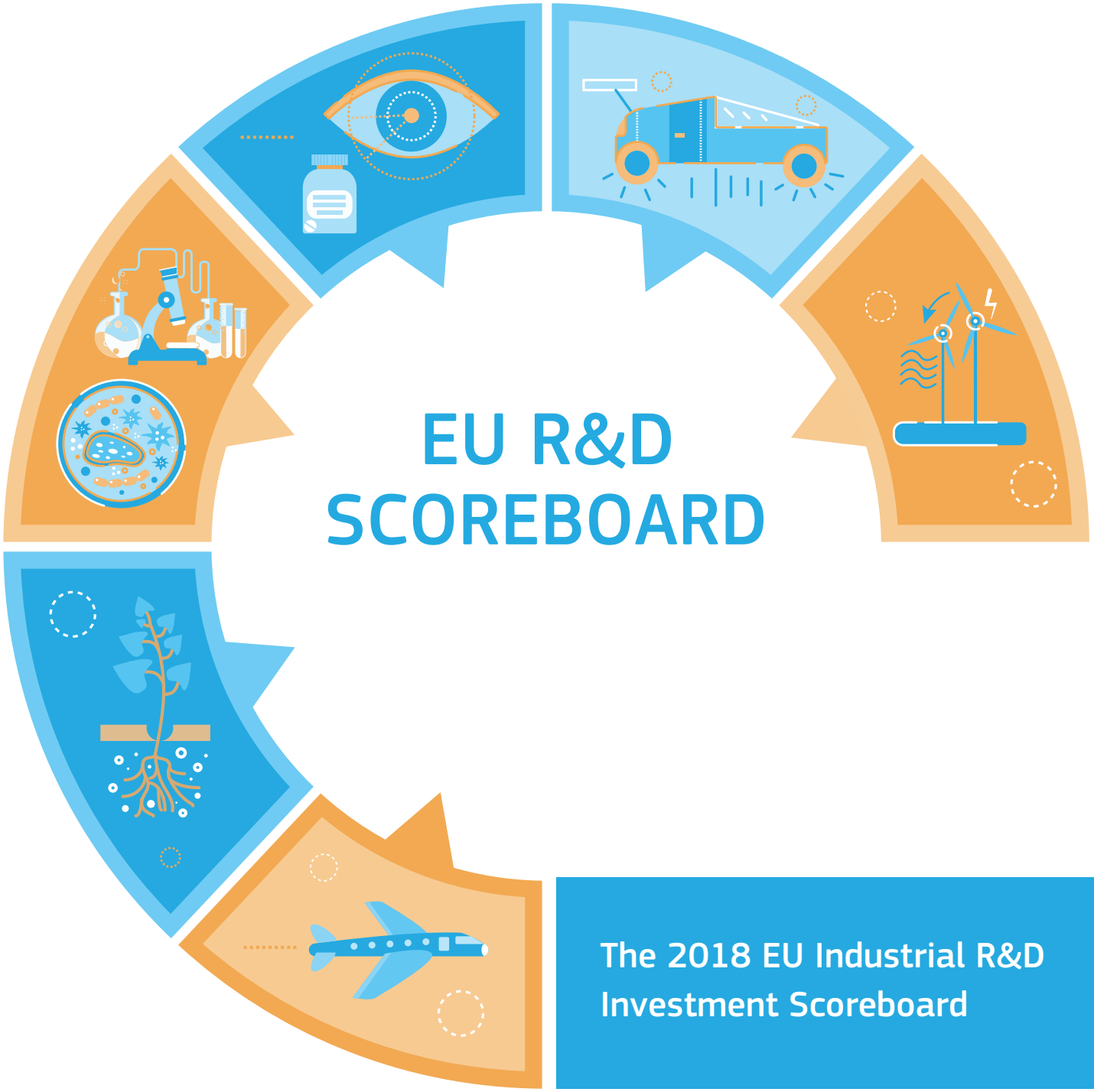
European Commission



EU R&D SCOREBOARD

The 2018 EU Industrial R&D Investment Scoreboard

EUR 29450 EN

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EU R&D SCOREBOARD

THE 2018 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

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SUMMARY / INTRODUCTION



Summary

The 2018 edition of the EU Industrial R&D Investment Scoreboard (the *Scoreboard*) comprises the 2500 companies investing the largest sums in R&D in the world in 2017/18. These companies, based in 46 countries, each invested over €25 million in R&D for a total of €736.4bn which is approximately 90% of the world's business-funded R&D. They include 577 EU companies accounting for 27% of the total, 778 US companies for 37%, 339 Japanese companies for 14%, 438 Chinese for 10% and 368 from the rest-of-the-world (RoW) for 12%.

This report analyses the main changes in companies' R&D and economic indicators over the past year and their performance over the past ten years. It also includes a patent-based analysis aimed at characterising further the innovation activity of the business sector in the 28 member states of the EU. Finally, the report comprises a 10-year analysis of the performance of *Scoreboard* companies based in Asian countries, examining in particular the role of foreign direct investment and related mergers and acquisitions.

Highlights

1 The top 2500 global R&D companies in the Scoreboard (all with R&D over €25m) account for approximately 90% of the world's business-funded R&D. They invested €736.4 in R&D in 2017/18, up 8.3% on the previous year. The major contributors were the US (37%), the EU (27%), Japan (14%) and China (10%) followed by South Korea and Switzerland (4% each). Over the last decade, the EU has maintained a 26-27% share and the main change has been an increasing share for China with a decreasing share for Japan.

2 R&D is very concentrated with the top 10 companies contributing 15%, the top 50 40% and the top 100 53% of the total global 2500 R&D. Within the top 50 there are 18 based in the EU, 22 US companies, 6 from Japan, 2 from Switzerland and one each from South Korea and China. Samsung is the top R&D investor (with €13.44bn) followed by Alphabet and Volkswagen.

3 The R&D sector specialisations of the four main regions are very different. The EU has 20.1% in ICT, 22.4% in health but 30.5% in automotive in contrast to the US with 51.4% of its R&D in ICT with 26.7% in health and only 7.8% in automotive. Japan has many similarities with the EU having 24.9% in ICT, 30.8% in automotive but only 12.4% in health. China has some similarities with the US having 44.7% in ICT, 11.4% in automotive but only 3.4% in health.

4 Worldwide R&D growth in 2017/18 was driven by the ICT sector followed by health with M&A contributing to growth in most sectors. Since 2009 ICT services has shown the highest growth followed by automotive and ICT producers. The regional trends over the years are very clear with US companies increasing their share of the global ICT services sector with the EU's reducing whereas EU companies' share of automotive has increased with the US's decreasing. These share differences are magnified by similar sector intensity differences.

5 R&D intensity (the R&D/sales ratio) varies substantially between sectors with the highest intensity for the high tech ICT and health sectors followed by medium tech sectors such as automotive and engineering. The differences in sector specialisation for different regions lead to big differences in regional R&D intensity with the US averaging 6.3%, the EU and Japan 3.4% and China 2.8%. The sectoral intensity gaps have been increasing over the last few years with the EU companies widening their automotive intensity lead over those of the US and China but the US widening its intensity lead over the EU and China in both ICT and health. The EU gap in ICT is illustrated by the EU's one large software firm out of the 16 ranked in the global top 150. But there are 109 EU software companies in the EU1000 - more need to grow into global players.

6 The top 50 largest companies by R&D intensity are dominated by firms from ICT (24) and health (23) with the EU accounting for 14 of the companies, the US 25, Asia 9 and Switzerland 2. Furthermore, out of the 250 companies with R&D over €500m, there are only 30 with R&D intensity, R&D growth and sales growth of at least 10%. These companies, 22 from ICT and 5 from biopharma, are based in the US (22) and the EU and Asia (4 each).

7 The *Scoreboard* includes a separate listing of 1000 EU companies with R&D over €8m. The EU1000 shows a high degree of R&D concentration with 97% of the R&D from the 577 EU companies also in the global 2500 and 97% from the top 10 member states. The three largest countries (Germany, the UK and France) contribute 68% of both total R&D and total sales. For the three largest countries the largest contributing sectors are automotive (29.7%), health (22.3%) and ICT (15.5%). Most German R&D is in medium-high tech sectors (primarily automotive), the UK's in high tech (primarily pharmaceutical) but France has more of a balance for high/medium-high tech sectors.

8 The 2018 *Scoreboard* contains a study mapping business patents in the 28 member states of the EU, comparing the location of patent's inventors and applicants (ownership). The results reveal a contrasting picture of inventorship vs ownership across the EU, i.e. in many countries a high proportion of local inventions are owned by foreign companies and, on the contrary, in a few countries, the number of applicants is much higher than the local inventions. The study also shows differing concentrations of ownership with the top three companies owning 30-60% of patents in many smaller countries but only 9-12% for the three largest countries.

9 Lastly, the 2018 *Scoreboard* examines 10-year performance of companies based in Asia and look in particular at the important and growing role played by FDI and cross-border M&As. M&A activity towards the EU from Asian companies has grown substantially even if it is still small compared with the M&A from other regions towards the EU. Nearly all of Asia's growth of outward M&A activity is due to Chinese firms that increased M&A activity towards EU firms by more than fivefold, approaching the level of foreign M&As of Japan. A strong R&D intensity increase for the acquiring Chinese firms suggests that they have expanded their knowledge base by the acquisition of foreign companies.

Key findings

Worldwide, companies continued to increase significantly their R&D investments in 2017/18 for the eighth consecutive year while showing good performance in most financial indicators.

The top 2500 *Scoreboard* companies invested in R&D €736.4bn in 2017/18, an increase of 8.3% with respect to the previous period[1]. Companies also raised most financial indicators: net sales reversed the negative trend shown since 2011, increasing more than the R&D investment (9.8%); overall profits showed an impressive growth of 22.6%; capital expenditures recovered after 3 negative years (5.1%) and the number of employees continued to increase at a modest pace (2.1%). See evolution of key figures over the past 10 years in Figure S1.

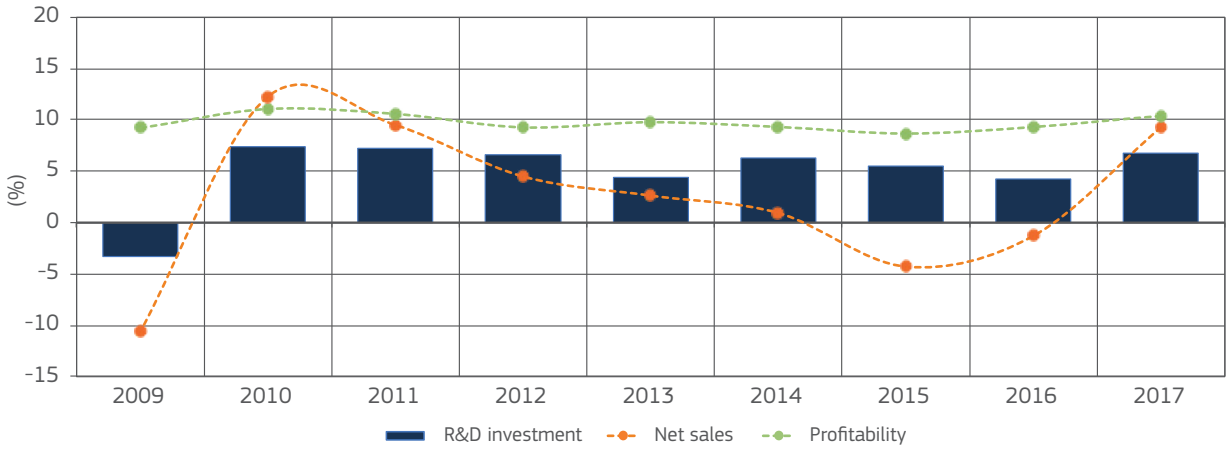


FIGURE S1: GLOBAL GROWTH RATE OF R&D AND NET SALES AND PROFITABILITY FOR THE PERIOD 2008-2017.
Note: Growth rates for the three variables have been computed on 1674 out of the 2500 companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

R&D growth worldwide led by ICT and Health industries while economic performance varied across sectors

Worldwide R&D growth was driven by the ICT services and producers sectors (13% and 11% respectively), followed by the Health sector (7.7%) while the lowest R&D performance was shown by the Industrials sector (3.3%) and by Aerospace & Defence (-4.3%).

The growth in net sales was led by oil-related companies due to the recovery of oil prices but significant increases were reported also in Automobiles, ICT industries and in the Industrials sector. The overall increase of profits was mostly due to oil-related companies but profits' growth of more than 20% were reported by ICT producers and Aerospace & Defence sectors while Health industries showed a decline in profits. The increases in Capex were observed especially in the ICT producers sector and also in oil-related companies.

[1] The apparent decrease from 2017 to 2018 is due to the appreciation of the Euro against most currencies. If the 2018 *Scoreboard* R&D is expressed at 2017 *Scoreboard* exchange rates, the total R&D for the 2500 companies is €800bn (see details in Annex 2 – Box A2.1 and Table A2.1).

R&D growth of EU companies below the world's average growth rate

The 577 companies based in the EU invested €200.1bn in R&D, an important increase in this period (5.5%) although at a lower pace than in the previous year (6.7%). The Japanese companies presented a similar R&D growth rate than their EU counterparts (5.8%) while companies based in the US and China showed a much higher R&D growth rates (9.0% and 20.0% respectively). See comparison of EU and global companies' R&D growth in Figure S2.

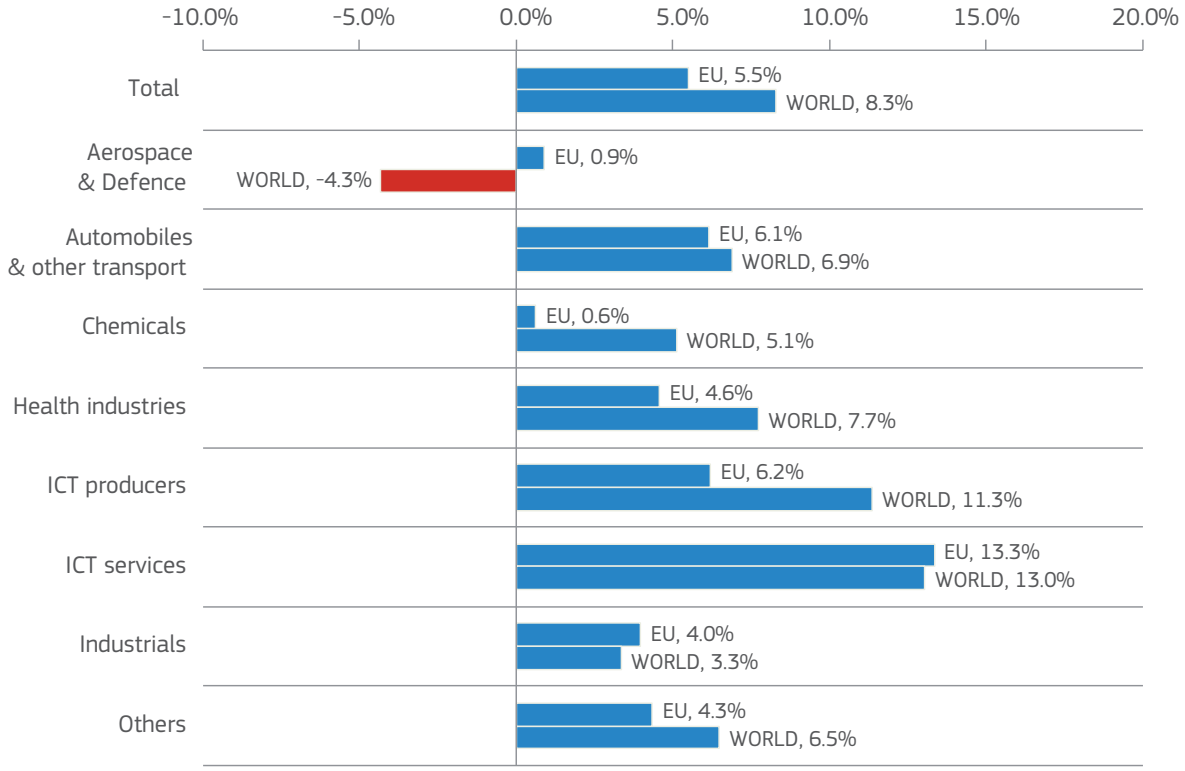


FIGURE S2: NOMINAL CHANGE OF R&D OVER THE PAST YEAR FOR THE EU AND WORLD SAMPLES OF COMPANIES.
Note: Growth rates have been computed for 566 EU and 2493 World companies for which R&D data are available for both years 2016 and 2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Other indicators of EU companies showed mixed performance

The net sales of the companies based in the EU reached €5.8trillion, 9% more than in the previous year. Net sales increases were registered in all industries. The best sales performance was shown in oil-related sectors but other industries showed also sales performance above the average, e.g. Chemicals (10.4%).

The EU companies increased modestly capital expenditures (1.7%). The best performance of EU companies was in terms of profits (37.5%), which lead to a significant increase of their profitability level (from 7.6% to 10.1%). The 577 EU companies employed 19.4million people, just 1.3% more than the year before.

Best R&D performance in the EU shown in Automobiles, Health and ICT industries

For the EU sample, the largest contribution to R&D growth was made by Automobiles (6.1%), Health industries (4.6%) and ICT services (13.3%) and the lowest contributions made by Aerospace & Defence (0.9%) and Chemicals (0.6%). Among the largest member states, German and French companies showed the highest R&D growth (6.3%

and 8.1% respectively) while companies based in the Netherlands increased R&D only by a modest 0.6%.

In the EU sample, R&D growth was led by automotive companies such as DAIMLER (15%), BMW (18%) and PEUGEOT (24%), and from other sectors GLAXOSMITHKLINE (14%), SCHNEIDER (50%) and SIEMENS (10%). The poorest R&D performance was shown by ALLERGAN (-27%) and VOLKSWAGEN (-4%). R&D growth for some of these companies was increased by acquisitions, these included Peugeot which purchased GM Europe (Vauxhall/Opel) in mid-2017 and Schneider which made 5 acquisitions in 2017.

Non-EU companies' R&D growth also led by ICT and Health industries

The largest contribution to the R&D growth of non-EU companies was made by ICT producers, ICT services, and Health industries with a negative contribution by the Aerospace & Defence sector. In the non-EU group, top R&D companies showing high R&D growth were MERCK US (49%), ALPHABET (18%), HUAWEI (17%), DELL (67%) and FACEBOOK (31%). The poorest performance was shown by BOEING (-33%), TOSHIBA (-39%) and HEWLETT PACKARD (-35%). Amongst these, acquisitions/divestments were important for Dell which acquired EMC and Hewlett Packard which sold its software division to Microfocus. Merck (US) acquired Afferent Pharma, Staywell and IOmet and Rigontec, Kalvista and Valee.

The high number of EU companies at the top of the world R&D ranking remains stable over time

In this *Scoreboard* edition, the top R&D investor is SAMSUNG (€13.44bn) from South Korea. The 2nd position is taken by the US company ALPHABET (€13.39) and the 3rd one for the German company VOLKSWAGEN (€13.14bn).

There is a high number of EU companies among the top R&D investors: 2 companies in the top 10, 18 companies in the top 50 (same number as in 2004) and 32 companies in the top 100.

Among the top 100 R&D investors, the number of EU and non-EU companies is similar for the Automobiles sector (11 vs 9) and Aerospace & Defence (2 each), however these numbers are very different in ICT industries (5 vs 29) and Health (10 vs 17).

The world top 50 companies ordered by R&D intensity are naturally almost all from the high tech industries of ICT (24) and Health (23) and are based in the EU (14), US (25), Asia (9) and Switzerland (2).

Over the past 10 years, the rapid R&D growth in Health, Automobiles and ICT industries reshaped the industrial structure

Worldwide an important sector shift occurred in ICT industries, mainly in ICT services that increased their R&D share from 10.8% to 14.2% but also in ICT producers (from 23.0% to 23.7%). On the other hand, sectors that underwent a decreases in R&D shares were mainly low-tech sectors and also, to a lesser extent, Industrials, Aerospace & Defence and Chemicals. See Figure S3.

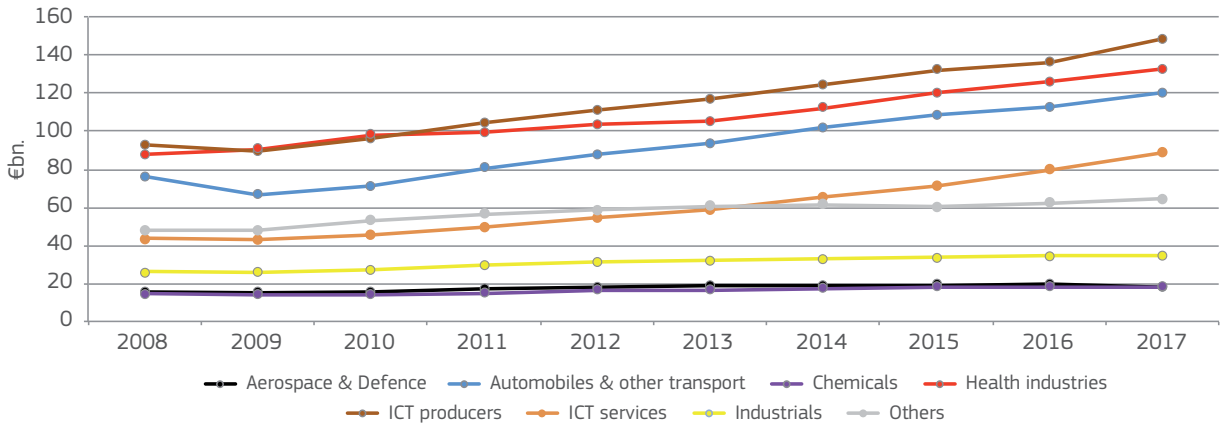


FIGURE S3: EVOLUTION OF THE GLOBAL R&D INVESTMENT FOR INDUSTRIAL SECTORS.
Note: Figures displayed refer only to the 1674 companies (398 EU; 516 US; 326 Japan; 149 China; 285 RoW) with R&D data available for the all period 2008-2017
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

EU companies reinforced their specialisation in medium-high tech sectors, increasing their R&D contribution to the global R&D of Automobiles by more than 6 percentage points. In contrast, EU companies reduced their global R&D share in ICT industries by more than 8 percentage points and to a lesser extent in low tech and Chemicals sectors. See Figure S4.

In line with the R&D shift, the net sales of EU companies increased their global weight in Automobiles, Aerospace & Defence and Health industries while decreasing it sharply in ICT industries and to a lesser extent in low tech.

Among non-EU companies, the main R&D shift was observed by US companies that strengthened their position in high tech sectors, especially in ICT services and Health. Companies based in Asia underwent contrasting changes in global R&D shares, the Chinese companies increased their global R&D shares, especially in ICT and low tech sectors, whereas those of Japanese companies fell across the bord.

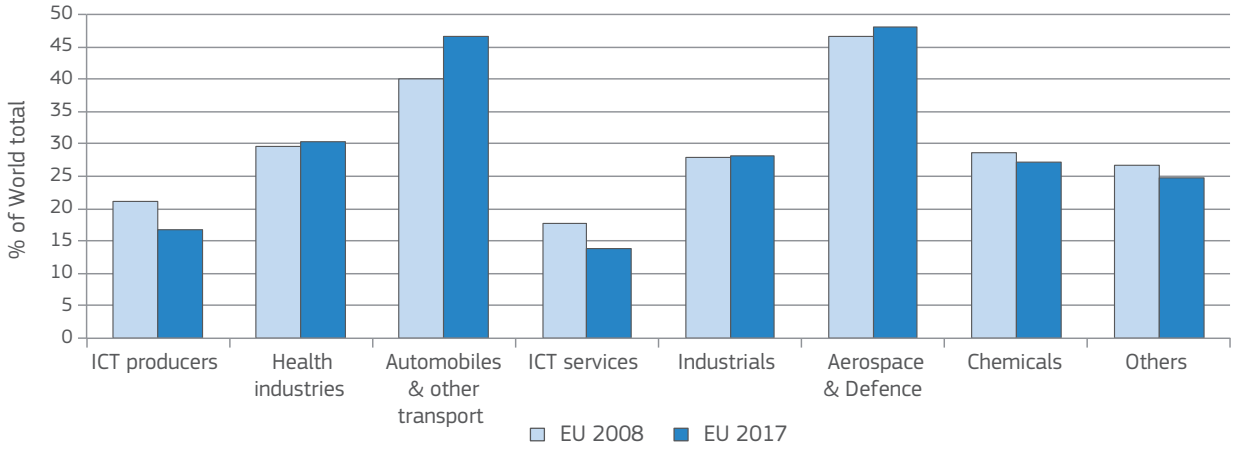


FIGURE S4: GLOBAL R&D SHARE OF EU COMPANIES FOR INDUSTRIAL SECTORS IN 2008 AND 2017.
Note: Calculated for a sample of 1674 companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

In terms of R&D intensity, EU companies are lagging as compared with the US and are being challenged by their Chinese counterparts

A comparison of the R&D intensity differences of the EU against US and Chinese companies over the past 6 years shows an increasing gap vis-à-vis the US and a positive difference against China that is decreasing over time. See Figure S5 and details in Chapter 3.

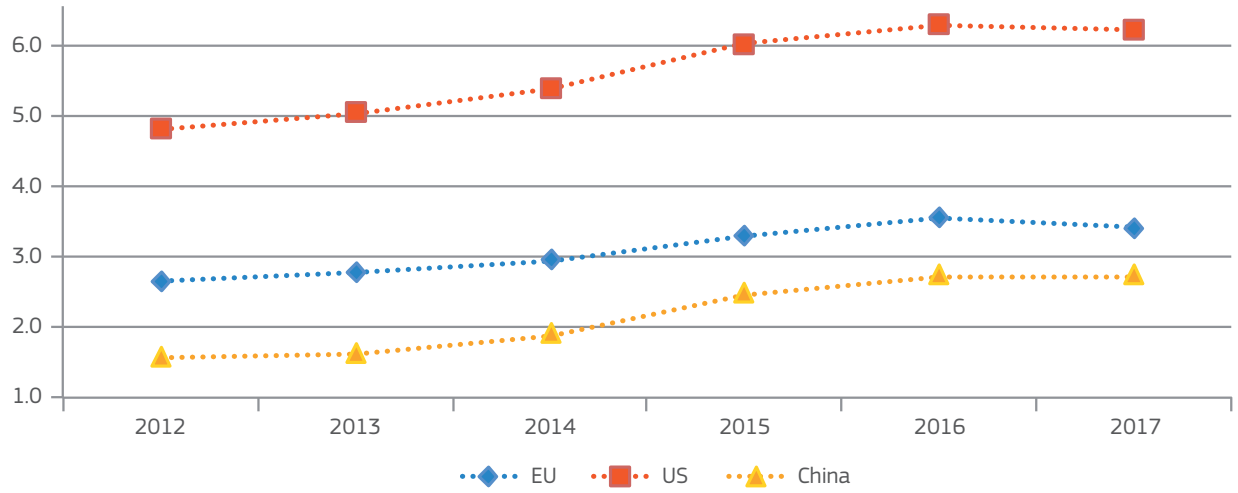


FIGURE S5: EVOLUTION OF THE AVERAGE R&D INTENSITY FOR THE EU, US AND CHINESE SAMPLE OF COMPANIES.
Note: R&D intensity have been computed for 497 EU, 623 US and 376 Chinese companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Against the US, the R&D intensity gap is explained by both structural factors (higher share of high tec sectors for US) and intrinsic factors (higher US' R&D intensities by sector). More specifically, the EU/US gap is mostly determined by increasing R&D intensity differences in ICT services, ICT producers and Health industries whereas in Automobiles the EU shows an increasing positive R&D intensity difference.

The positive R&D intensity difference with the Chinese companies, explained by both intrinsic and structural factors, is decreasing due to a faster R&D growth of Chinese companies in ICT industries than the R&D growth of the EU in Automobiles, Health and Aerospace & Defence. See the EU/US and EU/China R&D intensity differences by sector in Figure S6.

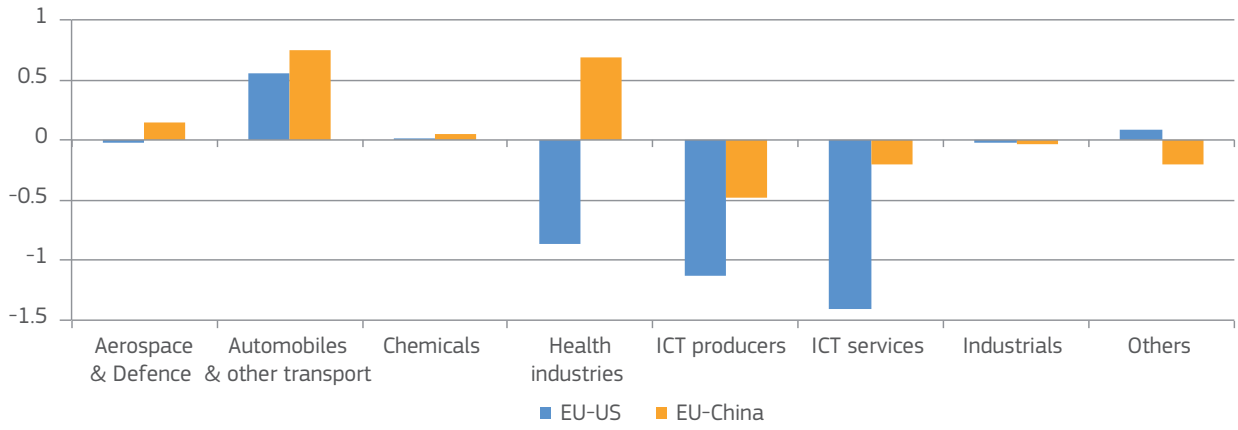


FIGURE S6: R&D INTENSITY DIFFERENCES OF THE EU AGAINST US AND CHINESE COMPANIES FOR INDUSTRIAL SECTORS IN 2017/18.
Note: R&D intensity have been computed for 497 EU, 623 US and 376 Chinese companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Mapping business patents according to inventors and owners reveals contrasting pictures of innovation performance across the EU

The analysis of the location of patents' inventors and applicants (ownership) shows that in the majority of cases, the number of patents invented in a country is much higher than the number of patents owned by local companies. These numbers are balanced in Denmark, France and Germany whereas in some countries the proportion of applicants is very high (in Cyprus, Luxemburg and Malta the number of applicants is between 4 and 10 times larger than the number of inventions). See Table S1.

The study also shows that Germany and the US compare as the most frequent second location of ownership for patents invented in EU countries (10 and 8 respectively). Moreover, business patents in some countries appear very much concentrated by a few companies, e.g. the ownership share of the top three companies is particularly high in Romania, Lithuania and The Netherlands (60%, 51% and 44% respectively). In contrast, the patent concentration by the top three companies is much lower in Italy (5%) and the UK (9%).

Inventor Country	Patents by applicant versus inventor *(% differences)*	1st applicant country *(ownership)*	2nd applicant country *(ownership)*	Share of top 3 companies
Romania	-85%	**Germany**	Romania	60%
Croatia	-69%	Croatia	UK	41%
Hungary	-63%	Hungary	**Germany**	37%
Slovakia	-49%	Slovakia	**Germany**	16%
Czechia	-40%	Czechia	**Germany**	15%
Poland	-36%	Poland	Switzerland	14%
Greece	-36%	Greece	**US**	29%
Estonia	-35%	Estonia	**Germany**	25%
Lithuania	-33%	Lithuania	**Germany**	51%
UK	-31%	UK	**US**	9%
Slovenia	-30%	Slovenia	**Germany**	20%
Bulgaria	-30%	Bulgaria	**US**	15%
Spain	-29%	Spain	**Germany**	14%
Italy	-16%	Italy	Sweden	5%
Portugal	-15%	Portugal	**Germany**	19%
Belgium	-13%	Belgium	**US**	14%
Latvia	-12%	Latvia	Finland	24%
Austria	-7%	Austria	**Germany**	10%
Denmark	-1%	Denmark	**Germany**	17%
France	1%	France	Switzerland	10%
Germany	1%	Germany	**US**	12%
Ireland	13%	Ireland	**US**	27%
Finland	14%	Finland	Switzerland	31%
Sweden	19%	Sweden	Switzerland	33%
Netherlands	23%	Netherlands	**US**	44%
Cyprus	371%	Cyprus	UK	39%
Luxembourg	484%	Luxembourg	**US**	42%
Malta	968%	Malta	Luxembourg	31%

TABLE S1: PATENTS IN THE EU'S BUSINESS SECTOR: DIFFERENCE BETWEEN APPLICANTS AND INVENTORS, AND CONCENTRATION (2013-2015).
Note: relative differences when counting patents by applicant rather than by inventor.
Source: own computation on Patstat 2011BA.

An analysis of 10-year performance of Scoreboard companies based in Asia shows the important and growing role of FDI and cross-border M&As

Expansion of Asian firms (in the form of M&A activity) towards the EU has grown by almost 150% over the period 2007 to 2016, but is still small compared to M&A activity from the US and RoW towards the EU. Asian firms perform the highest proportion of M&As within the region itself indicating the size and importance of its internal market. M&A activity outside Asia as of 2016 is mainly aimed at the EU and US, both having gained importance over the RoW during the 10 year period under analysis.

Importantly, nearly all of Asia's growth of outward M&A activity is due to Chinese firms that increased M&A activity towards EU firms by more than fivefold and approaching the level of foreign M&As of Japan by 2016. Where Chinese foreign M&A activity has grown considerably, Japanese firms show a stable development over time.

Introduction

The 2018 edition of the "EU Industrial R&D Investment Scoreboard" (the *Scoreboard*)[2] comprises the **2500 companies investing the largest sums in R&D in the world** and an additional 422 companies to provide data on the **top 1000 R&D investing companies based in the EU**[3]. In total, there are 2922 companies incorporated in the 2018 *Scoreboard.*

The *Scoreboard* is based on information taken from the companies' latest published accounts. For most companies these correspond to calendar year 2017, but significant number of companies have financial years ending on 31 March 2017 (Japanese companies in particular). There are few companies included with financial years ending as late as end June 2018 and a few for which only accounts to end 2016 were available.

In order to avoid double counting, The *Scoreboard* considers only data from parent or independent companies. Normally, these companies integrate into their consolidated accounts the data of their subsidiary companies.

It should be noted that the *Scoreboard* relies on the disclosure of R&D investment in companies' published annual reports and accounts, and that due to different national accounting and disclosure practices; companies of some countries are less likely than others to disclose R&D investment consistently. For example, it is a legal requirement in some countries that R&D investment is disclosed in company annual reports. For these reasons, companies from some countries such as Southern or Eastern European countries might be under-represented while others such as the companies from the UK could be over-represented.

The overall coverage in terms of R&D is similar to previous editions. The total amount of R&D investment of companies included in the 2018 *Scoreboard* (€736.4 billion) is equivalent to 90% of the total expenditure on R&D financed by the business sector worldwide[4].

The *Scoreboard* collects key information to enable the assessment of the R&D and economic performance of companies. The main indicators, namely R&D investment, net sales, capital expenditures, operating profits, number of employees and market capitalisation are collected following the same methodology, definitions and assumptions applied in previous editions. This ensures comparability so that the companies' economic and financial data can be analysed over a longer period of time.

The capacity of data collection is enhanced by information gathered about the ownership structure of the *Scoreboard* parent companies and the main indicators for their subsidiaries. In 2018, we have collected available indicators reported by the more than 700.000 subsidiary companies involved in this *Scoreboard* edition. This allows a better characterisation of companies, in particular regarding the sectoral and geographic distribution of their research and production activities and the related patterns of growth and employment.

As shown in last year's *Scoreboard*, the analysis of key indicators such as patent data of parent companies and their subsidiaries allows the reassignment of companies to countries where they perform their actual economic or innovation activity.

In this edition we have continued to use patent data to characterise the innovation activity of the business sector throughout the 28 member states of the EU.

[2] The EU Industrial R&D Investment Scoreboard is published annually by the European Commission (JRC-Seville/DG RTD) as part of the GLORIA project (Global Industrial Research & Innovation Analyses). GLORIA is the follow-up of the IRIMA project (Industrial Research and Innovation Monitoring and Analysis). See: http://iri.jrc.ec.europa.eu/home/.

[3] In this report, the term EU company refers to companies whose ultimate parent has its registered office in a Member State of the EU. Likewise, non-EU company applies when the ultimate parent company is located outside the EU (see also the glossary and definitions in Annex 2 as well as the handling of parent companies and subsidiaries).

[4] According to the latest figures reported by Eurostat (see Figure 1.1 in Chapter 1).

Report structure

In this edition, we follow the same structure of the 2017 EU R&D *Scoreboard* report, including an extensive description of the dataset, an overview of main changes in R&D and economic performance over the past year and emphasising long-term analyses supported by our history database.

In chapter 1 we provide an overview of the main characteristics of the industrial R&D, including the main economic factors and technological drivers that have shaped R&D investments over the past year. The dataset of this *Scoreboard* edition is described in detail and, in particular, the geographic and sector distribution of R&D and its concentration at company, industry and country levels.

Chapter 2 presents an overview of global trends for industrial R&D. It outlines the main indicators for the top 2500 companies and the main changes that took place over the past year. Companies are aggregated by industry and world region to analyse their performance in terms of R&D, net sales, profitability and employment over the past 10 years.

Chapter 3 presents an analysis of the main R&D and economic indicators of companies aggregated by industrial sector, with comparisons of EU companies and their main worldwide counterparts. This chapter also includes an analysis of the nature and evolution of the R&D intensity differences between the EU companies and their US and Chinese counterparts.

The performance of individual companies among the top R&D investors is analysed in chapter 4. The list of the top 50 and top 100 R&D companies is examined highlighting those companies showing remarkable R&D and economic results and improvement in their R&D ranking over the last 14 years. It also includes an analysis of the ranking of the top 50 large companies by R&D intensity.

Chapter 5 discusses trends in the R&D and economic performance of companies included in the extended sample comprising the top 1000 R&D investors based in the EU and focuses on the ten largest countries of the EU accounting for more than 98% of the total R&D of the sample of all 1000 companies based in the EU.

Chapter 6 presents the results of a patent-based study aimed at characterising further the innovation activity of the business sector in the EU and particularly in the member states not represented by the *Scoreboard* dataset. This shows the inventorship-ownership patterns for the EU-28 member states by examining the location of patents' applicants and inventors of the business sector.

Finally, chapter 7 examines ten year trends for top R&D companies in Asia compared to those in the EU and US, investigating, in particular, the role of FDI and related M&As in the performance of companies based in Asia.

The data have been collected by Bureau van Dijk – A Moody's Analytics Company, following the same approach and methodology applied since the first *Scoreboard* edition in 2004. For background information please see Annex 1.

The methodological approach of the *Scoreboard*, its scope and limitations are described in Annex 2, including a summary of main caveats in Box A2.1.

Annex 3 provides two complementary tables. The first one regarding main statistics for the world sample of companies aggregated by industrial sectors and the second one about the sector and country composition of the EU 1000 sample. The access to the full dataset is shown in Annex 4.

The complete data set is freely accessible online at: http://iri.jrc.ec.europa.eu/scoreboard18.html.

1

THE INDUSTRIAL **R&D LANDSCAPE**

1 The industrial R&D landscape

The top 2500 global R&D companies invested €736.4bn in R&D in 2017/18, accounting for 90% of the world's business-funded R&D. Industrial R&D is very concentrated in few companies and sectors. The top 100 R&D investing companies are responsible for half of the total R&D and the four largest R&D investing sectors account for three quarters of the global 2500 R&D.

This chapter provides an overview of global industrial R&D and the main economic factors and technological drivers that have shaped corporate R&D investments over the past year. It outlines the main characteristics of the 2018 *Scoreboard* dataset, including the distribution of companies and their R&D investments by country, world region and industrial sector.

1.1 | Economic context and technological drivers

This section summarises the main economic factors and technological trends that affected companies' R&D investment in the period 2017/18 covered by this report.

1.1.1 Economic environment for the *Scoreboard* companies in 2017/18

There were four major economic and governmental issues affecting the business environment for R&D companies in 2017/18. These were interest rates & exchange rates, growth rates of the major world economies, oil prices and the trade dispute between the US and China, which is also affecting some other countries. These four issues are discussed below. September 2018 also marked the ten year anniversary of the collapse of Lehman Brothers which was the event that triggered the financial crisis. Ten years on there is much good news to point to with banks better capitalised, asset prices recovered, solid global economic growth and low inflation in most advanced economies. However, the Bank of International Settlements reports that global debt in 2017 stood at 217% of global GDP compared to 179% in 2007 with a 56% increase in the debt of emerging market economies compared to 15% for advanced economies. But the make-up of this debt has changed with households less indebted but non-financial corporates and governments more indebted. In the latter case this is partly due to the costs of responding to the crisis. The emerging market debt rise includes a big increase in Chinese debt, an area of concern.

Interest rates and exchange rates

Interest rates are important for companies since they determine the cost of borrowing for investment. The trend in 2017/18 has been for central banks to take steps to normalise policy so that they have firepower available in the event of another financial crisis. In the US the Federal Reserve has ended its QE (Quantitative Easing) programme and moved on to quantitative tightening (selling the bonds it bought during the crisis) and, given the strength of the US economy, has been able to raise interest rates three times in 2018 (March, June, September) to reach a 2-2.25% range in September. This follows three rises in 2017. Given that US unemployment has fallen to its lowest level for 49 years. The Bank of England has ended its QE programme, raised rates twice

during 2017/18 to a level of 0.75% in August 2018 and is likely to raise them again. The ECB is ending its €2.4trn QE bond-buying programme in December 2018 having reduced it for the final three months of the year but is expected to maintain its record low interest rates until summer 2019. Even in Japan the central bank has allowed long-term interest rates to rise slightly. This means that, after 10 years, emergency monetary policy is being withdrawn – slowly in most economies but faster in the US.

One of the effects of the Fed's interest rate rises and of emerging market debt is that the dollar has appreciated (from 1€=$1.25 in February 2018 to 1€=$1.13 in late October) with corresponding falls for emerging market currencies, particularly for those countries that have debts denominated in dollars which are now more difficult to service or pay back. From January to mid-September 2018 the Argentinian peso was down 104%, Turkish lira down 70%, Brazilian real down 25%, S. African rand down 22%, Russian rouble down 18% and Indian rupee down 14%.

Growth rates of the major economies

The IMF's July and October 2018 world economic outlooks for 2018/19 highlighted mounting risks to its April 2018 outlook with growth projections revised down for the euro area and Japan. World output is now expected to grow by 3.7% in both 2018 and 2019. Advanced economies are projected to grow 2.4% and 2.1% in 2018 and 2019 respectively with US growth 2.9% /2.5% (2018/2019), the euro area 2.2%/1.9% and Japan 1.0%/ 0.9%. Emerging and developing economies are expected to average 4.7% for both 2018 and 2019 with China 6.6%/6.2% (but remember there are doubts about China's official growth statistics) and India 7.3%/7.4%. China has reduced the reserve requirements of its banks four times during 2018 to try to shore up its growth rate. In the US the combination of President Trump's tax cuts and strong economic growth led to booming second quarter 2018 profits for the corporate sector. Under the new US tax rules, US companies now have a minimum global tax rate of 13.1% rising to 16.4%. If all profits were, say, booked through Ireland at 12.5%, the company would have to pay the difference to the US IRS. The US tax changes also mean that much of the US company cash previously parked offshore to avoid US tax is now finding its way back to the US and this could be used to increase M&A activity.

Oil and commodity prices

Oil prices rose from an average of $53 in 2017 to an expected $69 average for 2018. The IMF's October outlook suggested that oil prices should be stable in 2019 averaging $69. However, given the increase in the oil price to around $85 in late September 2018 it is always possible that the $69 may prove to be optimistic and higher prices in 2019 would add to inflationary pressures. The higher price level for 2018/19 compared to 2017 suggests an increase in oil exploration activity and an improved outlook for oil service companies. Increased US shale oil production has helped to stabilise prices. In September 2018 the US became the world's largest producer of crude oil for the first time since 1973. US oil production In August 2018 rose above 11 million bpd putting the US ahead of Russia thanks to US shale. The IMF's commodity price index was up 3.3% from February to August 2018 driven by higher energy prices (energy up but food & metals prices down).

Trade tensions

The trade dispute between the US and China appears to be mainly based on a US perception of intellectual property (IP) theft and unfair trade practices by China such as government subsidies. The US has a $375bn trade deficit with China and claims IP theft of another $300bn annually. The US Trade Representative Report of 2017 estimated IP theft by China at $225bn to $600bn per year. Examples of IP theft include direct theft from US companies by both hackers and ethnic Chinese staff of trade secrets, counterfeiting of famous brands and forced technology transfer or mandatory joint ventures as a condition for doing business in China. IP theft plus higher Chinese tariffs on many products, non-tariff barriers, failure to deal with counterfeiters and government subsidies to Chinese

companies are blamed for increasing the trade deficit and costing US jobs. However, although US tariff increases have overwhelmingly been directed against China they have also, for example, included steel and aluminium tariffs against Canada, the EU and Mexico. Agreement was recently reached by the US, Canada and Mexico on a new agreement (USMCA) to replace NAFTA in 2020 and, assuming this is ratified, it should reduce tensions in North America. Any further escalation of national tariffs through 2019 could negatively affect global economic growth and is a major uncertainty facing companies.

Summary of companies' economic context

The majority of R&D in the *Scoreboard* is carried out by advanced economy companies and R&D directors in those companies are likely to have been negotiating their 2019 budgets with their CEOs in the last few months of 2018. Many CEOs have been enjoying increased profits (US Q2 corporate profits were up 16.3% on Q2 2017) and will be expecting global economic growth in 2019 although slightly less than in 2018 together with fairly low inflation in advanced economies, reasonably stable oil prices but concerns over lower home currency sales from emerging markets due to currency changes. However, there are clouds on the horizon exemplified by the falls in share and bond prices in mid-October triggered by an IMF warning of 'dangerous undercurrents' and the Fed predicting further interest rate rises. The risks include record global debt, very high debt in certain countries, escalating trade tensions (particularly US/China), rising interest rates and the risk of a no-deal Brexit. In the medium term, companies with substantial debt will also face a risk from rising interest rates as interest rate normalisation progresses, led by the US. Overall, most R&D directors should be able to negotiate higher budgets for 2019 but not by as much as most expected earlier in the year. But this carries the proviso that the predicted global growth for 2019 is not threatened much more by increased trade friction.

1.1.2 Key technological trends affecting the R&D companies in 2017/18

In 2017/18 the three main technological areas where R&D is developing new and improved products for the future are biotechnology, software /AI (artificial intelligence) and new/improved materials. Examples of new developments in these three areas include cancer immunotherapies, gene and stem cell therapies, software robots to automate back office processes, graphene and solid state batteries. Autonomous electric vehicles provide an example involving two of these areas (software/AI and new materials). Biologically compatible structures that facilitate the sustained release of hormones or enzymes provide another example involving two areas. A third example is digital health and the use of AI in drug discovery, in planning clinical trials and in diagnostics. Digital health start-ups in the US attracted nearly $6bn of investment in 2017. And radiotherapy company Elekta (Sweden) has partnered with IBM (US) to incorporate AI into its MOSAIQ oncology treatment management system.

The advent of new and rapidly developing technologies can be challenging for existing large companies with sizeable market shares in fields likely to be substantially affected by new technologies. Examples include Kodak (US) which failed to make the transition to digital photography, Nokia (Finland), the leader in mobile phones, which failed to make the transition to smartphones and Blockbuster video which was surpassed by Netflix (US). Even when a company invents a new technology as Xerox did with the mouse-driven PC, it may fail to bring it to market; in this case it was Apple and IBM/Microsoft that reaped the rewards.

New companies that challenge established ones often start as unicorns (private companies that grow rapidly from start-up to a value of over $1bn). Unicorns often succeed by developing new or greatly improved technologies. An example is Dyson which disrupted the apparently mature vacuum cleaner market with its patented bagless cyclone cleaners in attractive colourful new designs that enabled it to become market leader; its success has given it the resources to enter the electric car market. The global list of unicorns as of August 2018 gives an indication of where new innovative companies are being formed and developed and in which technological areas. Of 269 global unicorns, the US provides 125, China 76, the EU 29 (of which 15 are UK) and India 13. The majority are

in software/AI/internet with 9% in healthcare. Below we give some examples of new technologies in biotech, software/AI and new materials and others involving two of these areas and conclude with an update on autonomous electric vehicles.

Technological developments in biotech

Examples of important biotech developments include immunotherapy, gene therapy, stem cell therapy and advances in the treatment of neurological diseases.

Immunotherapy uses the body's immune system to attack, for example, cancer cells. Early success with immuno-oncology therapies has led to increasing interest with more than 2,000 therapies now in some stage of development. Some second and third generation immuno-oncology treatments are giving very encouraging results with response rates of 80-95%. An example is CAR-T therapies where T-cells are removed from the body, re-engineered to attack cancer cells and then re-introduced. Exemplar companies are Celgene (with a promising clinical trial for multiple myeloma), Gilead (*Yescarta* for non-Hodgkin lymphoma) and Novartis (*Kymriah* for lymphoblastic leukaemia – the first CAR-T therapy to be approved by the FDA).

Gene therapy is another expanding area and Car-T therapy is a form of gene therapy since T-cells are genetically modified for it and two-thirds of all gene therapy trials are for cancer. Earlier this year the FDA said that it expects to approve 40 gene therapies by 2022 and there could well be cures for diseases such as sickle cell anaemia within 10 years. Gene therapy has, for example, recently been used to cure a rare inherited retinal disease (LCA) that leads to blindness in children. Another example is Biogen's *Spinraza* for spinal muscular atrophy, a rare genetic disease that causes muscle wasting – most children with it will, if not treated, die before they are much older than one. *Spinraza* has just won the prestigious $3m annual Breakthrough Prize for Life Sciences.

Stem cell therapy. Stem cells are master cells that can transform into any type of cell in the body and therefore have huge potential to cure rather than treat disease. Early trials show stem cells' potential to cure damaged heart tissue after heart attacks, in preventing MS from progressing, in curing Crohn's disease, reviving the brains of stroke patients, repairing Achilles tendons, restoring the sight of AMD sufferers and helping patients paralysed by spinal injuries. This wide range of potential cures for serious disabilities means this area will receive increasing funding and is likely to see rapid progress over the next decade.

Neurological diseases such as Alzheimer's, MS and Parkinson's cause great suffering and there are no very effective treatments. There have, for example, been no new drugs approved for Alzheimer's in the last 15 years. However, there are now a number of promising new drugs in clinical trials for the major neurological diseases. Biogen, for example, has two drugs for Alzheimer's in Phase III clinical trials, one in Phase II and three in Phase I.

Software and Artificial Intelligence

Companies with ever more versatile software continue to provide examples of high growth R&D-led success. Software/Artificial Intelligence (AI) developments have been accelerated by the parallel development of ever more sophisticated chips by hardware companies. Cybersecurity is a particularly active area because of the way in which threats from state-sponsored hackers and malware are continually evolving and therefore requiring ever more effective countermeasures. AI is applied to cybersecurity by, for example, Darktrace (UK), a five-year old company that reached unicorn status in 2018 (having moved from start-up to a $1.65bn valuation). AI is also being applied to healthcare both in improving diagnoses and in developing breakthrough treatments by identifying patterns in the massive amounts of data and information now available on patients, drugs, treatments and human biotechnology. AI is also finding new applications in insurance, fraud detection, cognitive robotics and other areas. Accenture predicts that GDP growth rates in 2035 could be raised by 50-100% over baseline by absorbing AI into economies.

AI is central to robotics both in pure software robotics (such as Blue Prism's software robots for automating back office processes) and hardware robots ranging from robotic

vacuum cleaners to robotic warehouses (e.g. Amazon and Ocado), automated farming & construction and self-driving cars (see below). The McKinsey Global Institute (MGI) estimates that the giant tech companies spent $20bn to $30bn on AI in 2016. That means that R&D in AI with its many applications is currently large and bound to increase.

New materials

Examples of new materials include graphene, novel fuel cells, nanomaterials, higher efficiency photovoltaics, solid state batteries and, in the longer term, new higher temperature superconductors. These and other technologies will find applications such as giving enhanced range and faster charging times for electric vehicles. Most graphene applications are still in the early stages but there is potential for using the material in electronics, medicine, optoelectronics and nanostructures. Early graphene applications have been in water purification, sporting goods and supercar components. Other applications of novel materials include 3D printing, the fabrication of nanomachines, biomaterials for use in medicine, microelectronics and materials for optical quantum computing. High temperature superconductors are finding applications in fault current limiters, power cables, energy storages and the military (US electric motors for propulsion and submarine detection using quantum interference detection).

Examples of developments using two of these technologies

These include bioengineering, robotics and autonomous electric vehicles (see below). An example of bioengineering is in improved biomechanical devices which currently last only as long as their batteries. Nanotechnology is being explored in the US to develop ultra-thin, lightweight, stretchable and biocompatible membranes which can convert mechanical energy generated within the body to electrical energy so creating a self-sufficient power supply. Another example is a smart wound dressing that can deliver oxygen and blood-vessel-promoting biochemical factors while monitoring healing. This combines electronics, microfabrication, biomaterials, drug delivery, sensors and actuators. And AI nano-machines could be injected into humans to repair damage to parts of the body such as cells, muscles and bones.

Robotics combines AI/software, new materials and precision electromechanical devices and is finding more and more applications. Japan is particularly active in robotics because of its low birth-rate and ageing, declining population with an increasing demand for carers. MGI estimates that up to 800 million jobs could be displaced by automation by 2030 and these will include both blue and white collar jobs including some in finance, health and the law. It is not yet clear if new roles will be able to replace all those lost jobs.

Update on autonomous electric vehicles

Electric road vehicles. Increasing amounts of R&D are being directed at electric vehicles (EVs) and their autonomous operation. Most automotive companies are now making or trialling EVs using lithium batteries and some have active autonomous driving programmes. And there are several projects on new technology batteries. Tesla, which only makes pure electric vehicles, has found it more difficult than expected to bring its lower cost Model 3 up to its planned rate of mass production. It also leads the industry in reducing battery costs through investment in the Tesla/Panasonic first ever gigafactory (a factory able to produce many GWhrs p.a.). Production reached a level of 20GWhr in August 2018 and this is being raised to 35GWhr with the addition of further lines. Five Chinese battery companies are also building gigafactories and the two largest, Contemporary Amperex Technology (CAT) and BYD, will both have 24GWhr capacities. BYD plans to more than double its plant capacity by 2020. Both BMW and Volkswagen have ordered batteries from CAT. At least seven new battery gigafactories are planned to open in Europe by 2020. Some new entrants to the EV market such as Dyson are planning to use novel batteries but no reliable performance figures have yet been released for such batteries.

Global electric car sales for the first five months of 2018 were 598,000, up 71% on 2017. McKinsey says that global sales of electric vehicles passed one million for the first time in 2017 with two-thirds being pure electric. Global sales are expected to rise to 4.5 million in 2020 (5% of world light vehicle sales) and nearly 60 million by 2040. China is in the leadership position with larger sales than Europe and the US combined and 94% of these are produced in China. The low price of fuel and longer trip distances in the US reduce the cost advantage of EVs there, increase range anxiety and have held back US sales. The top three plug-in EV companies are Renault/Nissan/Mitsubishi, Tesla and BYD, all with over 90,000 vehicles sold in the first seven months of 2018.

Autonomous driving. Amongst the companies working on autonomous driving systems, Waymo, an Alphabet subsidiary, is the technology leader with 9 million self-driving road miles of testing so far but companies such as GM are also well advanced. Waymo's experience means it now has only one driver intervention per 5,000 miles of autonomous test driving compared to GM's 1 in 1,250miles and other car companies in the range 1 in 200miles to 80 in 100 miles. Car companies are partnering to accelerate their development of autonomous driving technology. For example, Honda has just formed a partnership with GM to develop self-driving cars for mass production and Waymo with FiatChrysler and also with JaguarLandRover. The first commercial application of autonomous vehicles is expected to be Waymo's robo-taxi service in Phoenix, Arizona to be launched around the end of 2018.

Electric aircraft. Electric propulsion is not confined to cars with Airbus/Rolls-Royce/Siemens cooperating on a project called AirbusE-FanX based on a modified 100-seat BAe146 jet. Early trials will use an electric engine replacing one of the conventional engines followed by all-electric commercial flights possibly as soon as 2025. Boeing & JetBlue are backing Zunum Aero which is building a prototype hybrid electric regional aircraft planned to test fly in 2020. Electric aircraft will require new materials and lighter, higher energy density batteries. Wright Electric and EasyJet are partnering to develop an electric jet by 2027 with a range of 335 miles. Pipistrel of Slovenia plans to test fly a 4-seat hybrid electric plane in 2019. Electric aircraft are being encouraged by Heathrow airport which is waiving landing fees for a year initially for the first regular electric service to use the airport. Hybrid electric aircraft are likely to be the first in use with battery electric power being used for take-off and landing to minimise airport noise and pollution.

1.2 | Characterisation of the R&D investment

This section outlines the main characteristics of the 2018 *Scoreboard* dataset and highlights, in particular, the industrial R&D concentration at company, industry and country levels.

The top 2500 global companies each invested more than €25 million in 2017/18, accounting together for a total of €736.4 billion.

The amount of R&D investment by these 2500 companies is equivalent to 54% of the total expenditure on R&D worldwide (GERD) and about 90% of the R&D expenditure financed by the business sector worldwide.

This is illustrated in figure 1.1 where the latest 2016 territorial statistics are compared with the corresponding figures from the previous 2017 *Scoreboard* (GERD €1381bn, of which R&D financed by the business enterprise sector "BES-R&D" was €824bn and the 2017 *Scoreboard* €742bn or 90% of global business-financed R&D).

The dataset is complemented with additional companies in order to cover the top 1000 R&D investing companies based in the EU, all of them having invested more than €8 million in R&D in 2017/18. Of these 1000, 577 appear in the world top 2,500 and another 423 are added with R&D between €8m and €25m. The total R&D for the EU1000 is €206.3bn in 2017/18.

This additional sample of 1000 companies is analysed separately in chapter 5.

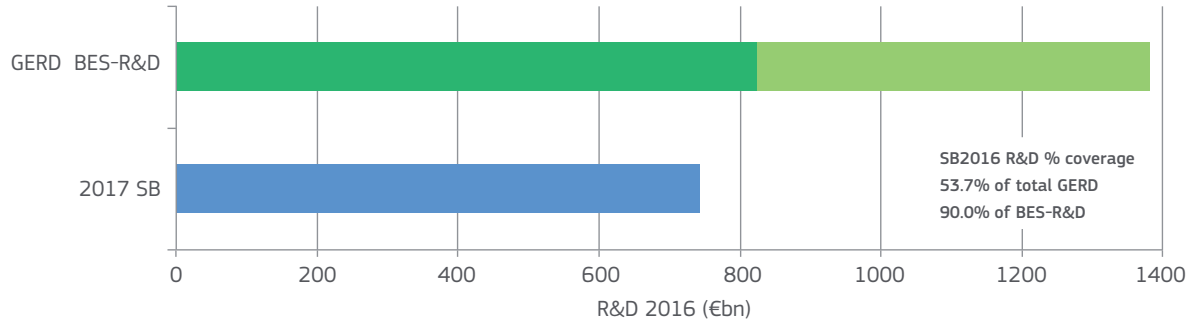


FIGURE 1.1: COMPARISON OF R&D FIGURES OF THE *SCOREBOARD* AND TERRITORIAL STATISTICS.
Note: Total R&D expenditure (GERD) and R&D financed by the business sector (BES-R&D) in 2016 (green dark overlapping bar represent the BES-R&D).
Sources: Latest figures reported by Eurostat including most countries reporting R&D. The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Companies' distribution by country

The 2018 *Scoreboard* comprises companies with headquarters in 46 countries of which 19 are member states of the EU. The sample includes companies based in the EU (577), the US (778), China (438), Japan (339), Taiwan (99), South Korea (70), Switzerland (59), Canada (28), India (31) and a further 19 countries. See Table 1.1 and Figure 1.2.

Number of companies by country			
EU		**non-EU**	
Germany	135	US	778
UK	135	China	438
France	75	Japan	339
Netherlands	40	Taiwan	99
Sweden	36	South Korea	70
Denmark	30	Switzerland	59
Italy	24	India	31
Ireland	24	Canada	28
Finland	18	Israel	21
Austria	16	Australia	14
Belgium	16	Norway	9
Spain	15	Brazil	7
Luxembourg	5	Singapore	6
Greece	2	Turkey	4
Portugal	2	New Zealand	3
Hungary	1	Russia	3
Malta	1	Saudi Arabia	2
Slovenia	1	Iraq	2
Poland	1	Further 9 countries	10
Total	577	Total	1923

TABLE 1.1: DISTRIBUTION OF COMPANIES BY COUNTRY.
Note: the 2500 companies all have R&D investment above €25 million.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

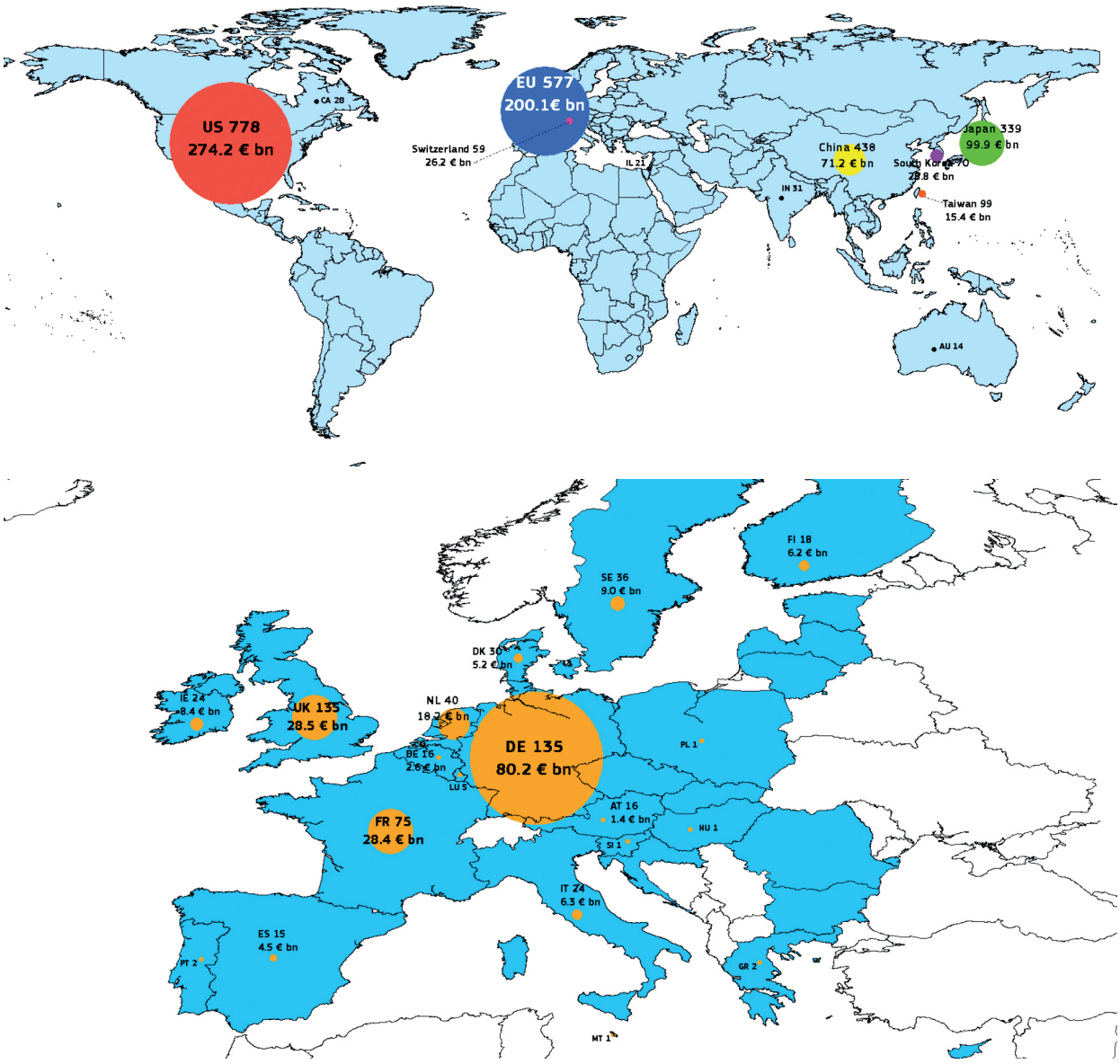


FIGURE 1.2: DISTRIBUTION OF THE 2500 COMPANIES IN THE 2018 *SCOREBOARD* BY HEADQUARTERS COUNTRY.
Note: Number of companies indicated besides the country code (the world map includes only countries with at least 10 companies). R&D is represented with a bubble whose size is proportional to R&D in 2017/18 in the country.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Companies' aggregation by industrial sector

Assigning companies to industrial sectors according to existing classification systems is not a straightforward task. In fact, sector definitions often do not fit unambiguously with actual company activities that may also change over time, and in addition, many companies operate in two or more very different industrial sectors. However companies usually indicate their main sector of activity in their annual reports, for example, public companies use a taxonomy such as the International Classification Benchmark (ICB)[5].

According to the ICB, the *Scoreboard* comprises companies operating in a wide range of manufacturing and services sectors, including more than 50 industries with a special concentration in the most innovative ones such as ICT, health, transport and the engineering related industries. In the *Scoreboard* we use different levels of sector aggregation to describe the sectoral distribution of companies' R&D. Tables 1.2 and 1.3 describe two typical levels of the industrial classification applied in the *Scoreboard*.

[5] http://www.ftse.com/products/downloads/ICBStructure-Eng.pdf

The number of companies by industry for the EU and non-EU regions is shown in Table 1.4. The top 3 companies by level of R&D investment for each type of industry are presented in Table 1.5

Industrial Sector	Sector classification ICB4 digits	N of firms	% of total R&D
Aerospace & Defence	Aerospace; Defence	51	2.6
Automobiles & other transport	Auto Parts; Automobiles; Commercial Vehicles & Trucks; Tyres	189	17.6
Chemicals	Commodity Chemicals; Specialty Chemicals	129	2.9
Health industries	Biotechnology; Health Care Providers; Medical Equipment; Pharmaceuticals	490	21.0
ICT producers	Computer Hardware; Electrical Components & Equipment; Electronic Equipment; Electronic Office Equipment; Semiconductors; Telecommunications Equipment	509	23.7
ICT services	Computer Services; Fixed Line Telecommunications; Internet; Mobile Telecommunications; Software	300	14.1
Industrials	Aluminium; Containers & Packaging; Diversified Industrials; Industrial Machinery; Iron & Steel; Nonferrous Metals; Transportation Services	293	5.4
Others*	Alternative Energy; Banks; Beverages; Construction & Materials; Electricity; Financial Services; Food & Drug Retailers; Food Producers; Forestry & Paper; Gas, Water & Multi-utilities; General Retailers; Household Goods & Home Construction; Leisure Goods; Life Insurance; Media; Mining; Nonlife Insurance; Oil & Gas Producers; Oil Equipment, Services & Distribution; Personal Goods; Real Estate Investment & Services; Support Services; Tobacco; Travel & Leisure	539	12.6
Total		2500	100

TABLE 1.2: INDUSTRIAL CLASSIFICATIONS APPLIED IN THE *SCOREBOARD* -8 INDUSTRIAL GROUPS.
* Sectors in the "Others" group are presented at ICB-3 digits level.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Sector R&D intensity*	Sector classification ICB4 digits**	N of firms	% of total R&D
high	Aerospace; Biotechnology; Computer Hardware; Computer Services; Defence; Electronic Office Equipment; Health Care Providers; Internet; Leisure Goods; Medical Equipment; Pharmaceuticals; Semiconductors; Software; Technology Hardware & Equipment; Telecommunications Equipment	1111	54.1
medium-high	Auto Parts; Automobiles; Commercial Vehicles & Trucks; Commodity Chemicals; Containers & Packaging; Diversified Industrials; Electrical Components & Equipment; Electronic Equipment; Financial Services; Household Goods & Home Construction; Industrial Machinery; Personal Goods; Specialty Chemicals; Support Services; Tires; Travel & Leisure	966	36.0
medium-low	Alternative Energy; Beverages; Fixed Line Telecommunications; Food Producers; General Retailers; Media; Oil Equipment, Services & Distribution; Tobacco	148	3.6
low	Aluminium; Banks; Construction & Materials; Electricity; Food & Drug Retailers; Forestry & Paper; Gas, Water & Multi-utilities; Iron & Steel; Life Insurance; Mining; Mobile Telecommunications; Nonferrous Metals; Nonlife Insurance; Oil & Gas Producers; Real Estate Investment & Services; Transportation Services	275	6.3
Total		2500	100

TABLE 1.3: INDUSTRIAL CLASSIFICATIONS APPLIED IN THE *SCOREBOARD* -4 SECTORS BY R&D INTENSITY.
Note: This classification takes into account the average R&D intensity of all companies aggregated by ICB 3-digits sectors: High above 5%; Medium-high between 2% and 5%; Medium-low between 1% and 2% and Low below 1%. Some sectors are adjusted to compensate the insufficient representativeness of the *Scoreboard* in those sectors using the OECD definition of technology intensity for manufacturing sectors.
* For simplification, in this report these 4 groups are also referred to as high tech, medium-high tech, medium-low tech and low tech.
** Sectors included in the "Others" group in table 1.2 are presented at ICB3 level.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Industry	EU	non-EU	Total
Aerospace & Defence	16 (31.4%)	35 (68.6%)	51
Automobiles & other transport	49 (25.9%)	140 (74.1%)	189
Chemicals	22 (17.1%)	107 (82.9%)	129
Health industries	112 (22.9%)	378 (77.1%)	490
ICT producers	64 (12.6%)	445 (87.4%)	509
ICT services	55 (18.3%)	245 (81.7%)	300
Industrials	83 (28.3%)	210 (71.7%)	293
Others	176 (32.7%)	363 (67.3%)	539
Total	577 (23.1%)	1923 (76.9%)	2500

TABLE 1.4: DISTRIBUTION OF COMPANIES BY INDUSTRIAL SECTOR AND REGION.
Note: The figures in brackets show each sector's EU & non-EU percentages of the total number of companies in each sector.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

The 577 EU companies comprise 23% of the total of 2500 global companies. The industry groups with higher percentages than this are Aerospace & Defence, Automobiles, Industrials and Others. ICT producers have a much lower percentage while Chemicals and ICT services are lower and Health is the same. The reverse is true for non-EU with ICT producers, ICT services and Chemicals, for example, having much higher percentages than the overall 77%.

Health industries		Automobiles & other transport	
ROCHE	Switzerland	VOLKSWAGEN	Germany
JOHNSON & JOHNSON	US	DAIMLER	Germany
MERCK US	US	TOYOTA MOTOR	Japan
ICT services		**ICT producers**	
ALPHABET	US	SAMSUNG	South Korea
MICROSOFT	US	HUAWEI	China
FACEBOOK	US	INTEL	US
Aerospace & Defence		**Industrials**	
AIRBUS	Netherlands	GENERAL ELECTRIC	US
BOEING	US	PHILIPS	Netherlands
UNITED TECHNOLOGIES	US	HONEYWELL	US
Chemicals		**Others**	
BASF	Germany	PANASONIC	Japan
DOWDUPONT	US	SONY	Japan
MONSANTO (acquired by Bayer in 2018)	US	LG ELECTRONICS	South Korea

TABLE 1.5: TOP 3 COMPANIES BY R&D FOR THE MAIN INDUSTRIES COMPRISED IN THE 2018 *SCOREBOARD*.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Distribution of the R&D investment by company, sector and country

Industrial R&D is highly concentrated. A small subset of companies, industries and countries account for a large share of the total R&D investment of the 2500 sample. As observed in the *Scoreboard* since 2004, this characteristic R&D concentration remains practically unchanged from year to year.

Figure 1.3 presents the distribution of the 2500 companies ranked by their level of R&D investment.

The R&D concentration (% of total R&D) for the top 10, top 50, top 100 and top 500 companies is respectively 15%, 40%, 53% and 81%.

There are 6 companies having an R&D investment of more than €10bn, 64 more than €2bn and 140 more than €1bn. The latter group of companies comprises 37 from the EU, 49 from the US, 22 Japanese, 14 Chinese, 5 each from South Korea & Switzerland and 3 from Taiwan.

The group of top 100 companies mostly operate in three sectors: 27 in Health industries (EU 10), 20 in Automobiles & other transport (EU 11) and 34 in ICT industries (EU 5).

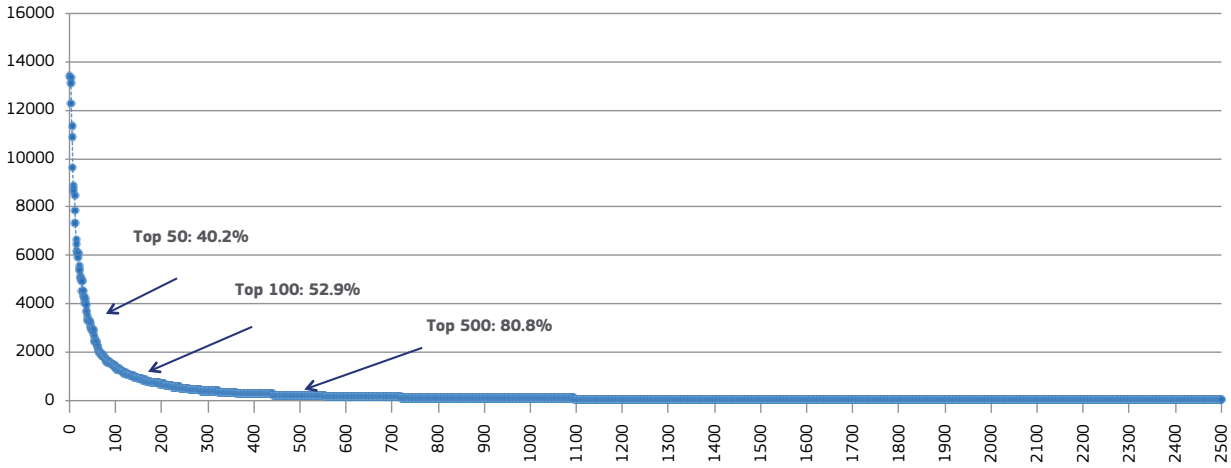


FIGURE 1.3: COMPANIES OF THE 2018 *SCOREBOARD* RANKED BY R&D.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

R&D is very much concentrated by country and world region. This is illustrated by figure 1.4 which shows the R&D shares of the main countries and regions.

The top 3, top 5 and top 10 countries account respectively for 62%, 75% and 91% of the total R&D investment. Within the EU, the R&D is even more concentrated, the top 3, top 5 and top 10 countries account respectively for 68%, 82% and 97% of the total R&D invested by the companies based in the 19 EU countries represented in the *Scoreboard*.

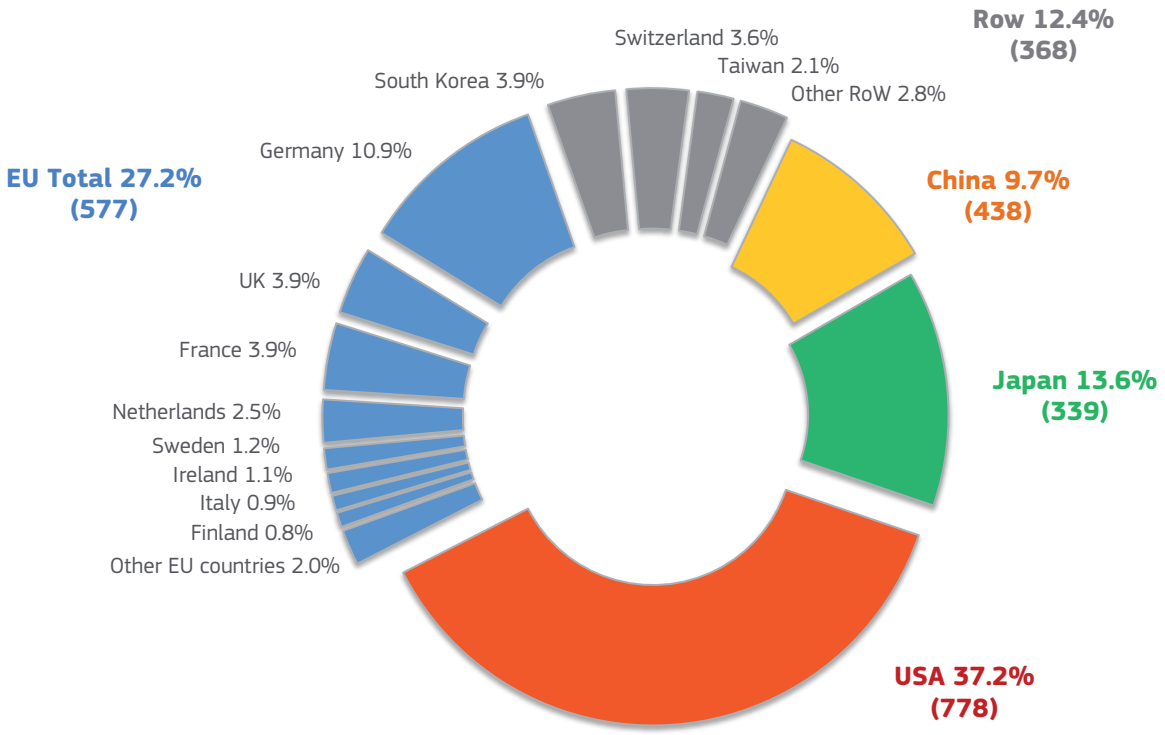


FIGURE 1.4: R&D INVESTMENT BY THE 2500 COMPANIES BY MAIN COUNTRY/REGION (% OF TOTAL €736.4bn).
Note: Number of companies indicated besides the country code (the world map includes only countries with at least 10 companies). R&D is represented with a bubble whose size is proportional to R&D in 2017/18 in the country.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

The R&D is also largely concentrated by industrial sector, as illustrated in figure 1.5 presenting the distribution of R&D by industry for the main countries/regions. The four largest R&D investing sectors (ICT producers, Health industries, Automobiles & other transport and ICT services) account for 76% of the total R&D of the 2500 companies. The main contribution to the total *Scoreboard* R&D:

- By EU companies is 47% to Automobiles & other transport, 47% to Aerospace & Defence and 29% to Health industries;
- By US companies is 68% to ICT services, 47% to health industries, 40% to ICT producers and 39% to Aerospace & Defence;
- By Japanese companies is 32% to Chemicals, 24% to Automobiles & other transport and 22% to Industrials;
- By Chinese companies is 14% to ICT producers and Industrials and 20% to other sectors.

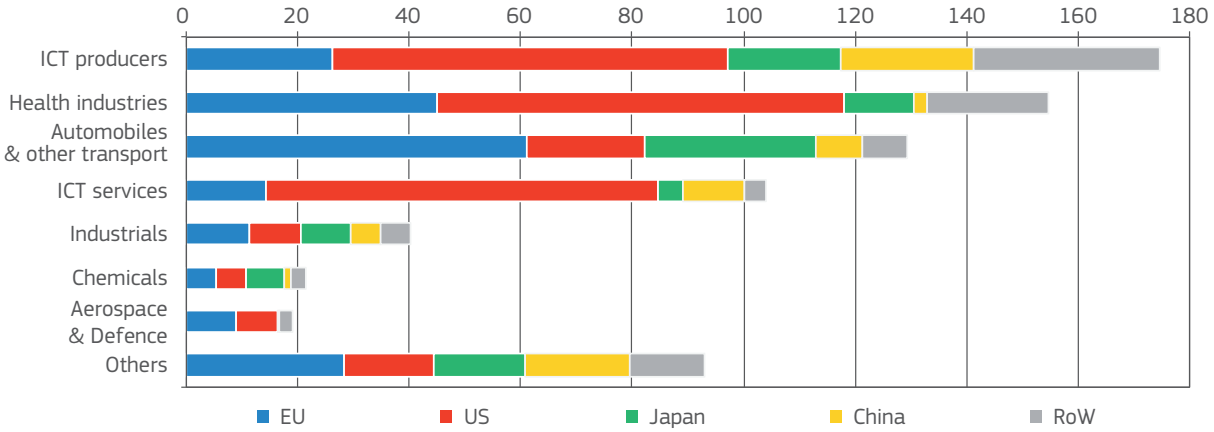


FIGURE 1.5: R&D INVESTMENT BY THE 2500 COMPANIES BY INDUSTRY AND MAIN COUNTRY/REGION (€bn).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Finally, the R&D shares of industrial sectors for each main country/region are presented in figure 1.6. This figure shows that each country/region has a characteristic R&D specialisation. The top three sectors by level of R&D investment for each region account for:

- 67% within the EU (Automobiles & other transport 31%; Health industries 22% and ICT producers 13%).
- 79% within the US (Health industries 27%; ICT producers 26% and ICT services 26%).
- 63% within Japan (Automobiles & other transport 31%; ICT producers 20% and Health industries 12%).
- 59% within China (ICT producers 33%; Automobiles & other transport 11%; and ICT services 15%).

Whereas the top five companies in the EU and the US both account for 20% of the total R&D of those regions, the top five in China account for 28% and for 24% in Japan. The top five companies in the EU contain four from the automobiles sector whereas the top five from the US have four from the ICT sector; that illustrates the different sector specialisations of the two regions. Japan is more similar to the EU with three of its top four companies from the automobiles sector.

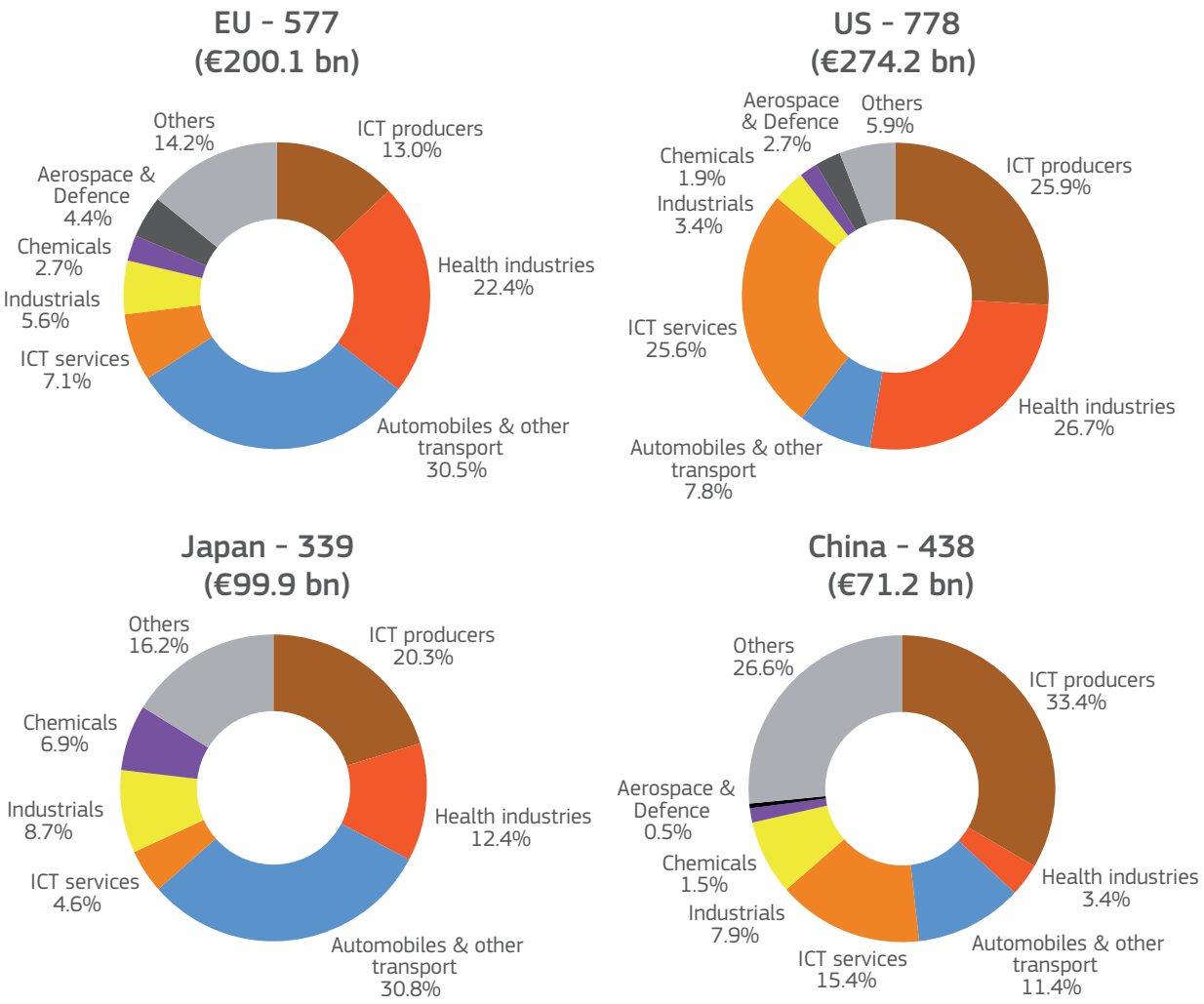


FIGURE 1.6: R&D SHARES OF INDUSTRIAL SECTORS WITHIN MAIN COUNTRIES/REGIONS
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

2

GLOBAL INDUSTRIAL **R&D TRENDS**

2 Global industrial R&D trends

2017/2018 was the eighth consecutive year of R&D investment increase. The growth of net sales reversed the negative trend shown since 2011 and was higher than that of R&D investment. The number of employees for the 2500 companies continued to increase but at a modest pace.

This chapter provides an overview of the main trends in R&D and economic indicators for the world's top 2500 companies that each invested more than €25 million in R&D in 2017/18. The first section concentrates on the evolution of companies' main performance indicators over the previous year and the second analyses the long-term performance of companies aggregated by the main world regions. The 2500 companies are grouped into five main sets: the top 577 companies from the EU, 778 companies from the US, 339 from Japan, 438 Chinese companies and 368 companies from the Rest of the World group (RoW). The RoW group includes companies from Taiwan (99), South Korea (70), Switzerland (59), Canada (28), India (31), Israel (21) and companies based in a further 18 countries.

2.1 | Changes in companies' indicators in 2017/18

In 2017/18, the 2500 companies in aggregate increased significantly their R&D investments and showed good results across most performance indicators, especially in terms of net sales that have increased more than the R&D investment for the first time since 2011. However, as observed in past *Scoreboard* editions, companies' results vary greatly across world regions and industries. Tables 2.1 and 2.2 at the end of this section present the one-year change of main indicators for the whole set of companies and also by main region and country.

R&D trends

- Overall R&D investment continued to increase significantly in 2017/18 for the eighth consecutive year. The 2500 *Scoreboard* companies invested €736.4 billion in R&D, 8.3% more than in 2016/17, following an increase of 5.9 % in the year before. *The 2017 Scoreboard reported R&D for the top 2500 companies as €741.6bn. The reason for the apparent decrease from 2017 to 2018 is exchange rates. The US$ depreciated from 1€=$1.05 at end 2016 to 1€=$1.20 at end 2017. If the 2018 Scoreboard R&D is expressed at 2017 Scoreboard exchange rates, the total R&D for the 2500 companies is €800bn.*

- The 577 companies based in the EU invested €200.1bn in R&D, an important increase in this period (+5.5%) although at a lower pace than in the previous year (+6.7%). The Japanese companies presented a similar R&D growth rate than their EU counterparts (+5.8%) while companies based in the US and China showed a much higher R&D growth rates (+9.0% and +20.0% respectively). See figure 2.1.

- Worldwide R&D growth was driven by the ICT producers sector (+11.3%), followed by the ICT services sector (+13.0%) and the Health sector (+7.7%). The lowest R&D growth was shown by the Industrials sector (+3.3%) and by Aerospace & Defence which reduced R&D by 4.3%.

- For the EU sample, the largest contribution[6] to R&D growth was made by Automobiles (+6.1%), Health industries (+4.6%) and ICT services (+13.3%) and the

[6] The company or sector contribution to the R&D growth of the sample is the nominal growth rate of the company or sector weighed by the R&D share of the company or sector.

lowest contributions made by Aerospace & Defence (+0.9%) and Chemicals (+0.6%). Among the largest member states, German and French companies showed the highest R&D growth (6.5% and 8.1% respectively) while companies based in the Netherlands increased R&D only by a modest 0.6%. In the EU sample, R&D growth was led by automotive companies such as DAIMLER (15%), BMW (18%) and PEUGEOT (24%), and from other sectors GLAXOSMITHKLINE (14%), SCHNEIDER (50%) and SIEMENS (10%). The poorest R&D performance was shown by ALLERGAN (-27%) and VOLKSWAGEN (-4%). See figure 2.2.

R&D growth for some of these companies (and for some of the non-EU ones) was increased by acquisitions, these included Peugeot which purchased GM Europe (Vauxhall/Opel) in mid-2017 and Schneider which made 5 acquisitions in 2017.

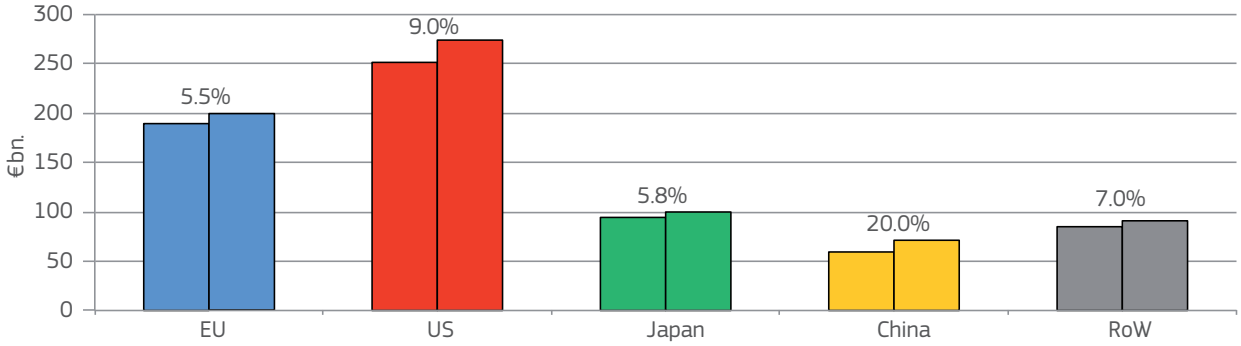


FIGURE 2.1: R&D INVESTMENT BY MAIN WORLD REGION IN THE LATEST TWO YEARS.
Note: Growth rates have been computed for 572 EU, 776 US, 339 Japanese, 438 Chinese and 366 RoW companies for which data are available for both years 2016 and 2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

- The largest contribution to the R&D growth of non-EU companies was made by ICT producers, ICT services, and Health industries with a negative contribution by the Aerospace & Defence sector. In the non-EU group, top R&D companies showing high R&D growth were MERCK US (49%), ALPHABET (18%), HUAWEI (17%), DELL (67%) and FACEBOOK (31%). The poorest performance was shown by BOEING (-33%), TOSHIBA (-39%) and HEWLETT PACKARD (-35%). Amongst these, acquisitions/divestments were important for Dell which acquired EMC for $67bn in September 2016 and Hewlett Packard which sold its huge software division to Microfocus in September 2017. Merck (US) acquired Afferent Pharma, Staywell and IOmet in mid-2016 and Rigontec, Kalvista and Valee in 2017.

Other indicators

- The growth of net sales reversed the negative trend shown since 2011 and increased more than the R&D investment in 2017/18 (9.8% vs 8.3%). ***The growth in net sales was led by oil-related companies due to the recovery of oil prices but significant increases are observed also in Automobiles, ICT industries and in the Industrials sector***. The overall profits of companies showed an impressive growth of 22.6% also due to oil-related companies. In the same line, companies' capital investments (Capex) showed a significant recovery following 3 negative years. Capex increases are observed especially in the ICT producers sector and also in oil-related companies. The number of employees for the 2500 companies continued to increase but at a modest pace (2.1%).
- The net sales of the 577 companies based in the EU reached €5.8trillion, 9% more than in the previous year. Net sales increases were registered in all industries. The best sales performance was shown in oil-related sectors but other industries showed also sales performance above the average, e.g. Chemicals (10.4%).
- The EU companies increased modestly capital expenditures (1.7%). The best performance of EU companies was in terms of profits that showed an impressive growth of 37.5%, leading to a significant increase of their profitability level (from 7.6% to 10.3%). The 577 companies employed 19.4million, just 1.3% more than the year before.

- The 778 companies based in the US increased significantly net sales (9.1%) and more modestly capital expenditures (5.4%). US companies showed a high increase on profits (11.7%), above their growth rate of sales therefore increasing their profitability (from 12.7% to 13.5%). Finally, the US companies increased employee numbers by 2.7% to 11million.

- The 339 companies based in Japan raised net sales by 8.2% and capital expenditures by 3%. They increased significantly profits (14.5%) and profitability increased to 8%. Number of employees of Japanese companies grew moderately by 2.4%.

- The 438 Chinese companies showed a robust growth in net sales (17.9%) and net profits (34.7%), reaching a profitability level of 7.9%. Chinese companies increased employees' number by 3.4%. In terms of capital expenditure, Chinese companies showed a much better performance than their counterparts (14.2%).

- Sales per employee are highest for the RoW group at €499k followed by the US (€391k), Japan (€323k), the EU (€300k) and China (€258k).

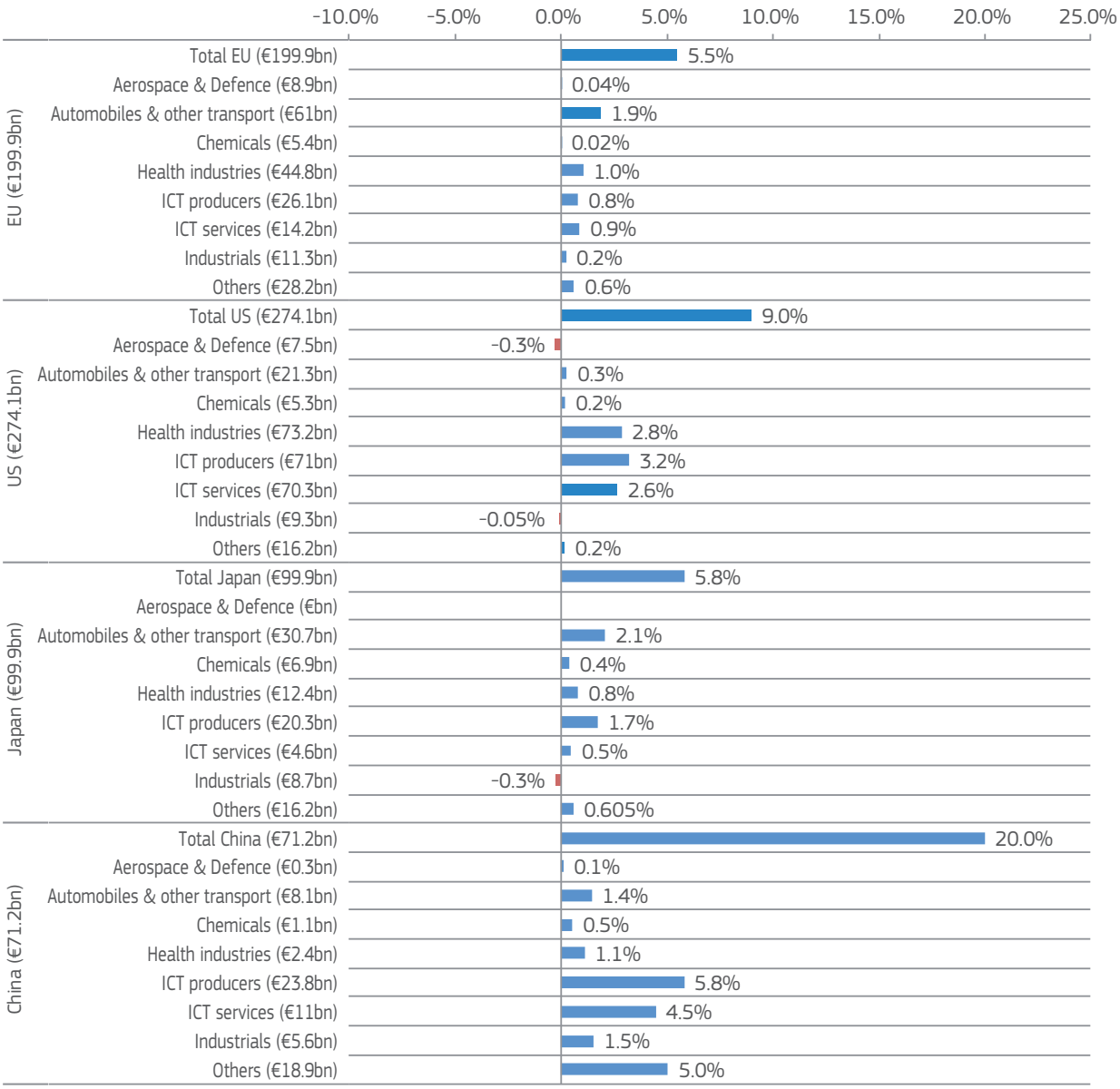


FIGURE 2.2: INDUSTRIES' NET CONTRIBUTION TO THE ONE-YEAR R&D GROWTH RATE OF MAIN REGIONS*.
* R&D growth rate of the industry weighed by its R&D (the sum of industry contributions is the Region's R&D growth).
Note: Growth rates have been computed for 572 EU, 776 US, 339 Japanese, 438 Chinese and 366 RoW companies for which R&D data are available for both years 2016 and 2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Factor	World 2500
R&D in 2016/17, € bn	736.4[7]
One-year change, %	8.3
Net Sales, € bn	18448.0
One-year change, %	9.8
R&D intensity, %	4.0
Operating profits, € bn	1909.3
One-year change , %	22.6
Profitability, %	10.5
Capex, € bn	1151.3
One-year change , %	5.1
Capex / net sales, %	6.3
Employees, million	55.0
One-year change, %	2.1
Market Cap, € bn	24538.5
One-year change, %	16.3
One-year change, %	8.3

TABLE 2.1: OVERALL PERFORMANCE OF THE 2500 COMPANIES IN THE 2018 *SCOREBOARD*.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Factor	EU	US	Japan	China	RoW
No. of companies	577	778	339	438	368
R&D in 2017/18, € bn	200.1	274.2	99.9	71.2	91.0
World R&D share, %	27.2	37.2	13.6	9.7	12.4
One year change, %	5.5	9.0	5.8	20.0	7.0
Net Sales, € bn	5822.3	4320.1	2906.0	2554.6	2845.0
One year change, %	9.0	9.1	8.2	17.9	7.6
R&D intensity, %	3.4	6.3	3.4	2.8	3.2
Operating Profit, € bn	587.8	580.7	232.3	195.3	313.2
One year change, %	37.5	11.7	14.5	34.7	19.6
Profitability (1)	10.3	13.5	8.0	7.9	11.1
Capex, € bn	339.6	254.6	178.7	168.4	210.1
One year change, %	1.7	5.4	3.0	14.2	5.4
Capex intensity, %	5.9	5.9	6.1	6.6	7.7
Employees, million	19.4	11.0	9.0	9.9	5.7
One year change, %	1.3	2.7	2.4	3.4	1.2
Sales/employee, k€	577	778	339	438	368

TABLE 2.2A: OVERALL PERFORMANCE OF THE 2500 COMPANIES IN THE 2018 *SCOREBOARD*.
Note: The RoW group comprises companies based in Taiwan, South Korea, Switzerland, India and a further 20 countries.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Factor	Germany	UK	France	Netherlands
No. of companies	135	135	75	40
R&D in 2017/18, €bn	80.2	28.5	28.4	18.2
World R&D share, %	10.9	3.9	3.9	2.5
One year change, %	6.3	6.9	8.1	0.6
Net Sales, €bn	1893.6	1105.1	1104.8	468.8
One year change, %	6.6	16.7	9.1	7.1
R&D intensity, %	4.2	2.6	2.6	3.9

TABLE 2.2B: PERFORMANCE OF COMPANIES BASED IN THE LARGEST R&D COUNTRIES OF THE EU.
Note: The RoW group comprises companies based in Taiwan, South Korea, Switzerland, India and a further 20 countries.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

[7] The apparent decrease from 2017 to 2018 is due to the appreciation of the Euro against most currencies. If the 2018 Scoreboard R&D is expressed at 2017 Scoreboard exchange rates, the total R&D for the 2500 companies is €800bn (see details in Annex 2).

Factor	South Korea	Switzerland	Taiwan	India
No. of companies	70	59	99	31
R&D in 2017/18, € bn	28.8	26.2	15.4	4.9
World R&D share, %	3.9	3.6	2.1	0.7
One year change, %	9.5	3.0	9.1	25.7
Net Sales, € bn	970.9	361.3	529.6	283.6
One year change, %	9.0	2.9	8.0	9.7
R&D intensity, %	3.0	7.3	2.9	1.7

TABLE 2.2C: PERFORMANCE OF COMPANIES BASED IN THE LARGEST COUNTRIES OF THE ROW GROUP.
Note: The RoW group comprises companies based in Taiwan, South Korea, Switzerland, India and a further 20 countries.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

2.2 | Long-term performance of companies

This section presents the evolution of the main company indicators over the past 10 years for the major world regions.

2.2.1 Long-term R&D trends

The figures below illustrate 10 years evolution of R&D and the other main indicators for companies based in the EU, US, Japan and China. Figure 2.3 shows the world R&D share of each region and Figures 2.4 to 2.7 present the annual growth rates of R&D and net sales and profitability. These figures are based on our history database comprising the R&D and economic indicators over the whole 2008-2017 period for 1674 companies (EU 398, US 516, Japan 326, China 149 and RoW 285).

Over the past 10 years, the R&D share of EU companies over the total R&D remained practically unchanged at about 27%. *This figure directly depends on the exchange rate of the Euro against main currencies. Last year the share was about 26% and the increase mostly reflects the appreciation of the Euro against de US$ over the last period (see Box A2.1 in the methodological notes).* The main change in this indicator is observed for the Japanese companies whose R&D share fell by ca. 8 percentage points. The loss of R&D share by Japanese companies corresponds to increases in R&D shares for the other countries/regions, especially for companies based in China.

Companies based in the EU have showed positive R&D trends for most of the 10-years period. From 2012 to 2016, the growth rate of EU R&D has been significantly higher than that of net sales, except for the last year where net sales have recovered strongly. In the last period, companies' capital expenditures have improved following several years of negative performance or stagnation. In terms of profitability the EU companies showed a stable behaviour (with a significant increase over the past two years).

Companies based in the US continued to show significant R&D investment growth, especially in the past two years, that showed very high R&D growth. The level of capital expenditures of US companies fell significantly over previous years but also recovered significantly in the past year. In terms of net sales, US companies continue to recover the negative figures of 2015 recording a strong growth in 2017, similar to the level of R&D growth. The US-based companies have continued to show a stable high level of profitability since 2010. The profitability of the US companies is higher than their EU counterparts and especially higher than the Japanese and Chinese ones.

Japanese companies, hit hard by the crisis in 2008-2009 and by the earthquake in 2011, showed a two years positive trend for both R&D investment and net sales. However in 2015 and 2016 the growth rates of R&D and especially that of net sales decelerated again. Finally, in the last period, Japanese companies showed a significant recovery for R&D, net sales and also capital expenditures. The profitability of Japanese companies continued the slightly upward trend observed since 2013, but remained at low levels, especially compared with that of the US companies.

The Chinese companies show a strong R&D trend over the whole 10 years period and their level of capital

expenditures that have decreased over the past two years recovered robustly in 2017. In terms of net sales, they have had high positive growth rates, except over 2015/16 where net sales significantly fell but recovering considerably over the last year. The China-based companies have decreased profitability slightly over the past years and remain lower as compared with their worldwide counterparts, especially lower than that of US companies.

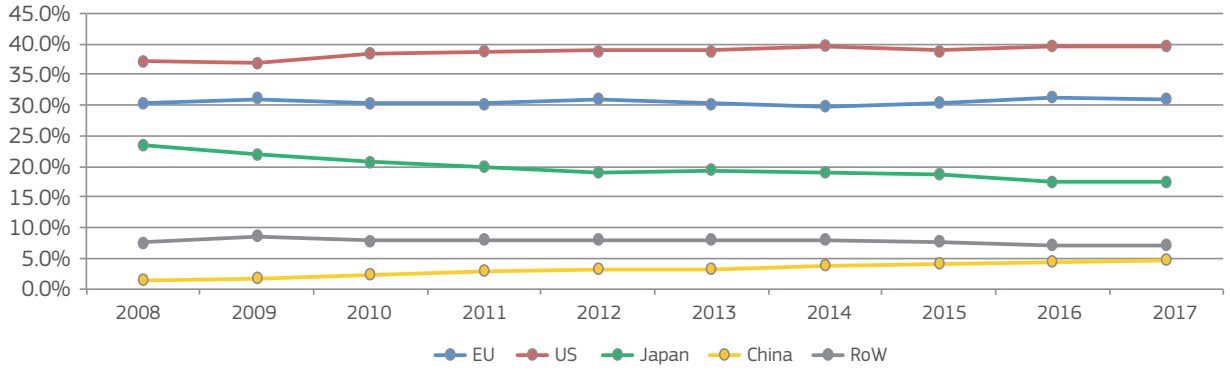


FIGURE 2.3: EVOLUTION OF R&D SHARES OF MAIN REGIONS.
Note: Figures displayed refer only to the 1674 companies (398 EU; 516 US; 326 Japan; 149 China; 285 RoW) for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

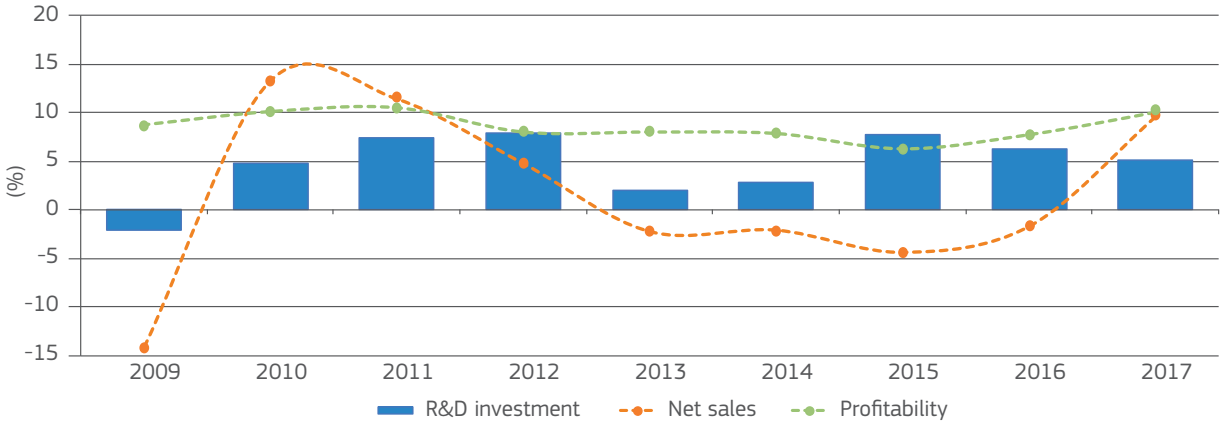


FIGURE 2.4: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY FOR THE EU COMPANIES.
Note: Growth rates for the three variables have been computed on 398 out of the 577 EU companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

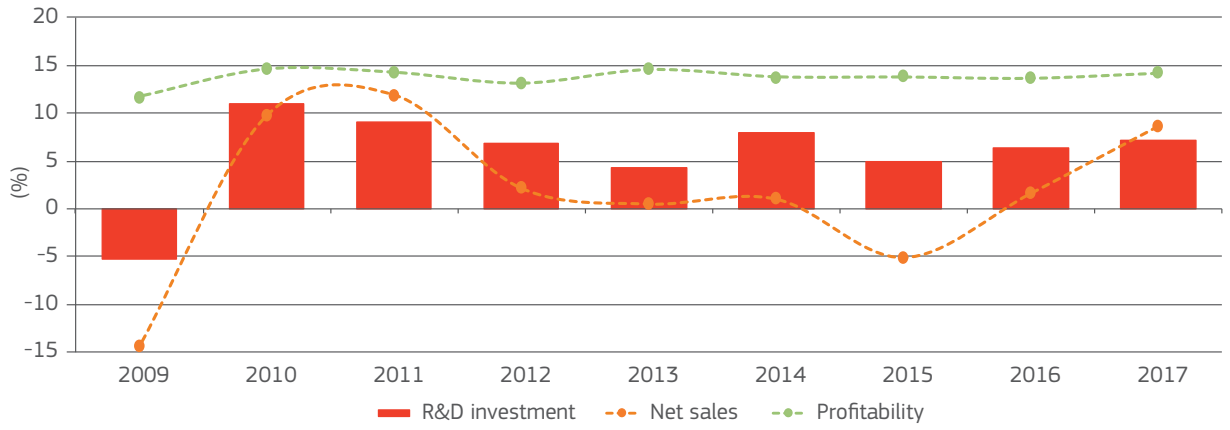


FIGURE 2.5: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY FOR THE US COMPANIES.
Note: Growth rates for the three variables have been computed on 516 out of the 778 US companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

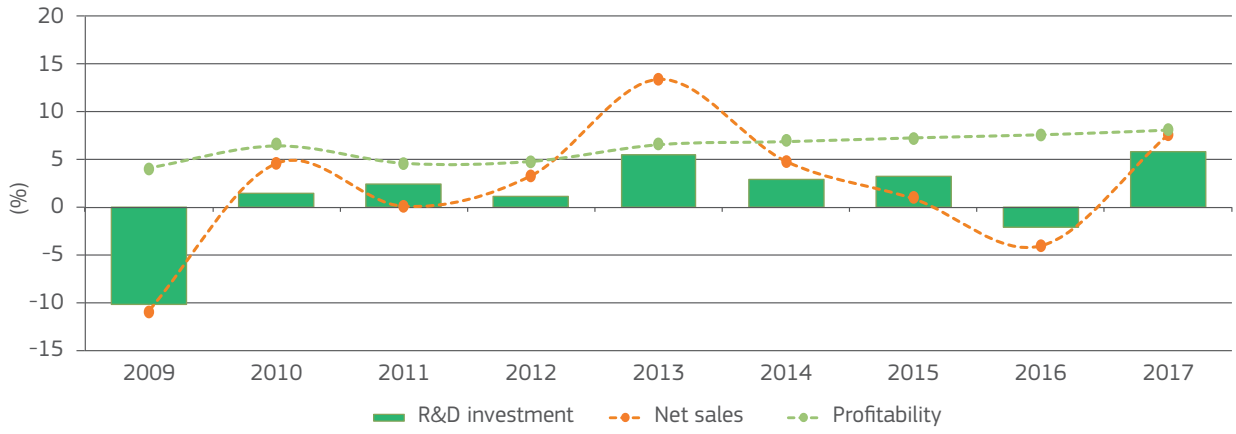


FIGURE 2.6: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY FOR THE JAPANESE COMPANIES.
Note: Growth rates for the three variables have been computed on 326 out of the 339 Japanese companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

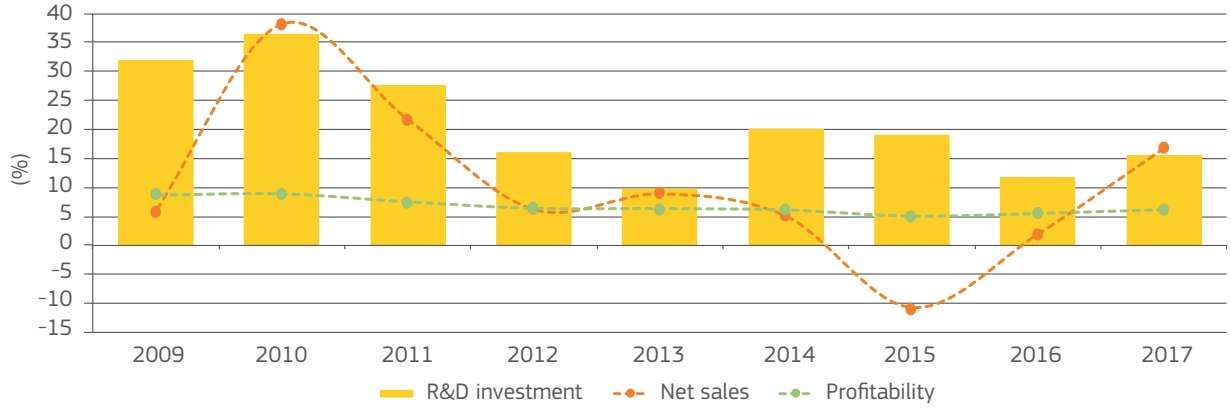


FIGURE 2.7: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY BY THE CHINESE COMPANIES.
Note: Growth rates for the three variables have been computed on 149 out of the 438 Chinese companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

2.2.2 Change in R&D, net sales and employees over 2008-2017

The changes in R&D, net sales and number of employees over the past 10 years are presented respectively in figures 2.8, 2.9 and 2.10. Companies are aggregated by main region and by groups of industrial sectors with characteristic R&D intensities[8] (see definition in Chapter 1 – Table 1.3).

These figures refer to a set of 1484 companies that reported R&D, net sales and employees over the whole period 2008-2017 (EU-407, US-473, Japan-327, China-124 and RoW group-153).

Ten-year changes in R&D

- Worldwide companies increased R&D by 48%:
  - By sector, high tech 55%, medium-high tech 45%, medium-low tech 20% and low tech 32%.
  - By region, EU 51%, US 57%, Japan 10% and China 437%.
- For EU companies, R&D increased in medium-high tech sectors (70%) and high tech (44%).
- The US companies increased significantly R&D in high tech (71%) and medium-low tech (53%) and decreased R&D in low tech sectors by 11%.

[8] For simplification, in this section these groups may be also referred to as high tech, medium-high tech, medium-low tech and low-tech.

- The Japanese companies increased R&D in medium-high tech (19%) and low tech sectors (5%) and decreased it in high tech (-2%) and medium-low tech sectors (-4%).
- For the companies based in China, all sectors showed 3-digits increases in R&D, mainly in high tech (658%) and medium-low tech (610%).

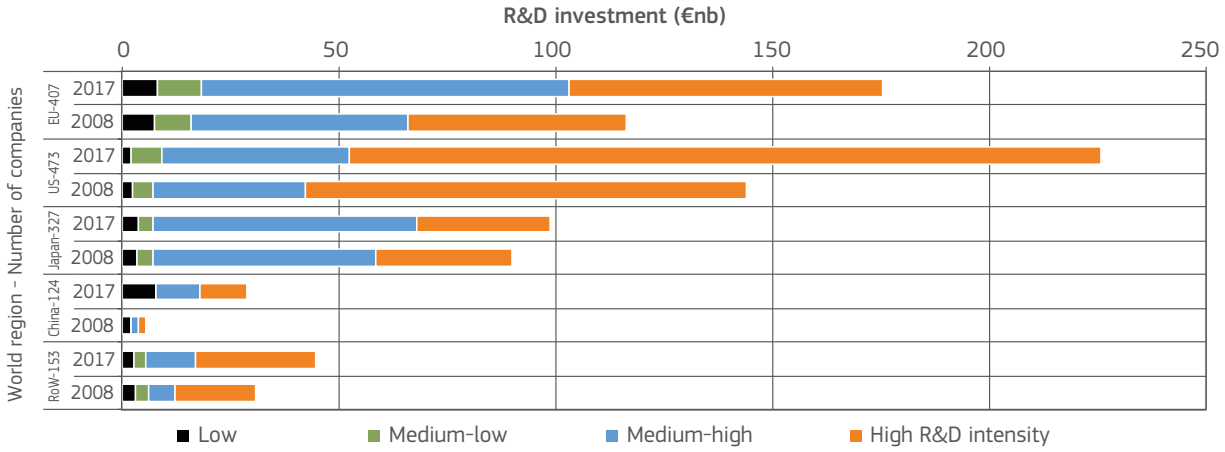


FIGURE 2.8: R&D INVESTMENT IN 2008 AND 2017 BY MAIN REGION AND SECTOR GROUPS.
Note: Figures displayed refer only to the 1484 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Ten-year changes in net sales

- Worldwide companies increased net sales by 21%:
  - By sector, high tech 55%, medium-high tech 34%, medium-low tech 13% and low tech -8%.
  - By region, EU 13%, US 12%, Japan 20% and China 131%.
- For the EU companies, net sales increased in medium-high tech (48%) and high tech (43%) and decrease in low tech (-17%).
- For the US companies, net sales increased in high tech (66%) and medium-low tech (24%) and main decreased in low tech (-56%).
- For the Japanese companies, net sales increased in medium-high tech (30%) and decreases in medium-low sectors (-2%).
- The companies based in China showed 3-digits rise in net sales for most sectors. Net sales went up in medium-high sectors (282%), medium-low sectors (222%) and high tech (191%).

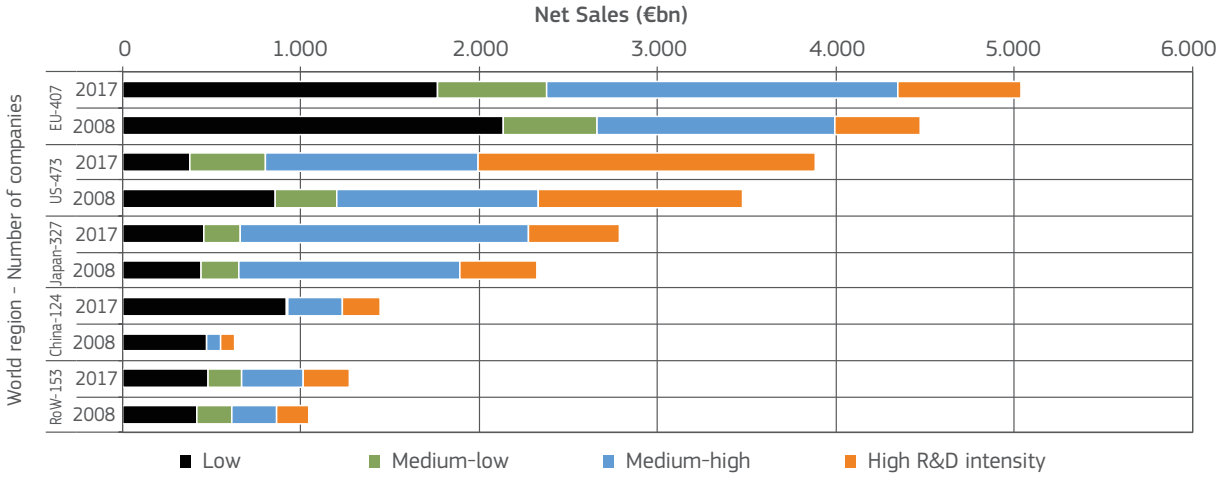


FIGURE 2.9: NET SALES IN 2008 AND 2017 BY MAIN REGION AND SECTOR GROUPS.
Note: Figures displayed refer only to the 1484 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Ten-year changes in employment

- Worldwide companies increased employment by 19%:
  - By sector, high tech 31%, medium-high tech 24%, medium-low tech -1% and low tech 8%.
  - By region, EU 11%, US 14%, Japan 20% and China 49%.

- The EU companies increased employment in high tech (29%) and medium-high tech (26%) and decreased employment in medium-low and low tech sectors (-14% and -2% respectively).

- For the US companies, employment increased in high tech (26%), medium-high tech (8%) and decreased significantly in low tech (-25%).

- For the Japanese companies, employment increased in medium-low tech (34%) and medium-high tech (22%).

- For the companies based in China, main employment increases were in medium-low tech (121%) and medium-high tech (86%).

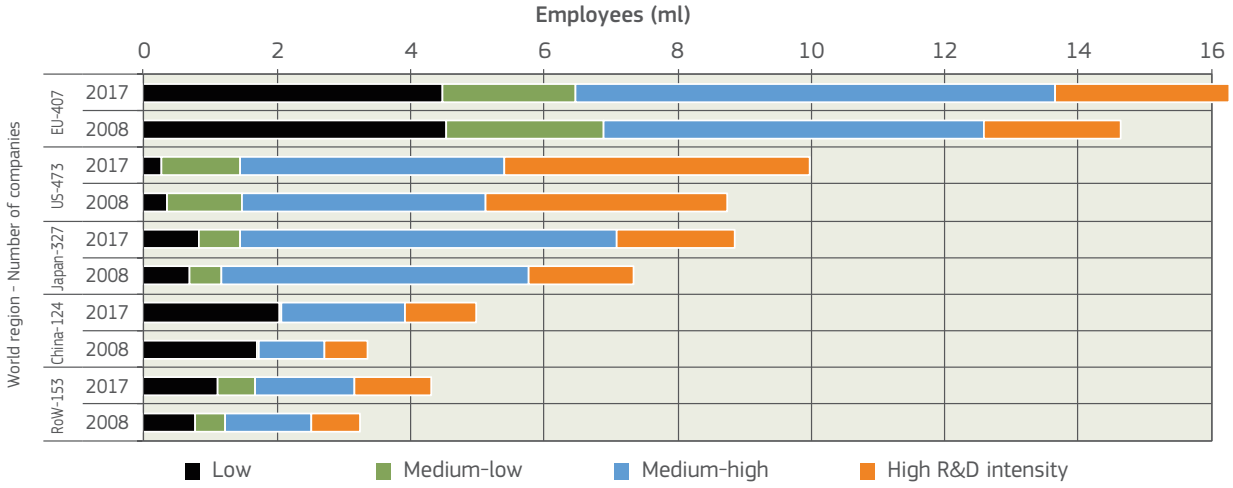


FIGURE 2.10: EMPLOYMENT IN 2008 AND 2017 BY MAIN REGION AND SECTOR GROUPS.
Note: Figures displayed refer only to the 1484 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

It is important to remember that data reported by the Scoreboard companies do not inform about the actual geographic distribution of the number of employees. A detailed geographic analysis should take into account the location of subsidiaries of the parent Scoreboard companies (see for example in the 2015 Scoreboard report, an analysis of the location of companies' economic and innovation activities).

Comparison EU/US in terms of R&D, net sales and employment

The comparison of 10-years changes in R&D, net sales and employment of the EU-407 sample with the US-473 one shows that:

- Both samples increased employees and net sales by comparable amounts EU (11% and 13% respectively) and US (14% and 12% respectively).

- In low-tech sectors, both samples dropped net sales (EU -17% vs US -56%) and employees (EU -2% vs US -25%).

- US companies increased their R&D more than the EU companies (US 57% vs EU 51%) and, according to their sector specialisations, the US's higher R&D increase was in high tech sectors (71%) while that of the EU's was in medium-high tech sectors (70%).

- In summary, the EU and US companies increased net sales and employment at a similar rate, however they show contrasting differences between high tech and medium-high tech sectors:

In high tech, the EU companies' R&D increase of 44% is accompanied by 29% increase in employees while for the US' ones their 71% increase in R&D corresponded only to 26% increase in employees. However, the US companies showed a much higher increase of the productivity ratio net sales/employee.

In medium-high tech, the EU companies' R&D increase of 70% is accompanied by a 26% increase in employees while for the US' ones their 22% increase in R&D corresponded to an 8% increase in employees. Moreover, the EU companies showed a much higher increase of the productivity ratio net sales/employee.

3

R&D TRENDS BY **INDUSTRY AND REGION**

3 R&D trends by industry and region

The rapid R&D growth in ICT, Health and Automobiles industries over the past 10 years reshaped the worldwide industrial structure with EU companies increasing their share in Automobiles and US and Chinese companies' increasing their share in ICT industries. These changes are magnified by regional differences in R&D intensity where EU companies appear lagging as compared with the US and being challenged by their Chinese counterparts.

This chapter presents the main R&D trends among the 2018 *Scoreboard* companies for the major regions and main industrial sectors. Industries are presented at various levels of aggregation according to the R&D volumes and R&D intensity of companies and depending on the issues to be illustrated.

The first section discusses the main changes that took place over the past year for the major industrial sectors and world regions. The second section examines the changes on the distribution of the R&D investment of the *Scoreboard* companies across regions and industrial sectors over the past 10 years. Finally, the third section compares the R&D intensity differences of the EU against US and Chinese companies over the past 6 years.

3.1 | Main changes in indicators in 2017/18

Figures 3.1 and 3.2 provide the nominal one-year change of R&D and net sales for the main world regions and industrial sectors aggregated into 8 industrial groups (defined in Chapter 1 – Table 1.2). More disaggregated information (at sector level, ICB 3-digits) is found in Annex A3 – Table A3.1, including main statistics for the world 2500 sample.

Worldwide, R&D growth was driven by the performance of the ICT industries, which registered a double digit R&D growth rate for both ICT services (13%) and ICT producers (11.3%) and, to a lesser extent, by Health industries (7.7%). The worst performance was shown by Aerospace & Defence (-4.3%)[9].

In terms of net sales, the high growth rate of the world sample (9.8%) was mostly driven by oil-related sectors (due to the recovery of the oil price) but also by sectors that increased sales by a double digit rate (Chemicals, ICT Producers and Industrials). The lowest sales growth was shown by Aerospace & Defence (2.4%).

The impressive growth rate of companies' profits (22.6%) was due to oil-related sectors and also to ICT producers (24%) and Aerospace & Defence (22%). There was only one sector showing a decrease in profits, Health industries (-6%). The profitability level increased for sectors showing higher growth rate of profits than net sales. The highest levels of profitability are showed by high tech sectors such as ICT services (14.6%) and the Health industries (14.2%).

For the EU sample, R&D growth was also driven by the high R&D investing industries that increased significantly their R&D, i.e. ICT services (13.3%), ICT producers (6.2%), Automobiles (6.1%) and Health industries (4.6%). However, as observed in past *Scoreboard* editions, important sectors continued to show low R&D growth, in particular Aerospace & Defence (0.9%) and Chemicals (0.6%).

Among the largest EU companies, the twelve showing the biggest increases and decreases in R&D in 2017/18 are presented in table 3.1. The R&D growth of some of these companies is partly the result of mergers and acquisitions.

[9] This is partly explained by the R&D figures of Boeing. This company, accounting for about 40% of the US' sector R&D, reported extraordinary high R&D costs in 2016 (as stated in the company's annual report, due to "*reclassification of $1,235 million of 787 flight test aircraft costs to research and development and higher reach-forward losses on the 747 and KC-46A Tanker programs*". As a result of this, Boeing's R&D figures in 2017 indicate a 33% drop with respect to 2016.

Examples are Peugeot which acquired Opel & Vauxhall from GM, Valeo's acquisition of FTE Automotive and Schneider's five acquisitions in 2017. Bayer acquired Monsanto in January 2018 so this will show up in the 2019 *Scoreboard*. Aptiv is the name given to one of the parts of Delphi Automotive when it split into two separate companies – that is the reason for its 26.5% reduction.

company	One-year R&D growth (%)	company	One-year R&D growth (%)
DAIMLER	15.0	AKZO NOBEL	-25.7
BMW	18.3	ROYAL BANK OF SCOTLAND	-20.0
PEUGEOT	23.7	TOTAL	-13.1
GLAXOSMITHKLINE	14.0	DEUTSCHE BANK	-9.3
SIEMENS	9.5	ASTRAZENECA	-4.2
LLOYDS BANKING	83.6	AIRBUS	-7.8
BAYER	8.1	BANCO SANTANDER	-14.8
SCHNEIDER	49.9	APTIV	-26.5
VALEO	26.3	PHILIPS	-13.3
SAP	9.7	BARCLAYS	-30.7
SANOFI	5.7	VOLKSWAGEN	-3.9
CONTINENTAL	9.5	ALLERGAN	-27.0

TABLE 3.1: LARGEST R&D INCREASES AND DECREASES AMONG THE EU COMPANIES IN 2017/18.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Regarding net sales, the EU sectors showing the highest increase were in Others (12%, mainly from oil-related sectors), Chemicals (10.4%) and Industrials (8.4%). The lowest growth in net sales was recorded in and Aerospace & Defence (2.3%).

Among the largest EU companies, the following showed the highest increase in net sales: ROYAL DUTCH SHELL and BP (31%), CHRISTIAN DIOR (104%), AHOLD (27%), TOTAL (17%), METRO (29%). Oil prices were responsible for the increases at three of these companies.

And those that showed the biggest net sales decrease were: CECONOMY (-36%), STANDARD LIFE (-28%), JOHNSON CONTROLS (-20%), DEUTCHE BANK (-11%), ORANO (-64%).

For the non-EU sample of companies, R&D growth was driven by the high tech industries, especially by high R&D increases in the US and China, i.e. ICT producers (US 13%, China 17%), ICT services (US 11%, China 32%), Health industries (US 11%, China 36%).

Among the largest non-EU companies, the twelve showing the biggest increases and decreases in R&D in 2017/18 are presented in table 3.2. The R&D growth of some of these companies is partly the result of mergers and acquisitions. Examples include Dell which acquired EMC for $67bn and Merck (US) with the six acquisitions mentioned earlier. Amongst the large decreases in R&D, the 35% decrease on Hewlett Packard's R&D was due to the sale of its large software division to Microfocus.

Regarding the growth of net sales by non-EU companies, the best performance were observed in Chinese companies across most of sectors and for US companies in high tech sectors, e.g. in ICT services (China 34%, US 13%) and Chemicals (China 45%, US 15%).

Among the largest non-EU companies, the following showed the highest increase in net sales: AMAZON.COM (31%) CHINA PETROLEUM & CHEMICALS (22%), PETROCHINA (25%), EXXON MOBIL (18%), SAMSUNG (19%), JXTG (47%) and CHEVRON (22%).

And those that decreased significantly net sales: PETROLEOS DE VENEZUELA (-24%), STATOIL (-23%), ALTABA (-99%), HYUNDAI HEAVY INDUSTRIES (-31%), TOSHIBA (-19%) and CHINA GREATWALL (-88%).

company	One-year R&D growth (%)	company	One-year R&D growth (%)
MERCK US	48.7	BOMBARDIER	-16.9
ALPHABET	18.4	HONEYWELL	-14.4
HUAWEI	16.6	PETROBRAS	-51.1
DELL TECHNOLOGIES	67.2	PFIZER	-4.9
FACEBOOK	31.0	REGENERON PHARMACEUTICALS	-60.0
MICROSOFT	13.0	CELGENE	-11.2
SAMSUNG	11.5	ALTABA	-57.3
APPLE	15.3	GILEAD SCIENCES	-17.7
JOHNSON & JOHNSON	16.0	GENERAL MOTORS	-9.9
SNAP	722.0	HEWLETT PACKARD	-35.3
TATA MOTORS	74.2	TOSHIBA	-39.5
BRISTOL-MYERS SQUIBB	22.9	BOEING	-33.0

TABLE 3.2: LARGEST R&D INCREASES AND DECREASES AMONG THE NON-EU COMPANIES IN 2017/18.
Note: Amazon showed a 41% increase in its 'technology & content' investment to $23bn. However, as explained in chapter 4, since Amazon does not separate the technology and content components, it is not possible to include most of this R&D in the *Scoreboard*.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

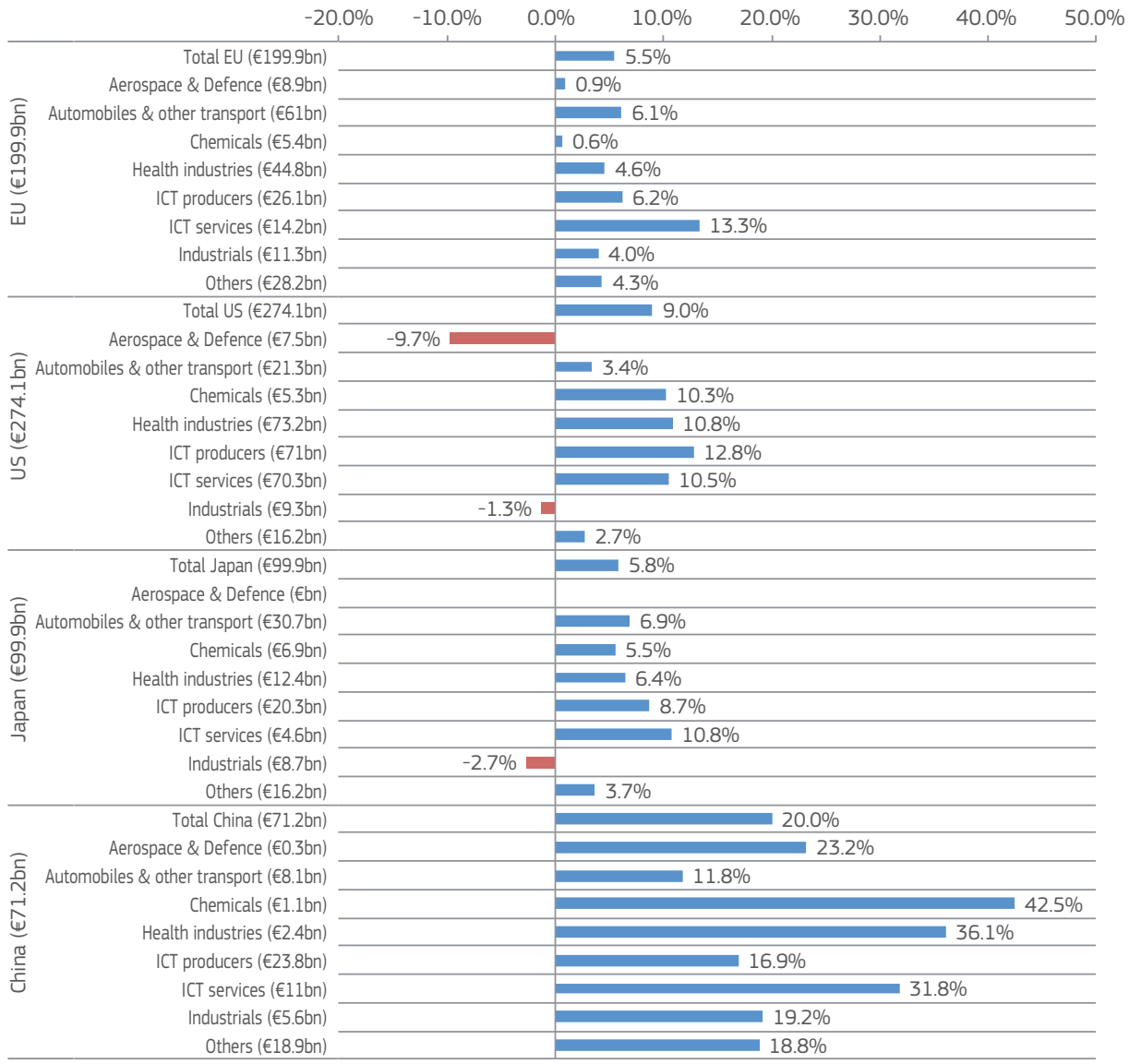


FIGURE 3.1: NOMINAL CHANGE OF R&D OVER THE PAST YEAR FOR MAIN INDUSTRIES AND REGIONS.
Note: Growth rates have been computed for 572 EU, 776 US, 339 Japanese and 438 Chinese companies for with data are available for both years 2016 and 2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

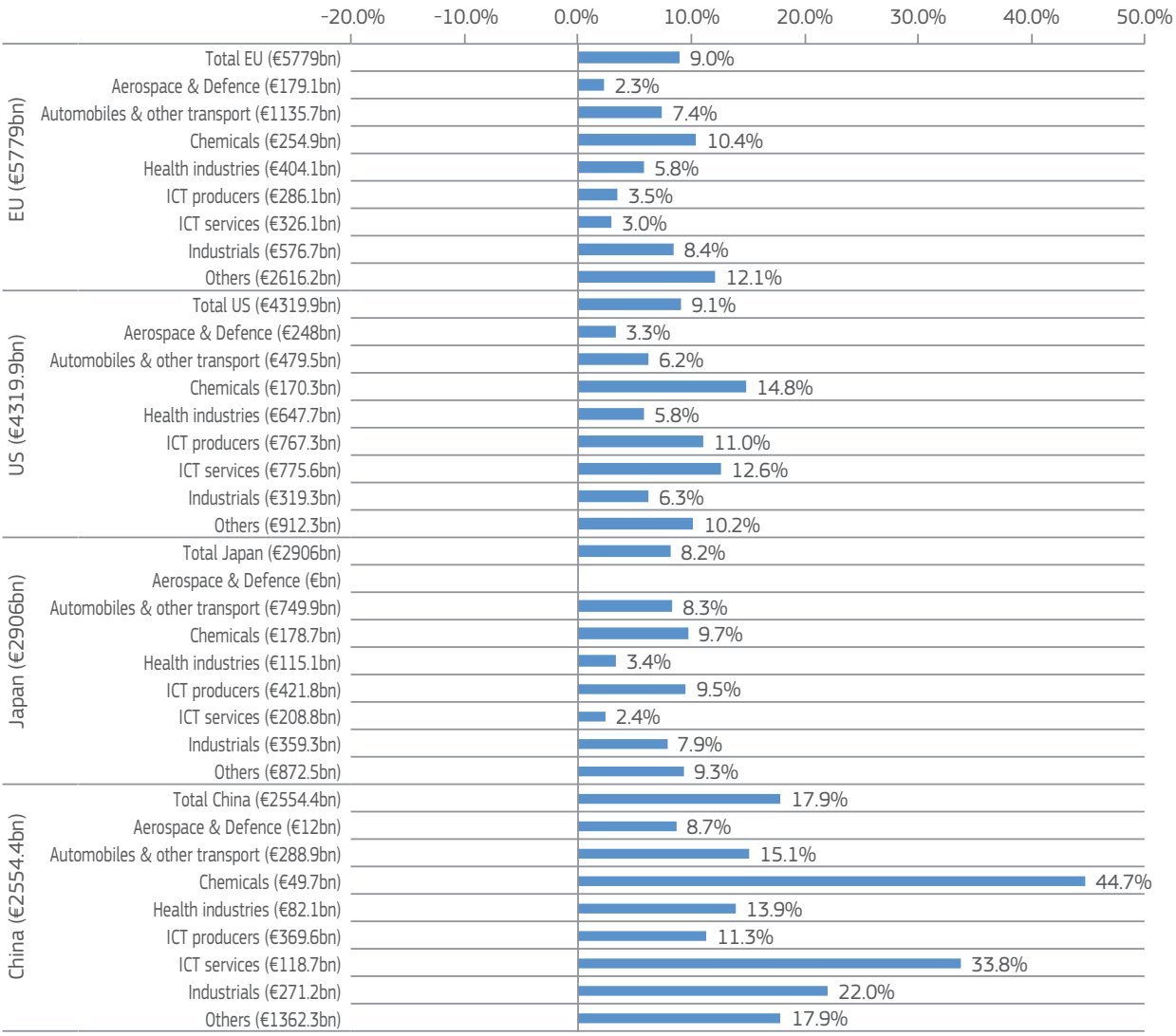


FIGURE 3.2: NOMINAL CHANGE OF NET SALES OVER THE PAST YEAR FOR MAIN INDUSTRIES AND REGIONS.
Note: Growth rates have been computed for 565 EU, 727 US, 339 Japanese and 435 Chinese companies for which Net Sales data are available for both years 2016 and 2017.
Source: The 20178 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

3.2 | Ten-year change in sector composition

This section examines the changes on the distribution of the R&D investment of the *Scoreboard* companies across regions and industrial sectors over the past 10 years. The analysis shows characteristic differences and changes in the global R&D shares, reflecting the R&D speciality of regions and structural changes over 2008-2017. The Figure 3.3 shows the evolution of the R&D shares for main industries and Figures 3.4 and 3.5 show the R&D weight of the EU and US companies in the global composition of each industry. The financial crisis was triggered by the collapse of Lehmann Bros. in September 2008 and there appears to be some evidence of the effects of this in Figure 3.3 where the automotive sector, which is sensitive to the economic environment, shows a decrease in share from 2007 to 2009 and then a recovery through to 2015.

On the whole, the main sector shift in the past 10 years is observed in ICT industries. In ICT services the R&D share increased from 10.8% to 14.2% and ICT producers from 23.0% to 23.7%. On the other hand, sectors that underwent a decreases in R&D shares were mainly low-tech sectors and also, to a lesser extent, Industrials, Aerospace & Defence and Chemicals.

EU companies reinforced their specialisation in medium-high tech sectors, increasing significantly their R&D contribution to the global R&D of Automobiles by more than 6 percentage points (from 40.1% to 46.7%). On the other side, EU companies reduced their global R&D share in ICT industries by more than 8 percentage points and to a lesser extent in low tech and Chemicals sectors.

US companies strengthened their position in high tech sectors, increasing substantially their global R&D weight in ICT services and Health (respectively by 8 and 4 percentage points). On the other extreme, US companies strongly reduced their R&D share in Automobiles and Aerospace & Defence (by 6 percentage points).

For Asian companies, contrasting changes in global R&D shares are observed for those based in China and Japan. Chinese companies increased their global R&D shares for all sectors (mostly in low tech, ICT services and Industrials) whereas Japanese companies' global R&D shares fell across the bord (mostly in ICT industries, low tech sectors and Automobiles).

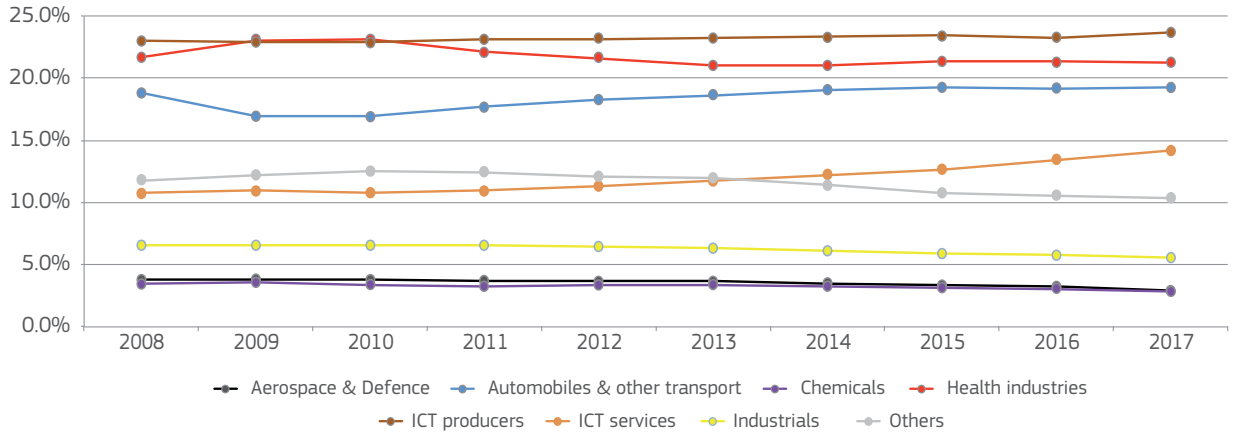


FIGURE 3.3: EVOLUTION OF THE GLOBAL R&D SHARE FOR INDUSTRIAL SECTORS.
Note: Calculated for a sample of 1674 companies for which data on R&D, Net Sales and Operating Profits are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

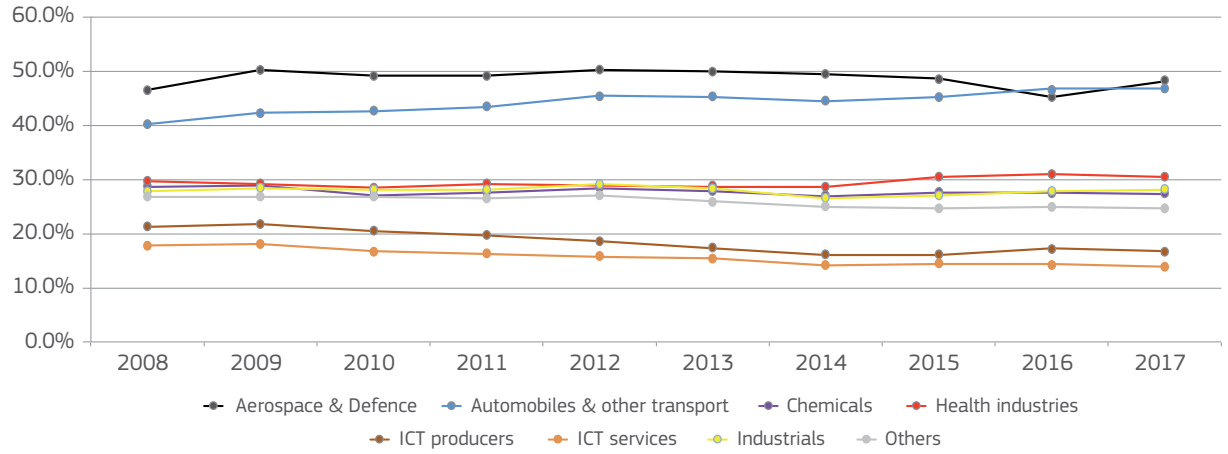


FIGURE 3.4: EVOLUTION OF THE GLOBAL R&D SHARE OF THE EU COMPANIES FOR MAIN INDUSTRIAL SECTORS.
Note: Figures displayed refer only to the 398 EU companies with R&D data available for the all period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

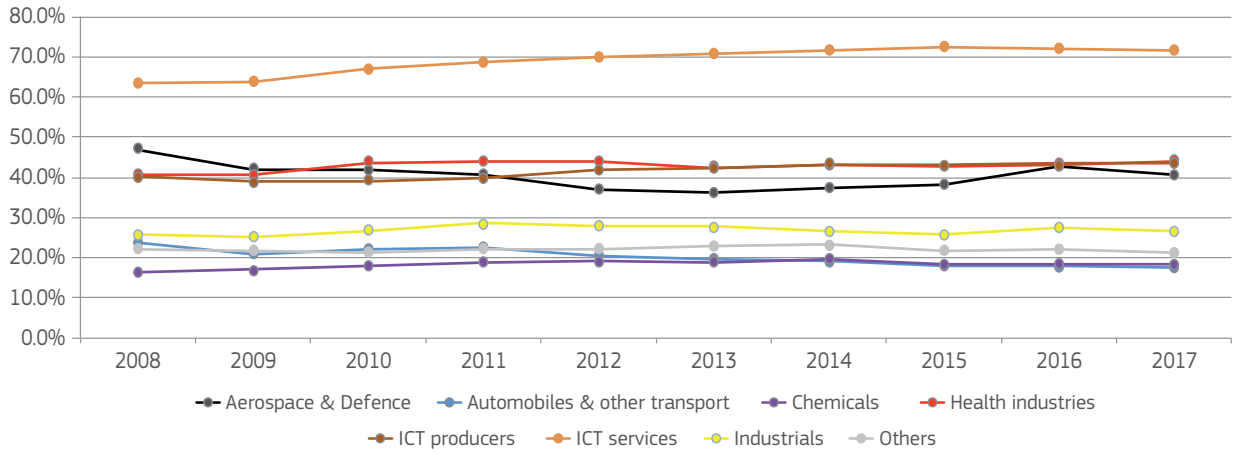


FIGURE 3.5: EVOLUTION OF THE GLOBAL R&D SHARE OF THE US COMPANIES FOR MAIN INDUSTRIAL SECTORS.
Note: Figures displayed refer only to the 516 US companies with R&D data available for the all period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

3.3 | R&D intensity differences across regions: structural vs intrinsic factors

It is interesting to analyse the difference of R&D intensity between samples of companies based in different regions or countries in terms of structural and intrinsic factors (see Box 3.1)[10]. This has been discussed in past *Scoreboard* editions (e.g. in 2012) especially focusing the EU/US case. In this section, the analysis is extended to EU/China comparisons, also taking into account the trends of such R&D intensity differences. The figures 3.6 and 3.7 show respectively the evolution of the structural and intrinsic R&D intensity differences between the EU/US and EU/China over the past 6 years[11]. Figures 3.8 and 3.9 show the R&D intensity differences broken down by main industries.

Comparison EU/US:

- As observed in previous *Scoreboards*, the sample of EU companies present a persistent and increasing R&D intensity gap vis-à-vis its US counterparts. The largest part of this gap is due to structural factors (sector composition effect) but the gap over the past 6 years has increased also in terms of intrinsic factors (R&D intensity differences sector by sector) in similar proportions to the structural gap.
- At the sector level, the EU/US gap is mostly explained by increasing R&D intensity differences in ICT services, ICT producers and Health industries whereas in Automobiles the EU shows an increasing positive R&D intensity difference.

Comparison EU/China:

- The EU companies show higher R&D intensities than their Chinese counterparts, especially with regard to intrinsic factors. However, the trend over the past 6 years indicates a reduction of this difference that is more pronounced in terms of structural factors.
- At the sector level, the EU companies show higher R&D intensities than the Chinese ones in Automobiles, Health and Aerospace & Defence; and lower R&D intensities in both ICT producers and ICT services. The trends over the past 6 years indicate a strengthening of such R&D intensity differences, especially regarding the ICT producers sector.

[10] It should be reminded that the scope of this analysis is limited to the considered sample of companies that do not necessarily represent the actual industrial structure of their respective territorial unit, i.e. due to the limited number of companies, the samples are not representative in terms of sector composition although the R&D coverage is very high thanks to the characteristic concentration of industrial R&D.

[11] Over this period, there is a sufficient number of companies with data fully available to allow a meaningful analysis.

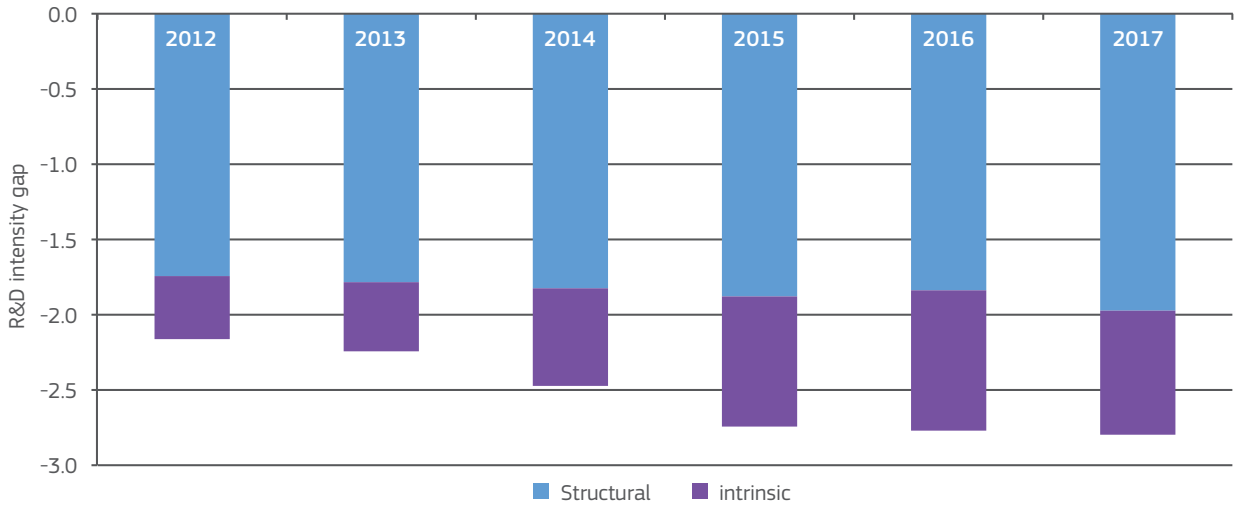


FIGURE 3.6: TREND IN THE EU-US R&D INTENSITY GAP– STRUCTURAL VS INTRINSIC COMPONENT.
Note: R&D intensity gaps have been computed for 497 EU and 623 US companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

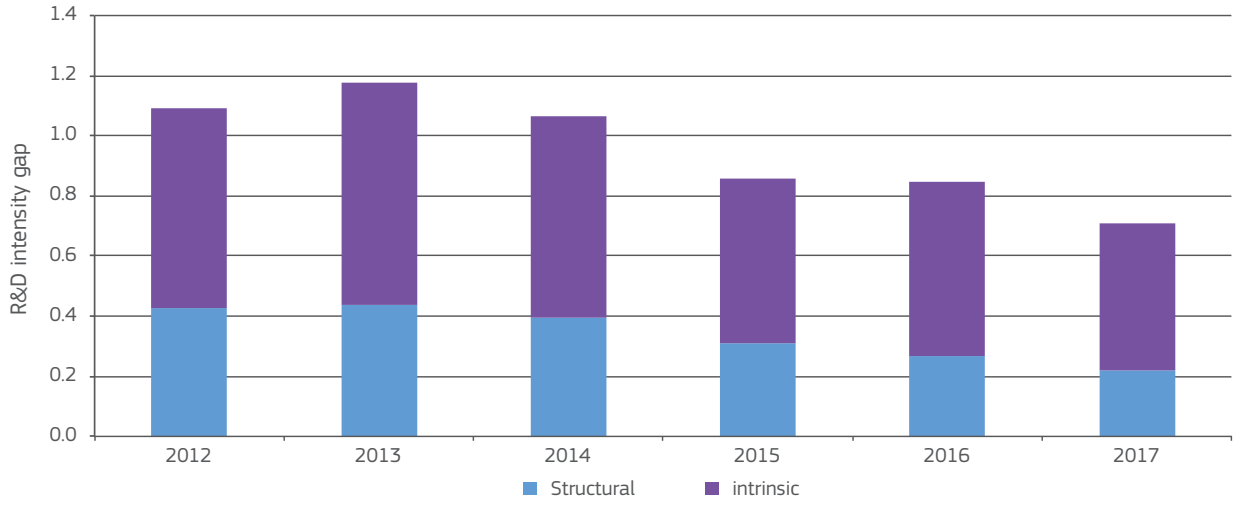


FIGURE 3.7: TREND IN THE EU-CHINA R&D INTENSITY GAP– STRUCTURAL VS INTRINSIC COMPONENT.
Note: R&D intensity gaps have been computed for 497 EU and 376 Chinese companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

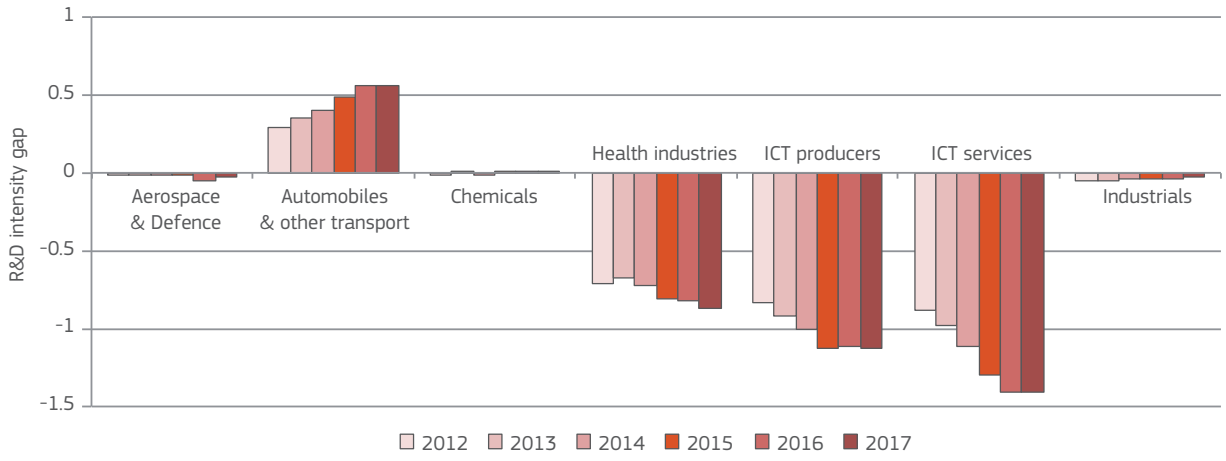


FIGURE 3.8: EU-US R&D INTENSITY GAP – SECTORAL TRENDS.
Note: R&D intensity gaps have been computed for 497 EU and 623 US companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

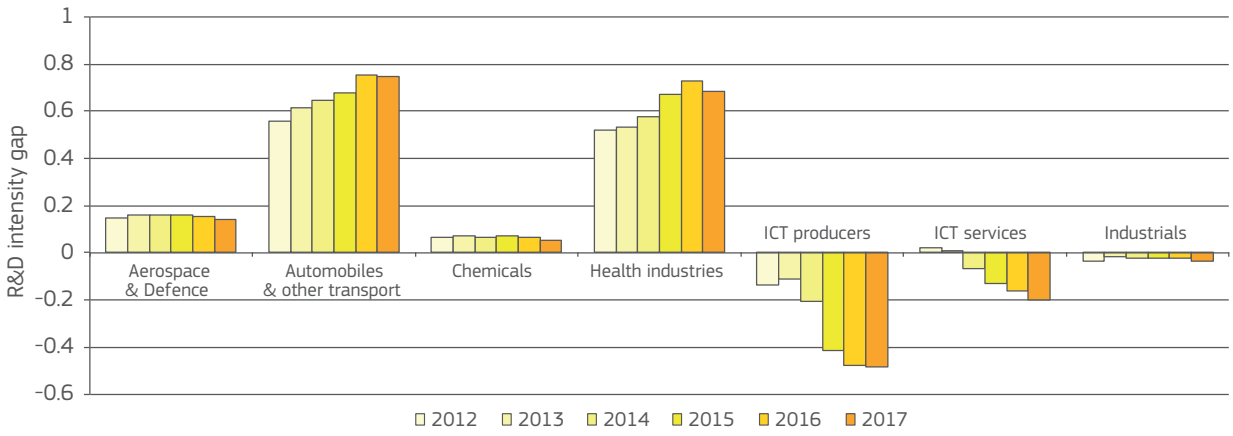


FIGURE 3.9: EU-CHINA R&D INTENSITY GAP – SECTORAL TRENDS.
Note: R&D intensity gaps have been computed for 497 EU and 376 Chinese companies for which R&D and Net Sales data are available for the entire period 2012-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

Box 3.1

R&D intensity difference between two regions in terms of structural and intrinsic factors

The difference in R&D intensity between world regions or countries can be expressed in two terms: one representing the sectoral composition effect (i.e. due to structural differences) and the other representing underinvestment in R&D (i.e. due to intrinsic differences in R&D intensities, sector by sector). The following formula can be applied:

$$RDI_X - RDI_Y = \sum_i RDI_{Y,i}(P_{X,i} - P_{Y,i}) + \sum_i P_{X,i}(RDI_{X,i} - RDI_{Y,i})$$

where:

- *X* and *Y* refer to the world regions/countries for which the comparison is performed;

- *RDI* = R&D intensity

- *P* is the share of sector *i* (in terms of production/turnover) within the given world region/country (*X* or *Y*)

The first term on the right side of the formula is the sectoral composition effect, taking into account the different shares of the various sectors within the compared world regions/countries. If this term is negative, it means that the share of the R&D-intensive sectors within the total economy of region/country *Y* is larger than that in region/country *X*.

The second term on the right side of the formula is the 'R&D underinvestment effect', accounting for the differences in R&D intensity sector by sector. If this term is negative, it means that the R&D intensities of sectors with high share within the total economy of region/country *X* are lower than those in region/country *Y*.

4

PERFORMANCE OF TOP **GLOBAL R&D INVESTORS**

4 Performance of top global R&D investors

SAMSUNG is the top R&D investor worldwide, followed by ALPHABET and VOLKSWAGEN. The other companies in the top-ten are MICROSOFT, HUAWEI, INTEL, APPLE, ROCHE JOHNSON & JOHNSON and DAIMLER. Within the top 50 R&D investors there are 18 based in the EU, 22 US companies, 6 from Japan, 2 from Switzerland and one each from South Korea and China.

This chapter describes the performance of individual companies, with a focus on the results of companies at the top of the world R&D ranking, highlighting those companies that show considerable changes in economic and R&D performance. *Due to data availability, R&D figures for some companies may be under- or over-stated. The most extreme example of this is Amazon which would be positioned at #3 or #4 in the world R&D ranking if it had separated its R&D and content investments in its annual report (see explanations in Box 4.1).*

4.1 | Main changes in 2017/18

In this section, the world's top 100 R&D companies are analysed, underlining those presenting important performance changes over the last reporting period.

In this *Scoreboard* edition, the top R&D investor is the company SAMSUNG (€13.44bn) from South Korea. The 2nd position is taken by the US company ALPHABET (€13.39) and the 3rd one for the German company VOLKSWAGEN (€13.14bn). The other companies in the top-ten are MICROSOFT, INTEL, APPLE, and JOHNSON & JOHNSON from the US, HUAWEI from China, ROCHE from Switzerland and DAIMLER from Germany.

The top 100 companies, accounting for 53% of the total R&D by the 2500 companies, showed growth of R&D (7.9%) somewhat below the world average (8.3%) and also lower growth of net sales (8.0% vs 9.7%).

Seventy-six companies in the top 100 have shown positive R&D investment growth. Among them, 40 companies had double-digit R&D growth, and of these, 23 companies also showed double-digit growth in net sales.

Most of the top 100 companies showing double-digit R&D increases are in the ICT producers (13), Health industries (9) and ICT services (7). The 5 companies showing the largest increase in R&D are TATA MOTORS (74.2%), DELL TECHNOLOGIES (67.2%), HON HAI PRECISION INDUSTRY (59.9%), ABBOTT LABORATORIES (52.3%) and WESTERN DIGITAL (50%). Several of these large increases are due to acquisitions. Examples are DELL which acquired EMC for $67bn, ABBOTT laboratories which acquired St. Jude Medical for $25bn in January 2017, HON HAI which acquired Sharp of Japan in mid-2016 and WESTERN DIGITAL which acquired SanDisk for $19bn in mid-2016.

As mentioned above, 17 companies had double-digit growth in R&D and net sales, the top 5 companies among them are DELL, ABBOTT, WESTERN DIGITAL, TENCENT and ALIBABA.

Twenty-four companies in the top 100 have experienced a decrease in R&D investment. The companies with the largest decrease in R&D are HONEYWELL (-14%); BANCO SANTANDER (-15%); GILEAD SCIENCES (-18 %); ALLERGAN (-27%) and BOEING (-33%). HONEYWELL spun off its resins & chemicals business as AdvanSix in late 2016 and announced in 2017 that other units would be divested.

The R&D intensity of companies in the top 100 (7.1%) remained practically the same of the previous year, due to R&D growth (7.9%) being similar to net sales growth (8.0%). The EU companies in the top 100 have slightly higher R&D intensity than that of non-EU companies (7.3% vs 7.1%). This difference is largely due to big low intensity non-EU companies such as Petrochina and China State Construction.

Among the top 100 companies, 5 made losses (DELL, ALLERGAN, GENERAL ELECTRIC, ERICSSON and TEVA PHARMACEUTICAL) with 22 showing profitability of only 5% or less but 31 showed profitability over 20%. All but two of the 31 operate in high R&D-intensive sectors (PROCTER & GAMBLE and BANCO SANTANDER).

4.2 | Long-term performance of top R&D companies

This section analyses the behaviour of the top companies over the long-term based on our historical database containing company data for the period 2002-2017. Results of companies showing outstanding R&D and economic results are underlined.

The R&D ranking of the top 50 companies is presented in figure 4.1 and table 4.2 shows changes in such ranking since the first *Scoreboard* in 2004. A ranking of the top R&D investors by R&D intensity is shown in Table 4.3, indicating the reasons for main changes observed over the last period. It is important to note, as stated in the previous reports, that the growth of companies is often accompanied by mergers and acquisitions.

There are 18 EU companies (same number as in 2004) and 32 non-EU companies among the top 50 R&D investors.

In the EU group, four companies left the top 50 (Alcatel, Istituto Finanziario Industriale, Philips, BAE Systems) and four companies joined the top 50 (Boehringer Ingelheim, Fiat Chrysler, SAP and Continental). ALCATEL first merged with LUCENT and the combined entity was later acquired by NOKIA.

In the non-EU group, thirteen companies left the top 50 (FUJITSU, CANON, DELPHI, HITACHI, HEWLETT-PACKARD, MATSUSHITA ELECTRIC, NEC, MOTOROLA, NORTEL NETWORKS (acquired), WYETH (acquired), SUN MICROSYSTEMS (acquired), NTT and TOSHIBA) and thirteen companies joined the top 50 (Amgen, Apple, Denso, CELGENE, Gilead Sciences, Alphabet, Huawei, Oracle, Panasonic, Qualcomm, Takeda Pharmaceuticals, Facebook and Abbvie that demerged from ABBOTT).

The distribution of the top 50 companies by main industrial sector and region changed from 2004 to 2018 as follows:

- Automobiles & Parts, from 13 (EU 7) to 14 (EU 8)
- Health industries, from 11 (EU 3) to 16 (EU 5)
- ICT industries, from 13 (EU 3) to 16 (EU 4)

Three EU companies improved in the R&D ranking by at least 20 places – these are Bayer (now ranked 29th), SAP (now 47th) and CONTINENTAL (48th).

There are 13 non-EU companies that gained more than 20 places. They include Samsung (now 1st), ALPHABET (now 2nd), HUAWEI (now 5th), APPLE (now 7th), ORACLE (now 17th), QUALCOMM (now 28th), TAKEDA (now 49th), LG ELECTRONICS (now 50th), GILEAD SCIENCES (now 49nd), BRISTOL-MYERS SQUIBB (now 26th), CELGENE (now 41rd), FACEBOOK (15th) and BOEING (57th).

Two companies dropped twenty or more places but remained within the top 50: SONY (now 39th) and PANASONIC (now 36th).

Box 4.1
Understatement or overstatement of R&D figures

The *Scoreboard* relies on consistent disclosure of R&D investment in published annual reports and accounts. However, due to different national accounting standards and disclosure practices, in some cases, R&D costs cannot be identified separately in companies' accounts, e.g. appearing integrated with other operational expenditures such as engineering costs. To avoid overstatement of R&D figures, the *Scoreboard* methodology excludes R&D figures that are not disclosed separately (see methodological notes in Annex 2). Inevitably, the strict application of this criterion can lead to understating the actual R&D effort of some companies.

An example of a possible large understatement of R&D figures is the US company Amazon. The figure for Amazon's R&D used in the *Scoreboard* is just the very small capitalised element of R&D. The vast majority of Amazon's R&D is expensed under the heading 'Technology & Content' – an investment of $22.62bn in 2017, up 41% on 2016. Amazon does not split this figure between technology and content. However, from Amazon's annual reports for 2012-15 it is estimated that approximately $10.3bn of the $12.5bn for 2015 is technology (R&D). This has been increased by another $10.1bn from 2015 to 2017 and up to two-thirds of the increase is thought to be R&D. Assuming conservatively that only half is R&D, then 2017 R&D is $15.3bn plus the capitalised R&D of $0.4bn, i.e. $15.7bn (€13.1bn) - that would place this company in the 3rd or 4th position of the world R&D ranking.

Companies showing the largest 10-years changes in R&D, net sales and employees

Companies among the top 100 R&D investors presenting remarkable results in terms of R&D, sales and employees over the past 10 years are listed in table 4.1 (ordered by level of R&D growth).

The high growth companies, at the top of the table, showed more than 3-fold increase of R&D and employees and more than 5-fold increase of net sales.

Firm		R&D investment 2017 (€bn)	Change in R&D 2008-2017 (%)	Change in net sales 2008-2017 (%)	Change in employees 2008-2017 (%)
High growth firms	BAIDU	1.7	4135.5	2551.7	516.0
	TENCENT	2.2	3002.5	3223.2	623.2
	ALLERGAN	1.7	1110.2	528.7	251.1
	APPLE	9.7	944.3	511.4	250.4
	ALPHABET	13.4	474.8	408.6	296.2
	SHIRE	1.4	218.3	401.6	511.4
Low growth firms	PROCTER & GAMBLE	1.6	-6.7	-12.9	-30.3
	IBM	4.3	-7.3	-23.6	-8.0
	NOKIA	4.9	-7.6	-54.4	-18.1
	GENERAL MOTORS	6.1	-8.9	-1.5	-25.6
	LEONARDO	1.5	-14.3	-23.3	-38.5
	HITACHI	2.5	-20.1	-6.3	-15.1

TABLE 4.1: COMPANIES AMONG THE TOP 100 R&D INVESTORS SHOWING THE LARGEST CHANGES IN R&D, NET SALES AND EMPLOYEES.
* Procter and Gamble demerged several units over the 10-year period.
Source: The 2018EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

On the other extreme, the firms at the bottom of the table underwent a simultaneous drop of R&D, net sales and employees. Some of these large changes are due to acquisitions and divestments. An example is SHIRE which acquired Baxalta for $32bn in 2016 and made at least three other acquisitions in 2014-15. ALLERGAN also has a long record of acquisitions and doubled its sales and quadrupled its R&D just from 2013 to 2016. ALLERGAN was acquired by Activis in early 2015 and Activis then changed its name (and that of the combined entity) back to ALLERGAN. Amongst the big decreases is PROCTER & GAMBLE which decided to divest 100 brands in 2014 and sold 43 of these to Coty for $12.5bn.

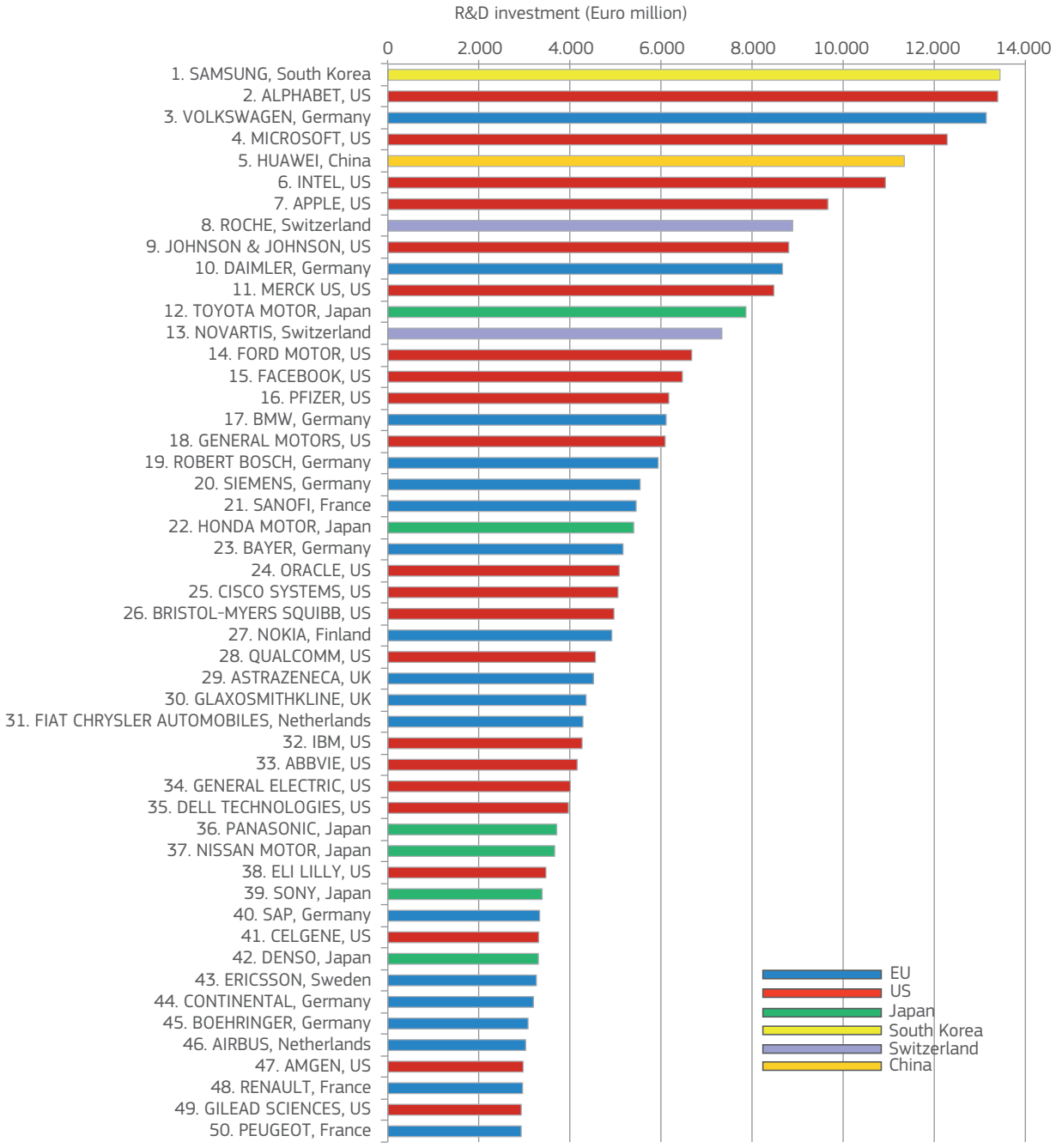


FIGURE 4.1: THE WORLD'S TOP 50 COMPANIES BY THEIR TOTAL R&D INVESTMENT IN THE 2018 *SCOREBOARD*.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Rank 2018	Company	Country	R&D in 2017/18 (€bn)	R&D intensity (%)	Rank change 2004-2018
1	SAMSUNG	South Korea	13.4	7.2	up 32
2	ALPHABET	US	13.4	14.5	up > 200
3	VOLKSWAGEN	Germany	13.1	5.7	up 5
4	MICROSOFT	US	12.3	13.3	up 9
5	HUAWEI	China	11.3	14.7	up > 200
6	INTEL	US	10.9	20.9	up 8
7	APPLE	US	9.7	5.1	up 97
8	ROCHE	Switzerland	8.9	19.5	up 10
9	JOHNSON & JOHNSON	US	8.8	13.8	up 3
10	DAIMLER	Germany	8.7	5.3	down 7
11	MERCK US	US	8.5	25.3	up 18
12	TOYOTA MOTOR	Japan	7.9	3.6	down 7
13	NOVARTIS	Switzerland	7.3	17.5	up 7
14	FORD MOTOR	US	6.7	5.1	down 13
15	FACEBOOK	US	6.5	19.1	up > 200
16	PFIZER	US	6.2	14.1	down 14
17	BMW	Germany	6.1	6.2	up 11
18	GENERAL MOTORS	US	6.1	5.0	down 12
19	ROBERT BOSCH	Germany	5.9	7.6	up 9
20	SIEMENS	Germany	5.5	6.7	down 15
21	SANOFI	France	5.5	15.5	down 5
22	HONDA MOTOR	Japan	5.4	4.8	up 9
23	BAYER	Germany	5.2	11.2	up 37
24	ORACLE	US	5.1	15.3	up 22
25	CISCO SYSTEMS	US	5.1	12.6	up 5
26	BRISTOL-MYERS SQUIBB	US	5.0	28.7	up 16
27	NOKIA	Finland	4.9	21.2	down 17
28	QUALCOMM	US	4.6	24.5	up 64
29	ASTRAZENECA	UK	4.5	24.1	down 4
30	GLAXOSMITHKLINE	UK	4.4	12.8	down 19
31	FIAT CHRYSLER	Netherlands	4.3	3.9	up 13
32	IBM	US	4.3	6.5	down 22
33	ABBVIE	US	4.2	17.7	new
34	GENERAL ELECTRIC	US	4.0	4.0	up 3
35	DELL TECHNOLOGIES	US	4.0	6.0	new
36	PANASONIC	Japan	3.7	6.3	down 29
37	NISSAN MOTOR	Japan	3.7	4.1	down 3
38	ELI LILLY	US	3.5	18.2	up 3
39	SONY	Japan	3.4	5.4	down 24
40	SAP	Germany	3.3	14.2	up 30
41	CELGENE	US	3.3	30.5	up > 200
42	DENSO	Japan	3.3	8.8	down 7
43	ERICSSON	Sweden	3.3	15.9	down 26
44	CONTINENTAL	Germany	3.2	7.3	up 73
45	BOEHRINGER SOHN	Germany	3.1	17.0	up 17
46	AIRBUS	Netherlands	3.0	4.5	down 11
47	AMGEN	US	3.0	15.6	down 10
48	RENAULT	France	3.0	5.0	down 3
49	GILEAD SCIENCES	US	2.9	13.5	up > 200
50	PEUGEOT	France	2.9	4.5	down 12

TABLE 4.2: THE TOP 50 COMPANIES IN THE 2018 *SCOREBOARD*: RANK CHANGE 2004-2018.
Note: companies in "blue" went up more than 20 ranks and in "red" lost more than 20 ranks.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

4.3 | Ranking of large companies by R&D intensity

The previous section analysed the top 50 companies by size of R&D investment. However, since some large companies have very large sales, the size of their R&D investment may not be a reliable guide to the importance of R&D in maintaining the company's competitive edge. For example, Petrochina has R&D of €1.6bn and is #88 in the *Scoreboard* but R&D is neither a key driver nor the main component of its competitive edge. That is highlighted by its R&D intensity of 0.6%. The same applies to China State Construction which has an R&D intensity of 1.2% and to Shell with an intensity of 0.3%. This section therefore examines the subset of large companies in the *Scoreboard* with R&D intensity of 10% or more and R&D of at least €1bn. These are substantial companies for which R&D is a key factor in their continuing success. The criteria for inclusion in the top 50 by R&D intensity are:

- R&D should be over €1bn in 2017/18 which means only the top 139 companies in the *Scoreboard* are eligible.
- And R&D intensity should be over 10%. The top 50 such companies are selected with Cisco Systems at #50 with intensity of 12.6%. That means 12.6% or more is required to be in the top 50 for 2018 compared to 12.7% in 2017.

The top 50 large companies with high R&D intensity are displayed in table 4.3 which also shows each company's R&D, R&D rank and intensity rank with the intensity rank change from 2017. We will now look at the top 50's new entrants and leavers, at its make-up by sector and region and then at a special subset of high growth/high intensity companies.

4.3.2 New entrants, leavers and big changes

There are five new entrants for 2018 – Snap, Adobe, GSK, Leonardo and Cisco. Snap entered because of a massive increase in R&D; it was #599 in the 2017 *Scoreboard* but rose to #110 for 2018. Three of the other four companies had intensities below 12.7% in 2017 (but over 12% for both GSK & Cisco) while Adobe had R&D below €1bn in 2017. These five replaced 2017 top 50 companies Intuit, Applied Materials, Altaba, Micron Technology and Vertex Pharma. The R&D of Intuit, Altaba and Vertex fell below €1bn in 2018, Micron's intensity fell below 10% and Applied Materials' intensity fell to 12.2% (making it #51 in 2018) because its sales grew much more than its R&D.

A total of 11 companies rose or fell in the top 50 rankings by 9 or more places. The big risers were AbbVie, Astellas, Biogen, Johnson & Johnson whose R&D increased so the intensity rose and Ericsson & Sanofi whose sales were down with a modest rise in R&D so the intensity also increased but for a different reason. The big fallers were Huawei, ASML and Boehringer for which sales rose more than R&D (so intensity was down). Boehringer's R&D also declined a little (by 1.1%). Then two companies reduced their R&D - Gilead by 17.7% and Allergan by 27%.

4.3.3 The top 50 by sector and world region

Just three sectors – biopharmaceuticals, hardware and software account for 47 of the top 50 with three other sectors contributing one company each. This is not surprising since these three sectors are the most R&D intensive and companies in them depend on a flow of new and innovative products to maintain their competitive edge. The details are:

- Biotech & pharmaceuticals accounts for 23 companies in the top 50
- Technology hardware contributes 15 of the top 50
- Software accounts for 9 of the top 50
- Aerospace & Defence, general retail and travel & leisure each contribute one company.

The average R&D intensity for the 23 biopharma companies is a high 18.1% compared to the sector average from past *Scoreboard* analyses of the global

biopharma sector of 10-11%. This reflects the presence of the four large US biotechs in the top 50 together with biotech-oriented pharmaceutical groups such as Roche (which fully acquired Genentech in 2009). The average for the 14 hardware companies in the top 50 is 17.3% (we use 14 not 15 since we exclude the exceptional 183% for Snap) compared to a global average of 8-9%. For software the average intensity of the 9 companies in the top 50 is 16.6% compared to a global average of 15%.

The regional make-up of the top 50 is heavily weighted towards the US which has exactly one half of the 50 companies. The details are:

- The US has 25 of the top 50 high intensity large companies
- The EU is the next largest with 14 of the top 50
- Asia has 9 of the top 50
- Switzerland has 2 companies (Roche & Novartis)

There is a clear regional specialisation in certain sectors with the US having 7 of the 9 software/internet companies with one each from the EU and Asia. The US also has 7 of the 15 hardware companies but is more closely followed by the EU with 5 and then Asia with 3. In biopharma, the US has 10 companies, the EU 7, Asia 4 and Switzerland 2. This is consistent with the *Scoreboard*'s findings from the whole dataset of 2,500 global companies where the US is by far the largest regional contributor to ICT producers/ICT services and the largest to health industries.

An R&D intensity above sector average as is the case for most of the top 50 is a driver of sales growth since innovative new products give a company an edge over competitors in the market provided the R&D is well-directed. It is therefore not surprising that many companies in the top 50 have moved well up the rankings in the main *Scoreboard* of 2,500 companies in both R&D and sales in the last few years. Examples are Alphabet (#2 in 2018 but #26 in 2012), Baidu (#81 in 2018 but #450 in 2012), Salesforce.com (#107 in 2018 but #493 in 2012), Celgene (#41 in 2018 but #97 in 2012) and NXP Semiconductors (#109 in 2018 but # 203 in 2012).

The ranking of the top 50 companies by R&D intensity in table 4.3 takes no account of the differing growth rates of the various companies. There is a special subset of all high R&D intensity companies that also have high R&D growth and high sales growth. These are companies that are increasing their market share and also investing more in new products and services to improve their market position still further. We examine a set of these companies in the next section.

4.3.4 High R&D intensity companies with high R&D & sales growth

Of the 139 *Scoreboard* companies with R&D over €1bn, table 4.3 shows that only 50 have R&D intensity of 12.6% or more. Furthermore, just 17 of the 139 companies have all three measures of R&D intensity, R&D growth and sales growth in double figures (10% or more). If, however, we broaden the R&D criterion to the top 250 companies in the *Scoreboard* which have R&D of €500m or more we find that 30 of them have all three measures in double figures. Not surprisingly, 13 of the 30 also appear in the top 50 by R&D intensity – these are the companies with R&D over €1bn and intensity of 12.6% or more. The 30 high growth/high intensity companies are displayed in table 4.4 which shows the companies, their rank by R&D intensity, their sectors, R&D, R&D intensity, R&D growth and sales growth. The sectoral split is as follows:

- Technology Hardware accounts for 12 of the top 30
- Software contributes 10 of the 30
- Biopharmaceuticals accounts for another 5 companies
- There are also companies from the automotive (2) and electronics sectors to take the total up to 30

The big difference between this sectoral split and that for the top 50 companies by R&D intensity alone is that biopharma companies, by far the largest of the three main sectors in the top 50, becomes the smallest of the three in the top 30. That reflects the longer term nature of biopharma R&D where pipeline drugs need extensive clinical trials before being approved by regulators. This means that it is harder to grow both sales and R&D as fast in the short-term compared to companies in the hardware or software sectors.

The regional make-up of the top 30 has some similarities to that of the top 50 by R&D intensity but with a higher US proportion:

- The US has 22 of the 30 companies (73.3%) compared to 50% for the top 50. The 22 companies consist of 10 from hardware, 8 from software, 3 from biopharma and one automotive (Tesla)

- Both the EU and Asia have 4 companies (13.3%) each from four different sectors. These are automotive, hardware, pharma and software for the EU and electronics, hardware, pharma and software for Asia. The four Asian companies comprise 2 from Japan and 2 from China.

The US is clearly very strong in the ICT sectors as was mentioned above in the top 50 analysis.

Given the high growth and high intensity of the top 30 companies in table 4.4, one would expect to find many companies there that have moved well up the main global 2,500 *Scoreboard* rankings in the last few years. Examples include Snap (#110 in 2018 but around #1100 in 2016), Facebook (#15 in 2018 but #295 in 2012) and Tesla (#120 in 2018 but #467 in 2014).

2017/18 world rank by R&D Intensity. ( )= 2016/17 rank	R&D €bn (rank in brackets is by 2017/18 R&D)	Company name (All have R&D>€1bn)	Industrial Sector	R&D Intensity 2017/18 %	Intensity rank change from 2016/17 & reason (if change >5)
1 (new)	1.26bn (110)	Snap	Hardware	183%	R&D up over €1bn
2 (2)	1.06bn (130)	Ctrip.com International	Travel & Leisure	30.8%	=
3 (3)	3.31bn (41)	Celgene	Biotech	30.5%	=
4(4)	4.96bn (26)	Bristol-Myers Squibb	Biopharma	28.7%	=
5 (6)	1.1bn (127)	Electronic Arts	Software	25.6%	+1
6 (5)	8.47bn (131)	Merck US	Biopharma	25.3%	-1
7 (8)	4.56 (28)	Qualcom	Hardware	24.5%	+1
8 (7)	1.74bn (78)	Daiichi Sankyo	Pharma	24.6%	-1
9 (5)	4.51bn (29)	AstraZeneca	Biopharma	24.1%	-4
10 (17)	1.6bn (83)	Mediatek	Hardware	24.0%	+7 (sales down)
11 (15)	4.92bn (27)	Nokia	Hardware	21.2%	+4
12 (10)	10.92bn (6)	Intel	Hardware	20.9%	-2
13 (20)	8.88bn (8)	Roche	Biopharma	19.5%	+7 (R&D up)
14 (11)	6.47bn (15)	Facebook	Software/internet	19.1%	-3
15 (17)	2.74bn (52)	Broadcom	Hardware	18.7%	+2
16(12)	1.5bn (94)	Nvidia	Hardware	18.5%	-4
17 (26)	1.88bn (69)	Biogen	Biotech	18.4%	+9 (R&D up)
18 (19)	2.4bn (58)	Takeda Pharma	Pharma	18.4%	+1
19 (15)	3.47bn (38)	Eli Lilly	Pharma	18.2%	-4
20 (29)	4.15bn (33)	AbbVie	Pharma	17.7%	+9 (R&D up)
21 (24)	7.33bn (13)	Novartis	Pharma	17.5%	+3
22= (31)	1.63bn (82)	Astellas Pharma	Pharma	17.0%	+9 (R&D up)
22=(13)	3.08bn (45)	Boehringer Sohn	Pharma	17.0%	-9 (R&D ↓, sales ↑)
24 =New)	1.02bn (136)	Adobe Systems	Software	16.8%	R&D up over €1bn
24= (30)	1.3 (109)	NXP Semiconductor	Hardware	16.8%	+6 (R&D up)
26 (40)	3.26 (43)	Ericsson	Hardware	15.9%	+14 (R&D ↑, sales ↓)
27 (27)	2.97bn (47)	Amgen	Biotech	15.6%	=
28 (40)	5.45bn (21)	Sanofi	Pharma	15.5%	+12 (R&D↑, sales↓)
29 (23)	1.07bn (129)	ST Microelectronics	Hardware	15.4%	-6 (R&D down)
30=(38)	1.66(81)	Baidu	Software	15.3%	+8 (R&D up)
30=(28)	5.08bn (24)	Oracle	Software	15.3%	-2
32 (36)	1.3bn (107)	Salesforce.com	Software	14.9%	+4
33 (22)	11.33bn (5)	Huawei	Hardware	14.7%	-11 (sales↑>R&D↑)
34 (34)	13.39bn (2)	Alphabet	Software/internet	14.5%	=
35 (43)	1.14bn (123)	eBay	General Retail	14.3%	+8 (R&D up)
36= (40)	1.3bn (108)	Otsuka	Pharma	14.2%	+4
36= (44)	3.33bn (40)	SAP	Software	14.2%	+8 (R&D up)
38 (35)	6.17bn (16)	Pfizer	Pharma	14.1%	-3
39 (47)	2.14bn (62)	Merck DE	Pharma	13.9%	+8`(R&D up)
40 (50)	8.8bn (9)	Johnson & Johnson	Pharma	13.8%	+10 (R&D up)
41 (32)	2.93bn (49)	Gilead Sciences	Biotech	13.5%	-9 (R&D down)
42 (36)	12.28bn (4)	Microsoft	Software	13.3%	-6 (sales↑>R&D↑)
43 (new)	1.52bn (93)	Leonardo	Aerospace & Defence	13.1%	New (intensity ↑)
44= (21)	1.72bn (80)	Allergan	Pharma	12.9%	-23 (R&D down)
44= (46)	1.93bn (68)	Novo Nordisk	Pharma	12.9%	+2
44= (45)	1.8 (76)	ZTE	Hardware	12.9%	+1
47= (33)	1.16bn (119)	ASML	Hardware	12.8%	-14 (sales↑>R&D↑)
47= (new)	4.35bn (30)	GSK	Pharma	12.8%	New (intensity ↑)
47= (49)	2.04bn (64)	Western Digital	Hardware	12.8%	+2
50 (new)	5.05bn (25)	Cisco Systems	Hardware	12.6%	New (intensity ↑)

TABLE 4.3: RANKING BY R&D INTENSITY OF TOP LARGE *SCOREBOARD* COMPANIES WITH R&D>€1BN
Note: The colours indicate world region (red for US, blue for EU, black for Asia & green for Switzerland)
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Rank by R&D intensity	Company (All high growth & high intensity)	Sector	R&D 2017/18 & rank €bn	R&D Intensity (>10%)	R&D Growth (>10%)	Sales Growth (>10%)
1	Snap	Hardware	1.26bn (110)	183%	722%	104%
2	Incyte	Pharma	0.96bn (147)	74.9%	145.3%	38.9%
3	Ubisoft	Software	0.78bn (175)	45.2%	21.0%	18.6%
4	Workday	Software	0.76bn (183)	42.5%	33.8%	36.1%
5	Alexion Pharma	Pharma	0.73bn (193)	24.7%	16.0%	15.1%
6=	Eisai	Pharma	0.97bn (145)	21.8%	26.0%	11.3%
6=	AMD	Hardware	0.97bn (146)	21.8%	15.1%	24.7%
6=	Intuit	Software	0.94bn (150)	21.8%	14.4%	10.3%
9	Ferrari	Automotive	0.74bn (188)	21.7%	13.9%	10.0%
10	Symantec	Software	0.80bn (174)	19.7%	16.3%	20.6%
11	Facebook	Software/internet	6.47bn (15)	19.1%	31.0%	47.1%
12	Analog Devices	Hardware	0.81bn (171)	19.0%	48.1%	49.3%
13	Broadcom	Hardware	2.74bn (52)	18.7%	23.1%	33.2%
14	Nvidia	Hardware	1.5bn (94)	18.5%	22.8%	40.6%
15	Abbvie	Pharma	4.15bn (33)	17.7%	21.1%	10.1%
16	Adobe Systems	Software	1.02bn (136)	16.8%	25.4%	24.7%
17	Renesas	Electronics	0.94bn (151)	16.3%	62.6%	65.6%
18	Baidu	Software	1.66bn (81)	15.3%	27.2%	20.2%
19	Kla-Tencor	Hardware	0.51bn (250)	15.1%	15.5%	16.0%
20	Salesforce.com	Software	1.3bn (107)	14.9%	28.5%	24.9%
21	Huawei	Hardware	11.33bn (5)	14.7%	16.6%	15.7%
22	Alphabet	Software/internet	13.39bn (2)	14.5%	18.4%	22.8%
23	Microsoft	Software	12.28bn (4)	13.3%	13.0%	14.3%
24	ASML	Hardware	1.16bn (119)	12.8%	12.6%	33.2%
25	Western Digital	Hardware	2.04bn (64)	12.8%	50.0%	46.9%
26	Applied Materials	Hardware	1.48bn (95)	12.2%	15.3%	34.3%
27	Tesla	Automotive	1.15bn (120)	11.7%	65.2%	68.0%
28	Shire	Pharma	1.43bn (98)	11.3%	22.1%	33.0%
29	LAM Research	Hardware	0.99bn (141)	10.7%	17.3%	38.2%
30	Texas Instruments	Hardware	1.26bn (111)	10.1%	10.1%	11.9%

TABLE 4.4: RANKING BY R&D INTENSITY OF *SCOREBOARD* COMPANIES (R&D>€500M AND BOTH R&D & SALES GROWTH >10%)
Note: The colours indicate world region (red for US, blue for EU, black for Asia).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

5

ANALYSIS OF THE TOP EU **1000 R&D INVESTORS**

5 Analysis of the top EU 1000 R&D investors

The EU1000 shows a high concentration of R&D. The three largest countries (Germany, the UK and France) contribute to two thirds of both total R&D and total sales. Most German R&D is in the automotive sector, the UK's in pharmaceuticals while France has more of a balance R&D sector composition.

This chapter examines the R&D and economic trends of companies based in Members States of the EU. This specific analysis is based on an extended sample of companies representing the top 1000 R&D investors in the EU, i.e. the 577 EU companies included in the world top 2500 sample and 423 additional companies based in the EU. The EU1000 have a total R&D of €206.3bn but just the top 577 companies account for €200.1bn or 97% of this. The distribution of the EU 1000 companies across industrial sectors and countries can be found in Annex 3.

The first section presents the one-year changes in R&D and the financial performance indicators of companies, especially those based in the top 10 largest Member States. The second section analyses the long-term trends of company results, mainly in terms of R&D, net sales and employment.

5.1 | Changes in the main indicators in 2017/18

As explained in chapter 1 for the world sample of companies, industrial R&D is very concentrated by country and sector. Among the EU 1000 sample, there are 899 companies based in the top 10 Member States accounting for 97.1 % of the total R&D. Moreover, the overall performance of the EU 1000 group is largely driven by the results of companies based in Germany, France and the UK, accounting for 61% of the companies, 68% of the total R&D and 68% of total net sales. Just three broad sectors (automotive, health and ICT) account for 72% of the EU1000's total R&D.

The top 1000 R&D companies in the EU invested €206.3bn, 5.4% more than the previous year.

The German companies made the largest contribution to the results of the EU 1000 sample. They increased R&D by 6.3% and net sales by 6.5%. These results reflect to a large extent the performance of the German companies in the country's large Automobiles sector (5.7% in R&D and 6.3% in net sales). Indeed the top five German automotive companies account for 45% of all German R&D in the EU1000. Companies from this sector showing the highest R&D growth were DAIMLER and BMW and from other sectors SIEMENS, BAYER and SAP.

The companies based in the UK increased R&D by 6.9% but showed a large increase in net sales (16.2%) due mainly to the impact of the oil price in companies such as SHELL and BP. The largest contributions to R&D growth were made by companies from several different sectors, e.g. GLAXOSMITHKLINE, LLOYDS, SHIRE, VODAFONE, ROLLS-ROYCE.

Companies based in France increased R&D by 8.2% and sales by 9.1%. Among these companies, the largest contribution to the R&D growth came from the Automobiles sector (PEUGEOT, RENAULT, VALEO), ICT producers and Health (e.g. SCHNEIDER and SANOFI). As mentioned in earlier chapters the R&D growth of Peugeot, Valeo and Schneider benefited from recent acquisitions.

Apart from the three top Member States, among the group of largest EU countries, those whose companies increased R&D above the EU average were:

Italy by 9.5%, mostly due to R&D increases of companies such as TELECOM ITALIA, LEONARDO and INTESA SANPAOLO.

Sweden by 6.1%, with large contributions from companies such as ELECTROLUX, ERICSSON, HEXAGON and FINGERPRINT CARDS.

Among the large countries, the groups of companies that decreased R&D are from Ireland (-3.8%) and from Spain (-2.4%). In Ireland, high R&D growth of companies such as ALLIED IRISH BANKS and ACCENTURE has been offset by a large reduction of R&D by ALLERGAN. And in Spain, high R&D growth of companies such as GRIFOLS and INDRA SISTEMAS has been offset by reduction of R&D by BANCO SANTANDER and SENER GRUPO DE INGENIERIA.

In terms of net sales, companies from Spain showed higher than average growth and those from Ireland presented negative results.

In 2017/18, the average R&D intensity of the EU-1000 companies decreased because of the lower increase of R&D investments compared to that of net sales, 5.4% vs 8.5%.

It is important to remember that in many countries, the aggregate country indicators depend to a large extent on the figures of a very few firms. This is due, either to the country's small number of companies in the Scoreboard or to the concentration of R&D in a few large firms. For example, five German automotive companies account for 45% of German R&D, Ericsson and Volvo account for 53% of the total R&D by the Swedish companies, Nokia for 76% of the companies based in Finland, Telecom Italia and Leonardo for 54% of the companies based in Italy and Airbus & FiatChrysler for 40% of Netherlands R&D.

Country	No. of companies	R&D in 2017 (€bn)	R&D Share within EU (%)	R&D one year growth (%)	Net Sales one year growth (%)
Germany	219	81.3	39.4	6.3	6.5
UK	275	30.5	14.8	6.9	16.2
France	111	29.0	14.0	8.2	9.1
Netherlands	53	18.5	8.9	0.6	5.3
Sweden	77	9.5	4.6	6.1	4.5
Ireland	27	8.5	4.1	-3.8	-1.1
Italy	39	6.5	3.2	9.5	6.3
Finland	36	6.4	3.1	1.1	5.2
Denmark	42	5.3	2.6	1.7	3.8
Spain	20	4.6	2.2	-2.4	8.3
Top 10 countries	**899**	**200.2**	**97.0**	**5.2**	**8.4**
Other EU	101	6.1	3.0	13.0	11.2
Total EU	**1000**	**206.3**	**100**	**5.4**	**8.5**

TABLE 5.1: R&D TRENDS FOR COMPANIES BASED IN THE TOP 10 EU MEMBER STATES.
Note: For the sample of 1000 EU companies.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

Sector	R&D in 2017 (€bn)	Germany 1-year change (%)		France 1-year change (%)		UK 1-year change (%)	
		R&D	Net Sales	R&D	Net Sales	R&D	Net Sales
Aerospace & Defence	9.0	-1.8	13.5	-3.0	2.9	15.4	5.6
Automobiles & other transport	61.3	5.7	6.3	14.5	15.3	-8.2	6.6
Chemicals	5.7	2.1	10.6	-7.6	10.2	-0.3	19.9
Health industries	46.0	7.1	5.0	7.2	-0.7	8.3	14.1
ICT producers	26.7	8.9	5.7	23.1	2.2	2.3	5.4
ICT services	15.2	10.7	3.4	9.8	2.3	17.7	2.9
Industrials	12.1	10.8	7.9	-7.2	20.4	24.1	24.1
Others	30.3	2.9	6.4	5.2	8.9	3.7	18.1
Total	**206.3**	**6.3**	**6.5**	**8.2**	**9.1**	**6.9**	**16.2**

TABLE 5.2: GROWTH OF R&D AND NET SALES FOR THE GERMAN, FRENCH AND UK COMPANIES - BREAK DOWN FOR 7 MAJOR INDUSTRIAL SECTORS.
Note: For the sample of 1000 EU companies.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

5.2 | Long-term trends for companies based in the large Member States

This section presents the evolution of the main company performance indicators over the past 10 years for the companies in the EU 1000 group.

5.2.1 Long-term trends

The annual growth rates of R&D and net sales and profitability for companies based in Germany, France, UK and Netherlands over the past 10 years is provided respectively in figures 5.1, 5.2, 5.3 and 5.4. These figures are based on our history database comprising these indicators over the whole 2008-2017 period for EU companies based in Germany (147), France (81), UK (126) and NL (30).

Companies based in Germany continued the strong performance in terms of R&D shown since 2010, recovering to and then improving on levels of R&D growth prior to the crisis. However, the growth of net sales has not followed the same path, a slowdown from 2010 to 2013 has been followed by a hesitant recovery from 2013 to 2014/15, then again sales decreased from 2015 to 2016 and finally recovered significantly over the last period. On the other hand, German companies have maintained a stable level of profitability over the past 10 years in the 5-8% range with a positive trend over the past two years.

Companies based in France showed a low but positive trend in R&D growth after the decrease from 2013 to 2014, but at much lower levels than their EU or non-EU counterparts although growth recovered significantly from 2016 to 2017. The growth of net sales reversed the negative trend showed over 2010-2014 increasing significantly from 2016 to 2017. The average profitability of the French companies showed a negative trend from 2011 to 2015 but it then increased from 2015 to 2016 and remained stable in 2017 at 9%.

Companies based in the UK showed a strong recovery of R&D and net sales in 2009 to 2010 that then reversed in 2010 to 2012. In 2012-2013 their R&D investment resumed to grow at significant pace but with a level of net sales practically unchanged. In 2014/15 the R&D level remained practically unchanged although with a significant decrease of net sales but both R&D and sales increased strongly from 2015-2017. The average profitability of the UK companies was the highest of the three countries throughout the period although, like their French counterparts, showed a decreasing trend from 2011-2015 but a strong increase in 2016/17 remaining stable at 10-11% over the last two years.

Companies based in the Netherlands registered an increase in R&D and sales over 2009-2012 and then a slowdown over 2012 to 2013. From 2015 to 2016, R&D and sales grew moderately and over the last period R&D stagnated while sales continued to grow at significant pace. The profitability of companies based in the Netherlands remained stable at 5-6% from 2010 to 2016, showing a slight upward trend to 7% in 2017. Two companies –FiatChrysler and Airbus account for 40% of Netherlands R&D. Their HQs are in the Netherlands but their main operations are located elsewhere.

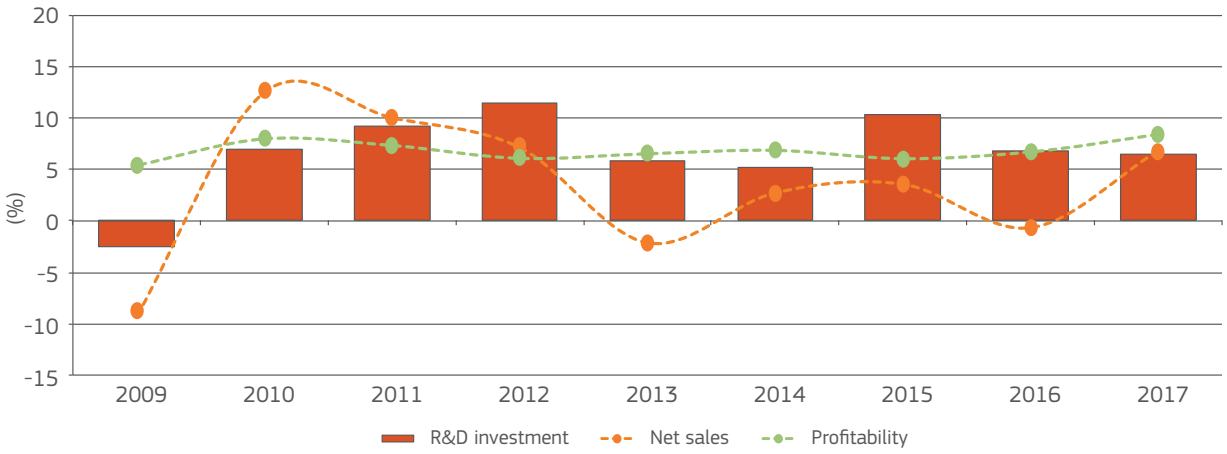


FIGURE 5.1: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY BY THE GERMAN COMPANIES.
Note: Growth rates for the three variables have been computed on 147 out of the 219 German companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

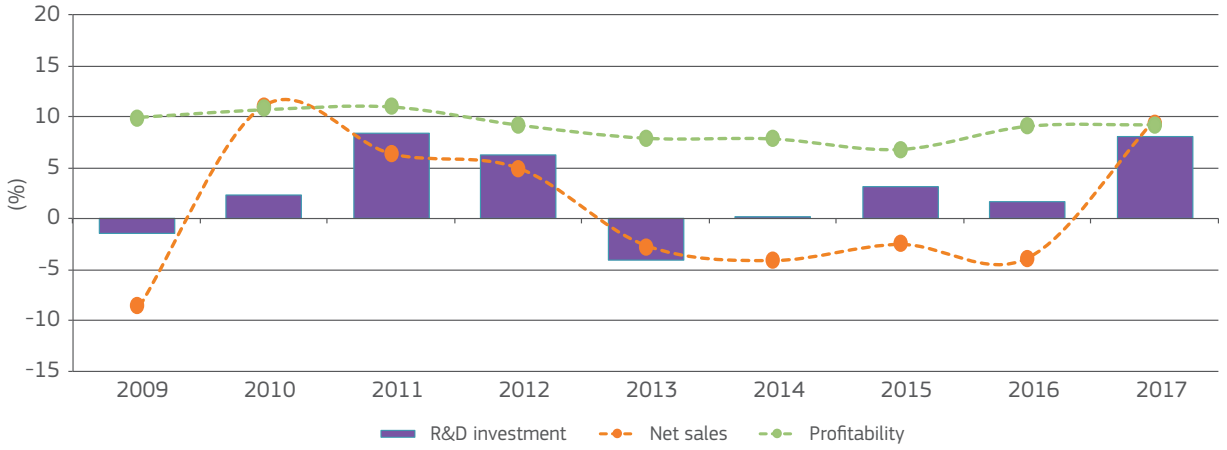


FIGURE 5.2: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY BY THE FRENCH COMPANIES.
Note: Growth rates for the three variables have been computed on 81 out of the 111 French companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

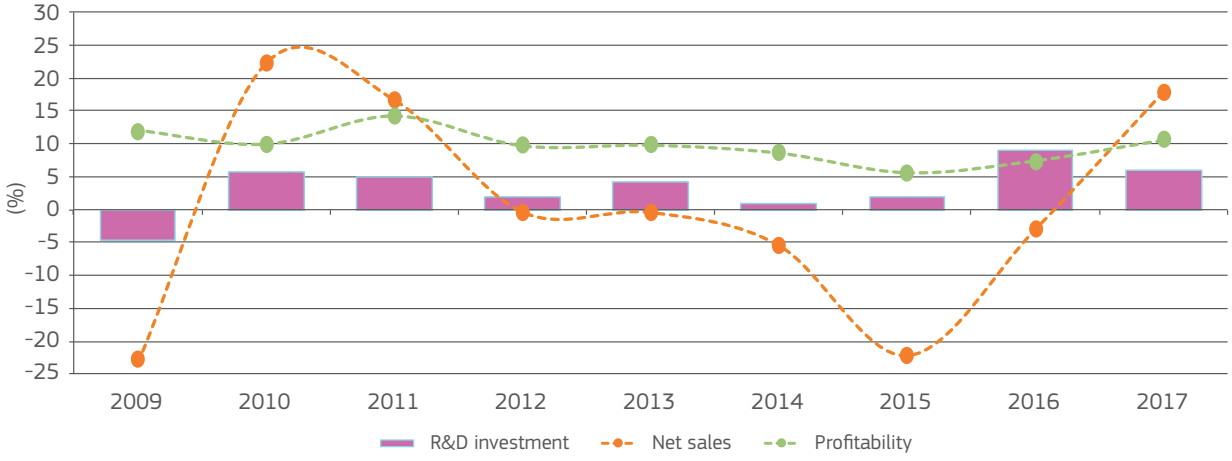


FIGURE 5.3: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY BY THE UK COMPANIES.
Note: Growth rates for the three variables have been computed on 126 out of the 275 UK companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

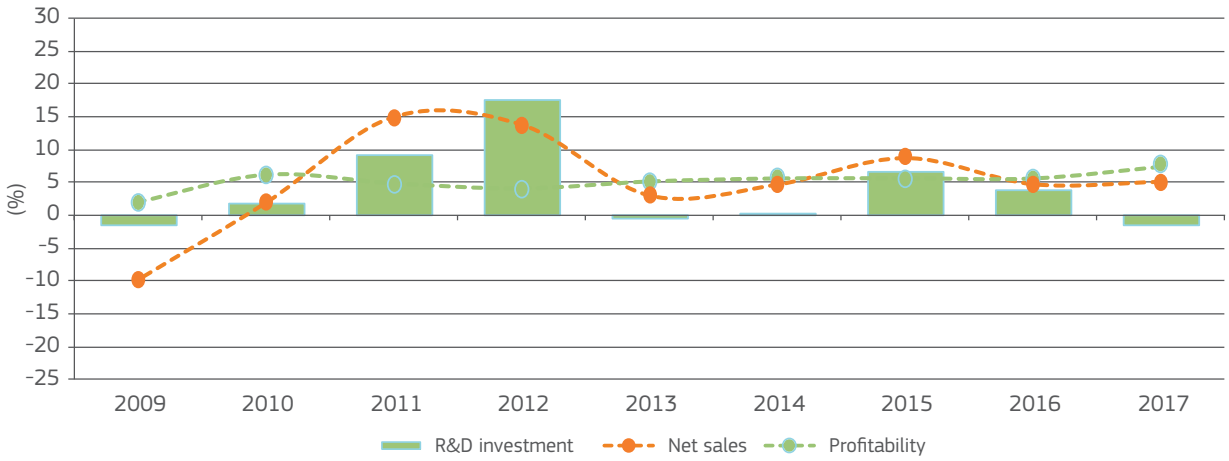


FIGURE 5.4: ONE-YEAR R&D INVESTMENT AND NET SALES GROWTH AND PROFITABILITY BY THE DUTCH COMPANIES.
Note: Growth rates for the three variables have been computed on 30 out of the 53 Dutch companies for which data are available for the entire period 2008-2017.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

5.2.2 Change in R&D, net sales and employment over 2008-2017 for groups of sectors and top EU company aggregates

The levels of R&D, net sales and employment in 2008 and 2017 are presented in figures 5.5, 5.6 and 5.7 for groups of industrial sectors with characteristic R&D intensities[12] (see definition in Chapter 1 – Table 1.3).

The figures refer to a set of 618 companies that reported R&D, net sales and number of employees in the first and the last year of the period 2008-2017 (DE-153, FR-77, UK-131, NL-29 and Other EU-228).

Over the past 10 years, the R&D, net sales and employment changes for the whole sample of EU companies are very similar to those of the EU sample within the world set (concentration effect).

The overall changes for each indicator are:

- R&D increased by 50%(high tech 43%, medium-high tech 70%, medium-low tech 15% and low tech 10%)
- Net sales increased by 12%(high tech 43%, medium-high tech 46%, medium-low tech 14% and low tech -14%)
- Employment increased by 11% (high tech 29%, medium-high tech 26%, medium-low tech -15% and low tech -2%).

These three indicators changed in very different proportions across member states and sector groups. By sector groups the highest increases were:

- In high tech (R&D - DE 80%; Net sales - DE 76%; Employment, DE 56%)
- In medium-high tech (R&D - UK 129%; Net sales - UK 60%; Employment - DE 29%)
- In medium-low tech (R&D – Other EU 72%; Net sales - UK 69%; Employment - UK 1%)
- In low tech sectors (R&D - NL 179%; Net sales - NL 127%; Employment - NL 77%)

The above results analysed by member state show distinct characteristics of the R&D investing companies in each country. Germany has the largest proportion of its R&D in medium-high tech, with the UK having the largest proportion in high tech while France has almost equal proportions in high tech and medium-high tech. In terms of changes over 2008-2017:

- German companies increased their R&D by 80% and employment by 56% in high tech whereas French companies grew R&D only by 37% and employment

[12] For simplification, in this section these groups are referred to as high tech, medium-high tech, medium-low tech and low-tech.

by a similar rate (36%). This means that the ratio R&D/employees in the high tech sector increased for German companies but stagnated for French ones. On the other hand, German companies increased the ratio sales/employee more than the French companies for high tech and for the whole sample.

- UK companies showed a large percentage increase (over 100%) in medium-high tech R&D but from a low base and a moderate increase in high tech R&D. There was an overall stagnation in sales (-7%) due to a 27% decrease in the low tech sector which has companies with very large sales, e.g. oil & gas, mining and banks. However, there was a large net sales growth in 3 groups (high, medium-high and medium- tech groups).

- Companies based in the Netherlands, which has negligible R&D in low and medium-low tech sectors, showed significant increases for the 3 indicators.

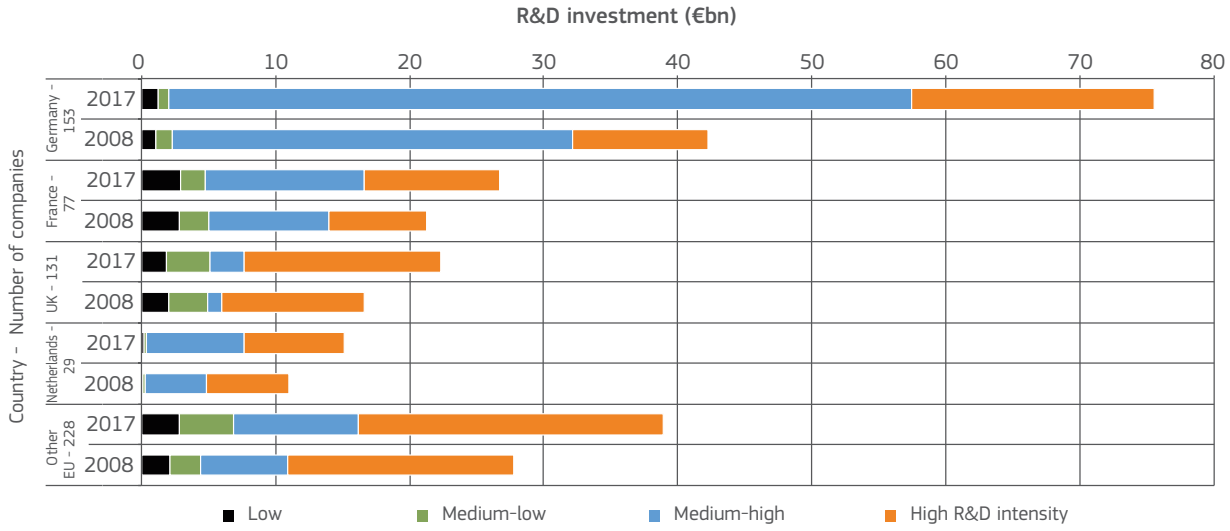


FIGURE 5.5: R&D INVESTMENT IN 2008 AND 2017 BY SECTOR AND MAIN EU GROUPS.
Note: Figures displayed refer only to the 618 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

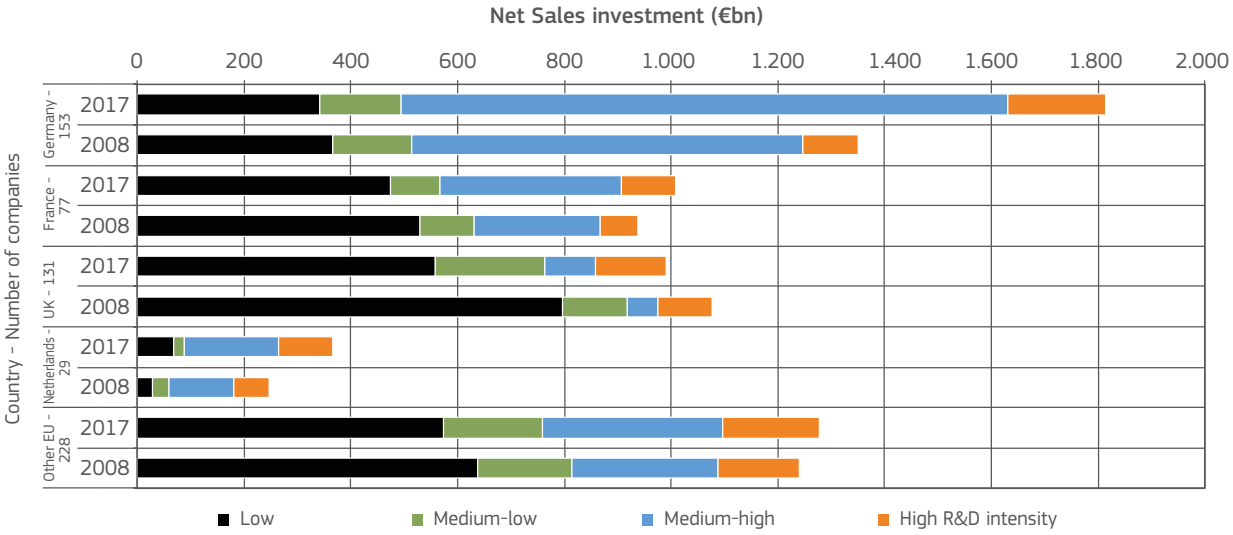


FIGURE 5.6: NET SALES IN 2008 AND 2017 BY SECTOR AND MAIN EU GROUPS.
Note: Figures displayed refer only to the 618 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

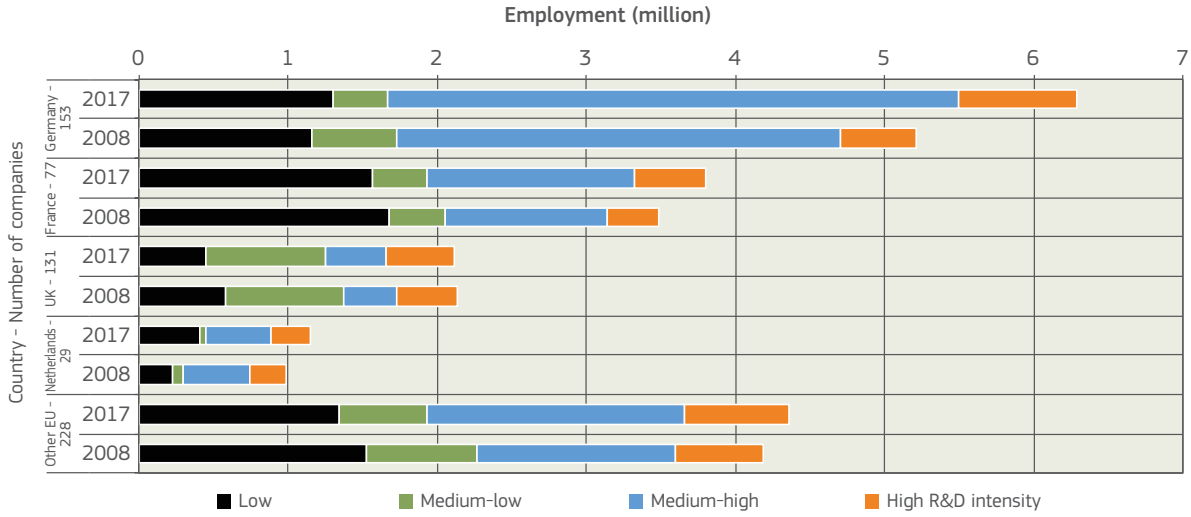


FIGURE 5.7: EMPLOYMENT IN 2008 AND 2017 BY SECTOR AND MAIN EU GROUPS.
Note: Figures displayed refer only to the 618 companies for which data are available for all variables (R&D, Net Sales and Employment) both years (2017 and 2008).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.

6

MAPPING BUSINESS **INNOVATION ACTIVITIES THROUGHOUT THE EU**

6 Mapping business innovation activities throughout the EU

The number of patents invented in a country is much higher than the number of patents owned by local companies. Germany and the US compare as the most frequent second location of ownership for patents invented in EU countries (10 and 8 respectively). Concentration of business patents by companies changes a lot from one country to the other.

This chapter make use of patents data at European level to complement and integrate the information gathered from the *Scoreboard* companies on the EU R&D landscape. The main aim is to provide further insights on technological innovations in the EU, especially for countries scarcely (or not at all) represented in the *Scoreboard* among the top corporate R&D investors.

6.1 | Business R&D activities in the EU-28

For 14 years, the *Scoreboard* has monitored the activities of the top corporate R&D investors worldwide. Despite efforts to increase its coverage of R&D activities in European countries, a number of countries are still not represented in the *Scoreboard*.

Indeed, also when considering the top 1000 EU companies, eight countries are still not represented, while for a number of other countries the R&D activities financed by the business sector are hardly captured (see table 6.1). This is mainly due to two reasons, either R&D performers in such countries are too small to be included in the *Scoreboard* sample, or they are subsidiaries of foreign *Scoreboard* companies and thus their R&D is consolidated and attributed to the country where the headquarters of the parent company is located.

For these reasons, *Scoreboard* figures are not directly comparable with Eurostat ones. Indeed, due to size and corporate group consolidation, *Scoreboard* figures can be higher or lower than the Eurostat figures of R&D *financed by* the business enterprise sector, the BES-R&D (see column 2 of table 6.1). For the sake of clarity, we remind the reader that the BES-R&D is different from BERD; the latter captures the R&D *performed in* the business enterprise sector, but that can be financed by different entities. In general, BERD tend to be higher than BES-R&D (see column 3 of table 6.1).

How to close this information gap? In this chapter we use the full sample of patents filed at the European Patent Offices (EPO) to provide evidence on the patenting activities of the business sector in the EU-28 countries. We do so using a field in the Patstat database that allows isolating those patents for which the applicant operates in the business sector. In order to control for the multiple filing of the same invention at different Intellectual Property Offices, different patent applications have been matched through INPADOC (International Patent Documentation) families to avoid double counting.[13] This allows us fulfilling a long lasting need for a better coverage of the technological activities of the business sector in the EU countries with a focus on inventorship-ownership patterns across countries and companies.

[13] http://www.epo.org/searching/essentials/patent-families/inpadoc.html.

Country	Companies in the 2018 EU1000 *Scoreboard*	SB-R&D/ BES-R&D	BERD/ BES-R&D	BES-R&D *(R&D funded by business enterprise sector)*
Germany	219	1.22	1.05	58239
France	111	1.06	1.17	27203
UK	275	1.40	1.35	21333
Italy	39	1.12	1.16	11077
Sweden	77	1.20	1.22	8396
The Netherlands	53	2.15	1.15	6663
Austria	32	0.24	1.44	5222
Belgium	34	0.41	1.19	5929
Spain	20	0.79	1.15	6039
Denmark	42	0.93	1.08	4771
Finland	36	1.18	1.22	3325
Ireland	27	5.83	1.47	1516
Poland	4	0.01	1.19	1684
Czech Republic	2	0.05	1.57	1122
Hungary	1	0.15	1.48	751
Portugal	4	0.14	1.09	953
Slovenia	2	0.24	1.10	590
Greece	3	0.26	1.05	535
Romania			1.18	292
Luxembourg	18	2.18	1.10	312
Bulgaria			2.06	155
Slovakia			1.12	232
Croatia			1.10	175
Estonia			1.12	124
Lithuania			0.96	111
Latvia			1.23	31
Malta	1	0.93	1.13	33
Cyprus			1.14	17

TABLE 6.1: COMPARING *SCOREBOARD* R&D WITH BES-R&D AND BERD IN THE EU-28 (2015).
Note: BES-R&D reported in €million.
Source: own computation on the Industrial Research and Innovation Scoreboard 2016 and Eurostat.

6.2 | Patents from the business sector across countries

Patents can be assigned to countries on the basis of the inventor residence as reported in the respective document, this is normally used to proxy where corporate R&D is performed and knowledge produced. Similarly, patents can be localised according to the ownership of the property right, reflecting the subject capturing the returns from innovation.

It is well-known that there are great differences in the patenting activities across industrial sectors and across EU countries. In figure 1 we report a map coloured according to the patent per capita from the business sector; patents are assigned to countries according to the location of inventors as reported in the patent documents. The figure basically confirms the geography of innovation activities in the EU, as reported by other works. The leadership in technological development (patent per capita) is mainly concentrated in central and northern Europe.

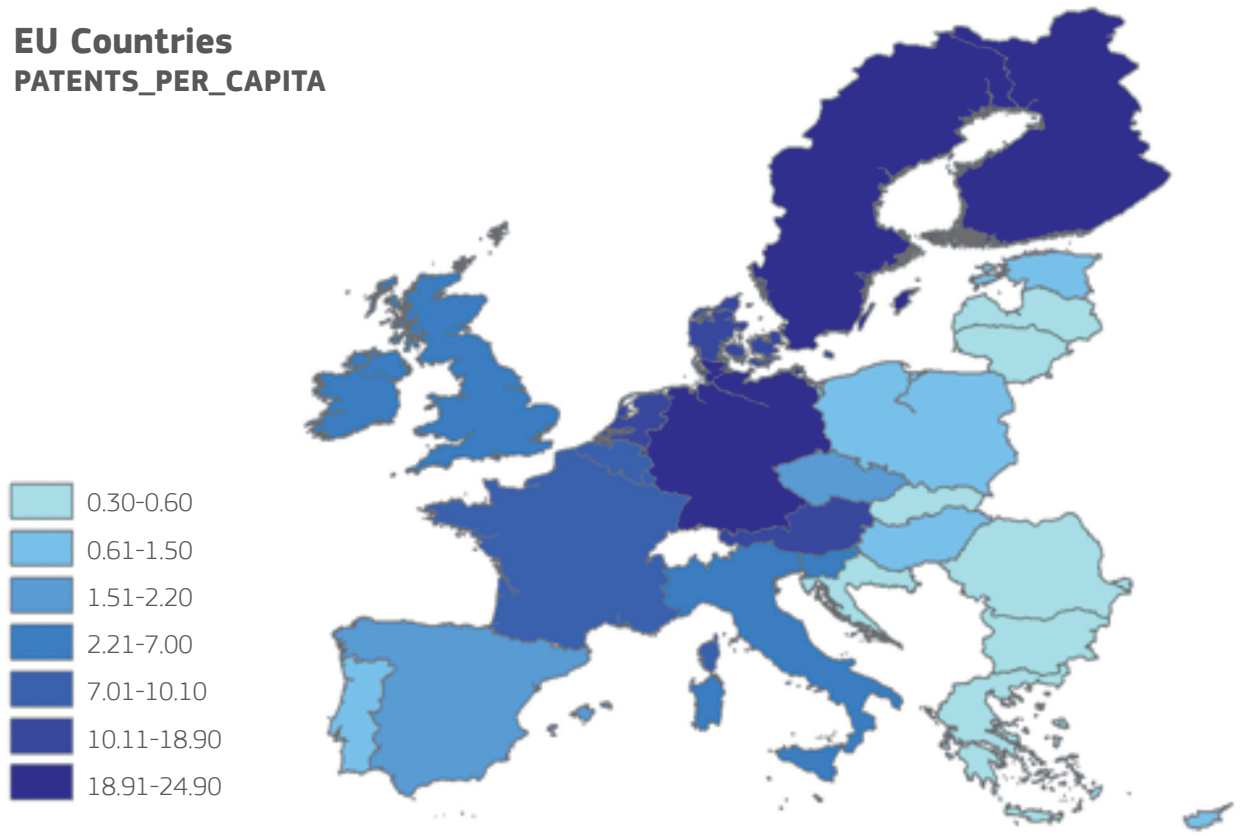


FIGURE 6.1: PATENTS PER CAPITA FROM THE BUSINESS SECTOR IN THE EU (ALLOCATED BY INVENTOR).
Note: patents are for 100,000 inhabitants. Numbers refer to the 2013-2015 period.
Source: own computation based on Patstat 2018A.

The differences between the leaders and the bottom of distribution are very large; in Sweden there where about 25 patents per 100,000 inhabitants filed at EPO during the period considered (we average numbers between 2013 and 2015), while countries in the bottom of the distribution show numbers of two orders of magnitude lower (around 0.3). All-in-all, these differences reflect differences in the capabilities and possibilities needed to produce frontier technological knowledge as well as sector specialisations. Differences are so huge that it is difficult to foresee a closing gap in the short term. However, it should also be considered that part of the differences between countries is due to differences in their industrial specialisation.[14]

Thus far, we have considered knowledge generation and we now ask: to what extent EU countries differ when considering instead knowledge exploitation?

In table 6.2 we report, the percentage difference of the number of patents allocated by applicant with respect that allocated by inventor. For countries with negative figures the number of patents computed by applicant is lower than that computed by inventor; these countries produce more knowledge that what they actually 'own'. According to this metric, EU countries can be classified in three groups: 1) those in 'deficit' (on the left part of the table); 2) those in substantial balance (difference lower than 5%), and; 3) those in 'surplus', owning more patents than that were actually invented there.

[14] Indeed, there are big differences between sectors in their propensity to patent (the number of patents per €m of R&D) that can influence aggregate figures. For example, automotive components and IT hardware have on average ten times as many patents per €m of R&D as pharmaceuticals. A more detailed analysis of the differences in patent propensity across sectors can be found in Dernis, H., Dosso, M., Hervás, F., Millot, V., Squicciarini, M., & Vezzani, A. (2015). World corporate top R&D investors: Innovation and IP bundles (No. JRC94932). Joint Research Centre (Seville site).

Countries in deficit		Countries balanced		Countries in surplus	
Romania	-85%	Denmark	-1%	Ireland	13%
Croatia	-69%	France	1%	Finland	14%
Hungary	-63%	Germany	1%	Sweden	19%
Slovakia	-49%			Netherlands	23%
Czech Republic	-40%			Cyprus	371%
Poland	-36%			Luxembourg	484%
Greece	-36%			Malta	968%
Estonia	-35%				
Lithuania	-33%				
United Kingdom	-31%				
Slovenia	-30%				
Bulgaria	-30%				
Spain	-29%				
Italy	-16%				
Portugal	-15%				
Belgium	-13%				
Latvia	-12%				
Austria	-7%				

TABLE 6.2: PERCENTAGE DIFFERENCES APPLICANTS VERSUS INVENTORS (2013-2015).
Note: relative differences when counting patents by applicant rather than by inventor.
Source: own computation on Patstat 2018A.

Three European countries show a substantial balance between patents invented and patents owned: Denmark, Germany and France. The majority of EU countries show a negative balance. In particular, the number of patent per applicant in Romania, Croatia and Hungary is less than half of that by inventors. The majority of patent invented in these countries is filed by a company based somewhere else.

Finally, the group of countries with a clear surplus in the ownership of innovation compared to its creation. Among these countries there are Finland and Sweden, top performer also when considering patents invented per capita (see map above); these two countries seems to have a very active and creative business sector. However, also countries not particularly performing in terms of patent invented belong to this group. Among these countries (Cyprus, Luxembourg and Malta), the number of patent owned is between 4 and 10 times higher than those invented.[15] Three countries – Ireland, Luxembourg and The Netherlands – host many company HQs for tax or takeover-protection reasons and this can substantially affect the figures as can the existence of 'patent box' tax reliefs in some countries.

6.3 | Inventorship-Ownership patterns in EU countries

As we said, allocating patents by inventorship or ownership may provide different pictures (and insights) on the innovation activities of the business sector across the EU. However, it is also possible to consider inventor and applicant locations to respond to questions of the kind: who owns the patents invented in EU countries?

In table 6.3, for each EU-28 member state we report the distribution of patents there invented over the applicant countries. In particular, we report the top 3 countries in term of patent ownership and their share of ownership of the overall country of inventorship patent portfolio.

[15] Companies often operate in several countries and may have diverse locations for their decision, production and innovation centres. Different location choices may be due to market strategies, optimisation of costs or fiscal purposes.

Inventor Country	First applicant country		Second applicant country		Tird applicant country	
	Country	Patent share	Country	Patent share	Country	Patent share
Austria	Austria	76%	Germany	11%	Switzerland	4%
Belgium	Belgium	62%	USA	12%	France	11%
Bulgaria	Bulgaria	55%	USA	12%	Germany	11%
Cyprus	Cyprus	67%	United Kingdom	25%	Japan	5%
Czechia	Czechia	53%	Germany	16%	Switzerland	11%
Germany	Germany	87%	USA	3%	Switzerland	3%
Denmark	Denmark	81%	Germany	8%	USA	4%
Estonia	Estonia	63%	Germany	8%	Virgin Islands	7%
Spain	Spain	70%	Germany	10%	USA	9%
Finland	Finland	88%	Switzerland	3%	Sweden	2%
France	France	82%	Switzerland	5%	Germany	3%
United Kingdom	United Kingdom	63%	USA	11%	Netherlands	5%
Greece	Greece	61%	USA	14%	Germany	6%
Croatia	Croatia	27%	United Kingdom	18%	Denmark	14%
Hungary	Hungary	31%	Germany	27%	Sweden	16%
Ireland	Ireland	42%	USA	21%	France	20%
Italy	Italy	80%	Sweden	4%	USA	4%
Lithuania	Lithuania	56%	Germany	23%	USA	8%
Luxembourg	Luxembourg	55%	USA	31%	Switzerland	6%
Latvia	Latvia	59%	Finland	14%	Germany	10%
Malta	Malta	63%	Luxembourg	15%	Belgium	5%
Netherlands	Netherlands	86%	USA	4%	Germany	3%
Poland	Poland	60%	Switzerland	12%	USA	11%
Portugal	Portugal	76%	Germany	8%	USA	3%
Romania	Germany	51%	Romania	14%	USA	13%
Sweden	Sweden	79%	Switzerland	6%	Japan	4%
Slovenia	Slovenia	65%	Germany	15%	Switzerland	6%
Slovakia	Slovakia	40%	Germany	26%	USA	7%

TABLE 6.3: COUNTRY OWNERSHIP OF EU INVENTED PATENTS (2013-2015)
Note: in the second and third column shares greater than 10% are highlighted.
Source: own computation on Patstat 2011BA.

The majority of business patents in the EU are owned by a company located in the country where inventors are, Romania being the only exception: German companies own about 51% of the patents invented there. The share of home ownership varies greatly: from the 27% of Croatia to the 88% of Finland. Companies from Croatia, Hungary, Ireland and Slovakia own less than 50% of patents invented there.[16] Particularly interesting is the case of Ireland, where the majority of patents invented there is owned by foreign companies with HQs there for tax reasons, but for which the total number of patent owned is still larger than that of those invented.

We come now to the second country in terms of ownership, as reported in the second column of the table. Germany and the US compare as the most frequent of origins of ownership (10 and 8 respectively). In some countries more than one quarter of patents invented there are owned by companies located in a single foreign country: Cyprus (UK, 25%), Slovakia (DE, 26%), Luxembourg (US, 31%), Hungary (DE, 27%).

[16] Actually, these figures may even be slightly overestimated. Indeed, subsidiaries of foreign companies can be registered in a country as local companies. As described in note 2, we cleaned names and relocated patents across countries, but not considered the ownership structure in this exercise.

Finally, in the last column we report the third country in terms of patent ownership. The US and Germany appear frequently also in this column (8 and 5 times respectively). Also Switzerland based companies own relevant shares of patents invented in the EU countries (it compares 4 times in the second column and 5 times in the third). In many cases the third country in terms of ownership still holds more than 10% of patents, hinting that for a number of countries the foreign ownership is rather geographically concentrated.

Inventors' Country	Top three patenting companies	Share of patents of top 3 companies
Austria	Zumtobel Lighting (AT)- Siemens (DE) - Borealis (AT)	10%
Belgium	Alcatel Lucent (FR)- Cnh Case New Holland Belgium (BE) - P&G Procter Gamble (US)	14%
Bulgaria	Ez As A Drink Productions (US)- Index 6 (BG) - Johnson Controls (FR)	15%
Cyprus	Ottos Consultants (CY)- Gt Gettaxi (CY) - Elysee Piping Systems (GB)	39%
Czechia	Skoda Auto (CZ)- Zentiva K S (CZ) - Siemens (DE)	15%
Germany	Siemens (DE)- Robert Bosch (DE) - Basf (DE)	12%
Denmark	Siemens (DE)- Novozymes (DK) - Novo Nordisk (DK)	17%
Estonia	Meiren Engineering (EE)- Perkinelmer Cellular Technologies (DE) - Guardtime Ip Holdings (VG)	25%
Spain	Bsh Bosch Und Siemens Hausgeraete (DE)- Hewlett Packard (US) - Telefonica (ES)	14%
Finland	Nokia (FI)- Kone Corporation (FI) - Waertsilae (FI)	31%
France	Thomson Licensing (FR)- Renault (FR) - Thales (FR)	10%
United Kingdom	Rolls Royce (GB)- Nxp Semiconductors (NL) - Jaguar/Land Rover (GB)	9%
Greece	Pharmathen (GR)- Bic Violex (GR) - Micrel Medical Devices (GR)	29%
Croatia	Yazaki Europe (GB)- Xellia Pharmaceuticals (DK) - Ericsson (SE)	41%
Hungary	Ericsson (SE)- Knorr Bremse Systems For Commercial Vehicles (DE) - Nokia (FI)	37%
Ireland	Alcatel Lucent (FR)- Connaught Electronics (IE) - Cook Medical Technologies (US)	27%
Italy	Electrolux Appliances (SE)- Nuovo Pignone (IT) - Indesit (IT)	5%
Lithuania	Thermo Fisher Scientific Baltics Uab (LT)- Uab Ekspla (LT) - Atotech Deutschland (DE)	51%
Luxembourg	Goodyear (US)- Tarkett Gdl (LU) - Paul Wurth (LU)	42%
Latvia	Sonarworks (LV)- Olainfarm (LV)	24%
Malta	Gfbiochemicals (MT)- Energy Machine Company (LU)	31%
Netherlands	Philips Electronics (NL)- Dutch State Mines Ip Assets (NL) - Nxp Semiconductors (NL)	44%
Poland	Advanced Digital Broadcast (CH)- International Tobacco Machinery Poland (PL) - Patents Factory Ltd (PL)	14%
Portugal	Novadelta Comercio e Industria De Cafes (PT)- Robert Bosch (DE) - Oliveira Irmao (PT)	19%
Romania	Continental (DE)- Renault (FR) - Honeywell International (US)	60%
Sweden	Ericsson (SE)- Volvo (SE) - Scania (SE)	33%
Slovenia	Bsh Bosch Und Siemens Hausgeraete (DE)- Lek Pharmaceuticals (SI) - Tajfun Planina Proizvodnja Strojev (SI)	20%
Slovakia	Bsh Bosch Und Siemens Hausgeraete (DE)- Continental Reifen Deutschland (DE) - Ga Drilling A S (SK)	16%

TABLE 6.4: MAIN COMPANY OWNERSHIP OF EU INVENTED PATENTS (2013-2015).[17]
Source: own computation on Patstat 2018A.

[17] Names have been retrieved from the pns_name field and further cleaned. Companies with the same name, but different locations, has been assigned to the location registering more patents. The relocation has involved relatively small number of companies with not marginal patenting activities; these companies have been manually checked.

Finally, after having looked at the country distribution of ownership we zoom in and rank the first three owners at the company level. Similarly to before, in table 6.4, for each EU-28 member state we report we report the top 3 countries in term of patent ownership and their combined share of ownership of the overall country of inventorship patent portfolio.

In some countries, the concentration of patents across private actors seems very high. For example, in Romania 60% of patents invented there are owned by only three companies. Other countries showing very high shares are Lithuania (51%) and The Netherland (44%). In the latter, Philips is by far the first actor in term of patenting activities, filing about 40% of the patent invented there.

In general, the first three companies own much lower shares. Italy is the country where patenting activity appears less concentrated (5%), followed by the United Kingdom (9%). This can be due both to differences in the way corporate groups are structured (using many different names for affiliates rather than keeping the name constant) or by a different sectoral structure of the economy or due to a stronger presence of small and medium enterprises. A visual inspection of the data suggests that the latter factor play an important role in determining the results.

7

TEN-YEAR TRENDS OF TOP **R&D PERFORMERS FROM ASIAN COUNTRIES**

7 Ten-year trends of top R&D performers from Asian countries

M&A activity towards the EU from Asian companies has grown substantially even if it is still small compared with the M&A from other regions towards the EU. Nearly all of Asia's growth of outward M&A activity is due to Chinese firms.

This chapter focuses on the contribution of corporate R&D to the rapid growth and expansion of Asian companies from the *Scoreboard* and compares this to their European and US counterparts. It looks at the trends of Scoreboard companies' foreign direct investment (FDI) by region of origin (Asia, EU, US and RoW) and region of destination. This provides additional insights on the extent to which M&A contributed to the rapid growth of Asian companies' R&D spending. This part of the analysis looks at the dynamics of M&A activity by Asian, EU and US companies, as well as the main sectors and regions of investment. For this, we use *Scoreboard* data together with data on mergers and acquisitions (M&A) from Zephyr.[18]

7.1 | Description of top R&D performers by regions

Firms in more and more countries are now investing heavily in R&D, and Asia is rapidly becoming home to global top R&D investors. Among the top 2500 R&D companies ranked in 2017, 38% are Asian-based corporations with 16% of the top 50 from Asia (12% from Japan, 2% each from S. Korea and China).

For analysing the trends of the largest R&D investing firms from the regions EU[19] , US, Asia[20] and RoW[21], we use a panel dataset that covers 10 years of R&D Scoreboard data (from 2007 to 2016) with the main variables: Sales, Employment, Capital Expenditures, R&D investments. Table 7.1 shows the averages of company characteristics by region of origin of the *Scoreboard* companies for the year 2016[22].

Region	No. of companies	R&D (€million)	R&D intensity, %	Net Sales (€million)	Employees (million)	Operating profit (€million)	Capex profit (€million)	Labour productivity (Net Sales in € per employee)	Profitability, %
Asia	803	233	3.2	7338	25221	574	524	290959	7.8
EU	515	353	3.5	10103	35024	770	710	288462	7.6
US	771	372	6.2	6026	14425	770	369	417789	12.8
RoW	175	294	4.5	6483	20123	900	524	322166	13.9
Total	**2264**	**312**	4.2	**7454**	**23380**	**711**	**509**	**318832**	9.5

TABLE 7.1: COMPANY AVERAGES BY REGION OF ORIGIN FOR THE YEAR 2016.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

[18] From Bureau van Dijk.
[19] EU28.
[20] China, Hong Kong, India, Japan, South Korea, Malaysia, Singapore and Taiwan.
[21] The rest of the countries not in the former groups, mainly Switzerland, Norway, South America, Canada, Middle East.
[22] Here, we use a subset of the top 2500 firms of the year 2016 with data available on Net Sales, Employees, and R&D.

On average, EU firms are the largest firms based on Net Sales and number of employees, followed by the Asian firms. Asian and EU firms are similar in terms of labour productivity, R&D intensity and profitability. US firms are the smallest firms based on number of employees and net sales, but are the more productive and profitable than their global counterparts.

A great part of these regional differences can be explained by the sectoral distribution within each region, as specified in Table 7.2. For example, the high proportion of firms from the Others sector group – a collection of low R&D intensive sectors – heavily weighs on the averages of the Asian and EU firms in terms of size (net sales and employees) and, subsequently, the lower R&D intensities that these regions have. On the other hand, the high R&D intensity in the US is mainly due to a high proportion of firms from the high R&D intensive Health industries amongst the top R&D investors and a much higher than average R&D intensity for the ICT Services sector group, which also has the highest proportion in the US.

	Asia				EU			
Sector	No. of companies as % of Region total	R&D €million	Net Sales €million	Employees million	No. of companies as % of Region total	R&D €million	Net Sales €million	Employees million
Aerospace & Defence	1	50	1960	22870	3	577	11565	35449
Automobiles & other transport	12	449	12708	35191	8	1315	24067	76581
Chemicals	6	162	5052	10958	4	255	11115	24010
Health industries	10	194	2447	10420	19	442	3796	13844
ICT producers	24	283	5023	23609	12	356	4235	21242
ICT services	6	218	6193	29913	10	233	5094	20846
Industrials	16	122	5049	18942	16	122	6377	30989
Others	25	193	11372	34308	29	176	16216	51588
All firms	**803**	**233**	**7338**	**25221**	**515**	**353**	**10103**	**35024**

	US				RoW			
Sector	No. of companies as % of Region total	R&D €million	Net Sales €million	Employees million	No. of companies as % of Region total	R&D €million	Net Sales €million	Employees million
Aerospace & Defence	2	537	15080	41103	5	334	4248	17326
Automobiles & other transport	5	672	15370	36729	5	379	7154	22502
Chemicals	4	209	5844	11332	6	258	7507	14140
Health industries	29	332	2905	4975	13	937	6218	15368
ICT producers	20	471	5496	13992	15	236	2884	13410
ICT services	20	440	3972	10621	11	92	2083	7802
Industrials	7	219	7366	24528	18	135	4794	21360
Others	13	195	11762	25968	27	189	11692	32204
All firms	**771**	**372**	**6026**	**14425**	**175**	**294**	**6483**	**20123**

TABLE 7.2: SECTOR DISTRIBUTION BY REGION.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

7.2 | M&A activity

Specifically for this analysis, we merged the Scoreboard companies with a dataset from Zephyr on mergers and acquisitions (M&As). This provides us with the data on each of the 11 852 M&As of the top 2500 Scoreboard companies between 2007 and 2016, such as the year of the M&A and details on the acquirer and acquired company (country and sector[23]). Table 7.3 shows the region of the acquiring Scoreboard companies and the targeted company by region of origin of all these M&As.

[23] The sectors are available on 4 digit level of the NACE classification.

Asia has the highest proportion of within region M&As (69.9%), which mitigates the idea that Asian firms acquire EU firms at a large scale in order to increase their knowledge base. Also in absolute terms, M&A activity by Asian firms towards EU firms remains rather limited, although a growing pattern can be perceived (see Figure 7.1 further down).

EU firms perform 46% of their M&A activity outside the EU, the highest of all regions. This is distributed amongst the RoW (21.1%), the US (19.6%) and a surprisingly small proportion to Asia (5.4%). The EU is the most popular destination for M&A activity by firms from RoW (27.5% - also due to the inclusion of European but non-EU firms, such as from Switzerland and Norway) and the US (18.4%), but only the second most popular destination for Asian firms (9.9% - after RoW, but before the US). Asia is the least popular region where EU, RoW and US firms perform their M&A activity: only 4-6% of M&As from companies from these regions target an Asian company.

from\to	Asia	EU	US	RoW
Asia	69.9	9.9	6.7	13.5
EU	5.4	54.0	19.6	21.1
US	4.2	18.4	63.6	13.8
RoW	5.7	27.5	20.9	46.0

TABLE 7.3: PERCENTAGE OF M&As FROM ONE REGION TO THE OTHER REGIONS.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

If we look into these data with greater detail, splitting Asia into several main countries like China, Japan, India and other Asian countries[24], we see that China has the highest within-country M&A activity: only 20% of the activity is performed outside China, of which one third targeting an EU or RoW firm and only 3.1% targeting US firms.

On the other hand, Japan shows a much more open character with a similar proportion of M&As taken place outside the country as the EU, mainly targeting EU, RoW and US companies and to a lesser extent firms within Asia. Japan is the only country with a higher proportion of its M&A activity towards China than inward M&A activity from Chinese firms.

from\to	China	Japan	Other Asia	India	EU	RoW	US	Number of M&As
China	80.1%	0.1%	2.1%	0.0%	7.7%	6.9%	3.1%	768
Japan	3.4%	55.8%	5.6%	4.2%	12.2%	9.6%	9.2%	1275
Other Asia	1.1%	1.3%	48.5%	0.5%	4.7%	40.1%	3.7%	379
India	0.0%	1.2%	2.5%	48.1%	18.5%	13.6%	16.0%	81
EU	1.8%	0.5%	1.3%	1.7%	54.0%	21.1%	19.6%	3275
RoW	1.9%	0.7%	1.6%	1.5%	27.5%	46.0%	20.9%	1373
US	1.6%	0.4%	1.0%	1.1%	18.4%	13.8%	63.6%	4701

TABLE 7.4: PERCENTAGE OF M&As BETWEEN REGIONS - WITH ASIA DISAGGREGATED IN VARIOUS MAIN COUNTRIES.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

If we look at the development over time (in absolute number of actual M&As, see Figure 7.1), we see that M&A activity by Asian firms has increased over the 10 year period of the dataset. The strongest growth is shown by M&As from Asian firms to the EU (+147% over 10 year period), and although overall over the 10 year period the EU is a secondary target region (as we saw in Table 7.3, after RoW), since 2013 the EU is the most popular destination for M&A activity from Asian firms, with also the proportion of M&As towards the US increasing. Thus, during this period, foreign M&A activity by Asian firms has both increased and shifted from mainly RoW towards the EU and US.

[24] South Korea, Malaysia, Taiwan, Hong Kong, Singapore and Thailand.

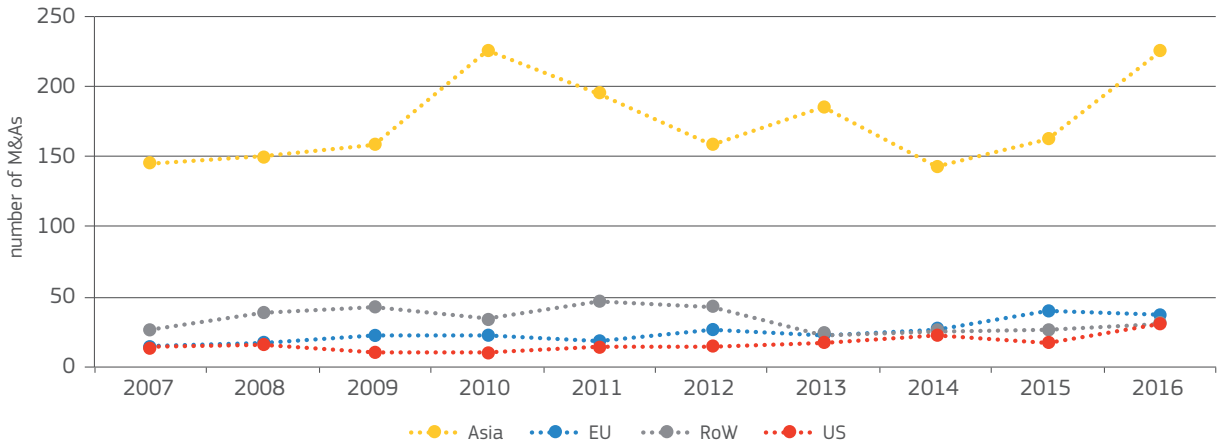


FIGURE 7.1: M&A ACTIVITY BY ASIAN FIRMS TO OTHER REGIONS
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

If we dig further into the M&A growth that Asian firms have shown by looking at the activities of the main Asian countries (China and Japan, see Figure 7.2), we can clearly see how China has become an important player in the 10 year period of our analysis and surpassed Japan in the number of within-country M&A activity by 2013. Moreover, as of 2016, China is approaching Japan in the number of M&As outside the country.

For comparison, also the tendencies of the two other major regions are depicted (with the same scale on the vertical axis). Both the EU and the US show – as Japan, but in contrary to China – very stable M&A activity, although both still on a higher level than China and Japan.

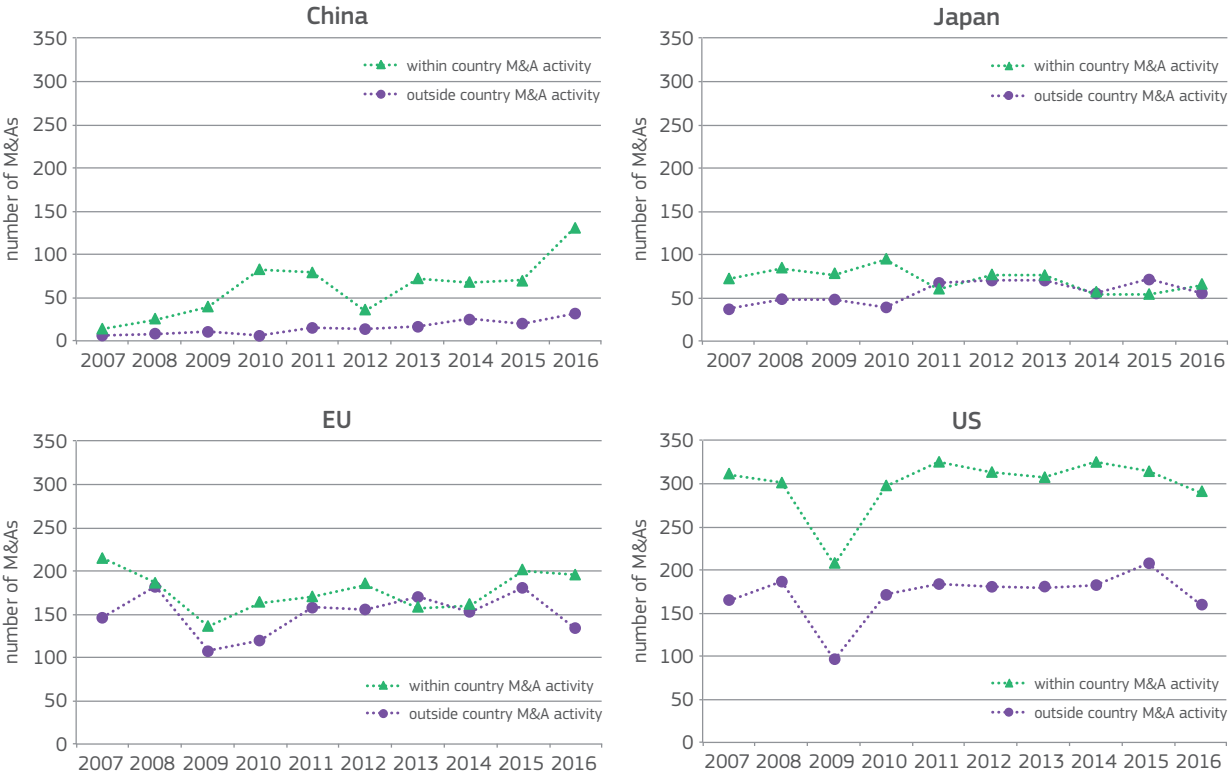


FIGURE 7.2: WITHIN-COUNTRY AND OUTWARD M&A ACTIVITY PER MAIN COUNTRY/REGION
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Thus, growth of Asian M&A activity towards the EU results almost completely from the growth of M&A activity by Chinese firms over the last 10 years. The proportion of Chinese M&A activity toward the EU has increased from 11% in 2007 (only 2 out of 18 M&As) to almost 50% in 2016 (17 out of 37) of this subset of main R&D investors from the R&D Scoreboard.

7.3 | Comparing acquiring firms with non-acquiring firms

Table 7.5 displays the ratios of R&D, Net Sales and number of employees for acquiring companies over non-acquiring companies for the 2264 of the top 2500 *Scoreboard* firms for which all these data were available for the year 2016[25]. Here, a ratio of 1.1 for R&D intensity of Asian firms means that acquiring Asian firms have an R&D intensity that is on average 1.1 times the R&D intensity of non-acquiring Asian firms in our dataset.

As becomes very clear from the table, acquiring companies tend to be larger in terms of net sales (4.1 times) and employees (2.7) and also invest significantly more than non-acquiring companies (4.0), resulting in similar R&D intensities (1.0) and higher labour productivity (1.5).

Region	R&D	Net Sales	Employees	R&D intensity	Labour productivity
Asia	3.9	3.6	2.1	1.1	1.7
China	2.1	2.5	1.4	0.8	1.8
Japan	5.0	4.4	3.7	1.2	1.2
Other Asian countries	12.4	7.6	9.0	1.6	0.8
EU	2.4	2.9	2.6	0.8	1.1
RoW	2.0	2.2	1.8	0.9	1.2
US	6.3	13.8	8.9	0.5	1.5
Total	**4.0**	**4.1**	**2.7**	**1.0**	**1.5**

TABLE 7.5: RATIO BETWEEN ACQUIRING AND NON-ACQUIRING FIRMS FOR SELECTED VARIABLES IN 2016.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

If we specify this ratio for the main countries in Asia, we see that Chinese acquiring firms had a lower R&D intensity than non-acquiring firms in 2016 (0.8), which is in contrast with their Asian counterparts and on par with EU and RoW counterparts. In fact, Chinese firms involved in M&A activity have the lowest average R&D intensity of all acquiring and non-acquiring firms: 2.3% compared to an average for all firms of 4.2% (both figures not depicted in the table). This provides evidence to the wide belief that Chinese companies are trying to increase their knowledge base by acquiring highly innovative firms.

This difference between acquiring and non-acquiring firms has been rather stable throughout the 10 year period of our dataset for all regions, except China as shown in Figure 7.2. Unfortunately, the number of firms for which R&D, Net Sales and Employment are available reduces from 2264 to 1408 firms when looking at the 10 year period 2007 to 2016. If we compare acquiring and non-acquiring firms throughout this period, we find an interesting development, as shown in the following figures.

For the EU, Japan and the US, the acquiring firms show a rather stable R&D intensity over time. For China on the other hand, the acquiring firms show a strong increasing trend, starting from a very low R&D intensity of 0.5% in 2007 to 1.9% in 2016, underpinning the idea that these firms have expanded their knowledge base by the acquisition of foreign companies. However, non-acquiring companies from China have kept on increasing their R&D intensity in a similar fashion, indicating that R&D is becoming a more and more important factor for Chinese firms in general.

[25] Here, a firm is considered as an acquiring firm from the year it has performed an M&A in our 10 year database and onwards. As such, the longer term effects of an acquisition are taken into account throughout the following years and it avoids changing subsamples from year to year. Of the 2264 firms in the sample, 1731 performed at least one acquisition over the period 2007-2016.

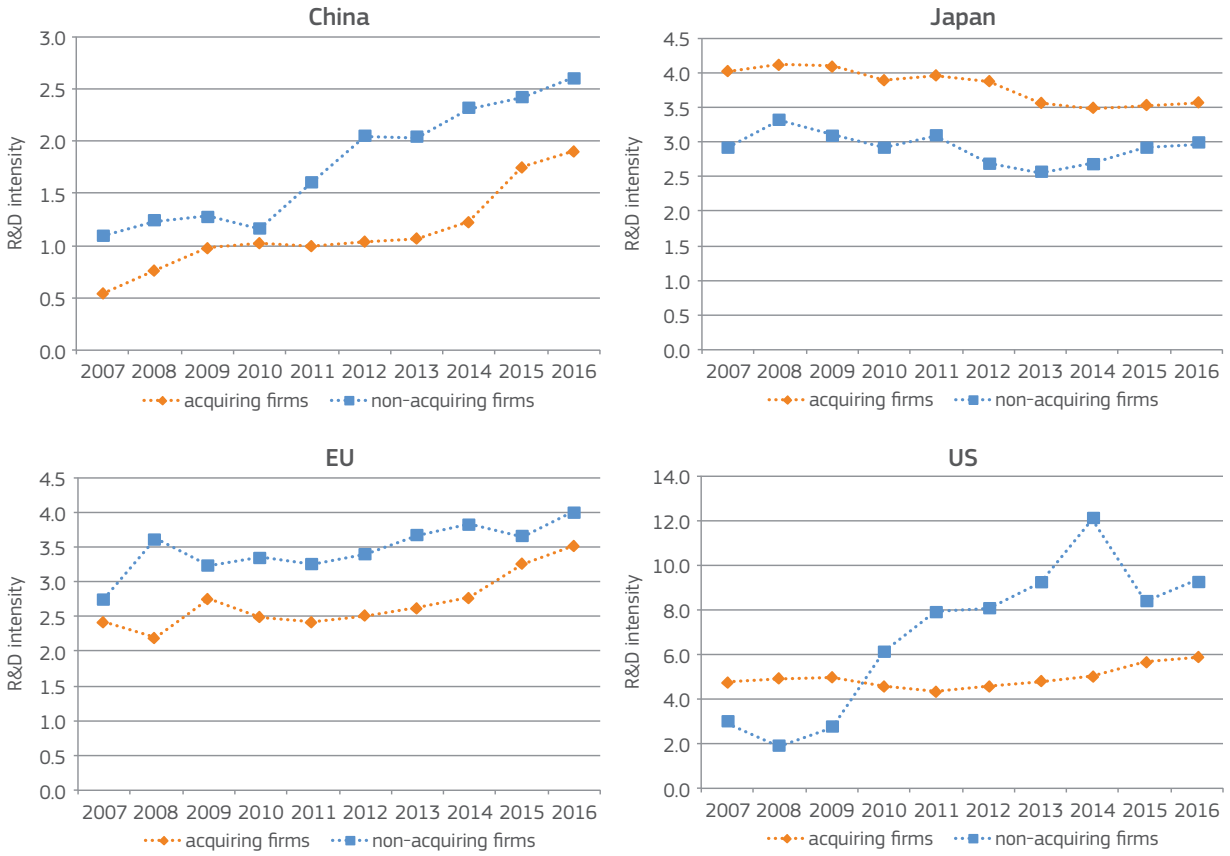


FIGURE 7.3: DEVELOPMENT OF R&D INTENSITY ACQUIRING VS – NON ACQUIRING FIRMS.
Note: scales of R&D intensity are different.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

7.4 | Sector analysis

The following table shows that there are no particular sectoral differences across regions in M&A behaviour. Firms from all sectors seem to behave similarly in all regions.

Firms from the ICT Services sector seem to be the most active in M&As across all the regions, showing a higher proportion of M&As than firms. US firms from the Health sector are much less involved in M&A activity than the proportion of firms from this sector in the US would make us expect. This can be due to the fact that the US Health sector has many private research labs, firms with low sales that concentrate on a breakthrough innovation with private funding. These firms are less involved in M&A activity.

Sector group	China		Japan		EU		US	
	% of companies	% of M&As	% of companies	% of M&As	% of companies	% of M&As	% of companies	% of M&As
Aerospace & Defence	2	2			3	4	2	5
Automobiles & other transport	11	10	12	8	8	7	5	3
Chemicals	3	2	10	11	4	6	4	4
Health industries	9	11	10	7	19	11	29	12
ICT producers	26	26	20	20	12	12	20	22
ICT services	10	16	2	6	10	13	20	28
Industrials	16	12	17	16	16	16	7	12
Others	24	21	28	32	29	32	13	13

TABLE 7.6: SECTOR GROUP OF ACQUIRING FIRMS.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

When we look at the sectors where the targeted firms[26] belong to, firms from the four regions show only a slightly different behaviour. Scoreboard firms from all four regions concentrate their M&A activities in few sectors[27]: around three quarters of all M&A activity targets only three main sectors, or in the case of the US even more than 90%.

Manufacturing is by far the most targeted sector, especially in Asia. The strength of the US Information & Communication sectors (roughly comparable to the ICT Services sector in ICB classification) is shown by the high M&A activity of US firms: 41% of M&As target a firm from this sector in the US.

Asia		EU		US		RoW	
target sector	**%**	**target sector**	**%**	**target sector**	**%**	**target sector**	**%**
Manufacturing	55	Manufacturing	41	Manufacturing	43	Manufacturing	44
Information & Communication	14	Information & Communication	22	Information & Communication	41	Information & Communication	23
Financial & Insurance Activities	9	Professional, Scientific & Technical Activities	10	Professional, Scientific & Technical Activities	8	Wholesale & Retail Trade	9
Top 3 target sectors	78	Top 3 target sectors	73	Top 3 target sectors	92	Top 3 target sectors	76

TABLE 7.7: RATIO BETWEEN ACQUIRING AND NON-ACQUIRING FIRMS FOR SELECTED VARIABLES IN 2016.
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

[26] Unfortunately, looking at acquiring vs targeted regions including also the sectoral dimension leaves us with too few observations for analysis.

[27] Due to data limitations, only NACE Rev 2 sector classification is available for targeted firms. This sector classification is not directly comparable with ICB classification as used in the remainder of the Scoreboard.

ANNEXES

- **A1** – BACKGROUND INFORMATION
- **A2** – METHODOLOGICAL NOTES
- **A3** – COMPLEMENTARY TABLES
- **A4** – ACCESS TO THE FULL DATASET

A.1 Background information

Investment in research and innovation is at the core of the EU policy agenda. The Europe 2020 growth strategy includes the Innovation Union flagship initiative[28] with a 3 % headline target for intensity of research and development (R&D)[29]. R&D investment from the private sector plays also a key role for other relevant Europe 2020 initiatives such as the Industrial Policy[30], Digital Agenda and New Skills for New Jobs flagship initiatives.

The project "Global Industrial Research & Innovation Analyses" (GLORIA)[31] supports policymakers in these initiatives and monitors progress towards the 3 % headline target. The *Scoreboard,* as part of the GLORIA project, aims to improve the understanding of trends in R&D investment by the private sector and the factors affecting it.

The annual publication of the *Scoreboard* is intended to raise awareness of the importance of R&D for businesses and to encourage firms to disclose information about their R&D investments and other intangible assets.

The data for the *Scoreboard* are taken from companies' publicly available audited accounts. As in more than 99% of cases these accounts do not include information on the place where R&D is actually performed, the company's whole R&D investment in the *Scoreboard* is attributed to the country in which it has its registered office[32]. This should be borne in mind when interpreting the *Scoreboard*'s country classifications and analyses.

The *Scoreboard*'s approach is, therefore, fundamentally different from that of statistical offices or the OECD when preparing business enterprise expenditure on R&D data, which are specific to a given territory. The R&D financed by business sector in a given territorial unit (BES-R&D) includes R&D performed by all sectors in that territorial unit[33]. **Therefore, the *Scoreboard* R&D figures are comparable to BES-R&D data only at the global level.**

The *Scoreboard* data are primarily of interest to those concerned with benchmarking company commitments and performance (e.g. companies, investors and policymakers), while BES-R&D data are primarily used by economists, governments and international organisations interested in the R&D performance of territorial units defined by political boundaries. The two approaches are therefore complementary. The methodological approach of the *Scoreboard*, its scope and limitations are further detailed in Annex 2 below.

Scope and target audience

The *Scoreboard* is a benchmarking tool which provides reliable up-to-date information on R&D investment and other economic and financial data, with a unique EU-focus. The 2500 companies listed in this year's *Scoreboard* account for more than 90%[34] of worldwide R&D funded by the business enterprise sector and the *Scoreboard* data refer to a more recent period than the latest available official statistics. Furthermore, the

[28] The Innovation Union flagship initiative aims to strengthen knowledge and innovation as drivers of future growth by refocusing R&D and innovation policies for the main challenges society faces.

[29] This target refers to the EU's overall (public and private) R&D investment approaching 3 % of gross domestic product (see: http://ec.europa.eu/europe2020/pdf/targets_en.pdf).

[30] The Industrial Policy for the Globalisation Era flagship initiative aims to improve the business environment, notably for small and medium-sized enterprises, and support the development of a strong and sustainable industrial foundation for global competition.

[31] GLORIA builds on the IRIMA project (Industrial Research and Innovation Monitoring and Analysis). See: http://iri.jrc.ec.europa.eu/home /. The activity is undertaken jointly by the Directorate General for Research (DG RTD A; see: http://ec.europa.eu/research/index.cfm?lg=en) and the Joint Research Centre, Directorate Growth and Innovation (JRC-Seville; see: https://ec.europa.eu/jrc/en/science-area/innovation-and-growth).

[32] The registered office is the company address notified to the official company registry. It is normally the place where a company's books are kept.

[33] The *Scoreboard* refers to all R&D financed by a company from its own funds, regardless of where the R&D is performed. BES-R&D refers to all R&D activities funded by businesses and performed by all sectors within a particular territory, regardless of the location of the business's headquarters. The sources of data also differ: the *Scoreboard* collects data from audited financial accounts and reports whereas BES-R&D typically takes a stratified sample, covering all large companies and a representative sample of smaller companies. Additional differences concern the definition of R&D intensity (BES-R&D uses the percentage of R&D in value added, while the *Scoreboard* considers the R&D/Sales ratio).

[34] According to latest Eurostat statistics.

dataset is extended to cover the top 1000 R&D investing companies in the EU.

The data in the *Scoreboard*, published since 2004, allow long-term trend analyses, for instance, to examine links between R&D and business performance.

The *Scoreboard* is aimed at three main audiences.

- **Companies** can use the *Scoreboard* to benchmark their R&D investments and so find where they stand in the EU and in the global industrial R&D landscape. This information could be of value in shaping business or R&D strategy and in considering potential mergers and acquisitions.
- **Investors and financial analysts** can use the *Scoreboard* to assess investment opportunities and risks.
- **Policy-makers, government and business organisations** can use R&D investment information as an input to policy formulation or other R&D-related actions such as R&D tax incentives.

Furthermore, the *Scoreboard* dataset has been made freely accessible so as to encourage further economic and financial analyses and research by any interested parties.

A.2 Methodological notes

The data for the 2018 *Scoreboard* have been collected from companies' annual reports and accounts by Bureau van Dijk – A Moody's Analytics Company (BvD). The source documents, annual reports & accounts, are public domain documents and so the *Scoreboard* is capable of independent replication. In order to ensure consistency with our previous *Scoreboards*, BvD data for the years prior to 2012 have been checked with the corresponding data of the previous *Scoreboards* adjusted for the corresponding exchange rates of the annual reports.

Main characteristics of the data

The data correspond to companies' latest published accounts, intended to be their 2016 fiscal year accounts, although due to different accounting practices throughout the world, they also include accounts ending on a range of dates between late 2015 and mid-2017. Furthermore, the accounts of some companies are publicly available more promptly than others. Therefore, the current set represents a heterogeneous set of timed data.

In order to maximise completeness and avoid double counting, the consolidated group accounts of the ultimate parent company are used. Companies which are subsidiaries of any other company are not listed separately. Where consolidated group accounts of the ultimate parent company are not available, subsidiaries are included.

In the case of a demerger, the full history of the continuing entity is included. The history of the demerged company can only go back as far as the date of the demerger to avoid double counting of figures.

In case of an acquisition or merger, pro forma figures for the year of acquisition are used along with pro-forma comparative figures if available.

The R&D investment included in the *Scoreboard* is the cash investment which is funded by the companies themselves. It excludes R&D undertaken under contract for customers such as governments or other companies. It also excludes the companies' share of any associated company or joint venture R&D investment when disclosed. However, it includes research contracted out to other companies or public research organisations, such as universities.

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.

Companies are allocated to the country of their registered office. In some cases this is different from the operational or R&D headquarters. This means that the results are independent of the actual location of the R&D activity.

Companies are assigned to industry sectors according to the NACE Rev. 2[35] and the ICB (Industry Classification Benchmark). In the *Scoreboard* report we use different levels of sector aggregation, according to the distribution of companies' R&D and depending on the issues to be illustrated. In chapter 1, Tables 1.2 and 1.3 describe two typical levels of the industrial classification applied in the *Scoreboard*.

Limitations

Users of the *Scoreboard* data should take into account the methodological limitations, especially when performing comparative analyses (see summary of main limitation in Box A2.1 below).

[35] NACE is the acronyme for "Nomenclature statistique des activités économiques dans la Communauté européenne".

The *Scoreboard* relies on disclosure of R&D investment in published annual reports and accounts. Therefore, companies which do not disclose figures for R&D investment or which disclose only figures which are not material enough are not included in the *Scoreboard*. Due to different national accounting standards and disclosure practice, companies of some countries are less likely than others to disclose R&D investment consistently. There is a legal requirement to disclose R&D in company annual reports in some countries.

In some countries, R&D costs are very often integrated with other operational costs and can therefore not be identified separately. For example, companies from many Southern European countries or the new Member States are under-represented in the *Scoreboard*. On the other side, UK companies could be over-represented in the *Scoreboard*.

For listed companies, country representation will improve with IFRS adoption.

The R&D investment disclosed in some companies' accounts follows the US practice of including engineering costs relating to product improvement. Where these engineering costs have been disclosed separately, they have been excluded from the *Scoreboard*. However, the incidence of non-disclosure is uncertain and the impact of this practice is a possible overstatement of some overseas R&D investment figures in comparison with the EU.

Where R&D income can be clearly identified as a result of customer contracts it is deducted from the R&D expense stated in the annual report, so that the R&D investment included in the *Scoreboard* excludes R&D undertaken under contract for customers such as governments or other companies. However, the disclosure practise differs and R&D income from customer contracts cannot always be clearly identified. This means a possible overstatement of some R&D investment figures in the *Scoreboard* for companies with directly R&D related income where this is not disclosed in the annual report.

In implementing the definition of R&D, companies exhibit variability arising from a number of sources: i) different interpretations of the R&D definition. Some companies view a process as an R&D process while other companies may view the same process as an engineering or other process; ii) different companies' information systems for measuring the costs associated with R&D processes; iii) different countries' fiscal treatment of costs.

Interpretation

There are some fundamental aspects of the *Scoreboard* which affect their interpretation.

The focus of the *Scoreboard* on R&D investment as reported in group accounts means that the results can be independent of the location of the R&D activity. The *Scoreboard* indicates the level of R&D funded by companies, not all of which is carried out in the country in which the company is registered. This enables inputs such as R&D and Capex investment to be related to outputs such as Sales, Profits, productivity ratios and market capitalisation.

The data used for the *Scoreboard* are different from data provided by statistical offices, e.g. the R&D expenditures funded by the business enterprise sector and performed by all sectors within a given territorial unit (BES-R&D). The *Scoreboard* refers to all R&D financed by a particular company from its own funds, regardless of where that R&D activity is performed. BES-R&D refers to all R&D activities funded by businesses and performed within a particular territory, regardless of the location of the business's headquarters. ***Therefore, the Scoreboard R&D figures are directly comparable to BES-R&D data only at the global level.***

Further, the *Scoreboard* collects data from audited financial accounts and reports. BES-R&D typically takes a stratified sample, covering all large companies and a representative sample of smaller companies. Additional differences concern the definition of R&D intensity (BES-R&D uses the percentage of value added, while the *Scoreboard* measures it as the R&D/Sales ratio) and the sectoral classification they use (BES-R&D follows NACE, the European statistical classification of economic sectors, while the *Scoreboard* classifies companies' economic activities according to the ICB classification).

Sudden changes in R&D figures may arise because a change in company accounting standards. For example,

the first time adoption of IFRS[36], may lead to information discontinuities due to the different treatment of R&D, i.e. R&D capitalisation criteria are stricter and, where the criteria are met, the amounts must be capitalised.

For many highly diversified companies, the R&D investment disclosed in their accounts relates only to part of their activities, whereas sales and profits are in respect of all their activities. Unless such groups disclose their R&D investment additional to the other information in segmental analyses, it is not possible to relate the R&D more closely to the results of the individual activities which give rise to it. The impact of this is that some statistics for these groups, e.g. R&D as a percentage of sales, are possibly underestimated and so comparisons with non-diversified groups are limited.

At the aggregate level, the growth statistics reflect the growth of the set of companies in the current year set. Companies which may have existed in the base year but which are not represented in the current year set are not part of the *Scoreboard* (a company may continue to be represented in the current year set if it has been acquired by or merged with another but will be removed for the following year's *Scoreboard*).

For companies outside the Euro area, all currency amounts have been translated at the Euro exchange rates ruling at *31 December 2017* as shown in Table A2.1[37]. The exchange rate conversion also applies to the historical data. The result is that over time the *Scoreboard* reflects the domestic currency results of the companies rather than economic estimates of current purchasing parity results. The original domestic currency data can be derived simply by reversing the translations at the rates above. Users can then apply their own preferred current purchasing parity transformation models.

Country	As of 31 Dec 2016	As of 31 Dec 2017
Australia	$ 1.46	**$ 1.54**
Brazil	3.43 Brazilian real	**3.97 Brazilian real**
Canada	$ 1.42	**$ 1.51**
China	7.33 Renminbi	**7.81 Renminbi**
Czech Republic	27.03 Koruna	**25.54 Koruna**
Denmark	7.43 Danish Kronor	**7.44 Danish Kronor**
Hungary	309.6 Forint	**310.6 Forint**
Hong Kong	8.33 HKD	**9.37 HKD**
India	71.63 Indian Rupee	**76.69 Indiana Rupee**
Iraq	1250 IQD	**1428.57 IQD**
Japan	123.15 Yen	**135.32 Yen**
Malaysia	4.72 Ringgit	**4.87 Ringgit**
Mexico	21.85 Mexican Peso	**23.73 Mexican Peso**
New Zeland	1.52 NZD	**1.69 NZD**
Norway	9.09 Norwegian Kronor	**9.85 Norwegian Kronor**
Poland	4.41 Zloty	**4.18 Zloty**
Russia	63.94 Rouble	**69.06 Rouble**
Saudi Arabia	3.95 SAR	**4.50 SAR**
Singapore	1.52 SGD	**1.60 SGD**
South Africa	14.42 ZAR	**14.79 ZAR**
South Korea	1265.82 Won	**1282.05 Won**
Sweden	9.55 Swedish Kronor	**9.84 Swedish Kronor**
Switzerland	1.07 Swiss Franc	**1.17 Swiss Franc**
Taiwan	$ 34.05 new dollar	**$ 35.79 new dollar**
Thailand	37.71 THB	**39.20 THB**
Turkey	3.17 Turkish lira	**4.53 Turkish lira**
UK	**£** 0.86	**£ 0.89**
US	$ 1.05	**$ 1.20**
United Arab Emirates	3.86 Dirham	**4.40 Dirham**

TABLE A2.1: EURO EXCHANGE RATES APPLIED TO *SCOREBOARD* DATA FOR COMPANIES REPORTING IN DIFFERENT CURRENCIES (AS OF 31 DEC 2017).
Source: The 2018 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

[36] Since 2005, the European Union requires all listed companies in the EU to prepare their consolidated financial statements according to IFRS (International Financial Reporting Standards, see: http://www.iasb.org/).

[37] Companies from some countries report their data in US dollars, e.g. in this edition, all companies based in Israel present their results in US dollars.

Box A2.1
Methodological caveats

Users of *Scoreboard* data should take into account the methodological limitations summarised here, especially when performing comparative analyses:

A typical problem arises when comparing data from different currency areas. The *Scoreboard* data are nominal and expressed in Euros with all foreign currencies converted at the exchange rate of the year-end closing date (31.12.2017). The variation in the exchange rates from the previous year directly affects the ranking of companies, favouring those based in countries whose currency has appreciated with respect to the other currencies. In this reporting period, the exchange rate of the Euro appreciated by 14% and 10% against the US dollar and the Japanese Yen respectively, and appreciated by 3% against the pound sterling. However, ratios such as R&D intensity or profitability (profit as % sales) are based on the ratio of two quantities taken from a company report where they are both expressed in the same currency and are therefore less affected by currency changes.

The growth rate of the different indicators for companies operating in markets with different currencies is affected in a different manner. In fact, companies' consolidated accounts have to include the benefits and/or losses due to the appreciation and/or depreciation of their investments abroad. The result is an 'apparent' rate of growth of the given indicator that understates or overstates the actual rate of change. For example, this year the R&D growth rate of companies based in the Euro area with R&D investments in the US is partly understated because the 'losses' of their overseas investments due to the appreciation of the Euro against the US dollar (from $1.05 to $1.2). Conversely, the R&D growth rate of US companies is partly overstated due to the 'benefits' of their investments in the Euro area. Similar effects of understating or overstating figures would happen for the growth rates of other indicators, such as net sales.

When analysing data aggregated by country or sector, be aware that in many cases, the aggregate indicator depends on the figures of a few firms. This is due, either to the country's or sector's small number of firms in the *Scoreboard* or to the indicator dominated by a few large firms.

The different editions of the *Scoreboard* are not directly comparable because of the year-on-year change in the composition of the sample of companies, i.e. due to newcomers and leavers. Every *Scoreboard* comprises data of several financial years (8 years since 2012 and 10 years since 2017) allowing analysis of trends for the same sample of companies.

In most cases companies' accounts do not include information on the place where R&D is actually performed; consequently the approach taken in the *Scoreboard* is to attribute each company's total R&D investment to the country in which the company has its registered office or shows its main economic activity. This should be borne in mind when interpreting the *Scoreboard*'s country classification and analyses.

Growth in R&D can either be organic, the outcome of acquisitions or a combination of the two. Consequently, mergers and acquisitions (or de-mergers) may sometimes underlie sudden changes in specific companies' R&D and sales growth rates and/or positions in the rankings.

Other important factors to take into account include the difference in the various countries' (or sectors') business cycles which may have a significant impact on companies' investment decisions, and the initial adoption or stricter application of the International Financial Reporting Standards (IFRS)[38].

[38] Since 2005, the European Union requires all listed companies in the EU to prepare their consolidated financial statements according to IFRS (see: EC Regulation No 1606/2002 of the European Parliament and of the Council of 19 July 2002 on the application of international accounting standards at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002R1606:EN:HTML).

Glossary

1. **Research and Development (R&D) investment** in the *Scoreboard* is the cash investment funded by the companies themselves. It excludes R&D undertaken under contract for customers such as governments or other companies. It also excludes the companies' share of any associated company or joint venture R&D investment. However, it includes research contracted out to other companies or public research organisations, such as universities. Being that disclosed in the annual report and accounts, it is subject to the accounting definitions of R&D. For example, a definition is set out in International Accounting Standard (IAS) 38 "Intangible assets" and is based on the OECD "Frascati" manual. **Research** is defined as original and planned investigation undertaken with the prospect of gaining new scientific or technical knowledge and understanding. Expenditure on research is recognised as an expense when it is incurred. **Development** is the application of research findings or other knowledge to a plan or design for the production of new or substantially improved materials, devices, products, processes, systems or services before the start of commercial production or use. Development costs are capitalised when they meet certain criteria and when it can be demonstrated that the asset will generate probable future economic benefits. 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.

2. R&D expenditures funded by the business enterprise sector (**BES-R&D**), provided by official statistics, refer to the total R&D performed within a territorial unit that has been funded by the business enterprise sector (private or public companies).

3. **Net sales** follow the usual accounting definition of sales, excluding sales taxes and shares of sales of joint ventures & associates. For banks, sales are defined as the "Total (operating) income" plus any insurance income. For insurance companies, sales are defined as "Gross premiums written" plus any banking income.

4. **R&D intensity** is the ratio between R&D investment and net sales of a given company or group of companies. At the aggregate level, R&D intensity is calculated only by those companies for which data exist for both R&D and net sales in the specified year. The calculation of R&D intensity in the *Scoreboard* is different from than in official statistics, e.g. BES-R&D, where R&D intensity is based on value added instead of net sales.

5. **Operating profit** is calculated as profit (or loss) before taxation, plus net interest cost (or minus net interest income) minus government grants, less gains (or plus losses) arising from the sale/disposal of businesses or fixed assets.

6. **One-year growth** is simple growth over the previous year, expressed as a percentage: 1 yr growth = 100*((C/B)-1); where C = current year amount, and B = previous year amount. 1yr growth is calculated only if data exist for both the current and previous year. At the aggregate level, 1yr growth is calculated only by aggregating those companies for which data exist for both the current and previous year.

7. **Capital expenditure (Capex)** is expenditure used by a company to acquire or upgrade physical assets such as equipment, property, industrial buildings. In accounts capital expenditure is added to an asset account (i.e. capitalised), thus increasing the asset's base. It is disclosed in accounts as additions to tangible fixed assets.

8. **Number of employees** is the total consolidated average employees or year-end employees if average not stated.

A.3 Complementary tables

Rank	Sector	R&D in 2017/18, € bn	One-year change, %	Net Sales, € bn	One-year change, %	R&D intensity, %	Operating profits, € bn	One-year change, %	Profitability, %	Employees, million	One-year change, %
1	Pharmaceuticals & Biotechnology	138.9	7.6	911.7	5.1	15.0	132.0	-10.6	14.9	2.5	2.3
2	Technology Hardware & Equipment	117.2	10.8	1348.4	10.7	8.7	177.9	18.4	14.0	3.7	1.2
3	Automobiles & Parts	117.0	7.1	2590.4	7.3	4.5	167.5	10.8	6.5	7.4	3.7
4	Software & Computer Services	94.4	13.6	1116.8	14.3	8.4	171.7	17.4	15.4	3.7	5.9
5	Electronic & Electrical Equipment	57.3	12.4	1174.1	10.0	4.9	126.6	32.9	10.8	5.0	3.7
6	Industrial Engineering	26.7	6.1	828.6	8.8	3.2	73.4	38.1	9.1	3.3	2.9
7	Chemicals	21.5	5.1	826.8	13.1	2.6	100.1	17.4	12.2	1.7	1.7
8	General Industrials	20.0	-0.6	689.7	6.0	2.9	50.8	-9.2	7.4	2.3	-4.1
9	Aerospace & Defence	19.0	-4.3	474.8	2.4	4.0	48.8	21.9	10.3	1.6	0.1
10	Health Care Equipment & Services	14.7	8.5	404.8	6.7	3.6	35.2	2.5	8.7	1.3	6.4
11	Leisure Goods	14.0	1.7	249.9	10.5	5.6	21.2	38.6	8.5	0.8	0.2
12	Construction & Materials	13.0	12.1	944.0	7.7	1.4	85.0	54.2	9.0	3.1	1.7
13	Banks	10.3	2.2	386.9	2.3	2.7	104.0	55.4	30.8	1.6	4.7
14	Fixed Line Telecommunications	8.4	4.9	490.4	0.8	1.7	66.2	4.0	13.7	1.3	-0.9
15	Oil & Gas Producers	7.9	2.4	2119.3	21.3	0.4	122.9	274.1	5.8	2.2	-1.9
Total 39 industries		**736.4**	**8.3**	**18448.0**	**9.8**	**4.0**	**1909.3**	**22.6**	**10.5**	**55.0**	**2.1**

TABLE A3.1: MAIN STATISTICS FOR THE 2018 *SCOREBOARD* SAMPLE OF WORLD COMPANIES AGGREGATED BY INDUSTRIAL SECTORS (TOP 15 SECTORS, ICB 3-DIGITS).
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

The analysis of chapter 5 applies an extended sample of 1000 companies based in the EU. It consists of 577 companies included in the world R&D ranking of top 2500 companies and additional 423 companies also ranked by level of R&D investment. The composition by country and industry of the EU 1000 sample is presented in the table A3.2 below.

Industry	Country codes																			
	AT	BE	CZ	DE	DK	ES	FI	FR	GR	HU	IE	IT	LU	MT	NL	PL	PT	SE	SI	UK	Total
Aerospace & Defence			1	3		1	1	5				1			2			1		9	24
Alternative Energy				3	2								1								6
Automobiles & Parts	3			20		1	1	5				5			3			3		8	49
Banks		2		5	2	1			1		2	2			2		2	2		3	24
Beverages		1			1															2	4
Chemicals	2	3		15			2	2							3	1		3		10	41
Construction & Materials	3	3		7	1	4	2	4			2	1	1		1			3		3	35
Electricity	1	1	1	1		2	2	1				2					1	1		3	16
Electronic & Electrical Equipment	3	3		15	2		3	8			1	4	2		5			4		15	65
Financial Services				5				1			1				1			3		3	14
Fixed Line Telecommunications				1	1	1		1				1			1			1		1	8
Food & Drug Retailers															1					3	4
Food Producers	1			2	1		2	3			2				5					9	25
Forestry & Paper		1					3											1		1	6
Gas, Water & Multiutilities	1			2	1			3				1								4	12
General Industrials	1	1		13			1	1			1	1	1		2			5		7	34
General Retailers		1		5				2												9	17
Health Care Equipment & Services		1		11	3			4			2				1			3		12	37
Household Goods & Home Construction				6			1	3				2	1					1	1	3	18
Industrial Engineering	5	1		34	2	2	7	9			2	7	2		5			11		8	95
Industrial Metals & Mining	2	4		4		1	1	1					3		1			2			19
Industrial Transportation				1	1			3				2						1		2	10
Leisure Goods				1	2		1									1		1		3	9
Life Insurance				1																2	3
Media								5										1		7	13
Mining													1					2		2	5
Mobile Telecommunications		1		2			1													3	7
Nonlife Insurance				1				1												1	3
Oil & Gas Producers	1					1	1	1				1								3	8
Oil Equipment, Services & Distribution								1			1		1		1						4
Personal Goods				5				2				4	1								12
Pharmaceuticals & Biotechnology	1	9		14	12	4	2	22	1	1	10	5			9	1	1	11	1	50	154
Real Estate Investment & Services	1			4	3			1					2		1					5	17
Software & Computer Services	2			19	6	2	4	17					1		3	1		6		48	109
Support Services	1			10				1			1		1		1			2		20	37
Technology Hardware & Equipment	3	2		6	2		1	4	1		1				5			7		11	43
Tobacco																		1		1	2
Travel & Leisure	1			3							1			1				1		4	11
Total	**32**	**34**	**2**	**219**	**42**	**20**	**36**	**111**	**3**	**1**	**27**	**39**	**18**	**1**	**53**	**4**	**4**	**77**	**2**	**275**	**1000**

TABLE A3.2: DISTRIBUTION OF THE SAMPLE OF 1000 COMPANIES BASED IN THE EU BY COUNTRY AND INDUSTRY.
Source: The 2018 EU Industrial R&D Investment Scoreboard. European Commission. JRC/DG RTD.

A.4 Access to the full dataset

The 2018 *Scoreboard* comprises two data samples:

- The world's top 2500 companies that invested more than €25 million in R&D in 2017/18.
- The top 1000 R&D investing companies based in the EU with R&D investment exceeding €8 million.

For each company the following information is available:

- Company identification (name, country of registration and sector of declared activity according to the *Scoreboard* sector classification).
- R&D investment
- Net Sales
- Capital expenditure
- Operating profit or loss
- Total number of employees
- Market capitalisation (for listed companies)
- Main company indicators (R&D intensity, Capex intensity, Profitability)
- Growth rates of main indicators over one year.

The following links provide access to the two *Scoreboard* data samples containing the main economic and financial indicators and main statistics over the past year.

R&D ranking of world top 2500 companies

R&D ranking of EU top 1000 companies

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