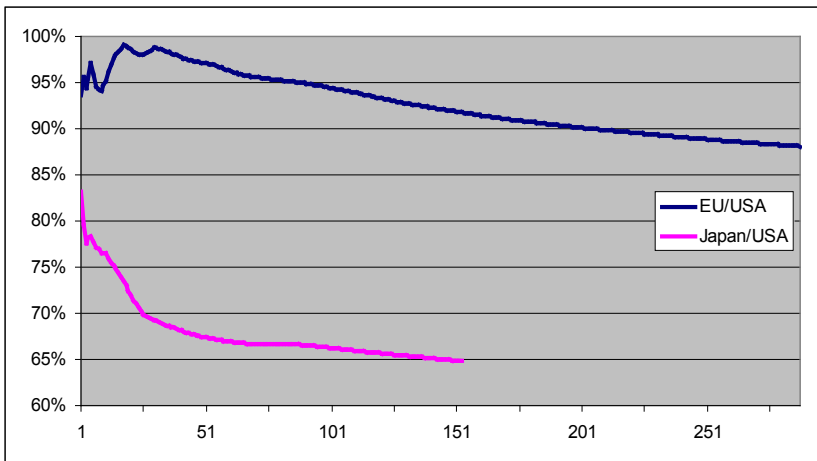
Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

- A first finding from the above is that the R&D activity is more concentrated within the European Union, as all the equivalent shares are higher in all years belonging to the analysed time horizon. The concentration is extremely important at top, where the biggest 20 EU companies by investment in R&D are counting for more than half of the R&D investment made by the top 500 EU R&D-investing companies.
- Secondly, the rest of the world shows high degree of concentration, as well. The top 50 companies with registered offices outside EU are responsible for almost 60 % of the total R&D investment made by the 2004 Scoreboard TOP500 companies in the same geographical area. Given the size-difference factor of almost 1 to 2 between EU and non-EU overall R&D investment, the differences in shares are explained by the different number of companies of the same size (in terms of investment in R&D) that are reported in the two samples of companies.
- Thirdly, a declining trend in the concentration levels of EU companies has been documented since 2000, which is significant particularly among the top companies (TOP20 and TOP100), despite the ongoing process of mergers and acquisitions which would act to counter this. This means that more and more companies in the lower part of the TOP500 list were increasing their R&D investment at a higher pace than the companies in

the upper part of the EU TOP500 companies. These may prove that the EU economy may enter a phase of development in which growing and emerging companies may add to the in-depth strength of its R&D and innovation activity. It may also mean that top R&D-investing companies started to outsource more of their R&D activities.

- Fourthly, the companies that are listed in the 2004 non-EU Industrial R&D Investment Scoreboard do not show the same trend of declining ratios of the R&D investment made by a number of top companies in total (TOP500 non-EU R&D investment).

FIGURE 5: RATIO OF CUMULATED R&D INVESTMENT FOR SIMILAR SAMPLES OF TOP COMPANIES REGISTERED IN EU AND JAPAN AS COMPARED TO US-REGISTERED COMPANIES, IN 2003 (%)



Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

Note: The ratio for top “n” EU companies as compared to top “n” US companies is computed by dividing the cumulated R&D investment of n EU companies by the cumulated R&D investment of the same number of top US companies. The same applies to Japanese companies as compared to US companies. As there are only 153 Japanese companies in the Scoreboard, the graph for Japanese companies stops at position 153 on the horizontal axis, while it goes up to 288 for the set of US companies.

The graph above was built by computing – based on data for financial year 2003 – the cumulated R&D investment of the top1 company, then top2 companies, continuing up to the maximum number of companies available for a given region or country and then calculating the share of each of these sums for all countries in the equivalent (similar) sum for US companies (sum that proved to have the highest value for all “n”). Therefore, Figure 5 has a horizontal axis showing number of companies (maximum 288 available for the US sample, with R&D investment of US companies taken as denominator) and a vertical



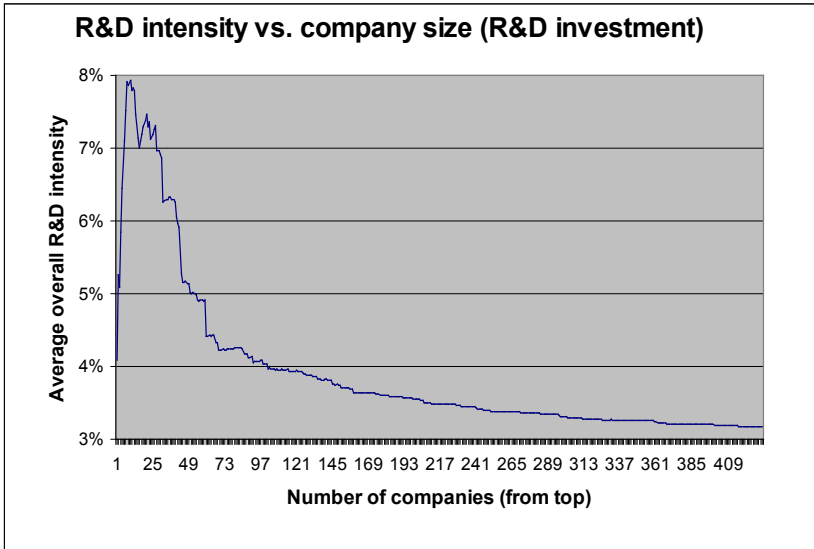
axis showing the relative ratio between the cumulated R&D investments of similar number of companies in any pair of two of the three major regions. The conclusions are as follows:

- For the top 90 companies investing in research, EU companies have almost the same R&D strength as the US companies, as the above defined ratio oscillates between 95 % and 100 %. Japanese companies are clearly lagging behind from the very beginning, and succeed to stay at more than 70% of the cumulated R&D investment of similar number of top US companies only for a small top 24 group of companies.
- EU companies lose momentum gradually compared to the US companies and the gap steadily increases, the ratio reaching 88% for the top 288 companies (maximum available for the US companies). There are an important number of US companies of a "smaller" size, which invest strongly in R&D, in a more consistent way than the EU companies, offering strength to the overall R&D performance of United States. These companies are concentrated in sectors which are intrinsically R&D intensive, which explains the gap in this indicator between the two regions.

We constructed another graph (see Figure 6), which depicts the influence of the size of R&D investment made by EU Scoreboard companies on their R&D intensity. We first calculated the sum of R&D investment for the top n companies and the corresponding sum of net sales for the same companies' groupings. We then computed the average R&D intensities (R&D investment as a ratio of net sales) for each group of n top companies and graphed these intensities against the number of companies. The result indicates a strong bias towards bigger R&D intensity for bigger R&D investors (the bigger the investments, the higher the intensities), which has two main analytical consequences:

a) There is heteroscedasticity present in the sample of Scoreboard companies, which occurs in relation to R&D investment volumes vs. sales (and, consequently, when investigating R&D intensities). Consequently, any analysis based on R&D data for the Scoreboard companies should be handled cautiously, performing algorithms that may lead to transformations towards homoscedasticity. Cross-section analysis using financial data for various groupings of R&D-investing companies will therefore need specific distributional tests to be performed *ex-ante*, in order to eliminate potential statistical ambiguities.

FIGURE 6: AVERAGE R&D INTENSITY OF THE TOP N EU COMPANIES GRAPHED AGAINST N (2003)



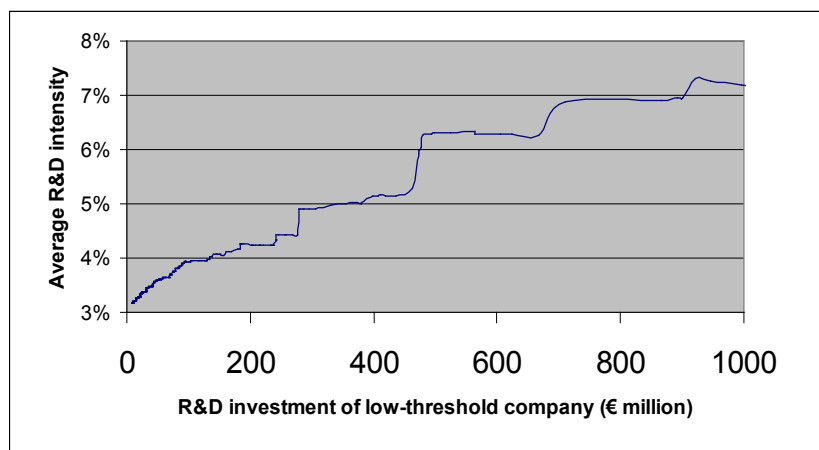
Note: n represents the number of companies starting from the top for which the average R&D investment/Net sales ratio (R&D intensity) is computed.

b) In order to do a comparison between two different sets of companies (such as companies belonging to different regions by location of registered offices) it will be needed to look carefully at the statistical properties of the data. By eliminating the companies having R&D investment below a given threshold, for example, one may produce serious changes in the statistical distribution and in the average overall R&D intensity of the entire initial sample of companies. The same remark is valid in a case when net sales reported by companies are considered for a threshold criterion. The influence a low threshold applied to the volume of R&D investment has on the average R&D/sales ratio for the corresponding group of companies can be also followed in Figure 7 presented below. As an example, the US annual Industrial Research Institute R&D Scoreboard (and Leaderboard) considers only companies with sales of more than \$100 million, which may corrupt the overall R&D intensity of “real” top R&D investors by downward biasing (some of these companies being excluded from the Scoreboard). The calculations made for the EU top companies listed in the EU 2004 Industrial R&D Investment Scoreboard produce an average overall R&D intensity of 3.21% for the entire sample of 500 companies, but of only 3.17% if we eliminate the 68 companies with net sales below \$100 million (€79 million), in order to ensure perfect comparability with the US companies listed in the IRI US Scoreboard. If we then eliminate from the



sample all the companies with R&D investment of less than €51.38 million in 2003, in order to ensure comparability with the non-EU companies listed in the EU Scoreboard, one may observe an upward jump of the average overall R&D intensity to the level of 3.59% (obviously, in the meantime, the number of companies in the new sample decreased at 185).

FIGURE 7: AVERAGE R&D INTENSITY OF THE TOP EU SCOREBOARD COMPANIES WITH R&D INVESTMENT ABOVE A THRESHOLD GRAPHED AGAINST THE VALUE OF THE THRESHOLD (2003 FINANCIAL YEAR)



5. A SECTOR-SPECIFIC ANALYSIS OF R&D AMONG SCOREBOARD COMPANIES

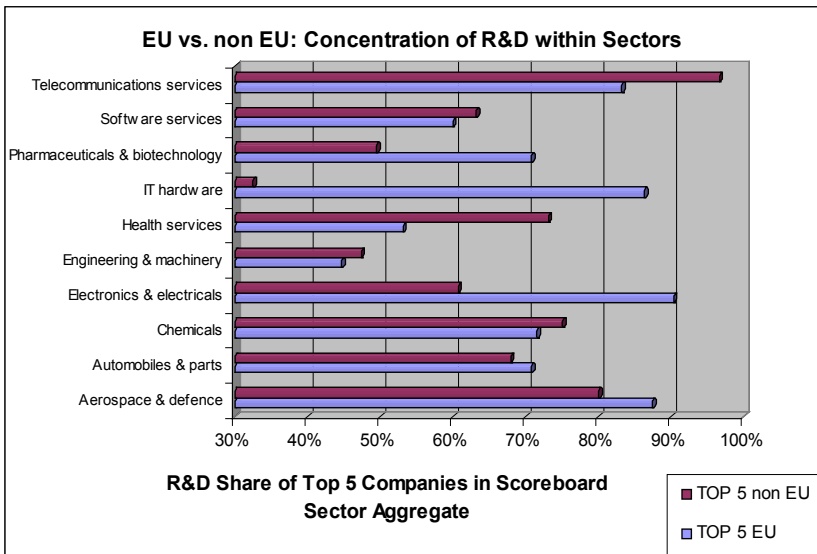
The sector concentration issue mentioned in previous sections is now detailed for ten major sectors covered within the Scoreboard analysis. Figure 8 shows – for financial year 2003 – the shares of the top 5 companies in total R&D investment of all the companies declaring themselves to act in the respective sector and that are listed in the TOP500 available in the 2004 Industrial R&D Investment Scoreboard, separately for companies registered in EU and non-EU regions. The comments apply strictly to the set of companies that are included in the 2004 Industrial R&D Investment Scoreboard and are summarised as follows:

- The share of R&D investment of top 5 companies in sector aggregate R&D investment, among all companies listed in the Scoreboard regardless their office registration region, was ranging from 45-85 % in 2003, with few exceptions. Only in one sector in the case of EU companies (engineering & machinery) and in three sectors in the case of non-EU companies (engineering, IT hardware and pharmaceuticals) is the share of the top 5 companies in total R&D investment of companies represented in Scoreboard's TOP500 in the respective sector lower than 50 %. This

means that the overall degree of concentration is not only high at the global economy level, but also in the case of each sector taken separately, among the top groups of 500 companies investing in R&D.

- There are similar shares computed for EU companies as for non-EU companies in sectors such as: aerospace & defence, automobiles & parts, chemicals and engineering & machinery. These sectors are “traditional sectors”, in which EU companies show a large share in worldwide sector R&D investment and a higher R&D intensity than their direct major competitors from outside EU, and therefore a relative strength in terms of R&D investment.

FIGURE 8: SHARES OF TOP 5 COMPANIES IN TOTAL SECTOR R&D INVESTMENT OF COMPANIES LISTED IN 2004 INDUSTRIAL R&D INVESTMENT SCOREBOARD REGISTERED IN EU VS NON-EU REGIONS – DATA FOR 2003 (%)



Source: IPTS, DG JRC Seville; The 2004 EU Industrial R&D Investment Scoreboard.

- The degree of concentration is much higher for EU companies that declare themselves to be mainly active in sectors such as IT hardware, electronics & electrical equipment or pharmaceuticals & biotechnology, which are sectors showing high or very high R&D intensity and show higher shares in overall R&D investment among non-EU companies than among EU ones. This finding is in line with the fact that regions with lower degree of concentration in a given sector are usually characterised by the presence of many medium-sized companies investing in research and development who ensure the strength of the economy in the respective sector of activity.



- The degree of concentration is lower for EU companies than for non-EU companies in sectors such as telecommunications services or health, but the reasons may differ between the two cases. In telecommunications services, the presence of a major Japanese company in the area of research investment is increasing the share a small number of top companies count for in the overall R&D investment made by all the companies declared as active in this sector (out of the companies listed in the Scoreboard). In the case of health, the important reason resides with the lack of major R&D investors among EU companies acting in this sector, which is only the 11th sector in the ranking of sectors by R&D investment of EU top 500 companies.

In Table 4, we saw the share (sector share) each group of companies declared to be active in a given sector has in overall R&D investment of top 500 EU and, respectively, top 500 non-EU Scoreboard companies. An analysis based on equivalent type of R&D-related data but only for the activity of top 20 companies spending on R&D within a EU national territory²⁵ (domestic investment of companies, regardless their ownership and location of registered office) show a very similar picture, but from a different perspective.

In the case of the top 20 companies spending on R&D within each of the very few countries for which data was available, the sectors which are generally well represented are pharmaceuticals, IT hardware (especially telecommunications equipment), automobiles & parts, and telecommunications services (very close to the image offered by table 4). Among these sectors, only two (Pharmaceuticals and Information technology hardware – which mainly includes telecommunications equipment) also have a high intrinsic R&D intensity, thus the global European R&D intensity has an intrinsic potential range related to the sector structure. By the same token, the very low share of dynamic R&D sectors, such as Software and computer services or Health services, leaves European companies at comparative disadvantage relative, for example, to US companies. The results for more sectors are presented in Table 8.

Large countries (such as France) and medium-sized countries (Belgium, the Netherlands, Sweden) in the EU invest a lot in R&D in traditional sectors for their economies. These do not necessarily show high R&D intensities, although they may induce positive externalities leading to economic growth (electronic & electrical equipment, engineering & machinery, automobiles & parts). These sectors cause horizontal multiplier effects in the economy, either by demanding products from other sectors, by supplying products to other domestic sectors, or by increasing the labour demand within the national economy. There are sectors such as food processing or forestry and paper, which are not R&D intensive, but occupy an important position in the R&D picture of a particular country (the UK, the Netherlands, Sweden, Finland), due to a tradition gained by the national companies in that area and to a high level of competitiveness already achieved on world global markets (through major players).

²⁵ The analysis was done by the same authors in IPTS, Dg JRC, Seville, Spain, but is not publicly available.

As it was the case for EU 2004 R&D Scoreboard companies, the average R&D intensity (R&D/Sales ratio) of the top 20 companies in one country seems to depend on the sector structure of the economy and of the R&D expenditure as well. The sectors showing intrinsically high R&D intensity, in most economies, are pharmaceuticals and biotechnology, IT hardware (including telecommunications equipment), software and computer services, aerospace and defence and health services.

The European countries analysed in our sample show R&D expenditure concentrated in only two out of these five sectors, namely pharmaceuticals and IT hardware. Moreover, for most of the sectors listed above the spill-over effect of R&D on the country economic growth is somewhat uncertain. The companies that are active in these sectors often deliver final (rather than intermediate) goods and services searching to increase consumer satisfaction (thus increasing the workforce's standard of living) and to increase or maintain their market shares (domestically and worldwide).

TABLE 8: MOST RELEVANT SECTORS' SHARES IN TOP 20 COMPANIES' R&D EXPENDITURE, IN 2002

SECTOR	BE	ES	HU	NL	FI	FI w	SE w	UK w
04 (Mining)							0.41%	
07 (Oil & gas)		1.77%	2.66%	9.98%	2.07%	0.77%		4.87%
11 (Chemicals)	21.04%		3.47%	24.51%	1.52%	1.74%		2.42%
15 (Forestry & Paper)					3.06%	3.99%	0.57%	
18 (Steel & Other Metals)	1.43%			2.48%	1.15%	1.10%	1.19%	
20 (Ship Building)		4.45%						
21 (Aerospace and Defence)	1.48%	19.01%					3.61%	12.18%
25 (Electronic & electrical equipment)	30.19%			48.73%				2.06%
26 (Engineering & Machinery)	3.02%	2.40%	5.06%	1.04%	11.22%	9.89%	13.68%	
31 (Automobiles & parts)		27.03%		2.41%			10.01%	8.95%
43 (Food producers & processors)				5.79%				7.05%
44 (Health)					1.23%	1.95%	1.00%	1.71%
48 (Pharmaceuticals & Biotechnology)	40.60%	12.48%	78.33%		3.35%	3.31%	26.04%	49.59%
54 (Media & photography)								1.86%
58 (Support Services)							0.37%	
67 (Telecommunication services)	2.24%	17.31%		1.07%	4.74%	2.09%	16.29%	5.05%
79 (Utilities Others)			2.24%				0.42%	
93 (IT Hardware)		12.49%			71.68%	75.17%	25.60%	4.27%
97 (Software & Computer Services)		3.06%	8.24%	3.99%			0.80%	

Source: IPTS, DG JRC Seville; own calculations.

Note: The sum of the percentage shares given in the columns (by country) is not necessarily 100%, due to rounding in percentage calculations. The subscript w after a name of EU Member States means that data are available only for the worldwide activity of the companies; for only 5 EU Member States available data for domestic (national) R&D expenditure were made available (Belgium, Spain, Hungary, the Netherlands and Finland).

In labour-intensive sectors the positive impact R&D investment has on the sector's growth may either lead to increased demand for labour across the economy as a whole or only in the specific area of economic activity concerned. Where a sector makes intensive use of natural resources, given the location constraints upon the production units, R&D may be oriented towards finding solutions that enable cost reductions or maintaining activity in regions which have suffered temporary losses of efficiency for any of a variety of external reasons (political, demographic, etc.). As it was earlier mentioned, some sectors produce a greater horizontal multiplier effect than others due to the fact that their products are used by more sectors in the economy and/or the fact that they need inputs from more sectors (the input-output table coefficients for these sectors are distributed throughout the table and are significantly larger than those of many other sectors). These industries may generate multiplied growth within the economy when growing themselves, and R&D invested in them could have a more significant impact than in other branches of activity. Often, the theatre of operations for a given company is not the domestic economy of the country in which the company is officially registered, but the global international markets for its products. R&D in such cases is very much related to the company's efforts to maintain or enhance its competitiveness at the worldwide level and to increase its share of total worldwide sales. The same phenomenon applies in the case of companies mostly producing end products for consumers. When companies struggle to increase their share of the global, to conquer an existing niche, or open up a new niche in the market, R&D is often oriented towards product differentiation based on quality or features. Analysis by country shows that R&D intensity is much higher when calculated for each domestic market (domestic R&D expenditure as a share of domestic net sales) than when computed on the international scale (worldwide level – total R&D investment of the company as a share of total net sales worldwide). Companies – especially if they have a clear national ownership structure – are inclined to concentrate their R&D activity in their home country.

6. CONCLUSIONS AND IMPLICATIONS

This article therefore uses the newly established *2004 EU Industrial R&D Investment Scoreboard* in order to construct a picture of the global distribution and concentration of industrial R&D, reveal sectorial distributions, compare aggregate differences between EU and non-EU firms, and derive patterns of specialisation. In the introduction, three questions were raised for a better understanding of the current patterns and trends of R&D investment in the EU and non-EU worlds.

The key finding – responding to the question of main features – of the EU 2004 R&D Scoreboard analysis is the fact that *R&D investment of the top 500 companies* in both regions (EU and non-EU) *is highly concentrated along three dimensions*: in large companies, in certain sectors of activity and geographically, by location of the registered office of the ultimate parent company.



The Scoreboard points to a number of differences between the behaviour of EU and US top R&D-investing companies. The implication is that a better economic and policy environment should be effective in stimulating R&D investment in middle (and small)-sized companies. In particular, the quality of the environment for the growth of smaller businesses with the potential to become mid-range or larger businesses is important.

The second question concerned the apparent paradox that European companies are often important players on the world market while corporate European R&D intensity lags behind the US or Japan, despite that in seven of the top ten R&D-performing sectors the EU-500 companies have equivalent or higher R&D/sales ratios than non-EU-500 companies. The main reason is that the mix of industrial sectors that comprises the EU economy differs from that of Japan and the US, as it was suggested by the third question. *The EU has a smaller proportion of output flowing from highly R&D-intensive sectors than the non-EU world.* This is particularly noticeable in IT Hardware, and Software & Computer Services. Together, IT Hardware and Software & Computer Services represent only 3.3 % of the sales of the top EU firms in this Scoreboard, compared to 15.5 % for the non-EU firms. The EU group of companies active in IT Hardware sector has only 38 companies; the non-EU group declared as active in IT Hardware sector has 107.

The analysis of the concentration among the companies reveals that R&D investment amounts are comparable for the biggest firms but the share of R&D performers at the middle and the bottom of the EU-500 Scoreboard is much smaller in the EU than in the non-EU. This indicates that efforts for increasing R&D investment in the EU should especially consider the latter group of companies. In this context, it should be noted that the Scoreboard does not list companies with R&D investment below € 8.54m so that there is no information on the vigour of smaller size companies by sector. To obtain this in a reasonably complete form, it is necessary to have available the annual reports and accounts for smaller companies.

The implication from the findings presented above is that clearer requirements for disclosing R&D investment and other form of intellectual capital in company accounts and for easy remote access to company accounts in some EU member states will be needed, particularly for private companies not listed on a recognised stock exchange. It comes along that i) relevant actions should put more stress on vigour of smaller/middle-sized companies in weaker (but emerging and promising) sectors (e.g. Health services), and ii) there is a need for adequate disclosure to better assess vigour of small (especially) and medium enterprises.

An important issue for policymakers is how industrial R&D investment responds to the business cycle and the macroeconomic environment in general. Accumulating business sector data over time will enable a better understanding of this issue. The industrial competitiveness is played globally. R&D investment of companies is an element of it and should be seen in such

strategic business prospective, especially if we refer to the top companies in the Scoreboard which are mostly operative on international markets.

If we consider the sectors of specialization for EU companies on one hand and which are the promising emerging markets on the other, a similar conclusion already made for SMEs can be formulated for large-size companies. *There is a need for policies and strategies which support the development of research in emerging and promising sectors, without penalizing the areas where Europe's traditionally strong position provides a competitive advantage that constitutes a leverage for policy action (such as pharmaceuticals & biotechnology, automobiles & parts and electronics & electrical equipment).*

The 2004 EU Industrial R&D Investment Scoreboard data show that - as far as the relations between companies' economic performances, R&D investments and employment is concerned - for all companies with registered offices in EU (except those registered in UK) there is a positive link between the annual growth rate of employment and net sales (2000-2003). There is not similar direct link between R&D investment and employment growth rates. This is one more element that confirms the R&D investment decision is a more strategic (long-term) undertaking. In fact, successful companies make good strategic choices, show operational excellence and make wise and balanced investments in the future (such as R&D investment, capital expenditure, brands, market development).

The analysis at micro-economic level, in the context of the Lisbon and Barcelona targets, has to be approached with caution, as sectorial monitoring may be more efficient in the case of R&D expenditure (including the business R&D expenditure) than the aggregate national-level benchmarking. The questions that might be raised include how much impact on overall economic development we should expect from a given amount of private industrial R&D expenditure in a particular sector, and how the effects produced at macroeconomic level by the same value of R&D expenditure in other sectors differs? R&D investment in one sector may be more beneficial to the social-economic system than that in another sector of activity and may reach the desired EU targets more rapidly. Therefore, a separate sectorial analysis of the R&D expenditure-elasticity of output (the response or sensitivity of the economic output – such as value added or turnover – to the variations in R&D expenditure) would be desirable.

Finally, the different patterns and trends detected within this analysis somewhat mirror the complexity of understanding R&D investment flows and providing a supportive policy framework which takes advantage of Europe's diversity and improves its competitive position. The analyses based on Scoreboard and BERD data indicates that national, regional and sectorial patterns deviate considerably from the overall picture of the EU.

REFERENCES

- Arundel, A. (2001): "Innovation Scoreboards: Promises, Pitfalls and Policy Applications", in *Innovation and Enterprise Creation: Statistics and Indicators*; Proceedings of the conference held at Sophia Antipolis, 23-24 November 2000, DG Enterprise, EUR 17038, Luxembourg, 246-251
- CPB (2002): *Research and Development Expenditures in the Netherlands by Enterprise and Research Institute*, The Netherlands Bureau for Economic Policy Analysis (CPB), The Hague, see also: <http://www.cpb.nl/eng/data/rd/>
- DTI (2004): *The 2004 R&D Scoreboard*, UK Department for Trade and Industry, London, http://www.innovation.gov.uk/projects/rd_scoreboard/introfr.html
- DTI (2003): *The 2003 R&D Scoreboard*, UK Department for Trade and Industry, London, http://www.innovation.gov.uk/projects/rd_scoreboard/introfr.html
- European Commission Scoreboard (2004): *Monitoring Industrial Research: The 2004 EU Industrial R&D Investment Scoreboard*, Directorate General Joint Research Centre and Directorate General Research, Technical Report EUR 20735 EN, Seville, see also: <http://EU-IRIScoreboard.jrc.es/>
- European Commission S&T Key Figures (2003): *S&T Key Figures 2003-2004*, Directorate General Research, Technical Report EUR 21399 EN, Brussels, 2003, see also: <http://EU-IRIScoreboard.jrc.es/>
- European Commission SEC (2003): *Investing in Research: an Action Plan for Europe*, COM 2003/226 final, SEC (2003) 489, Brussels, see also: <http://europa.eu.int/comm/research/era/3pct/pdf/com2003-annex.pdf>
- European Commission Workshop (2003): "Workshop: The Future of the European Innovation Scoreboard", Luxembourg, see also: http://194.78.229.48/extranettrend/reports/documents/TCW13_background_paper.pdf
- European Council (2002): "Regulation (EC) No 1606/2002 of the European Parliament and of the Council of 19 July 2002 on the application of international accounting standards", *Official Journal L 243*, 1-4, http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=32002R1606&model=guichett
- Eurostat – European Commission (2005): *R&D Expenditure in the European Union*, Statistics in Focus – Science and Technology 2/2005.
- Industrial Research Institute (2004): "Industrial Research Institute's 6th Annual R&D Leaderboard", *Research and Technology Management*, 6, 20-24.
- Industrial Research Institute (2003), *2003 US IRI R&D Scoreboard*, USA.

- OECD (2003): *OECD Science, Technology and Industry Scoreboard 2003*, Organisation for Economic Co-operation and Development, Paris, see also: <http://www1.oecd.org/publications/e-book/92-2003-04-1-7294/index.htm>
- OECD (2002): *Frascati Manual*, Organisation for Economic Co-operation and Development, Paris, see also: http://www.oecd.org/document/6/0,2340,en_2649_201185_33828550_1_1_1_1,00.html
- Porter, M.E. y Stern, S. (1999): *The New Challenge to American Prosperity: Findings from the Innovation Index*, Council on Competitiveness, Washington D.C., see also: <http://www.compete.org/pdf/innovation.pdf>