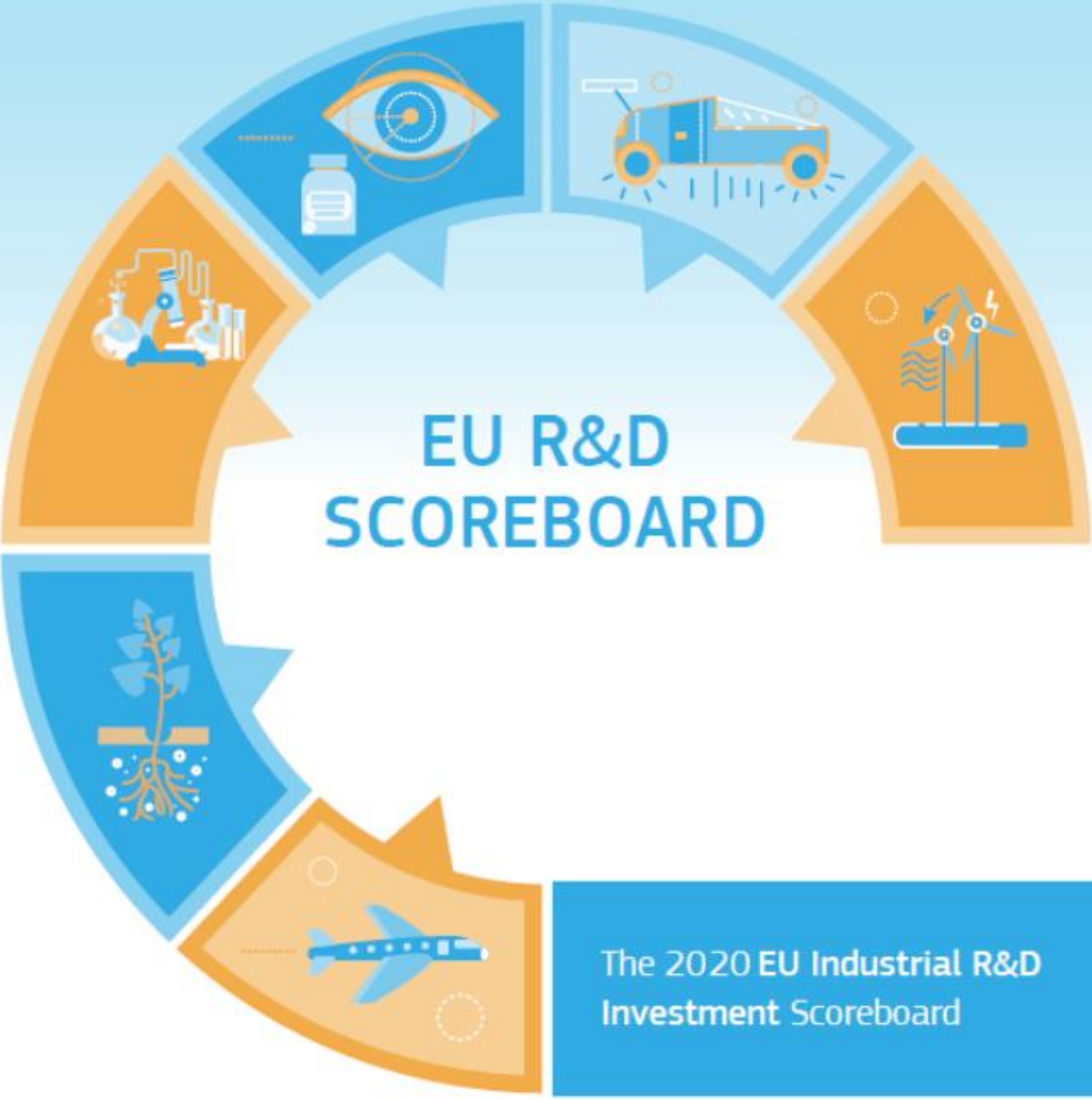
European Commission



EU R&D SCOREBOARD

The 2020 **EU Industrial R&D Investment** Scoreboard

EUR 30519 EN

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SUMMARY

The main objective of the EU Industrial R&D Investment Scoreboard (the *Scoreboard*) is to benchmark the performance of EU innovation-driven industries against major global counterparts.

The 2020 edition of the *Scoreboard* analyses the 2500 companies that invested the largest sums into R&D worldwide in 2019. These companies, with headquarters in 43 countries, and more than 800k subsidiaries all over the world, each invested over €34.7 million in R&D in 2019. The total investment across all 2500 companies was €904.2bn. Compared to the previous one, the main difference in data presentation within this *Scoreboard* edition relates to the EU's new membership composition following the departure of the UK on 31 January 2020[1]. Henceforth, in this report, **the EU is understood as EU27** (i.e., without the UK), and whenever the UK is included for comparative purposes, EU28 will be referred to.

The 2020 *Scoreboard* total R&D is equivalent to approximately 90% of the world's business-funded R&D. It includes 421 companies based in the EU (accounting for 20.9% of the total R&D in the sample), 775 US companies (38.5%), 309 Japanese companies (12.7%), 536 Chinese (13.1%) and 459 from the rest of the world (14.8%)[2].

This report analyses companies' R&D and economic indicators over recent years, focusing on the comparative performance of EU companies and their global counterparts.

In 2019, global corporate R&D continued to increase substantially, following the trends of recent years, despite a slowdown in companies' sales and a decline in profits. This is the tenth consecutive year of R&D growth driven by investments in the ICT, health, and automotive industries[3]. Companies based in the EU significantly increased their R&D (5.6%) in 2019, but this growth was well below the rates of US (10.8%) and Chinese companies (21%).

The impact of the COVID-19 crisis is not yet reflected in this edition as it uses data referring mostly to 2019. However, history demonstrates the important role that R&D plays in tackling major socio-economic issues and in reinforcing recovery and competitiveness. Indeed, past *Scoreboard* editions showed that companies which sustained or increased their R&D investment during previous crises emerged with a greatly improved competitive position in the aftermath of the crisis.

The *Scoreboard* results stress the need to step up the implementation of EU policies aimed at supporting industrial R&D and innovation, particularly in supporting recovery from the COVID-19 crisis, as well as the industrial digital and green transitions.

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_Union_(EU)

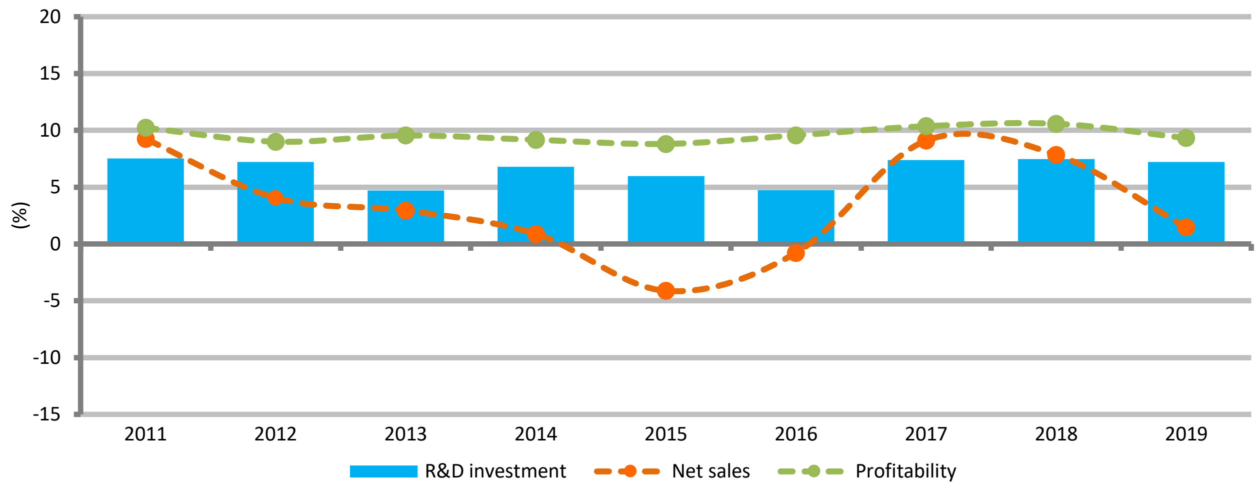
[2] The rest of the world (RoW) group comprises companies from UK (121),Taiwan (83), South Korea (59), Switzerland (58), Canada (30), India (29), Israel (21) and companies based in a further 17 countries.

[3] In the context of the report, automotive industries is used as synonymous for "Automobile and & other transports

Key findings

Worldwide investment in R&D continued to increase significantly in 2019 for the tenth consecutive year. The 2500 companies investigated for the *Scoreboard* invested a total of €904.7bn in R&D in 2019, 8.9% more than in 2018, the same increase of the year before. Companies based in the EU increased R&D by 5.6%, below the growth rate of US (10.8%) and Chinese (21.0%) companies, and above that of Japanese (1.8%) and the rest of the world (5.1%). Figure S1 shows the ten-year global trends of R&D, sales, and profitability. Figure S2 shows the one-year growth of R&D for the main world countries/regions: the EU, US, Japan, China, and the rest of the world (RoW).

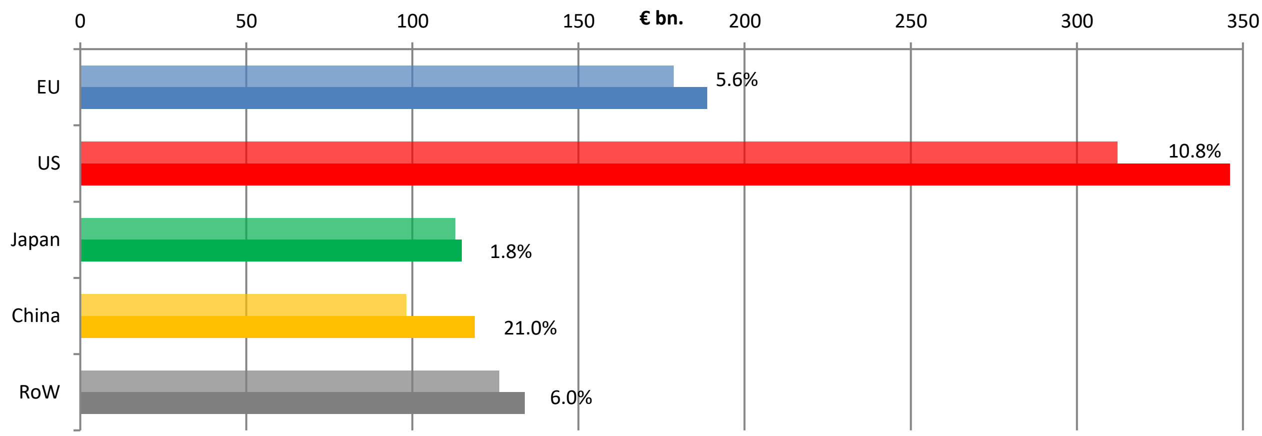
Figure S1: R&D, net sales, and profitability growth 2010-2019.



Note: Growth rates for the three variables were computed on 1759 out of the 2500 companies, for which data on R&D, net sales, and operating profits are available for the entire period of 2010-2019. These companies represent 87.0% of R&D, 86.8% of net sales, and 81.9% of operating profits out of the total sample in 2019.

Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Figure S2: R&D investment growth 2018-2019 by region/country.



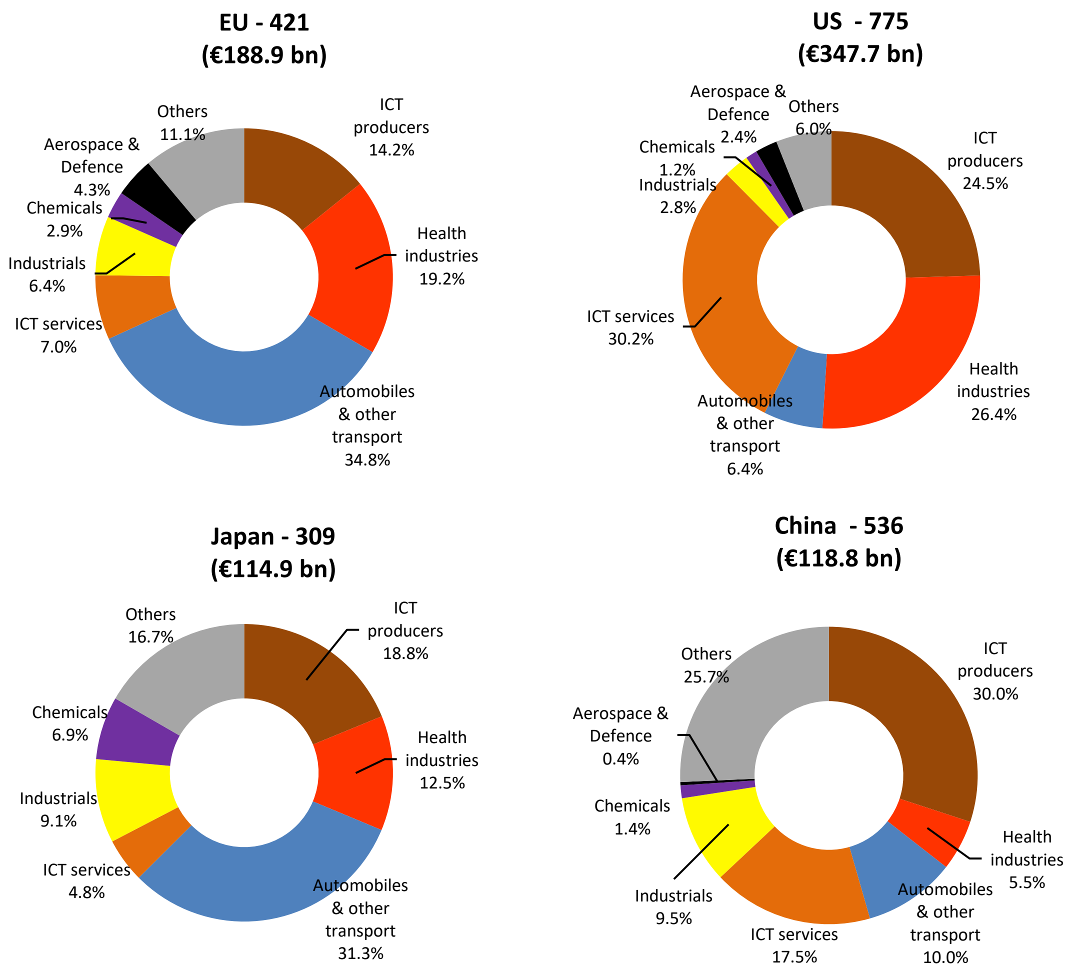
Note: Pale colours refer to the year 2018, and dark colours refer to the year 2019.
Percentage figures indicate the one-year R&D growth of the sector.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Global R&D investment is driven by fast-growing industries, mainly ICT and health; thus, differences in sector composition explain the different patterns of R&D growth across world regions.

Industrial R&D is extremely concentrated, with the top four sectors contributing 77% of the total R&D: ICT producers (23.0%), health industries (20.5%), ICT services (16.9%), and the automotive industry (16.3%). The R&D growth rates of these sectors in 2019 ranged from ICT services at 19.8% to health at 10%, ICT producers at 8.0%, and down to the automotive industry at 2.2%.

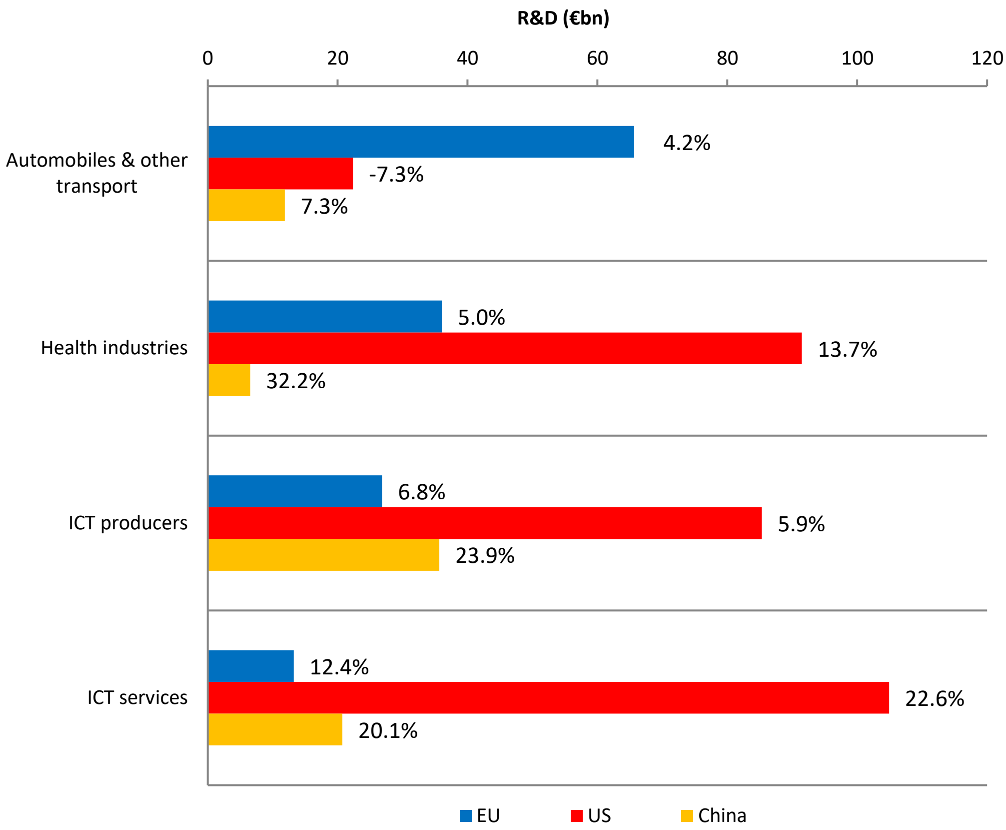
The EU has a stronger automotive industry than other regions but is behind the US in health (particularly in biotech), and lags behind China and even farther behind the US in ICT industries (mostly in software and the internet). Therefore, the EU's R&D performance is shaped by R&D growth within the automotive sector, whereas R&D in the US is dominated by the fast-growing ICT and health sectors. China's outstanding R&D growth is explained by the fact that they have more new companies and increased sales faster than other regions. Another factor is that China's ICT sector is stronger than the EU's and Japan's. Figure S3 shows the sector specialisation for the main world regions, and Figure S4 shows the one-year R&D growth for the top four sectors (automobiles and other transport, health industries, ICT producers, and ICT services)..

Figure S3: R&D investment in 2019 by region/country and sector group.



Note: Percentage figures indicate each sector R&D shares in each country/region.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Figure S4: R&D investment in 2019 by region/country and sector group – details.

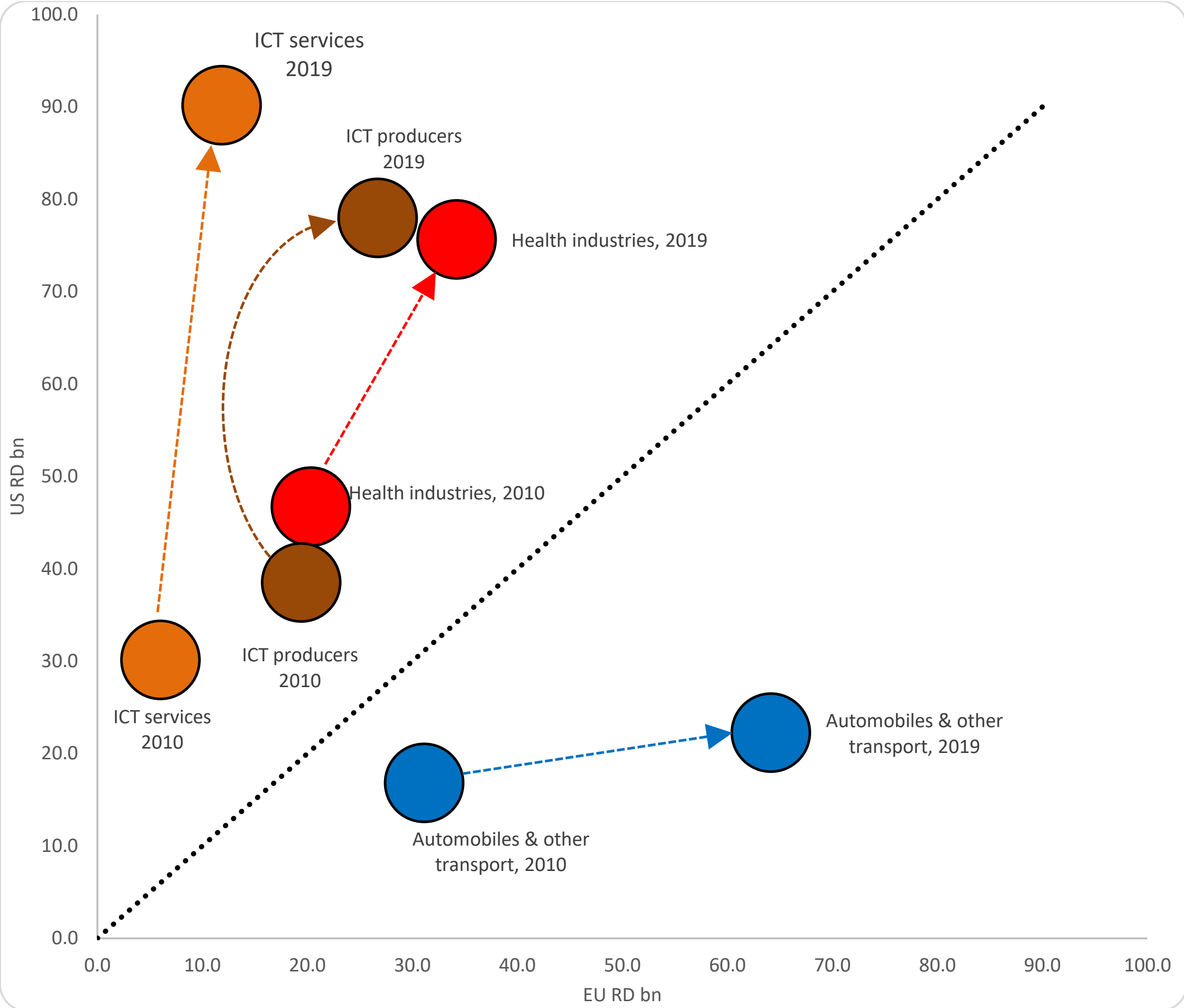


Note: Percentage in the figure indicate the one-year R&D growth of the sector.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Similar R&D trends observed for over 10 years shaped specialisation patterns, and increased differences between regions, particularly between the EU and the US.

Companies' R&D investments in the EU and the US have increased significantly over the past ten years in the top four R&D investing sectors. In 2010, EU companies were investing more than the US in the automotive industry, and the US was investing more in health and ICT industries (both services and producers). As shown in Figure S5, these differences have increased further in 2019, particularly in both ICT sectors. The ratio of R&D investment between the EU and the US remained constant in the health sector, increased significantly in the automotive sector, and substantially decreased in both ICT sectors.

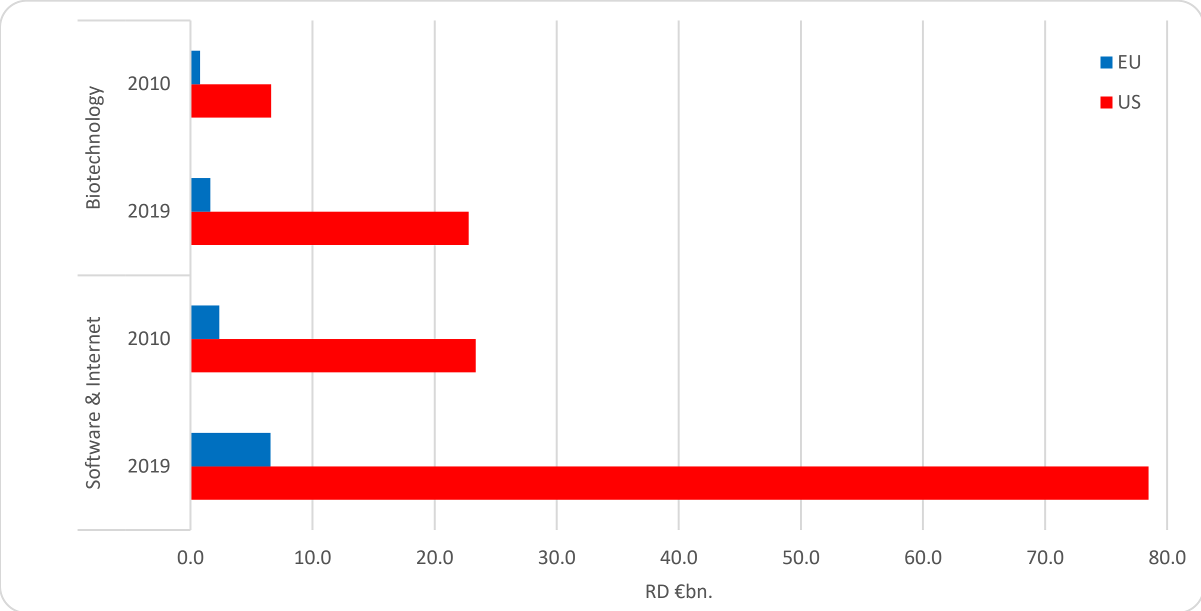
Figure S5: R&D investment in 2010-2019, comparison of selected sectors in the EU and US.



Note: data refers to 514 (EU:164, US:350) of the 805 companies (EU:204, US:601) in the four sector groups in the two regions considered for which R&D data are available for the all period 2010-2019, accounting for 90.2% of the R&D in 2019!
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

A closer look to the EU and US data at the sub-sector level shows more striking differences in R&D investment in the health industries (subsector biotechnology) and ICT services industries (subsector software & internet). In 2019, the US has many more companies in the *Scoreboard* in both sub-sectors (8.6 times more companies in biotechnology and 8.8 times more companies in software & internet); and much more R&D investments (€34.3bn vs €2.6bn in biotechnology and €92.7bn vs €7.5bn in software & internet). See Figure S6 for further details.

Figure S6: Comparison of the EU's and the US' R&D investments in biotechnology and software and internet.



Note: R&D investment reported for 78 (9 EU, 69 US) Software & Internet firms out of the 132 (14 EU, 118 US) companies for which data on R&D are available for the entire period 2010-2019. These companies represent 88.4% (87.0%EU, 88.5%US) of R&D in 2019 of the 132 firms of the total sample. R&D investment reported for 55 (9 EU, 46 US) Biotechnology firms out of the 183 (19 EU, 164 US) companies for which data on R&D are available for the entire period 2010-2019. These companies represent 66.3% (63.5%EU, 66.6%US) of R&D in 2019 of the 183 firms of the total sample.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

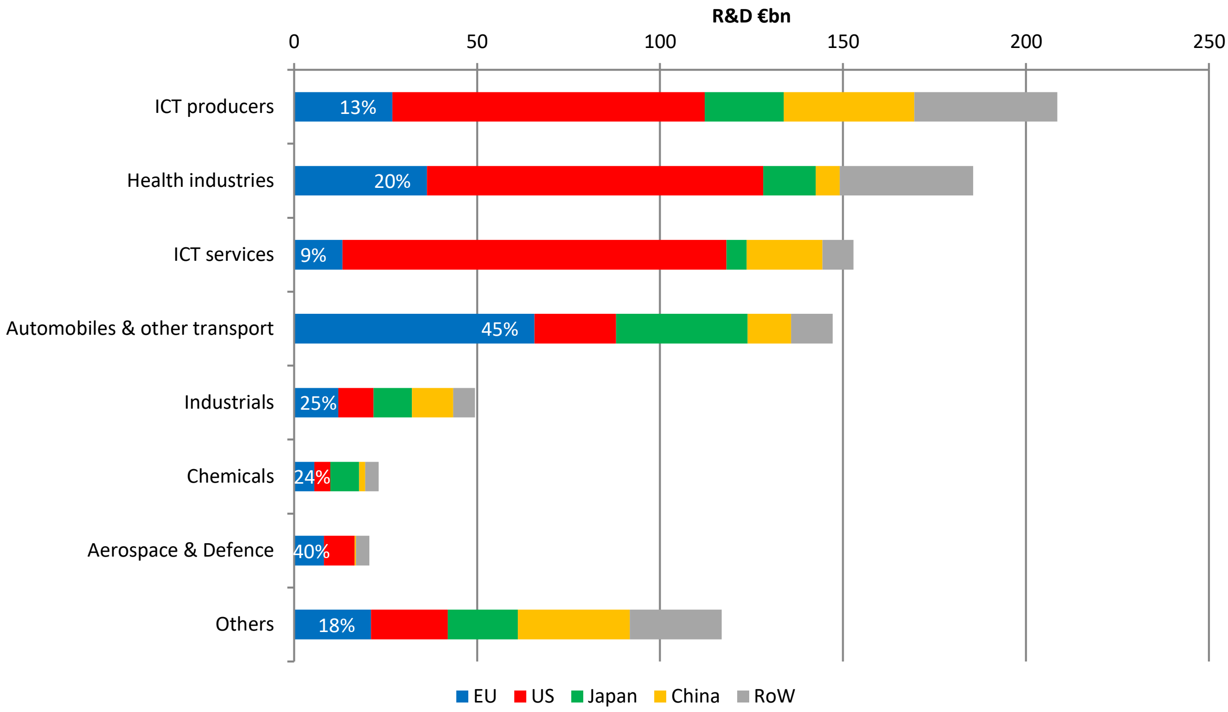
This is a major challenge for the EU since these are the key sectors required to support the industrial transition strategy. Indeed, the ICT industry is taking a larger share of the value added in sectors where the development of green technology is required to replace fossil fuels, e.g., in the transition to electric mobility. On the other hand, biotechnology is increasingly the basis for the development of new drugs, e.g., genetic engineering applied for developing a large range of drugs including vaccines.

The aggregate numbers should not hide successful examples of EU companies. For example, the young German company BioNTech is at the forefront of the development of novel mRNA technology for the treatment of a number of diseases including cancer and vaccines to fight COVID-19. BioNTech (world ranking #654) has been successful in getting EU R&D support since early in the company's history; it has been in the Scoreboard database since 2013 and has multiplied R&D investment six times over, and increased net sales tenfold since then.

The EU companies in the *Scoreboard* are highly internationalised, showing a diversified and strong technological and industrial base.

EU companies hold a high share of the global R&D in several key sectors. In the automotive and health sectors, the EU contributes to 45% and 20% of the total R&D respectively. The EU contributes 40% of the aerospace and defence sector's R&D, 25% of the R&D in the industrials sector, 24% of the chemicals sector's R&D, and 18% of the R&D for a group of sectors including services and resource-intensive sectors. Figure S7 shows the contribution of the main world regions to each main sectors' global R&D.

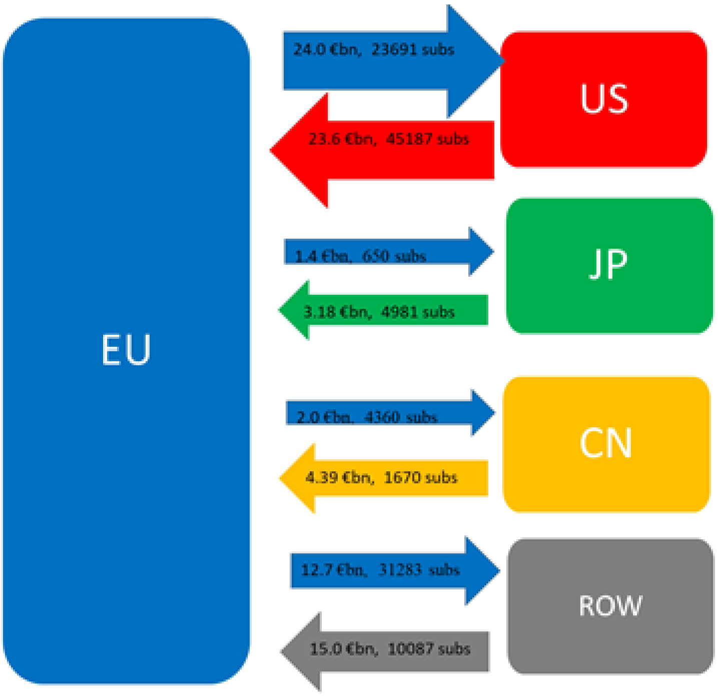
Figure S7: R&D investment in 2019 by sector group and country/region.



Note: Percentage figures indicate EU share in each main sectors' global R&D.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

An analysis of the ownership structure and the patent portfolio of the *Scoreboard* companies shows a high degree of internationalisation in EU companies. They have a higher number of subsidiaries than their global counterparts and are located in a great number of locations all over the world. An analysis of patents as a proxy for R&D location shows both the internationalisation of EU companies and the attractiveness of the EU for R&D investment by foreign companies. The analysis shows that around 20% of the R&D funded by EU companies is performed abroad. On the other hand, foreign-controlled companies operating in the EU invested in R&D slightly more than the amount that EU companies invested abroad. See Figure S8 for further details.

Figure S8: R&D investment flows into and from the EU.



Note: Based on a geographic redistribution of the R&D using patents as a proxy for R&D location. See JRC technical report[4]
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

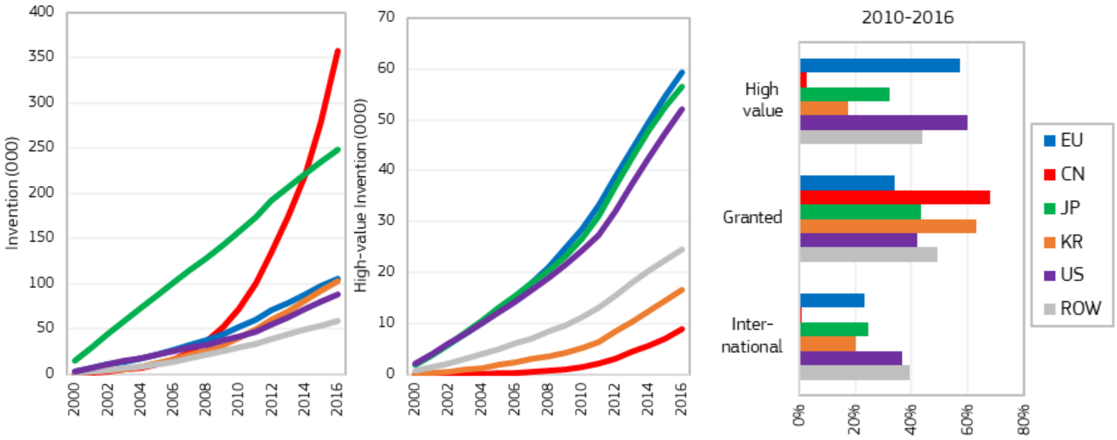
[4] "Estimating territorial business R&D expenditures using corporate R&D and patent data", JRC, 2016. https://iri.jrc.ec.europa.eu/sites/default/files/contentype//publication//reports//1568800313//Estimating%20territorial%20business%20RD%20expenditures.pdf

A patent analysis shows the positioning of the EU in developing *green* technologies.

The global share of *green* inventions[5] in overall patenting activity is 7%. Among major economies, the EU is second, behind South Korea, with 9.5% of *green* patents over the total. *Scoreboard* companies own about 40% of global patents and about 50% of green patents[6].

The EU is the global leader on high-value[7] *green* patents (protected in at least two patent authorities), with Japan and the US following closely. From 2000 to 2016, the EU produced around 60000 high-value *green* inventions, around six times more than those produced by China. The EU and the US have the highest share of high-value inventions, which on average accounted for around 60% of their total *green* inventions output between 2010 and 2016. South Korea (17%) and Japan (32%) have lower shares, while only 3% of Chinese inventions are of high-value. See Figure S9 for further details.

Figure S9: Green inventions trends.



Note: Cumulative trend of green inventions (left), high-value green inventions (centre), and share in the period of 2010-2016 of high-value, granted and international inventions (right) for major economies over their total number of green inventions.
Source: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

[5] According to the Cooperative Patent Classification (CPC) system. EPO/USPTO partnership. https://www.cooperativepatentclassification.org/index. For methodological details see Pasimeni, F., Fiorini, A., and Georgakaki, A. (2019). Assessing private R&D spending in Europe for climate change mitigation technologies via patent data. World Patent Information, 59, 101927.

[6] In the context of this report, all patents are considered inventions. The two terms are used as synonymous.

[7] High-value inventions are patent families including patent applications filed at least in two different patent authorities, and international inventions consider only patent applications filed in patent authorities distinct to the country of resident of the patent applicant. EU national patent authorities are considered as distinct for high-value inventions, while they form a unique geographical area for international inventions.

Large corporate R&D investors address the sustainability development goals (SDGs) in different ways and to a different extent.

The *Scoreboard* includes an analysis testing a novel indicator of companies' disclosure and reputation scores[8] related to the UN's Sustainability Development Goals (SDGs) to capture also the role played by industrial R&D investors. This shows that EU and Japanese companies overall achieve an average score of 54.9 and 54.1 respectively across five key SDGs from clean energy and sustainable production to climate action. For companies from China and the US, the scores in this respect are lower, at 41.2 and 38.3 respectively. See figure S10.

Figure S10: Scores for selected SDGs by region/country.

	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	7, 8, 9, 12, 13
EU (277)	59.9	60.2	51.2	51.3	51.6	54.9
US (649)	38.8	45.5	36.7	35.7	34.8	38.3
Japan (215)	58.1	57.4	50.3	54.2	50.2	54.1
China (148)	42.0	49.6	37.0	38.8	38.4	41.2
Row (294)	52.8	57.0	46.2	47.1	47.8	50.2
Total (1583)	48.0	52.2	42.9	43.3	42.6	45.8

Note: data refers to 1583 companies for which data are available, representing 86.4% of the R&D invested by the all sample in 2019 (the percentages of representation of R&D2019 by region are: 84.0% for EU, 95.6% for US, 94.7% for Japan, 52.9% for China, 88.2% for RoW). Last column reports the average of the five SDGs considered. Scores computed as average of the values for companies in each region (number of companies between brackets) for which data are available. Data in the last column refers to the average of the five SDGs considered.

Source: The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

[8] Data provided by Covalence SA (https://www.covalence.ch/). Scores are evaluated combining companies' disclosure and reputation information that is normalised into a 0-100 scale. A score of 50 represents a neutral value, scores above 50 indicate positive contribution to the SDGs and scores below 50 indicate that companies are not doing enough and/or have a bad reputation.

INTRODUCTION

The 2020 edition of the "EU Industrial R&D Investment Scoreboard" (the *Scoreboard*)[9] comprises this analysis report and the related dataset on the top investors in R&D worldwide. The *Scoreboard* dataset consists mainly in ranking the **2500 companies investing the largest sums in R&D worldwide.**

The *Scoreboard* is based on information taken from these companies' latest published accounts. For most companies, these correspond to the calendar year 2019. To avoid double counting, the *Scoreboard* only considered data from parent or independent companies. Normally, these companies integrate the data for their subsidiary companies into their consolidated accounts.

It should be noted that the *Scoreboard* relies on companies' published annual reports and accounts to include a disclosure of R&D investment, and that due to different national accounting and disclosure practices, depending on the country in which they are based, some companies are less likely than others to disclose R&D investment consistently. It is only a legal requirement in some countries that R&D investment is disclosed in company annual reports. For these reasons, companies particularly based in Southern or Eastern European countries might be under-represented, while companies from countries such as the UK could be over-represented (see methodological notes in Annex 2).

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 2020 *Scoreboard* (€904.2bn) is equivalent to almost 90% of the total expenditure on R&D financed by the business sector worldwide[10]. 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 across countries and industries and 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 2019, we collected available indicators reported by around 800k subsidiary companies of the 2500 parent companies in this edition. This allowed for a better characterisation of companies, particularly 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*, an analysis of key indicators (such as the patent data of parent companies and their subsidiaries) allows for the reassignment of many companies to the countries in which they perform their actual economic or innovation activity.

The reference period for the 2020 *Scoreboard* is the year 2019, so the effects of the COVID-19 crisis are not reflected in this dataset. These effects will be reflected in financial reports for 2020, and addressed in the next edition of the *Scoreboard*.

A main difference in the data presentation in this *Scoreboard* edition regards the new composition of the EU following the departure of the UK on 31 January 2020[11]. Henceforth, in this report, **the EU is understood as EU27** (i.e. without the UK), and whenever the UK is included for comparative purposes, EU28 will be referred to.

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[9] The EU Industrial R&D Investment Scoreboard is published annually since 2004 by the European Commission (Directorate-General for Research and Innovation, DG-R&I, and the Joint Research Centre, JRC). See: http://iri.jrc.ec.europa.eu/home

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

[11] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:European_Union_(EU)

Report structure

In this edition, the structure of the *Scoreboard* report considers new policy priorities, namely the twin green and digital transitions. The report provides a comprehensive description of the global industrial R&D landscape, including the main trends in R&D, and the economic performance of companies, aggregated on worldwide, regional, and industrial levels. The analysis focuses on benchmarking EU innovation-driven industries against global counterparts. It includes an analysis of the role of industrial R&D in addressing major challenges, and an assessment of the EU's industrial capability of developing green technology.

In Chapter 1, we provide an overview of the main characteristics of industrial R&D, including the main economic factors that have shaped R&D investments over the past year. This section comprises a description of the role of R&D in achieving sustainability goals and summarises related technology trends. The 2020 dataset is described in detail, with a particular focus on the geographic and sectoral distribution of R&D and its typical concentration at company, industry, and country levels.

Chapter 2 focuses on the positioning of the EU against its main competitors. It describes the main changes in R&D, net sales, profitability, and employment over the past year, and summarises the ten-year performance in R&D for the four industries which account for a large proportion of the total R&D in the *Scoreboard* (the health, ICT producers, ICT services, and automotive industries).

Chapter 3 examines the R&D and economic trends of an extended sample of companies headquartered in the EU and UK, which represents the top 1000 R&D investors in the EU28 at the time (2019). It includes the companies in the top 2500 R&D worldwide ranking (542/1000) and an additional number of companies to complete the ranking of the top 1000 (458/1000). The analysis includes a characterisation of two groups of companies: those in the top of the ranking (comprised in the global R&D ranking), and the rest of companies in the bottom of the R&D ranking.

Chapter 4 presents a patent analysis showing the positioning of the EU in developing green technologies[12]. The scope of this analysis goes beyond the *Scoreboard* sample of companies, comparing the range of EU firms in its entirety against their main competitors from major economies. It includes detailed sector and technology analyses, and focuses on the high-value *green* patents, i.e., those protected in at least two patent authorities' offices.

Chapter 5 provides an experimental pilot presentation on a novel approach to indicate the alignment of top investors in R&D with a selection of the UN Sustainable Development Goals (SDGs) as captured through a disclosure and reputation index. The performance of companies in relation to sustainable development, their disclosure practices as well as their perceived impact on society and the environment are considered. It includes qualitative scores about sectoral and worldwide regional performance in five key SDGs, from clean energy and sustainable production, to climate action, and findings with regard to the role of R&D for achieving most of the SDGs, showing that the rapidly advancing technologies of software/AI, biotechnology, and new materials and processes are particularly important in this respect.

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[12] According to the Cooperative Patent Classification (CPC) system. EPO/USPTO partnership. https://www.cooperativepatentclassification.org/index

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

The methodological approach of the *Scoreboard*, its scope, and limitations are described in Annex 2. Users of the *Scoreboard* data are advised to pay particular attention to the summary of the methodological caveats, explained in Box A2.1.

Annex 3 provides two complementary tables: one showing the main statistics for the world sample of companies, aggregated by industrial sectors; and the other showing the sector and country composition of the EU28 1000 sample. Access to the full dataset is provided in Annex 4.

The complete data set is freely accessible online at:
https://iri.jrc.ec.europa.eu/scoreboard/2020-eu-industrial-rd-investment-scoreboard

CHAPTER 1 - A PICTURE OF CORPORATE R&D INVESTMENT IN 2019

This chapter provides an overview of global industrial R&D issues, and the main factors that shaped corporate R&D investments in 2019. It focuses on the top 2500 investors in R&D worldwide and their economic activity in 2019[13].

1.1 The economic context and technological trends.

This section summarises the main economic factors and technological trends that influenced companies' R&D investments in 2019, including a brief forward-looking insight into events that are likely to continue affecting R&D investment in 2020 and beyond.

1.1.1 The economic context

COVID-19 effects not yet in this Scoreboard edition

The reference period for the 2020 *Scoreboard* is the year 2019, thus the effects of the COVID-19 crisis are not yet reflected in the dataset. These effects will be reflected in financial reports for 2020 and addressed in next year's *Scoreboard*. However, it is worth to outline the likely strong effects that this crisis is having on world economies and consequently on the capability of companies to invest in R&D.

Indeed, many companies are seeing sales and profits fall in 2020 and financial stringency is likely to increase pressure to reduce R&D budgets. However, experience with previous recessions has shown that companies that maintain, or better still, increase their R&D budgets in difficult times emerge with greatly improved product/service ranges and are in a much stronger competitive position for profitable growth in the upturn that always follows a recession.

The US/China trade dispute

The US/China trade dispute have caused companies to re-examine their supply chains. The priority used to be just-in-time and efficiency but now resilience, supply redundancy, reshoring and regionalisation are receiving much higher priority[14]. In addition, the US is decoupling substantial parts of its economy from China, sourcing more goods from Mexico and using suppliers from developing Asian countries where costs are lower than those in China.

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[13] The *Scoreboard* is based on information taken from the companies' latest published accounts. For most companies, these correspond to calendar year 2019, but a significant number of companies' financial years ended on 31 March 2020 (Japanese companies in particular but also many UK firms). There are few companies included with financial years ending as late as the end of June 2019, and a small number for which only the accounts up to the end of 2018 were available. Therefore, we should refer to the data of the last available year as 2019/20, those of the previous one as 2018/19 and so on. However, for most companies the last available year corresponds to calendar year 2019, the previous year to the calendar year 2018 (and so on). For reasons of clarity and consistency, we decided to refer to the last available year as 2019, the previous year as 2018 (and so on).

[14] See Preziosi, N., Fako, P., Hristov, H., Jonkers, K., Goenaga, X. (eds) Alves Dias, P., Amoroso, S., Annoni, A., Asensio Bermejo, J.M., Bellia, M., Blagoeva, D., De Prato, G., Dosso, M., Fako, P., Fiorini, A., Georgakaki, A.,Gkotsis, P., Goenaga, X., Hristov, H., Jaeger-Waldau, A., Jonkers, K., Lewis, A., Marmier, A., Marschinski, R., Martinez Turegano, D., Munoz Pineiro, A., Nardo, M., Ndacyayisenga, N., Pasimeni, F., Preziosi, N., Rancan, M., Rueda Cantuche, J.M., Rondinella, V., Tanarro Colodron, J., Telsnig, T., Testa, G., Thiel, C., Travagnin, M., Tuebke, A., Van den Eede, G., Vazquez Hernandez, C., Vezzani, A., Wastin, F., China – Challenges and Prospects from an Industrial and Innovation Powerhouse, EUR 29737 EN, Publications Office, Luxembourg, 2019, ISBN 978-92-76-02997-7, doi:10.2760/445820, JRC116516.

The trade dispute has led to Huawei being banned from US 5G and other networks and then from the networks of some close US allies. These bans have opened up opportunities for EU companies such as Ericsson and Nokia in 5G infrastructure.

In summary, companies see an economic environment that combines low inflation and low interest rates with reduced demand, falls in GDP, high and rising unemployment and reduced working hours. This poor economic environment leads to an overall decline in revenues and company earnings. However, these averages hide big sector differences with health and technology emerging relatively unscathed. Added to all this, a second wave of COVID-19 virus cases is growing in many countries in late summer/autumn 2020 and the uncertainty about when an effective vaccine will be widely available make for a very uncertain outlook for 2021.

1.1.2 Key technological trends

Three key technology areas in 2019 are showing both fast growth and a wide range of applications; these are software/AI/quantum computing, biotechnology and new, high performance materials & processes. The COVID-19 virus pandemic has led to increased activity in the first two areas. Software/AI has been given a boost since restrictions on travel and increased homeworking have raised the demand for digital communication tools and for increased automation of both factory and office tasks. In addition, the need to fight the virus with effective vaccines and new treatments have emphasised the importance of the new tools and techniques of biotechnology. Great progress has been made in developing a vaccine for the virus in less than a year - a task that normally takes 6-10 years[15]. And two of the leading vaccine candidates, Oxford University/AstraZeneca and Pfizer/BioNTec, have been developed by EU scientists.

The rapid progress in biotechnology in the 21st century was underlined by the award of the 2020 Nobel Prize for chemistry to two female scientists (from the EU and US) who developed the CRISPR-Cas9 technique for gene editing in 2011-13. This technique has revolutionised basic science, has been responsible for innovative crops and is leading to ground-breaking new medical treatments. Nobel prizes usually are awarded several decades after the work has been done but, in this case, the breakthrough was so significant that the two scientists were tipped for a Nobel as early as 2015[16]. We now outline recent advances in software/AI/quantum computing, biotechnology and new materials in the following sections.

Software, Artificial Intelligence (AI), Hardware & Quantum Computing

The broad field usually termed IT is taken as comprising software/AI, technology hardware and quantum computing and has seen continued progress during 2019 with certain areas such as remote meeting technology (e.g. Zoom, Google Hangouts, Microsoft Teams) and cloud storage (Amazon, Microsoft, Google) receiving a boost from the effects of the virus.

[15] https://www.politico.eu/article/coronavirus-vaccine-how-long-will-it-take-to-develop/
[16] https://www.ft.com/content/f56e609f-f399-4641-917e-26b16baf280a

The 2020s could be the decade when AI delivers as it enables computers to process data and deduce patterns way beyond what humans can do. Examples include AI already beating human champions at the complex game of 'Go', guiding self-driving cars and translating between languages. However, AI is also beginning to discover new drugs, diagnose diseases from medical scans and help astronomers find distant planets. Examples include the study published in Nature Medicine showing that AI correctly diagnosed tumours from scans in 94.6% of cases compared to 93.6% for trained humans – but the AI system was far quicker[17].

Microprocessor technology has been advancing rapidly as integrated circuits are made of ever finer features but progress will soon be limited by atomic dimensions. The next computing breakthrough is likely to be in quantum computing which is on the cusp of a commercial breakthrough with the number of Qubits per computer rising from 12 in 2006 (MIT) to 72 in 2018 (Google's Bristlecone), a plan of 128 in 2019 (Rigetti[18]) and Google saying its current chip designs can be expanded to 100 to 1000 qubits[19]. In September 2020 it was announced in the FT that Rigetti is leading a £10m consortium to build the UK's first commercially available quantum computer[20]. In August 2020, Google scientists using Google's Sycamore quantum computer performed the first accurate simulation of a chemical reaction[21]. This is a first step towards modelling more complex quantum systems which quantum computers should be very good at. That could mean thousands of different drug candidates being tested in the time it currently takes to make one. Another major application area for quantum computers is codebreaking and secure encryption - important for national security.

Biotechnology

While biotech is enabling advances in agricultural crops, animal genetics, bioenergy and biodegradation of waste, it is the successful development of new and highly effective drugs that has had most impact during the past year. Medical biotech R&D has been concentrated on biologic drugs – drugs made from all or parts of living organisms as opposed to the older chemical drugs. Vaccines are simple examples of biologic drugs. In this area, rapid progress has been made in developing new drugs made from monoclonal antibodies with companies such as MorphoSys and Regeneron making a wide range of antibodies and then developing new drugs from them. There has also been rapid progress in immuno-oncology with many new and effective immunotherapies developed to treat a wide range of cancers. And there are new immunology drugs to treat serious autoimmune diseases such as rheumatoid arthritis. The FDA lists 48 new drugs[22] approved in 2019, which contain NMEs (new molecular entities that have not been used previously). And up to 22nd October 2020, a further 42 new drugs containing NMEs have been approved[23]. There has also been good progress in other areas such as gene editing for both agricultural crops and for curing genetic diseases. A very recent announcement by Bit.bio describes how stem cells can be reprogrammed to turn into specific body

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[17] The Times 7/1/2020
[18] https://www.rigetti.com/what
[19] https://www.technologyreview.com/2020/02/26/916744/quantum-computer-race-ibm-google/
[20] https://www.rigetti.com/about
[21] https://www.newscientist.com/article/2253089-google-performed-the-first-quantum-simulation-of-a-chemical-reaction/#:~:text=A%20team%20at%20Google%20has,a%20practical%20amount%20of%20time.
[22] https://www.fda.gov/drugs/new-drugs-fda-cders-new-molecular-entities-and-new-therapeutic-biological-products/novel-drug-approvals-2019
[23] https://www.fda.gov/drugs/new-drugs-fda-cders-new-molecular-entities-and-new-therapeutic-biological-products/novel-drug-approvals-2020

parts[24]. And the Alzheimer's Society predicts that a gene therapy injection to halt dementia is a realistic possibility within a decade[25]. Very recently, R&D has shown that a pain gene can be 'switched off' to deal with chronic pain without using opioid drugs[26]. However, the major achievement of 2020 is undoubtedly the ultra-rapid development of vaccines for COVID-19. It is an incredible achievement to have five vaccine candidates from developed countries with strict approval regimes in Phase III clinical trials by end September 2020[27],[28] – the Oxford/AstraZeneca, Johnson & Johnson, Moderna, Novavax and Pfizer/BioNTec vaccines. There are as many as 40 COVID vaccines in mainly earlier stage clinical trials in both developed and developing countries[29]. At the time of this report, the UK MHRA and US FDA have approved the Pfizer/BioNTec vaccine, which has already become available for key workers and vulnerable population in UK and US. The same vaccine is undergoing approval from EMA, and is very likely to become widely available in the first half of 2021 also for EU citizens.

New materials & processes

R&D continues on a wide range of new materials including novel batteries and fuel cells, nanomaterials, graphene, high temperature superconductors, supercapacitors, super-efficient solar cells and others. And progress with novel processes such as modular nuclear reactors, nuclear fusion, mass energy storage, hydrogen propulsion, large scale 3D printing and others could offer important advances including clean energy solutions. Examples of the importance of R&D in these areas that were highlighted in 2019/20 include bulk applications of graphene such as graphene enhanced coatings used to protect the pillars and blades of offshore wind turbines[30]. And nanoparticles (quantum dots) developed to make solar cells that are up to 25% more efficient[31]. On a larger scale first houses are now being 3D printed to save labour costs (95% less labour hours) and construction time[32]. Lower tech innovations can bring benefits too such as a special white paint that can reflect 95.5% of sunlight and keep surfaces at temperatures up to 18°F lower than their surroundings[33] – this saves energy used for air conditioning.

While most past work on nuclear fusion has been government funded (e.g. the Culham & ITER projects), there are now private companies such as First Light Fusion[34] and Tokamak Energy[35] that are trying to speed up the commercialisation of fusion power. Tokamak is predicting 'clean and abundant fusion power by 2030'.

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[24] https://bit.bio/
[25] The Times 1/1/19
[26] The Times 6/1/2020
[27] https://www.nih.gov/news-events/news-releases/fourth-large-scale-covid-19-vaccine-trial-begins-united-states
[28] https://ir.novavax.com/news-releases/news-release-details/novavax-initiates-phase-3-efficacy-trial-covid-19-vaccine-united
[29] https://www.bbc.co.uk/news/health-51665497
[30] B. Munzing in Physics World 'Focus on Nanotechnology' 2019
[31] The Times 18/2/20 p22
[32] https://www.mightybuildings.com/prefab-tech
[33] https://nypost.com/2020/10/28/new-white-paint-can-reflect-95-5-of-sunlight-may-combat-global-warming/#:~:text=Engineers%20at%20Purdue%20University%20in,conditioning%20while%20consuming%20zero%20energ y.
[34] https://firstlightfusion.com/
[35] https://www.tokamakenergy.co.uk/

Progress with higher energy density batteries and hydrogen fuel cells has extended the range of electric vehicles and is bringing nearer the possibility of fully electrically powered flights of up to 1000 miles. The world's first fully electric commercial aircraft took flight in Canada in December 2019[36] using a plane from Harbour Air which intends to electrify its fleet of 40 seaplanes used on relatively short commercial flight routes. And Lilium is developing an electric VTOL (vertical take-off & landing) low noise jet for regional routes flying between city vertiports[37]. Lilium's aim is to have commercial flights operational in 2025. Realising low-cost long-range electric vehicles, long-range electric aircraft and cost-efficient energy storage for use with intermittent power generation sources such as wind turbines & solar all require high density energy storage. One option could be to improve markedly existing lithium batteries or use new solid-state batteries. A second is supercapacitors which could provide high energy density with almost instant recharging. Superdielectrics has developed electrically conducting polymers which offer storage densities of 26Wh/kg but the company aims to increase this up to 200Wh/kg (suitable for drones & electric aircraft) in five years[38]. The third is hydrogen and Airbus has unveiled plans for hydrogen aircraft able to carry 150-200 passengers up to 2300 miles paving the way for clean transcontinental flights within 15 years[39]. On a smaller scale, Zero Avia completed the world's first hydrogen fuel cell powered electric flight in a commercial aircraft (a 6-seat passenger plane) in September 2020[40]. Hydrogen is already being used to power buses, trucks and trains and a hydrogen fuel cell train was demonstrated on mainline tracks in September 2020[41] and the technology should be available to retrofit to diesel trains in 2023.

Combination breakthroughs

Cross-technology advances from two or three of Software/AI, biotech, new materials and other technology areas can often provide new breakthroughs. For example, an AI system trained on 2500 well-researched compounds, some of which were effective against E.coli, has been used to search a library of 100 million compounds to identify those effective against E.coli but different from all previously known compounds effective against it. The result was the discovery of a remarkable molecule that is to be tested against superbugs[42]. Another example is the discovery that a narrow range of UV wavelengths that can be generated by LEDs is safe for humans but lethal to viruses. This technology could be extremely useful for controlling future pandemics[43]. And we mentioned above the huge potential impact of quantum computing on biotech drug research. The pandemic has accelerated digital health reforms[44] with widespread video consultations and the use of companies such as Amazon, Microsoft and Palantir to create data models that optimise the allocation of equipment, hospital beds and staff.

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[36]https://www.theguardian.com/world/2019/dec/11/worlds-first-fully-electric-commercial-aircraft-takes-flight-in-canhttps://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/nuclear/smr-brochure-july-2017.pdfada

[37] https://lilium.com/journey

[38] https://www.superdielectrics.com/our-technology.html

[39] https://www.airbus.com/newsroom/press-releases/en/2020/09/airbus-reveals-new-zeroemission-concept-aircraft.html

[40] https://www.prnewswire.com/news-releases/zeroavia-completes-world-first-hydrogen-electric-passenger-plane-flight-301137976.html

[41] https://www.electricvehiclesresearch.com/articles/21888/trials-of-the-uks-first-hydrogen-powered-train-begin

[42] The Times 21/2/2020

[43] Physics World June 2020 p28-32

[44] https://www.ft.com/content/31c927c6-684a-11ea-a6ac-9122541af204

1.2 Industrial R&D landscape

This section outlines the main characteristics of the 2020 *Scoreboard* dataset. It describes the global top 2500 companies' distribution (and concentration) of industrial R&D at company, industry, and country levels. This comprises the analysis of the geolocation of industrial R&D, disaggregating parent companies' R&D by the location of their subsidiaries (based on patent analysis). Finally, this section includes a detailed analysis of the firms which have entered and left the *Scoreboard* over recent years.

The top 2500 global companies each invested more than €34.7 million in R&D in 2019, accounting altogether for a total of €904.2 bn; this is a 9.87% increase on the top 2500 companies' investments in the previous year.

The amount of R&D investment by these companies is equivalent to more than 60% of the total expenditure on R&D worldwide (GERD), and to around 90% of the R&D expenditure financed by the business sector worldwide. Box 1.1 shows a comparison of territorial statistics on R&D with the *Scoreboard* figures.

Box 1.1 - R&D figures from the *Scoreboard* versus territorial statistics

R&D figures used in the *Scoreboard* are conceptually different from, but complementary to, those provided by statistical offices. Following the Frascati manual[45], the *Scoreboard* refers to all R&D financed by companies from their own funds, regardless of where the R&D activities are performed. On the other hand, statistical offices report R&D expenditures funded by the business enterprise sector and performed within a given territorial unit (BES-R&D), regardless of the location of the business' headquarters. Thus, the main differences are due to the fact that R&D takes place across borders. For a given territorial unit, the *Scoreboard* reports R&D figures from companies headquartered there, including R&D performed abroad through their subsidiaries (outward R&D). On the other hand, territorial statistics report the 'intramural' R&D by local companies, and R&D by foreign-controlled companies (inward R&D). Therefore, at the global level, the *Scoreboard* and BES-R&D figures are comparable (up to a certain level)

To illustrate the extent of the *Scoreboard* R&D figures, we compare the latest available territorial statistics (2018) with the R&D data from the 2019 *Scoreboard* (company data for 2018). The comparison shows that the amount of R&D investment by the top 2500 companies (€823.4bn) is equivalent to **more than 60%** of the total expenditure on R&D worldwide (GERD, €1334.1bn) and to **about 90%** of the R&D expenditure financed by the business sector worldwide (BES-R&D, €918.2bn).

Sources: Latest figures reported by Eurostat including most countries reporting R&D, extracted on 26/11/2020. GERD, from all funding sources and performed in all sectors. BES-R&D, performed in all sectors and funded by the business enterprise sector.
The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

[45] See https://www.oecd.org/sti/inno/frascati-manual.htm

1.2.1 Geolocation of companies and their R&D activity

Location of companies' headquarters

The top 2500 Scoreboard sample includes companies from 43 countries of which 18 are Member States of the EU[46]. The sample includes companies based in the EU (421), the US (775), China (536), Japan (309), UK (121),Taiwan (88), South Korea (59), Switzerland (58), India (29), Canada (30), Israel (22) and a further 15 countries (see Table 1.1 and Figure 1.2a). The most significant change compared to last year is the increase in the number of Chinese companies (+29 companies). The US has registered a small increase (+6), while the EU (-3), Japan (-9) and South Korean (-11) have seen a decrease in the companies in the ranking.

Table 1.1 – Distribution of companies and R&D by country

EU	No. companies	R&D 2019 (€bn)	non-EU	No. companies	R&D 2019 (€bn)
Germany	124 (130)	86.6	US	775 (769)	347.7
France	68 (68)	33.8	China	536 (507)	118.8
Netherlands	38 (39)	20.3	Japan	309 (318)	114.9
Sweden	32 (33)	10.1	South Korea	59 (70)	32.9
Ireland	28 (27)	9.3	Switzerland	58 (58)	29.8
Denmark	32 (30)	6.0	Taiwan	88 (89)	18.1
Italy	24 (26)	5.9	Canada	30 (28)	4.9
Finland	16 (17)	5.7	India	29 (32)	4.9
Spain	14 (14)	4.7	Israel	22 (22)	3.1
Belgium	14 (12)	2.9	Australia	11 (12)	2.7
Austria	16 (17)	1.7	Norway	10 (10)	1.1
Luxembourg	7 (4)	1.1	Saudi Arabia	2 (3)	0.9
Portugal	3 (2)	0.2	Brazil	5 (6)	0.6
Slovenia	1 (1)	0.2	Turkey	6 (5)	0.6
Hungary	1 (1)	0.1	Singapore	6 (6)	0.6
Poland	1 (1)	0.1	United Arab Emirates	1 (1)	0.6
Greece	1 (2)	0.1	Liechtenstein	1 (1)	0.3
Malta	1 (0)	0.0	New Zealand	3 (3)	0.3
Total EU	**421 (424)**	**188.9**	Mexico	1 (1)	0.1
UK	121 (127)	32.0	Further 5 countries	6 (6)	0.3
Total EU + UK	542 (551)	220.9	Total	1958 (1949)	683.3

Note: Figures between brackets are the number of companies comprised in the previous *Scoreboard*.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

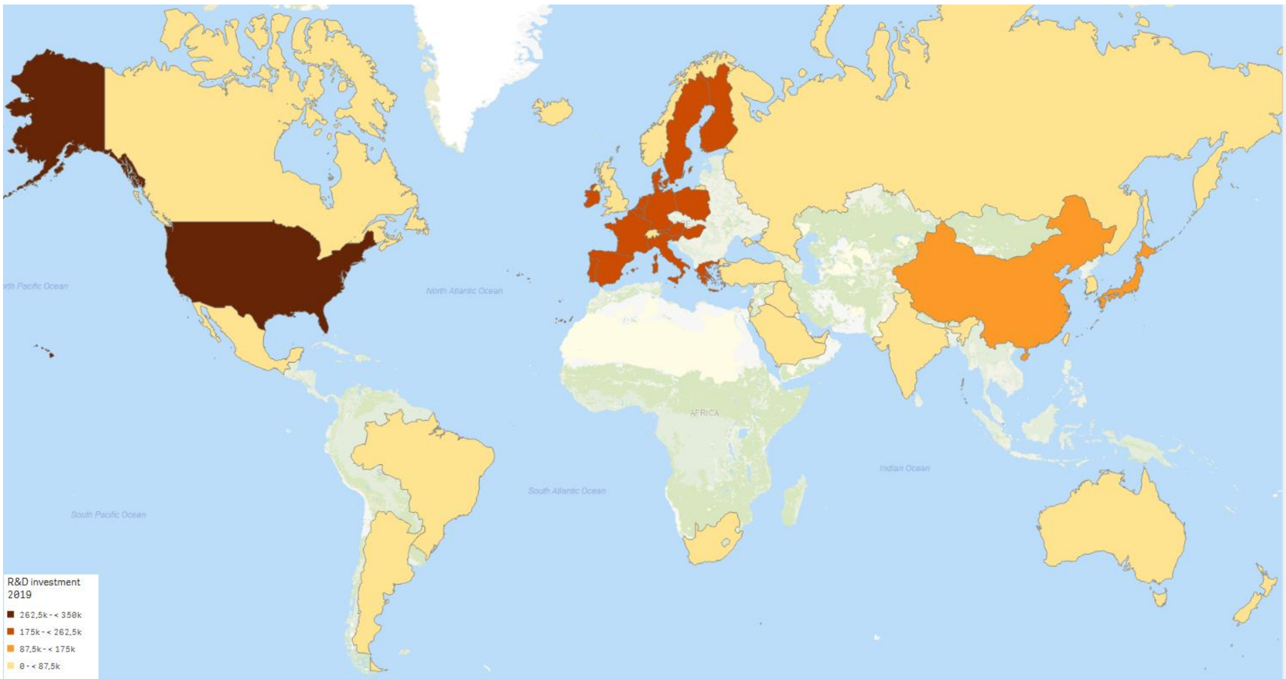
The US is the country with the greatest number of top investors in R&D worldwide (775 companies), followed by China (536) and the EU (421). For the first time since the publication of the *Scoreboard*, China is second only to the US in terms of number of companies in the R&D ranking. If the UK were still in the EU, then China would have been a close third.

If we look at R&D investment instead of the number of companies, the ranking changes, with the EU (€188.9bn) well ahead of China (€118.8bn). The US (€347.7bn) is still top of the rankings, while Japan

[46] In this report, EU refers always to EU 27.

(€114.9bn) ranks fourth, for the first time behind not only the US and the EU, but also China. The UK alone, with €32.0bn of R&D invested in 2019, ranks sixth globally, behind the US, the EU, China, Japan, and South Korea (€32.9bn).

Figure 1.2a – Map of the top 2500 R&D investing companies by headquarters country/region.



Note: colour darkness proportional to R&D investment in 2019 by the company headquartered in the country.
EU is considered as a single region, only member states where at least one company is headquartered are highlighted.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

R&D investment is very concentrated; companies headquartered in the top five countries in terms of R&D investment (the US, China, Japan, Germany and France) account for 77.6 % of the R&D in the sample (and 72.5% of the total number of companies).

If the EU is considered instead of the individual 27 EU Member States, then the EU and US, China and Japan host 81.6% of companies, that together were responsible for 85.2% of total investment in R&D in 2019.

Location of company subsidiaries

The top 2500 companies investing in R&D own just over 800000 subsidiaries[47], of which around 315000 are corporate[48]. While the companies' headquarters (HQ) are located in 43 different countries, there is at least one subsidiary of a *Scoreboard* company in 197 countries/territories, meaning almost every country has one. The US is the country with the greatest number of corporate

[47] Data on ownership structure provided by Bureau van Dijk (BvD) and refers to the subsidiaries owned by Scoreboard companies with a share of 50.1% or more.
[48] Corporate subsidiaries are all companies that are not banks, financial companies or insurance companies. They may be involved in manufacturing activities but also in trading activities (wholesalers, retailers, brokers, etc.). They also include companies active in B2B or B2C non-financial services.

subsidiaries (29.7% of the total), followed by the EU (22.9%) and China (13.4%) (see in Figure 1.2b the geographic representation of corporate subsidiaries).

The Figure 1.3 presents the distribution of number of corporate subsidiaries of the *Scoreboard* companies across the five world regions/countries considered:

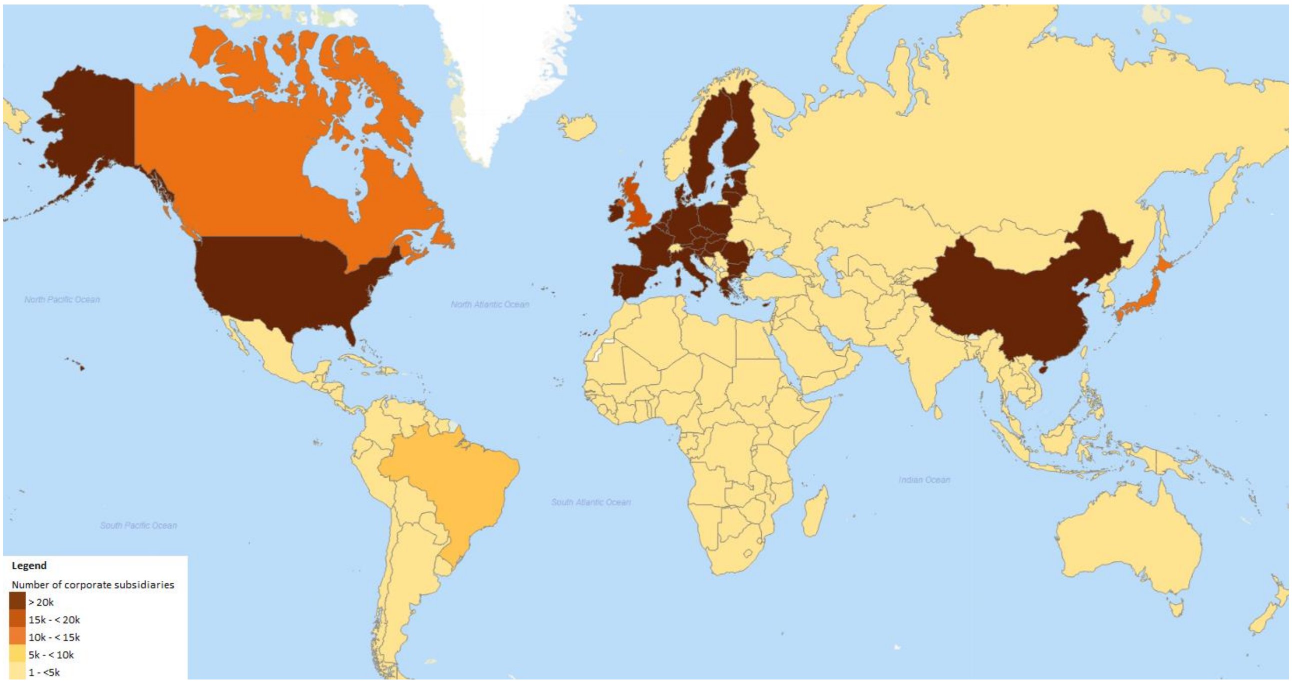
EU companies (EU HQ) own the largest number of corporate subsidiaries (~98,700, 31.7% of the total) across the regions/countries considered. Their subsidiaries are mostly located in the EU (40%) and in the US (24%).

US companies (US HQ) have 29.2% of the total number of corporate subsidiaries (~90,800), which are mostly also located in the US (49.5%) and in the EU (17.5%).

Japanese companies (Japanese HQ) have far fewer corporate subsidiaries (12% of the total, ~35000). The ones they do have are mostly located in the US (23.9%) and Japan (23.8%), and a smaller number in the EU (13.9%).

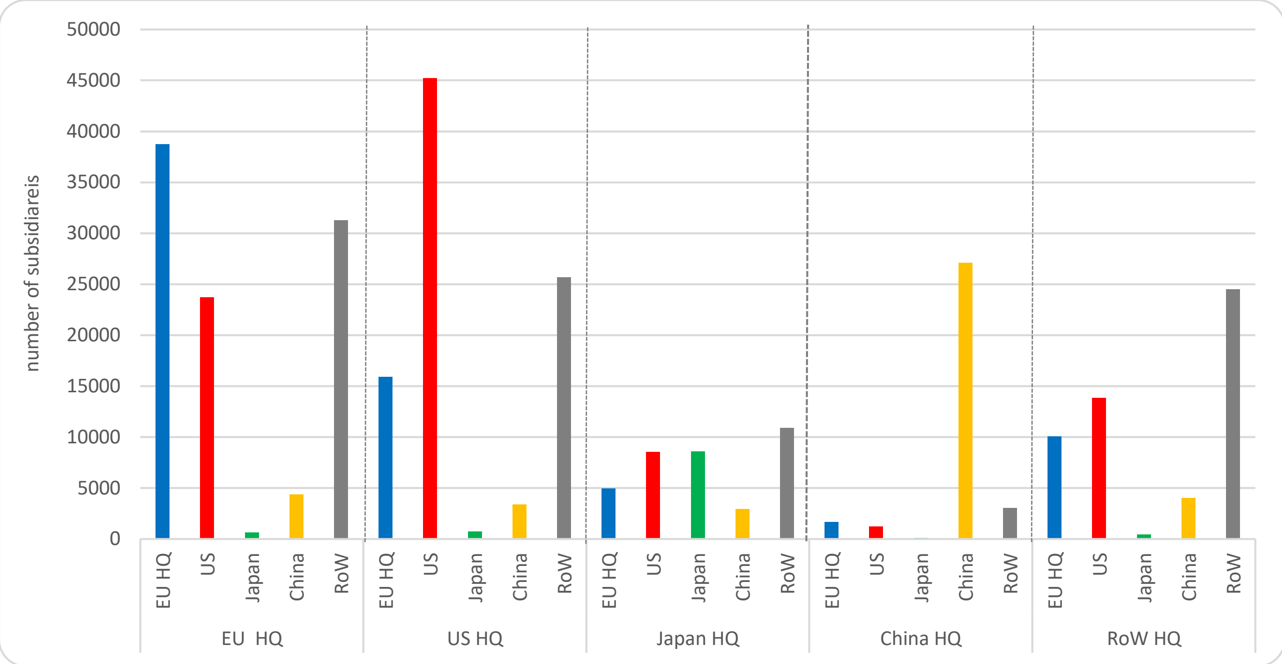
Chinese companies (Chinese HQ) have 11% of total corporate subsidiaries (~33100), which are mostly located in China (81.8%) followed by the EU (5.0%) and the US (3.7%).

Figure 1.2b – Map of the subsidiaries of the top 2500 companies for R&D investment by country/region



Note: Colour darkness proportional to the subsidiaries in the country. Data refers to 2387 companies (accounting for 98.5% of R&D in 2019) for which subsidiary data is available.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Figure 1.3 – Distribution of the number of subsidiaries by region.



Note: Data refers to 2387 companies (accounting for 98.5% of R&D in 2019) for which subsidiary data is available.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Actual location of R&D activity

We use the location of inventors of patents owned by the *Scoreboard* companies and their subsidiaries, filed at one of the five main IP offices in the period 2015-2017[49], as a proxy for the actual location of the R&D activities. In this manner, we redistribute the R&D of the *Scoreboard* parent companies from their headquarters to the location of their associated inventors, to obtain an estimation of the actual geographic distribution of industrial R&D worldwide.

This approach allows us to estimate "R&D flows" from the location of patents' owners (companies' headquarters) to the location of patents' inventors, and therefore to calculate total R&D flows across borders. For a given country, the inward flow is the R&D performed in the country but funded by foreign-controlled companies, and the outward flow is the R&D funded by local companies but performed abroad[50]. Similarly, a further characterisation of the patent portfolios by patent classification may also allow us to estimate R&D flows across sectors, i.e. providing a relationship between the patent, technology and sectors classifications.

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[49] We consider patent family applications
[50] See the JRC Technical report "Estimating territorial business R&D expenditures using corporate R&D and patent data", 2016.
https://iri.jrc.ec.europa.eu/sites/default/files/contentype//publication//reports//1568800313//Estimating%20territorial%20business%20RD%20expenditures.pdf

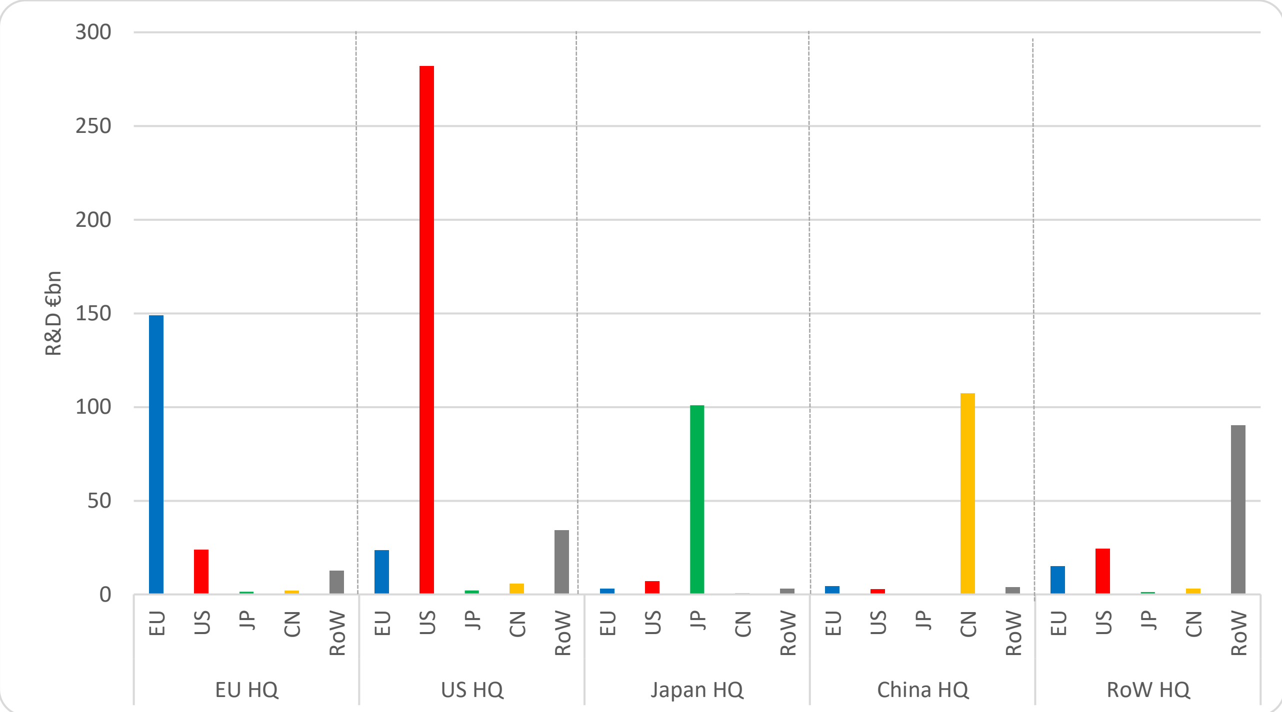
Figure 1.4a shows the geographic distribution of the R&D applying patent data for the five groups of *Scoreboard* companies.

Companies headquartered in the EU perform 78.8% of their R&D within the EU. The percentage is similar in the US for US companies (81.1%) and higher in Japan and China for Japanese and Chinese companies (88% and 90.4%, respectively). The proportion of around 80% of R&D done in the EU by EU-headquartered company is in line with the results reported in the 2019 EU R&D Survey[51].

If we look at the difference between R&D activities performed in the region by local companies and R&D financed by foreign companies located in the region, the EU has a small surplus, meaning more R&D is performed in the EU than is financed by companies with their headquarters in the EU.

By contrast, the US and Japan show a deficit (meaning the R&D performed in the region is less than that financed by companies with headquarters located in the region), while in China the small inward and outward R&D flows balance each other out.

Figure 1.4a – Distribution of R&D by location of inventors for main regions.



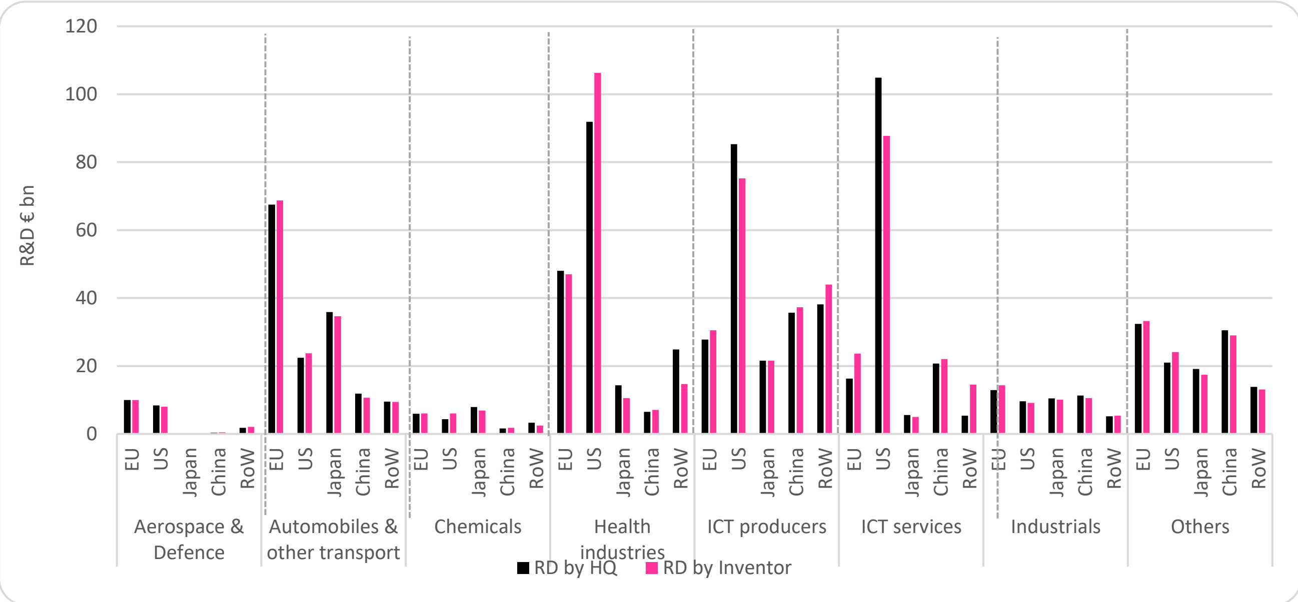
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

If we look at sectors inside regions, we see that the effects of cross-border R&D flows are more significant for some sectors than for others. Figure 1.4b shows the sector distribution of the R&D funded by local companies (HQ) and the actual R&D performed in the region (including the inward flow, R&D performed by foreign-owned companies, and excluding the outward flow, R&D funded by local companies but performed in another region). The differences between the two indicates the R&D surplus (or deficit) for the region.

[51] See Potters, L. and N. Grassano: The 2019 EU Survey on Industrial R&D Investment Trends; EUR 30005 EN; Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-11278-5, doi:10.2760/200895, JRC119026.

The EU shows a small surplus in the Automobiles, ICT and Industrials sectors and a small deficit in the Health industry. In the US, the Health sector posts a surplus, while US ICT producers and the ICT Services sector show a deficit with respect to other regions. For Japan and China, there seems to be very little difference across sectors.

Figure 1.4b – Distribution of R&D by sector: location by headquarters (HQ) vs location by inventors.



Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

1.2.2 Sector and green tech classifications

Classifying companies into specific industrial sectors is not an easy or unambiguous task, especially when dealing with big multinational companies, which by nature can operate in different sectors. To assign the companies in the Scoreboard to a specific sector, we use the main sector in which they carry out their business, which is usually indicated by the company themselves in their annual reports, using taxonomies such as the International Classification Benchmark (ICB)[52]. Table 1.2 reports the distribution of companies by sector according to the ICB and grouped in broad macro-sectors.

Companies in our sample operate in a wide range of sectors, although the bulk of them are concentrated in sectors characterised by high levels of innovation:

- One out of five companies in our sample belongs to the "Health industries" sector, which accounted for 20.5% of R&D investment in 2019.
- Almost one out of three companies in the sample is an ICT company, belonging either to the "ICT producers" (18.4%) or "ICT services" (12.9%) sectors. These companies together account for almost 40% of the total R&D in the sample;
- The "Automobile and transport" sector accounts for 16.3% of R&D in the sample, and is the one with the largest amount of R&D investment per firm, owing both to the nature of the R&D process

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

in this sector and the fact that it is the sector in which firms are biggest (with an average of 17,813 employees per firm).

The four sectors mentioned (Automobiles & other transport, Health industries, ICT producers and ICT services) represent 60% of companies and 76.7% of R&D investment.

This distribution of companies and R&D by sector is very similar to last year, with the biggest changes being a decrease of 16 firms in the ICT producers sector group and an increase of 15 firms in the Health industries sector.

Table 1.2 - Industrial classifications applied in the Scoreboard - 8 industrial groups.

Industrial Sector	Sector classification ICB4 digits	N. of firms	R&D 2019 (€ bn)	% of total R&D	R&D per firm (€ million)
Aerospace & Defence	Aerospace; Defence	45	20.6	2.3	457
Automobiles & other transport	Auto Parts; Automobiles; Commercial Vehicles & Trucks; Tires	187	147.3	16.3	787.7
Chemicals	Commodity Chemicals; Specialty Chemicals	130	23.1	2.6	178
Health industries	Biotechnology; Health Providers; Medical Equipment; Medical Supplies; Pharmaceuticals	530	185.6	20.5	350.2
ICT producers	Computer Hardware; Electrical Components & Equipment; Electronic Equipment; Electronic Office Equipment; Semiconductors; Telecommunications Equipment	461	208.5	23	452.3
ICT services	Computer Services; Internet; Software; Mobile Telecommunications	322	152.8	16.9	474.7
Industrials	Aluminium; Containers & Packaging; Diversified Industrials; Delivery Services; Industrial Machinery; Iron & Steel; Nonferrous Metals; Transportation Services	291	49.4	5.5	169.9
Others*	Alternative Energy; Banks; Beverages; Construction & Materials; Electricity; Financial Services; Food & Drug Retailers; Food Producers; Forestry & Paper; Gas, Water & Multiutilities; 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	534	117.2	13	219.5
Total		2500	904.7	100	361.9

Note: * Sectors in the "Others" group are presented at ICB-3 digits level.
Source: The 2020 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG R&I.

Table 1.3a shows the number of companies by sector and region, with the region's R&D share in the sector in brackets. These numbers clearly show the large role US companies play in the ICT sectors and Health sectors. Table 13.b, meanwhile, shows the region's R&D investment in the sector (in €bn), with the share of companies by sector and region in brackets.

The EU plays a crucial role in R&D in the Automobile industry and the Aerospace sector (which is, however, quite small). Sectoral analysis is further developed in Chapter 2.

Table 1.3a - Distribution of global 2500 companies by industrial sector and region – number of companies

Industry	EU	*EU 28*	US	Japan	China	RoW	Total
Aerospace & Defence	10 (39.7%)	*15 (48.8%)*	14 (40.6%)	0 (0%)	5 (2%)	16 (17.7%)	45 (2.3%)
Automobiles & other transport	42 (44.6%)	*47 (45.9%)*	33 (15.2%)	36 (24.4%)	44 (8.1%)	32 (7.8%)	187 (16.3%)
Chemicals	20 (23.9%)	*25 (25.8%)*	27 (18.7%)	34 (34%)	25 (7.1%)	24 (16.2%)	130 (2.6%)
Health industries	81 (19.5%)	*106 (25.9%)*	284 (49.5%)	36 (7.7%)	54 (3.5%)	75 (19.7%)	530 (20.5%)
ICT producers	49 (12.9%)	*58 (13.3%)*	122 (40.9%)	55 (10.4%)	125 (17.1%)	110 (18.7%)	461 (23.1%)
ICT services	32 (8.7%)	*48 (10.7%)*	162 (68.6%)	8 (3.6%)	70 (13.6%)	50 (5.5%)	322 (16.9%)
Industrials	71 (24.5%)	*79 (26%)*	42 (19.4%)	54 (21.2%)	85 (22.9%)	39 (12%)	291 (5.5%)
Others	116 (18%)	*164 (27.7%)*	91 (17.9%)	86 (16.4%)	128 (26.1%)	113 (21.5%)	534 (12.9%)
Total	421 (20.9%)	*542 (24.4%)*	775 (38.5%)	309 (12.7%)	536 (13.1%)	459 (14.8%)	2500

Note: The figures in brackets show each sector's regional percentages of total R&D in the sector. The cell representing the higher sectoral share by region is highlighted. The total in the final column shows the number of firms in the sector and in brackets their share of the total R&D. The total in the final row shows the number of firms in the region, with their share of R&D in brackets. The EU28 column does not account for the final column total

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Table 1.3b - Distribution of global 2500 companies by industrial sector and region – R&D invested (in € bn)

Industry	EU	*EU 28*	US	Japan	China	RoW	Total
Aerospace & Defence	8.2 (22.2%)	*10 (33.3%)*	8.3 (31.1%)	0 (0%)	0.4 (11.1%)	3.6 (35.6%)	20.6 (1.8%)
Automobiles & other transport	65.7 (22.5%)	*67.5 (25.1%)*	22.4 (17.6%)	35.9 (19.3%)	11.9 (23.5%)	11.4 (17.1%)	147.2 (7.5%)
Chemicals	5.5 (15.4%)	*6 (19.2%)*	4.3 (20.8%)	7.9 (26.2%)	1.7 (19.2%)	3.7 (18.5%)	23.1 (5.2%)
Health industries	36.3 (15.3%)	*48 (20%)*	91.9 (53.6%)	14.3 (6.8%)	6.5 (10.2%)	36.5 (14.2%)	185.6 (21.2%)
ICT producers	26.9 (10.6%)	*27.8 (12.6%)*	85.3 (26.5%)	21.6 (11.9%)	35.7 (27.1%)	39.1 (23.9%)	208.5 (18.4%)
ICT services	13.2 (9.9%)	*16.3 (14.9%)*	104.9 (50.3%)	5.5 (2.5%)	20.7 (21.7%)	8.4 (15.5%)	152.8 (12.9%)
Industrials	12.1 (24.4%)	*12.9 (27.1%)*	9.6 (14.4%)	10.5 (18.6%)	11.3 (29.2%)	6 (13.4%)	49.4 (11.6%)
Others	21 (21.7%)	*32.4 (30.7%)*	21 (17%)	19.2 (16.1%)	30.5 (24%)	25.2 (21.2%)	116.9 (21.4%)
Total	188.9 (16.8%)	*220.9 (21.7%)*	347.7 (31%)	114.9 (12.4%)	118.8 (21.4%)	133.9 (18.4%)	904.2

Note: The figures in brackets show each sector's regional percentages of total number of firms in the sector. The cell representing the higher sectoral share by region is highlighted. The total in the final column shows the total R&D invested in the sector and in brackets their share of the total number of companies. The total in the final row shows the R&D invested by firms headquartered in the region, with their share of firms in brackets. The EU28 column does not account for the final column total

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Apart from the grouping of sectors reported in Table 1.2, we also use in the report a different grouping, based on the R&D intensity (R&D/Net sales) of sectors and is reported in Table 1.4.

Companies operating either in high or medium-high R&D intensity sectors perform almost 90% of the R&D in the sample.

This is not surprising, given the nature of the *Scoreboard* and the kinds of firms included in the R&D ranking.

Table 1.4 - Industrial classifications applied in the Scoreboard – the 4 sector groups of different R&D intensity.

Sector R&D intensity*	Sector classification ICB4 digits**	N. of firms	R&D 2019 (€ bn)	% of total R&D	R&D per firm (€ million)
High	Aerospace; Biotechnology; Computer Hardware; Computer Services; Defence; Electronic Office Equipment; Health Providers; Internet; Leisure Goods; Medical Equipment; Pharmaceuticals; Semiconductors; Software; Technology Hardware & Equipment; Telecommunications Equipment	1140	504.9	55.8	442.9
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	923	304.7	33.7	330.1
medium-low	Alternative Energy; Beverages; Fixed Line Telecommunications; Food Producers; General Retailers; Media; Oil Equipment, Services & Distribution; Tobacco	150	30.7	3.4	204.7
Low	Aluminium; Banks; Construction & Materials; Electricity; Food & Drug Retailers; Forestry & Paper; Gas, Water & Multiutilities; Iron & Steel; Life Insurance; Mining; Mobile Telecommunications; Nonferrous Metals; Nonlife Insurance; Oil & Gas Producers; Real Estate Investment & Services; Transportation Services	287	63.9	7.1	222.6
Total		2500	904.2	100.0	361.7

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 for 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 four 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 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Green tech intensity of the Scoreboard companies

In addition to the sector classification, an insight into the priority areas of industrial R&D investments would provide policymakers with better insight into industrial strategies, and allow them to map these strategies against societal needs and policy goals.

The level of R&D intensity of a sector is a proxy of its technological content. However, as already stated in past editions of the *Scoreboard*[53], broad industrial classifications are not sufficient to characterise

[53] See for example Hernández, H., Grassano, N., Tübke, A., Amoroso, S., Csefalvay, Z., and Gkotsis, P.: The 2019 EU Industrial R&D Investment Scoreboard; EUR 3 0002 EN; Publications Office of the European Union, Luxembourg, 2020, ISBN978-92-76-11261-7, doi:10.2760/04570, JRC118983.

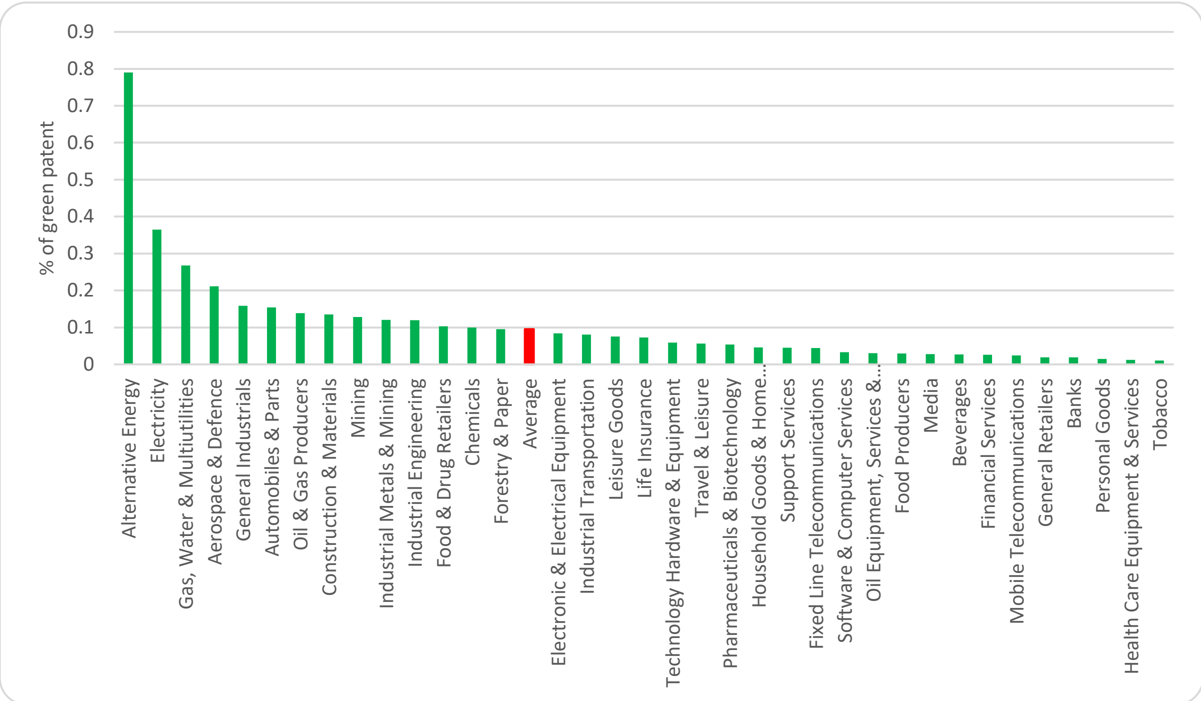
the technological profile of companies. To analyse companies' technological priorities, we need additional indicators comprising detailed technological classifications, such as patent or bibliometric analyses, as the one presented in Chapter 5.

Against the backdrop of Sustainable Development Goals, the need for climate change mitigation as a global challenge, the Paris Agreement, and for the EU the European Green Deal, this report looks at the patent portfolio of Scoreboard companies in green technologies. As an example, we look at the patent portfolio of companies to see how many of them have patented green technologies according to an existing patent classification system[54].

We retrieved patent data for 1364 of the top 2500 companies that accounts for 85.1% of the total R&D in the sample in 2019. Of the total patents owned by these companies, 9.5% are classified as green patents.

Looking at the share of green patents by ICB3 sector, we aggregate them according to their green patent intensity (ratio of green patents over total number of patents). Using the overall average, we divide the sectors into two groups, those with above-average green patent intensity and those with below average green patent intensity (see Figure 1.5).

Figure 1.5 – Share of green patents in each sector at the ICB 3 level



Note: Data refers to 1364 companies (accounting for 85.1% of R&D in 2019) for which patent data is available.
Patent data refers to the period 2010-2016.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

[54] See Pasimeni, F., Fiorini, A., and Georgakaki, A. (2019). [Assessing private R&D spending in Europe for climate change mitigation technologies via patent data]. World Patent Information, 59, 101927.

The majority of sectors and companies fall into this second group (800 companies out of 1364)

The sectors with above-average numbers of green patents include energy-related sectors (alternative energy, electricity, oil & gas), the construction sector, the automobile and the general industrials sectors, and the chemical sector. The automobile sector, in which the presence of Japanese and EU companies is very strong, is above average in terms of green patent intensity.

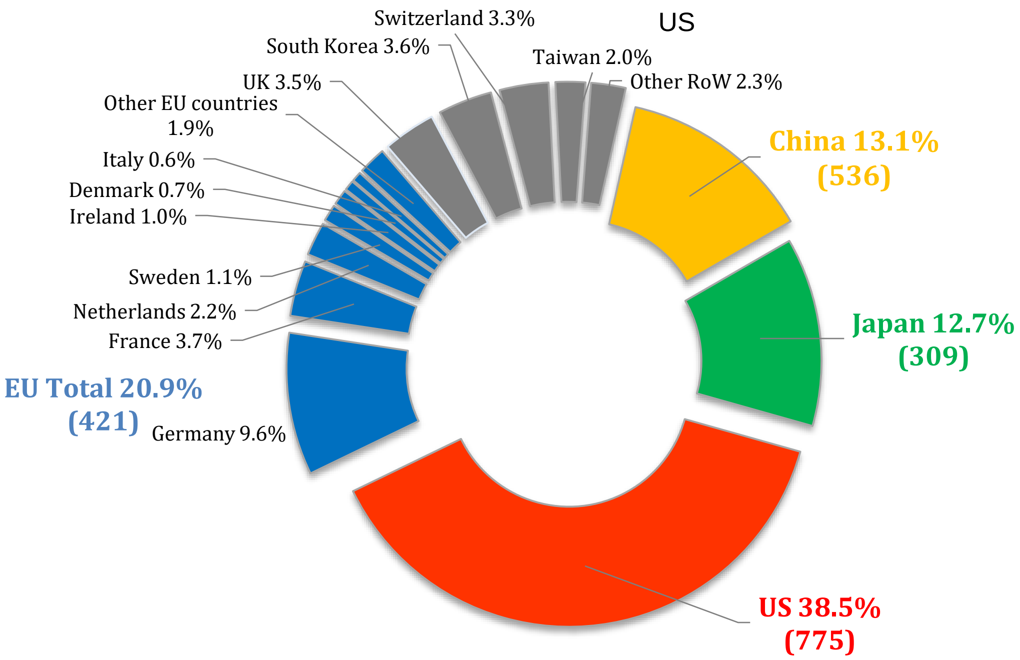
1.2.3 R&D investments by world region and industrial sector

The overall level of R&D investment has increased in 2019 by 8.9% compared to 2018 (see Table 2.1), but the distribution among regions has remained quite stable, with the US accounting for the majority both of companies and of R&D invested (see R&D shares for regions and countries in Figure 1.6).

Some trends reported in previous *Scoreboard* editions continued this year, like the growth of China, both in terms of companies and R&D share (from 11.7% in 2018 to 13.1% this year, compared to 5.9% in 2014). This growth has mainly been at the expense of Japan and the EU, whose share has declined in recent years. For the EU, it has decreased from 23.9% in 2014 to 20.9% in 2019, and for Japan from 14.3% in 2014 to 12.7% in 2019.

This growth is not only due to an increase in the number of Chinese companies investing in R&D, but also to a progressive increase in R&D investment.

Figure 1.6 – R&D investment by region and country

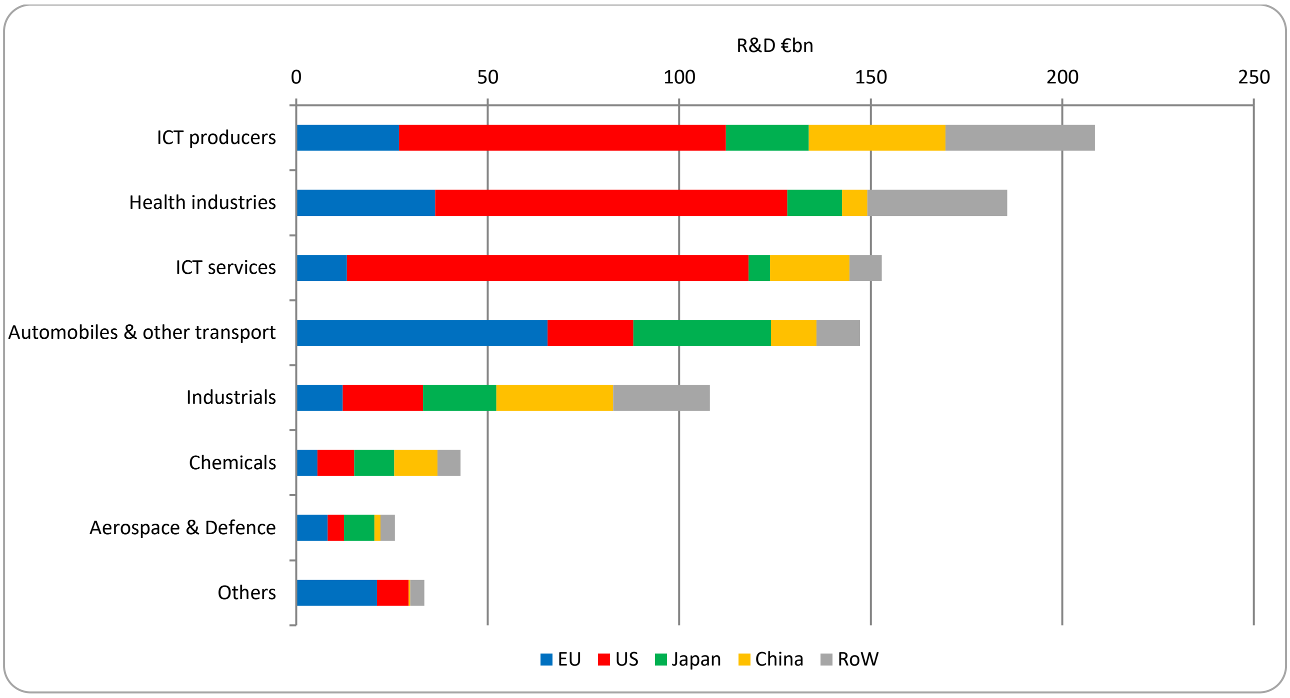


Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

1.2.4 R&D investments by industrial sector

Looking at sectors, the picture has also not changed much compared to last year, as "ICT producers" and "Health Industries" are still the top two sectors in terms of R&D invested, accounting together for almost 43.5% of R&D investment in 2019 (compared to 44.0% in 2018). See R&D shares for regions and industrial sectors in Figure 1.7.

Figure 1.7 – R&D investment by region and sector in €bn



Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

There is however, a notable exception. The "ICT services" sector has overtaken the automobile sector in terms of R&D invested. This is the result of a long-term trend that has seen automobile companies overtaken first by ICT hardware and now by ICT services companies in terms of numbers and R&D invested.

A closer look at sectoral groups (at ICB 3 Level) confirms this trend: while the top five sectors in terms of R&D invested are the same as in 2014 (1."Pharmaceuticals & Biotechnology", 2."Automobiles & Parts", 3."Technology Hardware & Equipment", 4."Software & Computer Services", 5."Electronic & Electrical Equipment"), now "Software & Computer Services" is second, "Technology Hardware & Equipment" third and "Automobiles & Parts" fourth.

This signals a sector shift that is happening in the top investors in R&D ranking, with the high-tech sectors progressively widening the gap to mid- and low-tech sectors.

1.3 Scoreboard 2020: main changes and entry-exit analysis

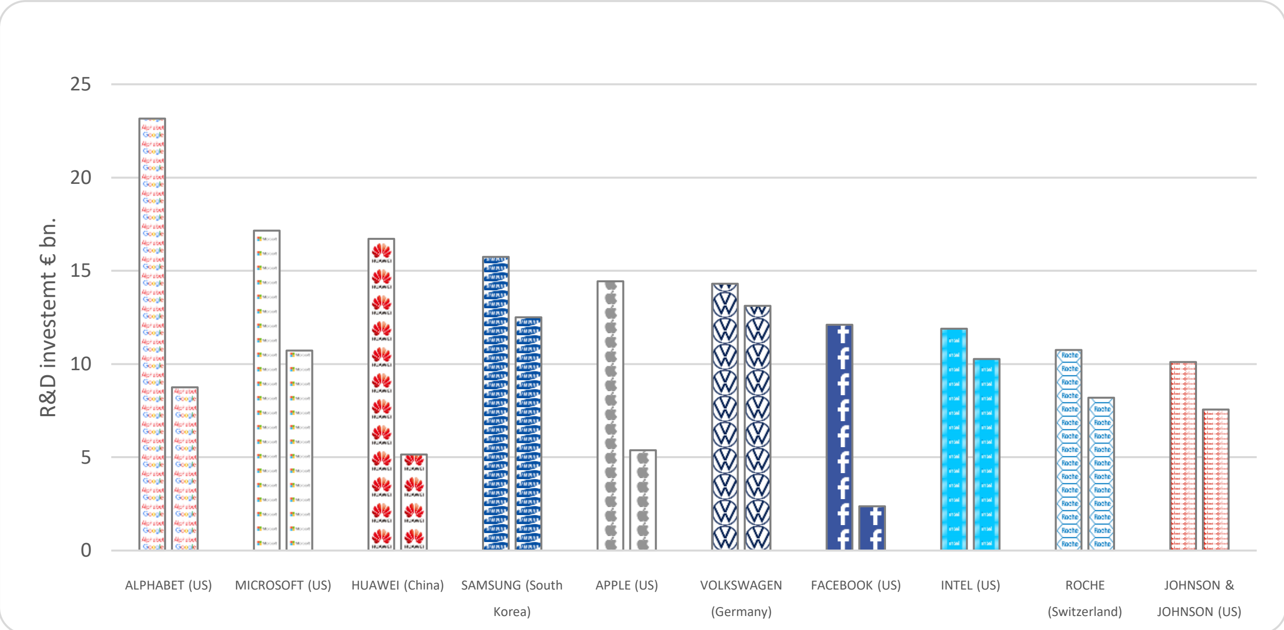
1.3.1 One-year comparison of Scoreboard 2019-2020

The ranking of the top 10 investors in R&D has registered one new entry. Facebook (11th in last year's ranking) is now 7th. Daimler, which was 10th last year, is now 11th (see Figure 1.8).

For the first time in 17 editions of the EU R&D investment Scoreboard, a Chinese company (Huawei) is in the top three companies worldwide for R&D investment. Only one EU company is in the top 10 (Volkswagen, at 6), along with six US companies, one from South Korea and one from Switzerland.

The growth of large tech companies (especially US companies) in the past 5 years has been exponential: Alphabet/Google increased its R&D by 165% in five years, Huawei by 225%, Apple by 168% and Facebook by 410%. The company that grew the least among the top 10 in the past five years is Volkswagen, which only increased its R&D investment by 9%.

Figure 1.8 Top10 investors in R&D – R&D investment in 2019 vs R&D investment in 2014 (Scoreboard 2020-2015).



Note: for each company, the bar on the left represents 2019 R&D investment, the bar on the right 2014 R&D investment.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Of the top 10 of 5 years ago, the three companies that dropped out include two pharmaceutical companies (Novartis was 5th and is now 14th, Pfizer was 10th and is now 16th) and one Automobile company (Toyota was 9th and is now 12th). These three spots have been taken by three ICT companies (Huawei was 15th and is now 3rd, Apple was 18th and is now 5th, Facebook was 55th and is now 7th). If we go further back in time, of the top 10 companies in the current Scoreboard, five were also among the top 10 in Scoreboard 2010 (Roche at 2nd, Microsoft at 3rd, Volkswagen at 4th, Johnson & Johnson at 8th, and Samsung at 10th).

The trends among the top 10 investors in R&D reflects general developments at sectoral level, with the rise of ICT sectors at the expenses of the Automobile sector (in terms of share in the numbers of companies and R&D).

It is likely that next year we will see a new rise of Health sector companies among the top investors, given the massive investment made in 2020 to find a vaccine for COVID-19.

Of the top 2500 investors in R&D in 2019, 2267 were already in the top 2500 sample of the year before. These companies account for 98.1% of R&D investment in 2019. Some companies made spectacular jumps ahead in the ranking, like Liuzhou Iron and Steel Company (China), which went from 2411th in last year's ranking to 725th, KPN (Netherlands), (from 2227th to 565th), and Myocardia (US) (2498th to 929th). Other companies fell a long way in the rankings, such as Tatung Company (Taiwan), which went from 2138th to 906th, Pitney Bowes (US) (from 970th to 2089th), and Element solutions (US) (from 1204th to 2220th).

Among the 233 companies that exited or entered the ranking, we can distinguish two categories (see Table 1.5).

The first category consists of companies on the fringes of the ranking. We can distinguish those that were in the ranking in 2019 (mainly toward the bottom) and did not make the cut this year because they did not invest enough (69 companies exited) from those that did not invest enough to enter the list last year but did this year (55 companies entered). These companies (both those who exited and those who entered the ranking) have been examined, and their movements into or out of the ranking can be considered natural.

The second category consists of companies that really entered or exited the ranking, meaning they were not on the radar before, or that they disappeared. There are 165 companies that fell out the ranking and 178 new companies that entered it.

Among the companies that exited, the main reason is because other companies have acquired them, and even if they still exist, they are not independent anymore. This is the case for three companies that were ranked quite high last year and are not in the ranking anymore: CELGENE CORP (ranked 37th) has been acquired by BRISTOL-MYERS SQUIBB; RED HAT (ranked 247th) has been acquired by IBM, and ARRIS INTERNATIONAL (ranked 253th) has been acquired by COMMSCOPE.

The companies that entered the ranking, meanwhile, are mainly either the result of a merge/split/demerge/spin off or - more rarely - companies that disclosed their R&D only in their last audited balance sheet, either for strategic reasons or because they recently went public. This is the case for the three highest-ranked new entries: CORTEVA (ranked 135th), which is the result of a spinoff from DowDupont in 2019, DOW INC (ranked 235th), which is a spinoff from DowDuPont; meanwhile, MAGNA INTERNATIONAL (268) had no R&D figures disclosed last year.

Table 1.5 Entry-Exit in the top 2500 in the last year

Region	Sector	Exit	Entry
EU	Aerospace & Defence	0	0
	Automobiles & other	3	2
	Chemicals	1	3
	Health industries	8	11
	ICT producers	3	1
	ICT services	1	1
	Industrials	4	2
	Others	13	10
EU Total		**33**	**30**
EU 28	*Aerospace & Defence*	*1*	*0*
	Automobiles & other	*3*	*3*
	Chemicals	*1*	*5*
	Health industries	*17*	*13*
	ICT producers	*6*	*1*
	ICT services	*4*	*4*
	Industrials	*6*	*3*
	Others	*17*	*17*
EU 28 Total		*55*	*46*
US	Aerospace & Defence	4	1
	Automobiles & other	0	0
	Chemicals	2	1
	Health industries	37	52
	ICT producers	14	4
	ICT services	12	14
	Industrials	4	5
	Others	4	6
US Total		**77**	**83**
Japan	Aerospace & Defence	0	0
	Automobiles & other	1	1
	Chemicals	0	0
	Health industries	1	0
	ICT producers	6	1
	ICT services	0	0
	Industrials	2	0
	Others	3	2
Japan Total		**13**	**4**
China	Aerospace & Defence	1	0
	Automobiles & other	4	5
	Chemicals	5	5
	Health industries	2	6
	ICT producers	12	22
	ICT services	6	8
	Industrials	4	11
	Others	19	25
China Total		**53**	**82**
RoW	Aerospace & Defence	2	1
	Automobiles & other	2	3
	Chemicals	2	2
	Health industries	15	8
	ICT producers	11	4
	ICT services	5	4
	Industrials	10	2
	Others	10	10
RoW Total		**57**	**34**
Total		**233**	**233**

Note: EU 28 values do not account for the total

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

A general methodological caveat when reading the *Scoreboard*: Only companies that disclose their R&D figures according to the *Scoreboard* methodology (see Annex 2) can be included in the ranking. Moreover, 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 #1 in the world R&D ranking if it had separated its R&D and content investments in its annual report (see explanation in Box 1.2).

In conclusion, entry-exit in the last year does not greatly affect the overall picture of R&D investment by sector and region. Keeping this in mind, it is also evident that the US and China have a more dynamic business environment than EU and Japan, with companies entering and exiting the ranking at a higher rate than the other regions. The net entry-exit is in fact positive for the US and China (meaning more companies entering than exited the ranking) and negative for the EU and Japan. Looking at this from a sectoral perspective, the Health (especially biotech) and ICT sectors (both producers and services) are the most dynamic.

1.3.2 Entry-exit analysis for Scoreboards 2015 vs 2020

To get a better picture of the entry-exit dynamics, we looked back over the last 5 years. In the past 5 years, 812 companies have entered/exited the ranking (see Table 1.6). The 1688 companies in both editions of the *Scoreboard* made up 88.8% of the R&D in 2019, so companies that are stable in the ranking made the vast majority of investment in R&D. This indicates that the bulk of the change took place at the bottom of the ranking.

Among those that fell out the ranking, apart from the entry-exit toward the bottom of the list, the main reason is mergers/acquisitions. Of the first 10 companies that were in Scoreboard 2015 but are not in Scoreboard 2020, 9 were in fact bought, disappeared or became a subsidiary of another company. These companies are:

- ALCATEL-LUCENT (ranked 54th), bought by Nokia;
- CELGENE (ranked 62nd), acquired by Bristol-Myers Squibb;
- MONSANTO (ranked 81st), acquired by Bayer;
- YAHOO (ranked 116th), partially acquired in 2017 by Verizon Communications;
- SHIRE PLC (ranked 164th), bought by Takeda Pharmaceutical;
- FREESCALE SEMICONDUCTOR (ranked 166th) merged into NXP Semiconductors in 2015
- SANDISK (ranked 168th), acquired by Western Digital;
- AVAGO TECHNOLOGIES (ranked 195th), which acquired Broadcom Corporation in January 2016 and merged into Broadcom Inc;
- ST JUDE MEDICAL INC (ranked 198th) company was acquired by Abbott Laboratories in January 2017;
- AMAZON.COM (ranked 206th), not included due to disclosure practice, see Box 1.2 below

Among those that have entered since Scoreboard 2015, some are the result of a merger/split/demerger/spin off, some disclosed figures they did not disclose before, and some are simply new companies founded in the past 5-10 years, with an extraordinary history of growth that led to their inclusion the Scoreboard.

Table 1.6 Evolution of Scoreboard 2015-2020

Region	**Sector**	**Exit**	**Entry**
EU	Aerospace & Defence	7	3
	Automobiles & other transport	9	11
	Chemicals	2	4
	Health industries	18	25
	ICT producers	17	5
	ICT services	13	8
	Industrials	22	7
	Others	54	27
EU Total		**142**	**90**
EU 28	*Aerospace & Defence*	*9*	*3*
	Automobiles & other transport	*14*	*14*
	Chemicals	*4*	*6*
	Health industries	*24*	*39*
	ICT producers	*29*	*6*
	ICT services	*22*	*13*
	Industrials	*24*	*8*
	Others	*75*	*43*
EU 28 Total		***201***	***132***
US	Aerospace & Defence	7	3
	Automobiles & other transport	5	1
	Chemicals	14	3
	Health industries	98	162
	ICT producers	69	13
	ICT services	74	66
	Industrials	18	6
	Others	39	19
US Total		**324**	**273**
Japan	Aerospace & Defence	1	0
	Automobiles & other transport	11	2
	Chemicals	6	2
	Health industries	2	1
	ICT producers	17	3
	ICT services	2	2
	Industrials	10	3
	Others	23	8
Japan Total		**72**	**21**
China	Aerospace & Defence	1	0
	Automobiles & other transport	6	18
	Chemicals	4	19
	Health industries	5	33
	ICT producers	23	71
	ICT services	11	46
	Industrials	11	41
	Others	23	89
China Total		**84**	**317**
RoW	Aerospace & Defence	3	2
	Automobiles & other transport	12	7
	Chemicals	10	6
	Health industries	20	37
	ICT producers	57	10
	ICT services	20	12
	Industrials	19	5
	Others	49	32
RoW Total		**190**	**111**
Total		**812**	**812**

Note: EU 28 values do not account for the total

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

These companies are:

- Alibaba (rank 26th) was not in the 2015 Scoreboard, but was present in SB13 (ranked 750th), then had no available figures for 2 years, before reappearing in SB17 in 58th place. The company went public in 2014, which is probably why figures were not published.
- UBER (ranked 37th), founded in 2009, and went public in 2019;
- HEWLETT PACKARD ENTERPRISE (ranked 97th), company resulting from the split of Hewlett Packard into HP (heir to the original company) and Hewlett Packard Enterprise in November 2015;
- LYFT (rank 120th), founded in 2012, went public in 2019;
- PAYPAL (ranked 125th), spinoff of eBay since 2015;
- MIDEA GROUP (ranked 128th) listed since 2013, data not available for 2015, entered the ranking in SB16,
- CORTEVA (ranked 135th), resulting from split of DowDupont in 2019;
- PINTEREST (ranked 152th), founded in 2010, went public in 2019;
- MEITUAN DIANPING (ranked 158th), founded in 2010, went public in 2018;
- BAOSHAN IRON & STEEL (rank 174th) founded in 2000, data not available in 2015;
- FERRARI (ranked 184th), spinoff from FCA group in 2014, went public in 2015.

Looking at entry-exit by region, the five-year trend shows growth of the number of Chinese firms at the expense of all other countries/regions, while. Looking at the sectoral dynamics, the more active sectors are the health sector and the two ICT sectors. However, it is worth noting that the ICT producers sector has experienced significantly more exits than entries, suggesting that a concentration may be happening in this sector.

Box 1.2 - 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 company disclosure practices, it is not always possible to identify R&D costs separately in companies' accounts, for example because they appear integrated with other operational expenditures such as engineering costs. To avoid overstating R&D figures, the *Scoreboard* methodology excludes R&D figures that are not disclosed separately (see methodological notes in Annex 2). Inevitably, strict application of this criterion can lead to understating or omitting some companies' actual R&D expenditure.

An extreme example of a possible understatement/omission of R&D figures is the US company Amazon. This company only publishes a figure for 'technology & content' investment ($35.9bn for 2019) in its annual report and nowhere does it indicate how much of this is accounted for by technology (R&D). Considering that a large part of Amazon's reported figure is R&D, its investment could be bigger than Alphabet's €23.2bn, making Amazon the #1 in the Scoreboard ranking.

The data collection methodology used for the *Scoreboard* subtracts any R&D tax credit disclosed in annual reports from the published R&D investment. This reduces the *Scoreboard* R&D for companies from countries with an R&D tax credit (such as Belgium, France, Japan, The Netherlands and the UK) compared to countries that do not have a credit such as Germany and Switzerland, or those like the US which have a less generous credit. In addition, many countries have a patent box innovation incentive, which is not deducted from their R&D.

CHAPTER 2 – WHERE THE EU STANDS COMPARED TO OTHER WORLD REGIONS

This chapter analyses trends in R&D and economic indicators of the world's top 2500 investors in R&D, aggregated by main industrial sector and world region.

The first part concentrates on describing companies' performance over the previous year, and the second part analyses the EU's position relative to its main competitors, and how performance has changed over the past 10 years.

The 2500 sample is divided into 5 sets, according to the location of companies' headquarters: EU (421), US (775), China (536), Japan (309) and RoW (459). The RoW group comprises companies from the UK (121), Taiwan (83), South Korea (59), Switzerland (58), Canada (30), India (29), Israel (21) and a further 17 countries. The EU group includes companies from 18 EU countries.

In 2019, global corporate R&D continued to increase considerably, continuing the trend observed in the past 9 years, despite a slowdown in sales growth and a strong decline in operating profits. As in previous years, R&D growth was mainly driven by large R&D investments in the ICT and Health industries by US and Chinese companies, while EU companies followed behind with a fair level of R&D growth.

2.1 Main changes in companies' Scoreboard indicators 2018 - 2019

The main indicators, ratios and one-year changes for the set of companies are presented in Table 2.1.

2.1.1 Worldwide picture

Investment in R&D continued to increase significantly in 2019 for the tenth consecutive year. The 2500 *Scoreboard* companies invested €904.2bn in R&D, 8.9% more than in 2018, matching the increase of the year before. The current COVID-19 crisis could affect this trend in either direction next year[55].

The companies based in the US and China showed double-digit R&D growth (10.8% and 21.0% respectively). EU companies increased R&D at a slower pace (5.6%, which is higher than last year's 4.9%) and Japanese ones by only 1.8%. The RoW group increased R&D by 6.0%, driven by R&D increases from companies based in the UK (9.0%), South Korea (8.7%) and Taiwan (8.0%).

EU companies' share in global R&D decreased slightly to 20.9% (last year it was 21.7%), and US companies increased their share to 38.5%. Chinese companies' share of R&D was higher that of Japanese companies for the first time (13.1% vs 12.7%).

[55] On the one hand, we are experiencing a worldwide effort as never before in modern history to find a vaccine, which will result in a boost to the R&D expenditure of Pharmaceuticals companies in next year's Scoreboard. At the same time, the lockdowns experienced in many countries in 2020 and the ongoing recession will affect many companies' profits, and maybe their R&D expenditure. The net effect of these two tendencies will determine if R&D will continue to grow next year

Global R&D growth was driven by the ICT services sector (19.8%), followed by the Health and ICT producers sectors (10.0% and 8.0% respectively). Automobiles and Aerospace & defence increased R&D at a slower pace (2.2% and 4.3%, respectively) and Chemicals, as in the previous period, continued to reduce R&D (-3.2%)[56].

The net sales of the 2500 companies increased modestly by 1.9% to €21.0 trillion, a growth rate well below that of R&D, breaking the positive trend showed over the previous two years. This was mostly due to a reduction in net sales in Chemicals (-4.3%) and Automobiles (-0.3%) sectors, while ICT services and Health industries showed large increases in net sales (8.4% and 7.7% respectively).

Table 2.1 - Main R&D and economic indicators by world region in the 2020 Scoreboard.

	EU	*EU 28*	US	Japan	China	RoW	Total
Number of firms	421	*542*	775	309	536	459	2500
R&D in 2019, € bn	188.9	*220.9*	347.7	114.9	118.8	133.9	904.2
One-year change, %	5.6	*6.1*	10.8	1.8	21.0	6.0	8.9
Net Sales, € bn	4819.1	*6082.2*	4917.5	3174.5	3608.2	4499.2	21018.4
One-year change, %	2.2	*1.2*	2.1	-2.3	10.2	-1.8	1.9
R&D intensity, %	3.9	*3.6*	7.0	3.6	3.3	3.0	4.3
Operating profits, € bn	424.3	*571.9*	647.6	180.6	258.4	566.8	2077.6
One-year change , %	-6.7	*-8.7*	-0.3	-29.1	4.2	-18.6	-9.8
Profitability, %	9.0	*9.5*	13.3	7.2	5.7	12.7	10.0
Capex, € bn	319.1	*391.8*	300.4	222.3	246.7	316.2	1404.7
One-year change , %	9.1	*7.7*	0.0	3.0	7.7	-0.1	3.7
Capex / net sales, %	6.7	*6.5*	6.1	7.0	6.9	7.1	6.7
Employees, million	16.79	*19.45*	10.86	8.95	11.98	7.84	56.42
One-year change, %	0.2	*0.1*	0.1	0.8	4.5	-2.0	0.8
RD per employee, €	11228.4	*11334.0*	31995.5	12705.9	9846.2	14864.2	15672.6
Market Cap, € bn	4607.9	*6039.0*	12779.7	2495.5	2461.6	4925.1	27269.8
One-year change, %	-3.7	*-3.1*	-1.0	-12.4	6.0	-1.0	-2.1

Note: EU 28 does not count in the final total column
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Capital expenditures increased worldwide by 3.7% (an increase of €49.3bn compared with the R&D increase of €74bn). The main contributions to the capex increase came from low-tech, Industrials and Chemicals sectors while Automobiles was the only sector showing a capex decrease.

Operating profits decreased significantly (-10.2%) across most world regions and sectors. Only Health industries (+13.2%) and ICT services (1.1%) increased profits in 2019.

The number of employees of the 2500 companies increased modestly by 1.7%. The ICT, Health and Aerospace & defence sectors increased the number of employees, while the Chemicals and Automobiles sectors decreased it.

[56] A significant cause of the reduction in R&D in the Chemicals sector is due to the split of DOWDUPONT (US), the sector's largest company, into three companies, one of which is no longer active in the Chemicals sector.

2.1.2 EU companies

Figure 2.1 depicts the set of 421 companies based in the EU, with the size and colour intensity of the companies' names being proportional to their R&D investment in 2019.

The EU companies are headquartered in 18 of the 27 EU countries. The majority of R&D investment is made by companies located in three countries, namely Germany, France and the Netherlands. More specifically, German companies are responsible for 45.9% of R&D investment by EU companies. French companies account for 17.9%, and those based in the Netherlands account for 10.8% of the EU's R&D. The top 10 companies in the EU are made up of seven German companies (VOLKSWAGEN at 6; DAIMLER at 11, BMW at 19, ROBERT BOSCH at 20, SIEMENS at 21, BAYER at 25, SAP at 38), one French company (SANOFI at 23), one Finnish (Nokia at 36) and one Dutch-based company (FIAT at 40). Five of these companies belong to the Automobile sector, two to the Health sector, two to the ICT producers sector and one to the ICT services sector.

Figure 2.1 – Word cloud of top EU investors in R&D.

Note: Reflects the ranking in the Scoreboard - size of the name and intensity of the colour proportional to R&D2019
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The 421 EU-based companies invested €188.9bn in R&D, meaning a substantial increase in this period (5.6%), significantly higher than the 4.9% increase in the previous year. EU companies' R&D share of 20.9% decreased slightly with respect to the previous year. The number of companies decreased from 424 in the Scoreboard 2019.

Looking at changes by sector, ICT services showed the largest R&D increase (12.4%), but this sector only accounts for 7% of the EU's R&D. The Automobiles and Health industries account for 34.8% and 19.2% of the total R&D and for most of the total growth of R&D of EU companies (4.2% and 5.0% respectively)[57].

In terms of countries, German companies (R&D growth of 4.7%) influenced the most the total EU R&D growth, mainly due to a low R&D growth of the German Automobiles sector (2.8%). Automobiles is by far the largest R&D sector in Germany, with a 53% share. By contrast, companies from France and the Netherlands showed R&D growth well above the EU average (8.3% for both economies). Other

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

countries whose companies showed R&D growth above the EU average were Sweden (9.8%) and Finland (8.8%).

Table 2.2 below shows the list of companies that made the largest contribution to R&D growth in the EU sample (top) and those that significantly held back the EU's R&D growth (bottom). Large changes in companies' R&D are not necessarily due to organic growth, but may be explained by mergers, acquisitions, divestments or accounting practices (see Section 2.1.4 below).

Table 2.2 - Companies most affecting R&D growth in the EU sample in 2019.

Companies that contributed most to the R&D growth of the EU sample			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
SAP	Germany	ICT services	18.6
VOLKSWAGEN	Germany	Automobiles & other transport	4.9
DAIMLER	Germany	Automobiles & other transport	6.5
BAYER	Germany	Health industries	10.2
FIAT CHRYSLER	Netherlands	Automobiles & other transport	13.9
PEUGEOT	France	Automobiles & other transport	11.3
ASML HOLDING	Netherlands	ICT producers	25.5
NOKIA	Finland	ICT producers	9.1
ESSILORLUXOTTICA	France	Health industries	188.4
C.H. BOEHRINGER SOHN AG & CO.	Germany	Health industries	9.4
Companies that affected most negatively the R&D growth of the EU sample			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
NXP SEMICONDUCTORS	Netherlands	ICT producers	-4.3
MYLAN	Netherlands	Health industries	-12.5
TELEFONICA	Spain	ICT services	-8.6
NOVO NORDISK	Denmark	Health industries	-4.8
BANCO SANTANDER	Spain	Others	-6.4
COMMERZBANK	Germany	Others	-40.7
DANSKE BANK	Denmark	Others	-29.2
DEUTSCHE BANK	Germany	Others	-19.7
ALLERGAN COMPANY	Ireland	Health industries	-20.4
BMW	Germany	Automobiles & other transport	-6.8

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Trends in sales, capex, profits and employees for the 542 EU companies

The net sales of EU companies reached €4.8 trillion, a 2.2% increase over the previous year. The sectors showing the best sales performance were Aerospace & defence (13.5%), Health industries (8.8%) and ICT producers (8.6%), while sales declined in the Chemicals (-8.3%) and Others (-0.5%) sectors. In the Others group, the decline in sales of oil companies, accounting for 15% of total sales in the EU sample, held back the EU's sales growth, especially Total (-4.3%) and ENI (-7.8%).

The 421 EU companies significantly increased capital expenditure (9.1%), a trend driven by the Industrials and low-tech sectors (an increase of €26.6bn, much larger than the R&D increase of €10bn).

The worst performance of EU companies was in terms of Operating profits (-6.7%), which decreased for most sectors except for Health industries and ICT services. In particular, the drop in profits was due to the performance of companies like ARCELORMITTAL, which was affected by the drop in steel prices and the US-China trade war, and DAIMLER, whose drop in operating profits probably resulted from the internal restructuring of the company's production from diesel to electric cars and vans.

The 421 companies based in the EU employed 16.8 million people, 0.2% more than the year before. Employment increased in the ICT producers sector, in the Health and Aerospace & defence sectors, while all other sectors reduced their number of employees.

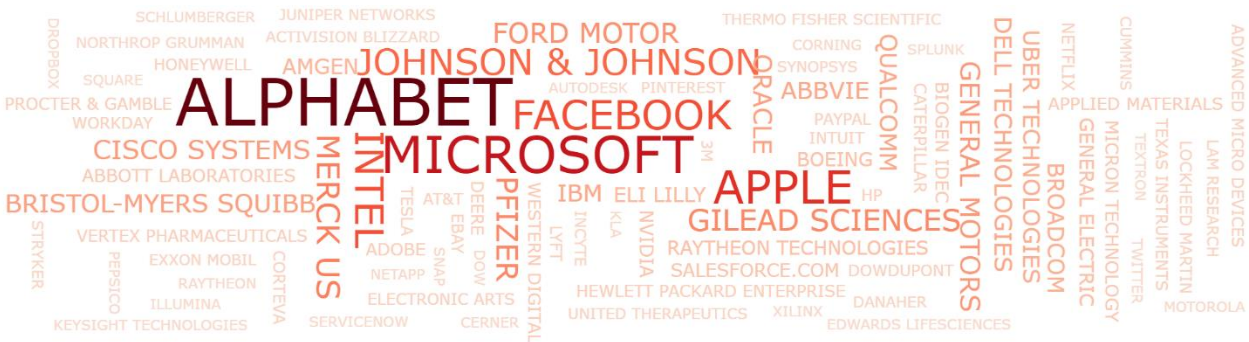
The market capitalisation of the listed companies based in the EU decreased by 3.7%.

2.1.3 Non-EU companies

Companies based in the US

Figure 2.2 depicts the set of 775 companies based in the US, with the size and colour intensity of the companies' names being proportional to their R&D investment in 2019. The top 2500 investors in R&D worldwide comprises 775 US companies. Among the top 10 companies in the US sample, 9 are from the ICT industry (ALPHABET at 1, MICROSOFT at 2, APPLE at 5, FACEBOOK at 7, INTEL at 8) or Health (JOHNSON & JOHNSON at 10, MERCK US at 13, GILEAD SCIENCES at 15, PFIZER at 16), and the tenth company is from Automobiles (FORD at 18).

Figure 2.2 – Word cloud of top US investors in R&D.



Note: Size of the name and intensity of the colour proportional to R&D in 2019

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The R&D performed by US companies is mainly in the ICT services (30.2%), Health industries (26.4%) and ICT producers (24.5%) sectors, with these 3 sectors accounting for 81.1% of total US R&D.

The 775 companies based in the US invested €347.7bn in R&D, representing a double-digit increase in 2019 (10.8%), and a similar growth rate as that of the previous year. US companies' global R&D share reached 38.4%, somewhat higher than in the previous year.

The R&D growth of the 775 US companies was driven by ICT services (22.6%) and Health industries (13.7%), which account respectively for 27.4% and 25.8% of total US R&D. US companies reduced R&D investment in the Chemicals and Automobiles sectors.

US-based companies modestly increased net sales (2.1%). A reduction of net sales in sectors such as Chemicals and low-tech industries offset the significant sales increases in ICT services and Health industries. Capex expenditures by US companies stagnated. The capex expenditure of US companies increased in low-tech sectors, Health industries and Aerospace & defence, and decreased in most other sectors, mainly in Automobiles, Chemicals and Industrials. US companies showed modest increases in profits (0.5%) and number of employees (0.1%). The market capitalisation of US-listed companies dropped by 1.0%.

Companies based in Japan

Figure 2.3 depicts the set of 309 companies based in Japan, with the size and colour intensity of the companies' names being proportional to their R&D investment in 2019. The top 2500 investors in R&D worldwide included 309 Japanese companies. In the top 10 Japanese companies, four are Automobile companies (TOYOTA at 12, HONDA at 17, NISSAN at 35, DENSO at 42), two are Leisure goods companies (PANASONIC at 39, Sony at 43), one is a Health company TAKEDA PHARMACEUTICAL at 45) and three are ICT companies, two producers (CANON at 63, HITACHI at 65) and one services (NTT at 86).

Figure 2.3 – Word cloud of top Japanese investors in R&D.

Note: size of the name and intensity of the colour proportional to R&D2019
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

R&D investment by the Japanese companies is mostly in the Automobile (31.3%) and ICT producers (18.8%) sectors, with a sector specialisation pattern similar to the EU, which is also led by the Automobile sector.

The 308 companies based in Japan invested €114.8bn in R&D, only 1.8% more than in the previous year. The global R&D share of Japanese companies continued to decline (12.7% in 2019 vs. 22% in 2009), as it has done for 10 years.

The largest contribution to the R&D growth of the Japanese group was made by Automobiles (2.2%), which accounted for 31% of the group's R&D, with Health industries (5%) accounting for 12.1% of Japan's R&D growth.

Net sales by Japanese companies dropped by 2.3%, mostly due to a decrease in sales in the Automobiles and ICT producers sectors. However, they increased capital expenditures by 3.0%, which was driven by investments in low-tech sectors, ICT services and Health industries. The operating profits of Japanese companies decreased by 29.1%, and market capitalisation decreased by 12.4%. The number of people employed by Japanese companies increased slightly (0.7%).

The drop in the profits of Japanese companies is mostly due to the performance of companies like SOFTBANK (loss in their venture fund financings start-ups); NISSAN MOTOR (due to falling sales and appreciation of the yen); and ENEOS HOLDINGS (affected by fall in oil and steel prices).

Companies based in China

Figure 2.4 depicts the set of 536 companies based in China where size and colour intensity of the companies' names are proportional to their R&D investments in 2019.

In the top 2500 investors in R&D worldwide, there are 536 Chinese companies, representing an increase of 29 compared to the Scoreboard 2019, and almost the same number as EU companies. Of the top 10 Chinese companies, two are ICT producers (HUAWEI at 3, ZTE at 95), three are ICT services companies (ALIBABA at 26, TENCENT at 46, BAIDU at 46), three are construction companies (CHINA STATE CONSTRUCTION ENGINEERING at 54, CHINA RAILWAY CONSTRUCTION CORPORATION at 74, CHINA RAILWAY GROUP at 75) and one is an automobile company (SAIC MOTOR at 82). HUAWEI is by far the biggest R&D investor in China, making up 16% of total R&D in the Chinese sample.

Figure 2.4 – Word cloud of top Chinese investors in R&D.

Note: size of the name and intensity of the colour proportional to R&D2019
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The R&D done in China is mainly in the ICT producers sector (30.0%), followed by the Construction sector, which accounts for 12.2% of the total.

The 536 companies based in China invested €118.8bn in R&D, a substantial increase (21.0%) over the previous year, but lower than the 27% increase of the previous year. Chinese companies showed double-digit R&D growth in all sectors except for Automobiles. Chinese companies' share in global R&D continued to increase in 2019, reaching 13.2%, higher than Japanese companies' level of R&D investment. The 536 Chinese companies showed robust growth in net sales (10.2%), driven by high sales growth in low-tech sectors but also in the ICT and Health sectors.

As with their EU counterparts, Chinese companies significantly increased capital expenditures (7.7%), driven by double-digit growth in investments in the low-tech and Industrials sectors (capex's increase of €17.6bn is comparable with the R&D increase of €20.6bn). The operating profits of Chinese companies stagnated in 2019 (0.2%), and the number of employees increased by 4.5%, well above the global average. Market capitalisation by the listed Chinese companies rose by 6.0%.

Largest contributions to R&D growth in the non-EU sample of companies

Table 2.3 below shows the list of companies that made the largest contribution to R&D growth in the non-EU sample of companies (top) and those that significantly held back R&D growth (bottom).

Table 2.3 - Companies most affecting R&D growth in the non-EU sample in 2019.

Companies that contributed most to R&D growth in the non-EU sample			
Company	**Country**	**Sector**	**1-year R&D growth**
ALPHABET	US	ICT services	24.4
HUAWEI	China	ICT producers	31.2
GILEAD SCIENCES	US	Health industries	97.9
UBER TECHNOLOGIES	US	ICT services	221.3
FACEBOOK	US	ICT services	32.4
MICROSOFT	US	ICT services	14.2
APPLE	US	ICT producers	13.9
SAMSUNG ELECTRONICS	South Korea	ICT producers	8.1
LYFT	US	Industrials	400.5
TAKEDA PHARMACEUTICAL	Japan	Health industries	33.6
Companies that most negatively affected R&D growth in the non-EU sample			
Company	**Country**	**Sector**	**1-year R&D growth**
THOMSON REUTERS	Canada	Others	-42.4
BIOGEN	US	Health industries	-12.2
MERCK US	US	Health industries	-4.5
NOVARTIS	Switzerland	Health industries	-5.4
NORTONLIFELOCK	US	ICT services	-64.1
BOMBARDIER	Canada	Aerospace & Defence	-61.7
FORD MOTOR	US	Automobiles & other transport	-9.8
GENERAL MOTORS	US	Automobiles & other transport	-12.8
GENERAL ELECTRIC	US	Industrials	-24.6
DOWDUPONT[58]	US	Chemicals	-48.1

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

[58] Mostly due to divestments in 2019 (see Box 2.1)

2.1.4 Large R&D changes in big companies

The growth in R&D investment may be organic, or may be driven by company mergers, acquisitions, divestments or changes in various accounting items. Acquisitions can be either of privately owned companies, or of listed companies or divisions or assets thereof. In the case of listed companies, the R&D of the target company can usually be found in the annual reports to examine whether the acquisition explains most of the R&D increase for the acquirer. In the case of private company targets, it is more difficult to find a figure for the target's R&D. However, if the cost of the acquisition is disclosed (although in many cases where unlisted companies are involved, it is not), this can often give an indication of the size of the target, and therefore of its R&D given the target's sector.

In Box 2.1 below, 24 companies are examined to help us understand the main reasons for the large R&D changes reported in 2019. The conclusion is that acquisitions are only responsible for some of the changes. It is also important to note that in some cases, the R&D figure itself is inflated for a single year by a special event such as stock-based compensation for previous years, and is likely to fall substantially next year, since the special event is unlikely to be repeated (e.g. cases such as Gilead, Uber, Lyft, and Pinterest).

Box 2.1 – Companies showing large R&D changes

Gilead Sciences: 2019 R&D up 97.9% over 2018, and sales up 1.5%. Gilead's largest recent acquisition was of Kite Pharma, which was completed in October 2017 for $11.9bn. As a 2017 acquisition, this would not explain the big increase in R&D from 2018 to 2019. However, Gilead's 2019 report explains that it entered into a 10-year R&D collaboration agreement with Galapagos in July 2019, and Gilead paid Galapagos $3.95bn up front as part of this agreement. This payment was all charged to 2019 R&D, and raised 2019 GAAP (Generally Accepted Accounting Principles) R&D. It is included in final accounts and therefore reflected in the Scoreboard data, but deducting it, as it is in non-GAAP R&D, would show an increase from 2018 to 2019 of only 7.2%. Non-GAAP 2019 R&D is $3.77bn, and this is a better reflection of true R&D in the accounting period than the GAAP figure of $9.1bn.

Uber Technologies: 2019 R&D up 221.3% over 2018, with sales up 24.5%. The increase appears to be mainly due to the recognition in 2019 of stock-based compensation for all previous years. This is a characteristic of US tech companies which have just had an IPO, because stock compensation for previous years is only issued once the IPO is completed and tradeable stock is available. Stock-based compensation is included in GAAP R&D, which is the figure in the final accounts and therefore in the Scoreboard. Deducting it, the non-GAAP R&D of $1.8bn is a better reflection of true R&D than the GAAP figure of $3.3bn. Uber also made a large acquisition in 2019 of Careem, the Middle Eastern ride-sharing company, for $3.1bn.

Lyft: 2019 R&D up 400.5% over 2018, with sales up 67.7%. In a similar fashion to Uber, Lyft recognised $968m of past stock-based compensation in 2019, after its IPO. Without this, 2019 R&D would have increased by much less than the 400% recorded in the annual report. R&D personnel costs did increase by $165m over 2018, because of headcount increases. Non-GAAP R&D was up by 70%, similar to the increase in sales, and was $0.5bn compared to a GAAP R&D of $1.51bn, which was up 400%.

Pinterest: 2019 R&D up 379.6% over 2018, and sales up 51.2%. Like Uber and Lyft, the explanation of the 380% increase in R&D from 2018 to 2019 lies in post-IPO share-based compensation, which totalled $867m of the $1207m R&D costs in 2019. Non-GAAP R&D was up by 42% to $0.34bn, an increase similar to that of sales, compared to a GAAP R&D of $1.2bn, up 380%.

Box 2.1 ctd . – Companies showing large R&D changes

United Therapeutics: 2019 R&D up 230.4%, with sales down 11%. In contrast to Uber, Lyft and Pinterest, the 230% increase in United Therapeutics' R&D from 2018 to 2019 is explained by the multiple Phase III clinical trials in progress to develop its pipeline of new drugs.

Barclays: 2019 R&D up 206.1% over 2018, with sales up 2.3%. The 206% increase in Barclays R&D is a result of its focus on digital banking, and the increase in software expenditure required to realise this.

China State Construction: R&D up 37.5% from 2018 to 2019, with sales up 18.5%. There were no major acquisitions in 2019, suggesting that this could be due to organic growth.

Salesforce.**com**: R&D up 46.7% from 2018 to 2019, with sales up 28.7%. Salesforce made several acquisitions in 2019, the largest being Tableau Software for $15.7bn in June 2019, and ClickSoftware for $1.35bn in August. Tableau's R&D for 2018 (the last publicly available report) was $383m, up $49m over 2017. We can therefore assume that Tableau's R&D for 2019 was over $400m, perhaps $440m. Salesforce's 2019/20 R&D was $2766m, up from $1886m in 2018/19. Deducting $440m from 2019/20 gives an increase in R&D without the acquisition of 23% rather than the reported 46.7%, which is similar to the sales increase.

China Railway Construction: 2019 R&D up 42.8% over 2018, with sales up 13%. The annual report states that R&D consists of employee costs and materials. Revenue is up 13.8%, so R&D is up three times as much as revenue. There do not appear to have been any substantial acquisitions in 2019 (the acquisition of the Spanish company Aldesa was in 2020), suggesting that this could be due to organic growth.

Netflix: The Scoreboard dataset shows an increase in R&D of 37.4% from 2018 to 2019, with sales up 27.6%. Netflix explains the R&D increase as an increase in the costs of technology personnel. However, Netflix only made a small acquisition in 2019 (StoryBots), but this was to increase its children's content.

DowDuPont: DowDuPont was split into three companies in mid-2019: DuPont, Corteva Agriscience (from 1 June 2019), now called Corteva Inc., and Dow (from April 2019). DuPont reports its 2019 R&D as $955m, down 12% from 2018 due to discontinued operations. Dow reports its 2019 R&D as $765m, down 4.4% from 2018, and Corteva reports its 2019 R&D as $290m, down 15.9% from 2018. These three companies are now included separately in the 2020 Scoreboard.

Huawei: The 2020 Scoreboard shows R&D growing 31.2%, and sales up 19.1% from 2018 to 2019. There are no reports of large acquisitions by Huawei in 2019 and, being an unlisted company, detailed financial reports are not available. It is possible that the larger increase in R&D compared to sales is the result of extra R&D which was initiated in order to respond to US sanctions, which have reduced its access to many high tech US components.

Facebook: R&D up 32.4% in 2020 Scoreboard, with sales up 26.6%. Facebook made seven acquisitions in 2019, but the purchase price was only disclosed for two of these: the US company CTRL-Labs for $0.5bn to $1bn, and the Spanish company PlayGiga for $70m. CTRL was a start-up founded in late 2015. Facebook is estimated to have acquired at least 72 companies since its foundation, costing it over $23bn. However, Facebook's 2019 sales were up 27% over 2018, so it is not unexpected that its R&D should be up 32% (In comparison, Alphabet's R&D for example is up more than its sales), and CTRL was too small to add a significant amount to Facebook's €12bn of R&D investment.

Box 2.1 ctd. – Companies showing large R&D changes

Takeda: R&D up 33.6% in 2020 Scoreboard, with sales up 56.9%. Takeda completed its acquisition of Shire for £46bn in early January 2019. The 2020 Scoreboard contains Takeda's results for the year to end March 2020, and these results therefore include Shire, so the increases in Takeda's 2019/20 R&D and sales over 2018/19 are the result of the acquisition. Shire is no longer in the Scoreboard. In the 2018 *Scoreboard* when the two companies were separate, Shire's R&D was approximately 55% of Takeda's.

Tencent: R&D up 32.5% and sales up 20.7% from 2018 to 2019. Tencent has acquired many video game companies and paid $8.6bn for Supercell in 2019, but the added R&D is small compared to its 2019 total R&D of €3.9bn. The annual report for 2019 mentions increased R&D costs, so the fact that R&D increased faster than sales for a tech-oriented company such as Tencent is understandable (the same is true of Apple & Alphabet).

Mitsubishi Heavy Industries (MHI): R&D up 32.8% in 2020 *Scoreboard*, with sales down 0.9%. In June 2019, Mitsubishi Heavy announced the acquisition of Bombardier's CRJ aircraft programme for $750m, but this is unlikely to have added significant R&D for a company with sales of $38bn.

Allergan: R&D down 20.4% from 2018 to 2019, with sales up 1.9%. AbbVie announced its $63bn acquisition of Allergan in June 2019, but the acquisition was not completed until May 2020. Whereas Allergan's GAAP R&D decreased from 2018 to 2019, non-GAAP R&D increased by 8.5%. The reason for the difference is that its 2018 R&D included milestone payments and upfront expenses for asset acquisitions (mainly bought-in drug candidates), whereas 2019 included a much smaller figure for these.

Biogen: R&D down 12.2% from 2018 to 2019, with sales up 6.9%. Biogen bought Nightstar Therapeutics for $800m on 7 June 2019 to add Nightstar's clinical and pre-clinical pipelines (mainly ophthalmology) to its own pipeline. However, the addition of Nightstar's R&D was much smaller than the 2018 reduction $486m in R&D associated with the cessation in that year of an expanded strategic collaboration agreement between Biogen and Ionis Pharmaceuticals. It is this charge that caused the R&D decrease.

Honeywell: R&D down 14% from 2018 to 2019, with sales decreasing by a similar amount (-12.2%). In 2018, Honeywell spun off Honeywell Turbo technologies (now Garrett Motion) and its consumer products business Resideo Technologies. Both spun-off companies are now listed. These spin-offs contributed to revenue decreasing by 12.2%, and R&D decreasing by 14%.

General Electric: R&D down by 24.6%, with sales down by 1.9%. GE has been undergoing a reorganisation, including a number of divestments, to focus its business on the aviation and power sectors. The transport business was sold to Wabtec in 2019, and cost cutting saw reductions in R&D, with three R&D centres closed.

General Motors: R&D down 12.8% and revenue down 6.7% from 2018 to 2019. In late 2017, GM sold its European Opel & Vauxhall operations to the PSA Group. The main driver for the reduction in R&D was probably GM's cost reduction programme, which included closure of some R&D operations.

Adobe: R&D up 25.5%, sales up 23.7% from 2018 to 2019. Adobe acquired Allegorithmic for an undisclosed sum in January 2019, and this would have added to its R&D and sales increases that, in any case, are similar.

Vertex Pharmaceuticals: R&D up 24.5%, sales up 36.6% from 2018 to 2019. In June 2019, Vertex agreed to acquire Exonics & Semma Therapeutics and signed a major collaboration agreement with Crispr Therapeutics. Non-GAAP R&D was up by only 7.5% - this was lower than the GAAP increase of 24.5% because of additional upfront collaboration expenses charged to R&D in 2019.

Box 2.1 ctd. – Companies showing large R&D changes

Workday: R&D up 27.9%, and sales up 28.5% from 2018/19 to 2019/20 (FY ends 31 January). Workday made four acquisitions in mid-2018 and one at the end of 2019: Adaptive Insights (for $1.55bn) & Rally Team (for an undisclosed amount) in June 2018, Trusted Key (for an undisclosed amount) and Stories.bi (for an undisclosed amount) in July 2018, and Scout RFP in December 2019. These contributed to the reported increases in R&D and sales, which were similar.

2.2 Positioning of the EU with respect to main competitors

This section compares the R&D performance of the EU set of companies in the *Scoreboard* over the past ten years with the US, Japanese and Chinese companies for the top 4 sectors for R&D investment, which account for 77% of total R&D in the *Scoreboard*, namely ICT producers (23.0%), Health industries (20.5%), ICT services (16.9%) and Automobiles (16.3%).

Figures 2.5, 2.6 and 2.7 compare the sector specialisation of the EU companies with that of US, Japanese and Chinese companies respectively. The figures present the R&D investment for the four main sectors in 2010 and 2019. Each dot represents a sector that placed below (above) the diagonal means the EU firms are investing more (less) than their counterparts in that sector. The distance from the diagonal represent how much more (less) the EU is investing compared to their counterparts in each specific sector.

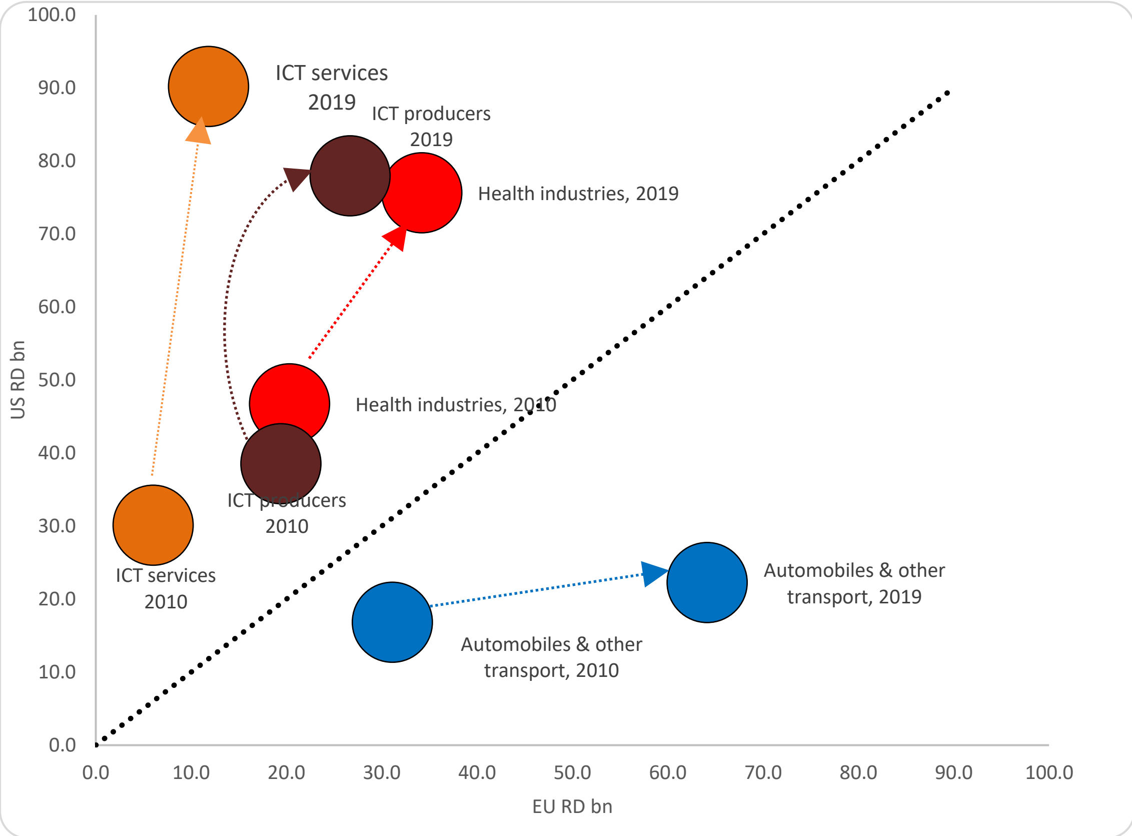
2.2.1 The EU vs the US

In 2010, US firms invested more than EU firms in the Health sector and in the ICT sectors (both service and producers), while EU firms invested more in the Automobile sector. This contrast in specialisation has sharpened over the past 10 years, with the gap between the two regions most pronounced in both ICT sectors.

From the EU perspective, the ratio of R&D investment between the EU and the US has remained constant in the Health sector, has increased (from 1.9 to 2.9) in the Automobile sector, and has dramatically decreased in both ICT sectors. In other words, in 2010, EU firms invested 44% of US firms' investments in the Health sector, and in 2019, the share is practically the same.

The gap between the two economies in this sector has remained constant across the period considered. In the other three sectors, the EU has significantly increased the difference in investments in Automobiles and parts (from investing 1.85 times as much as the US in 2010 to 2.88 times as much as the US in 2019), but has fallen further behind in ICT producers (from investing 50% of what the US was investing in R&D in 2010 to 34% in 2019) and ICT services (from 20% to 13%).

Figure 2.5 - EU-US by-sector comparison of R&D investment in 2010 and 2019.



Note: Data refers to 514 (EU:164, US:350) of the 805 companies (EU:204, US:601) in the four sector groups in the two regions for which R&D data is available for the entire period, accounting for 90.2% of the R&D in 2019.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

R&D intensity (R&D/Net sales) has grown in the past decade in both the EU and the US, but the gap has increased, meaning the growth has been faster in the US than in the EU.

The average R&D investment per company has grown substantially in the two regions, but more so in the US. In the EU, it was €306.3 million in 2010, and grew to €509.6 million in 2019 (66.4% growth). In the US, it grew from €324.0 million to €604.8 million (86.7% growth). On top of this, there are 1.4 times more US companies than EU companies in the top 2500, another explanation for the gap between the two regions.

While EU investment in R&D is led by traditional mid-tech sectors (Automobile), the US specialises in high-tech sectors (ICTs).

2.2.2 The EU vs Japan

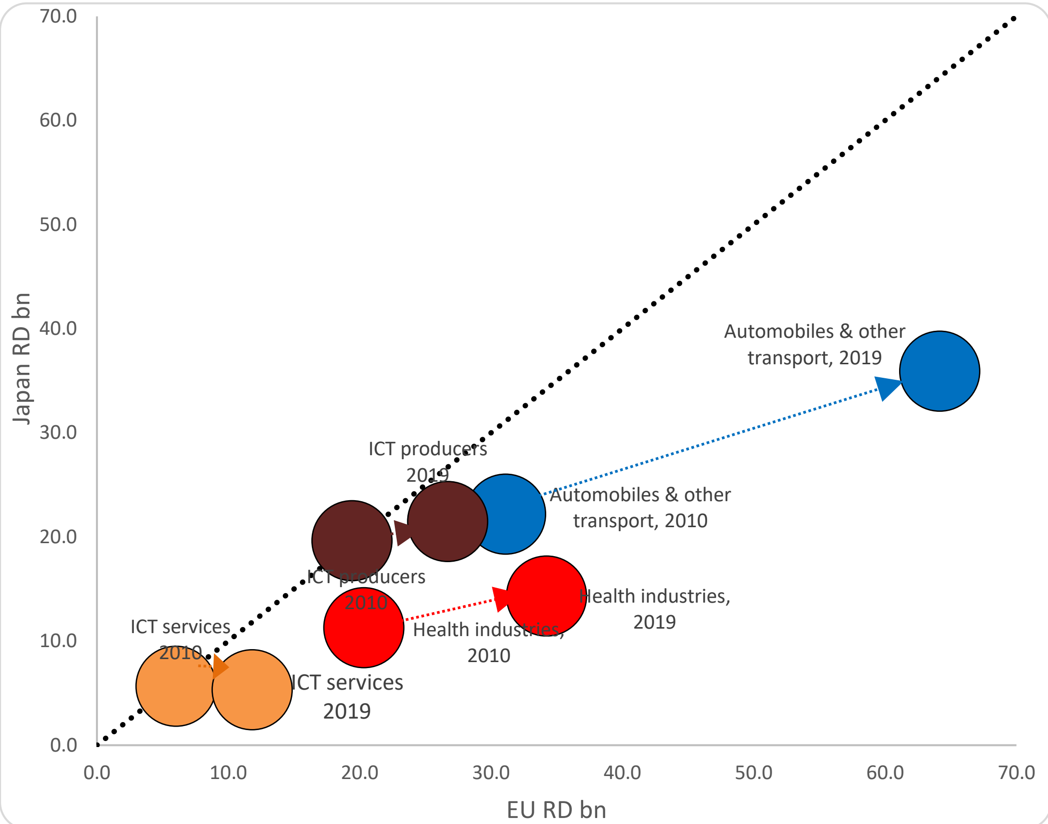
In 2010, EU companies in the *Scoreboard* invested more than Japan in all four major sectors under consideration.

In the Automobile sector, which represents the most important sector for both region in terms of R&D investment, the ratio of R&D investment between the EU and Japan has increased from 1.4 to 1.8.

R&D intensity (R&D/Net sales) has grown in the past decade in the EU, while remaining the same for Japan for the entire decade. This has resulted in the EU having a higher R&D intensity than Japan in 2019, while Japan had 1.2 times the EU's R&D intensity in 2010.

This specialisation pattern has changed over the past 10 years, with the gap between the two regions slightly increasing in all sectors.

Figure 2.6 – EU-Japan by-sector comparison of R&D investment in 2010 and 2019.



Note: Data refers to 296 (EU:164, JP:132) of the 339 companies (EU:204, JP:135) in the four sector groups in the two regions considered for which R&D data is available for the entire period, accounting for 97.5% of R&D in 2019.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The average R&D investment per company has grown more rapidly in the EU than in Japan. In the EU, it was €306.3 million in 2010, and grew to €509.6 million in 2019 (66.4% growth). In Japan, it grew from €295.6 million to €375.3 million (26.9% growth).

2.2.3 The EU vs China

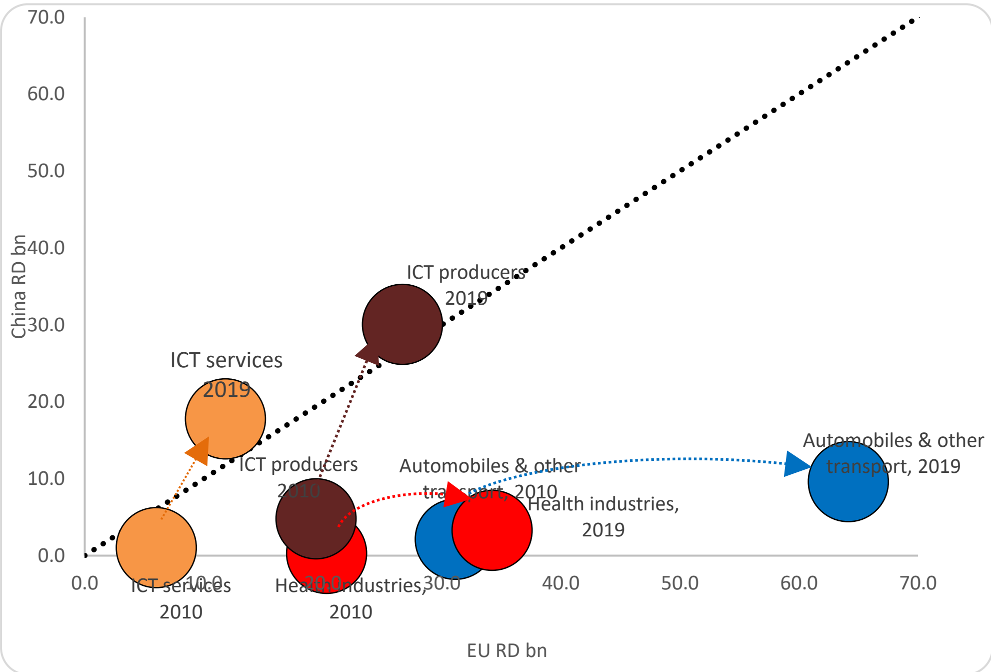
In 2010, the EU invested more than China in all the four major sectors under consideration. In the past 10 years, however, the R&D investment of Chinese companies operating in the ICT sectors has considerably overtaken that of EU companies in these same sectors. The result is that in 2019, the companies in the Chinese ICT sectors invested altogether more in R&D than their EU counterparts. By contrast, the EU retained its lead in the Health and Automobile sectors.

R&D intensity (R&D/Net sales) has grown in the past decade in the EU, while it has skyrocketed in China, which has now almost closed the gap with the EU.

The average R&D investment per company in the *Scoreboard* has grown significantly in China, from €47.2million in 2010 to €274.4 million in 2019 (477.1% growth). However, it remained little more than half that of the average EU company in 2019 (509.6 € million).

Thus, overall EU firms' R&D investments remain well ahead of that of Chinese firms. However, the gap is continually decreasing.

Figure 2.7 – EU-China by-sector comparison of R&D investment in 2010 and 2019.



Note: Data refers to 347 (EU:164, CN:183) of the 497 companies (EU:204, CN:293) in the four sector groups in the two regions for which R&D data is available for the entire period, accounting for 91.1% of R&D in 2019.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

CHAPTER 3 - A CLOSER LOOK AT EUROPE

3.1 Introduction: the top 1000 EU+UK extended sample

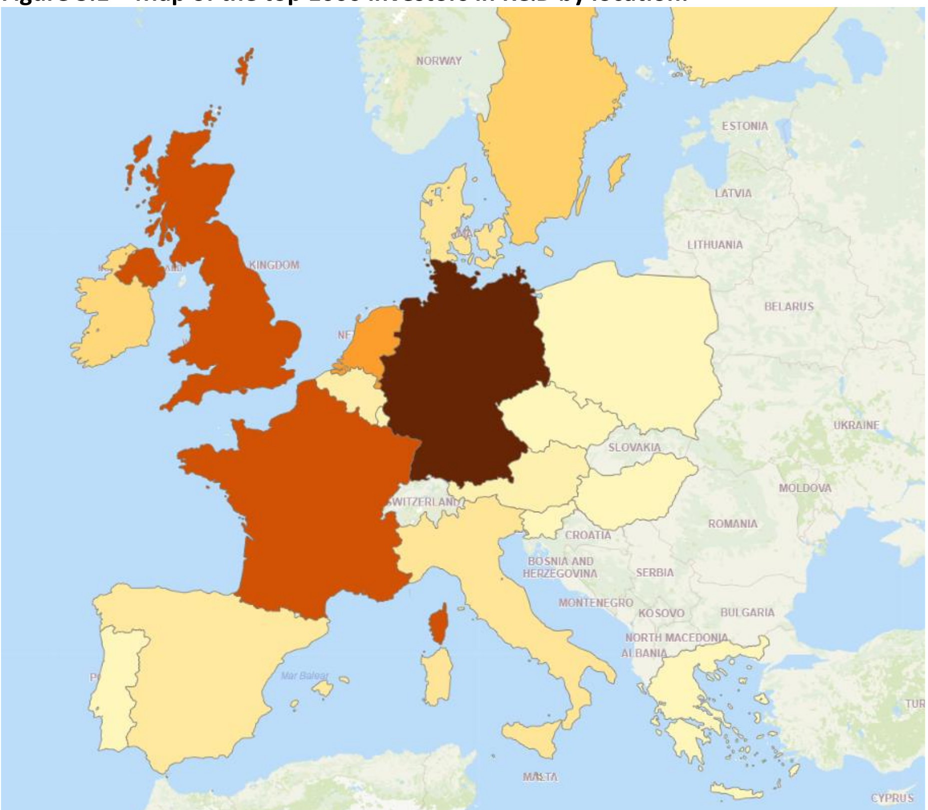
In order to deepen our understanding of R&D trends in Europe, we expand the focus from the 421 EU and 121 UK firms which fall within in the top 2500 investors in R&D worldwide to the top 1000 EU+UK companies (headquartered in Europe) for R&D investment. This chapter presents the main economic trends for the companies included in the top 1000 EU+UK sample, the characteristics of the sample and the dynamic entry-exit and rise and fall of companies. In 2019, the UK was still a member of the EU, and in order to better characterise the dynamics of R&D investment in Europe in 2019 (our data relates to the 2019 fiscal year) and to offer the possibility of a comparison with previous top 1000 EU-28 data, we analyse here the top 1000 EU+UK extended sample.

3.2 Top 1000 EU+UK R&D investors and their R&D activities

The top 1000 EU+UK extended list includes the 421 EU+121 UK companies from the ranking of the global top 2500. To this "top" group, we added 458 companies (299 from the EU and 159 from the UK) that do invest in R&D, but less than needed to enter the top 2500 rankings.

The companies in the top 1000 EU+UK sample are located in 19 of the 27 EU Member states and the UK. They invested a total of €229.5bn in R&D in 2019. Figure 3.1 presents the countries where these companies have their headquarters.

Figure 3.1 – Map of the top 1000 investors in R&D by location.

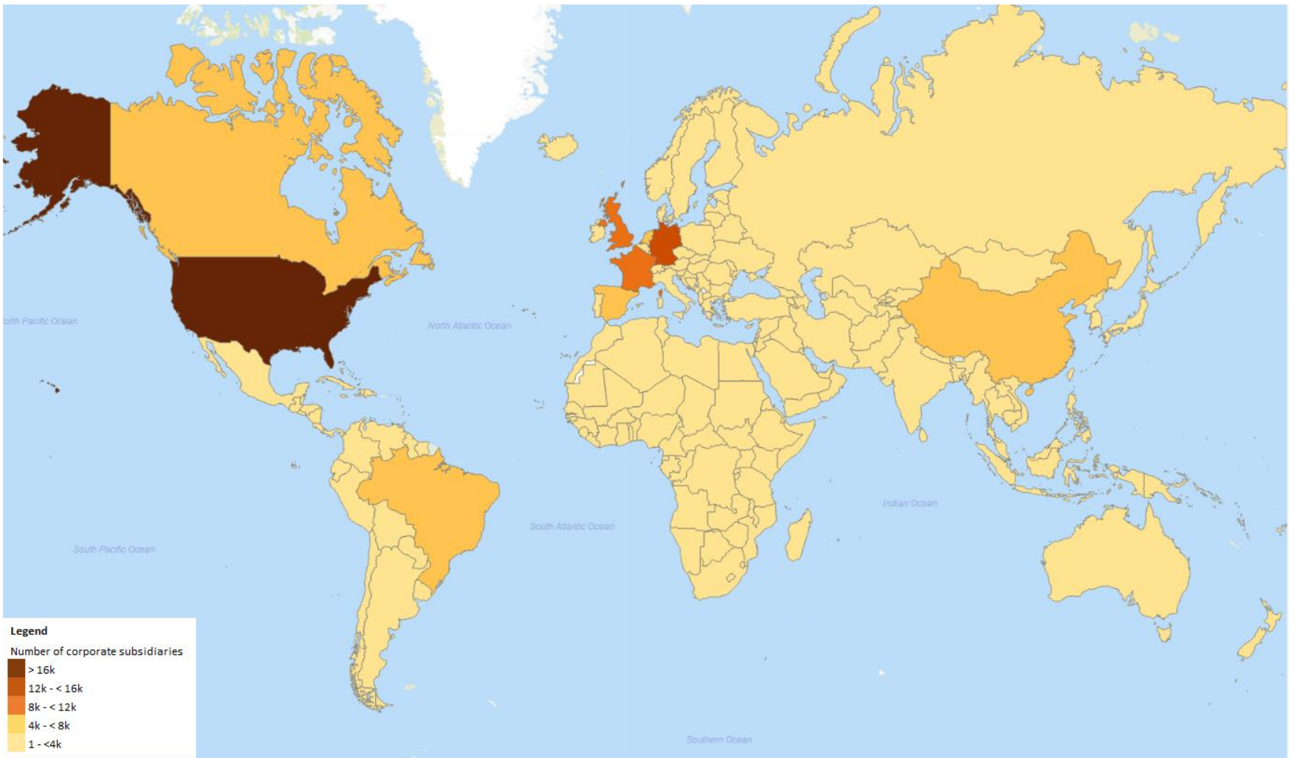


Note: colour darkness proportional to R&D investment in 2019 by companies headquartered in the country. Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The sample of the top 1000 EU+UK accounts for total R&D investment of only €8.5bn more than the top 542 companies which are also in the global top 2500, less than 5% more. This limited increase both in the number of Member States covered (19 against 18 covered by the "top" EU companies) and R&D invested illustrates how the top companies account for almost all R&D investment by companies headquartered in the EU+UK. In fact, the top 25 companies in the sample, headquartered in seven countries - Germany (12 companies), France (4 companies), Netherlands (2 companies), Sweden (2 companies), Finland (1 company), Ireland (1 company) and UK (3 companies) - account for 50% of the total R&D invested by the top 1000 EU+UK sample.

Even if R&D by headquarter is quite concentrated, the top 1000 EU+UK companies have activities scattered all around the globe. There is at least one corporate subsidiary[59] of an EU headquartered company in practically all the countries in the World. Figure 3.2 illustrates subsidiaries by country of location. Many corporate subsidiaries are located in the EU and UK (especially the big five; France, Germany, the UK, Italy and Spain), while the country accounting for the most of subsidiaries outside the Europe is the United States. We also find a significant presence in China, Brazil, Australia and Canada

Figure 3.2 – Map of the corporate subsidiaries of the top 1000 EU+UK R&D investing companies.



Note: colour darkness proportional to the subsidiaries in the country. Data refers to 937 companies (accounting for 97.6% of R&D in 2019) for which subsidiary data is available.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

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[59] Data on the ownership structure provided by Bureau van Dijk (BvD) and refers to the subsidiaries owned by the Scoreboard companies with a share of 50.1% or more. Corporate subsidiaries are all companies that are not banks or financial companies nor insurance companies. They can be involved in manufacturing activities but also in trading activities (wholesalers, retailers, brokers, etc.). They include also companies active in B2B or B2C non-financial services.

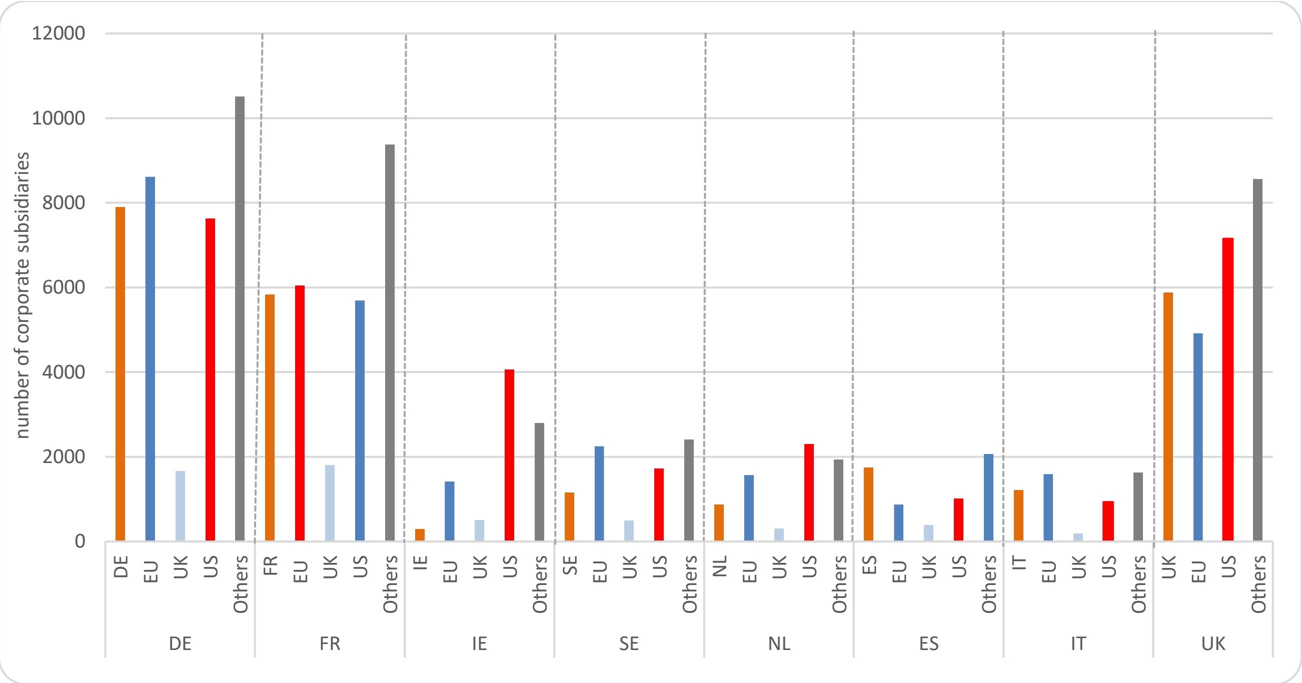
We can distinguish the corporate subsidiaries according to where they are located relative to the HQ of the company to which they belong. This grouping allow us to distinguish five kind of subsidiaries: those located in the same country as the mother company; those located in a different country inside the EU; those located in the UK; those located in the US (the country with the highest number of subsidiaries outside the EU+UK) and those located outside the EU or the UK.

Figure 3.3 reports the distribution of corporate subsidiaries in these five groups for the companies headquartered in eight selected countries (those with the highest number of corporate subsidiaries). Of the total ~ 145000 corporate subsidiaries in the sample, 18.4% are located in the same country has the HQ of the company they belong to, 27.1% are located in another EU country or in the UK, 23.1% in the US and the remaining 31.4% in other countries (mainly China, Canada, Brazil, Australia, Mexico and India).

Different countries present very uneven distributions of corporate subsidiaries. On one side, the clear cases of companies headquartered in countries like Ireland and the Netherlands, where 75.7% and 60.2% of the corporate subsidiaries respectively are located outside the EU+UK.

On the other side, companies located in Italy have the majority of their subsidiaries located either in the same country or in the EU+UK (54.0%). In between, there are countries like Germany, France, Sweden, Spain and the UK, where the subsidiary are almost equally split between inside/outside the EU+UK, but with slightly more outside the EU+UK than inside

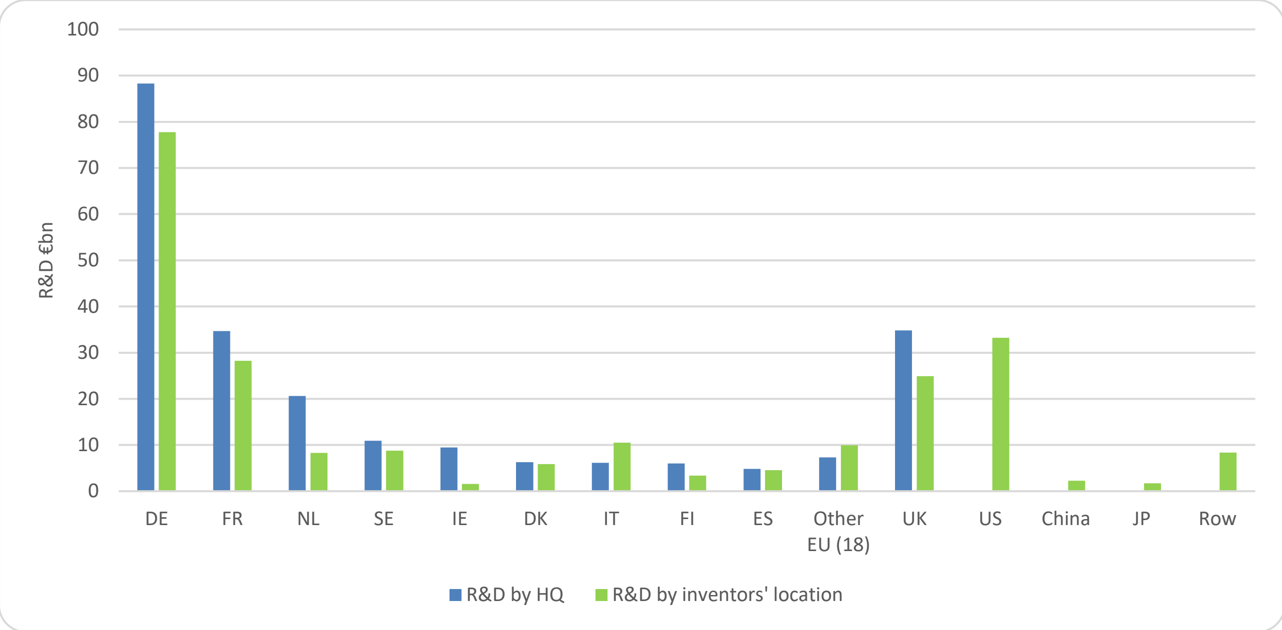
Figure 3.3 – Corporate subsidiaries location – details.



Note: Data refers to 937 companies (accounting for 97.6% of R&D in 2019) for which subsidiary data is available.
Only data for companies headquartered in the top eight countries in terms of total number of corporate subsidiaries are reported. The country codes at the bottom refer to the countries where the companies are headquartered. The country codes next to the x-axis refer to the countries where the corporate subsidiaries are located.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The location of subsidiaries reported in Fig 3.3 hints that companies located in different Member States and the UK could differ significantly also in their R&D location pattern. Using the same approach described in chapter 1 to proxy the location of R&D, we split and reassign (using the locations of inventors) the R&D of companies headquartered in Member States and UK in order to approximate the location where the R&D is actually performed. Fig 3.4 shows this data for the countries with a reasonable amount of companies for which patent information are available.

Figure 3.4 – R&D location –HQ investments vs location of inventors (patents).



Note: Data refers to 382 companies (accounting for 86.3% of R&D in 2019) out of 1000 for which patent data is available.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Countries like Germany, France, Sweden, the UK and especially Netherlands and Ireland have a negative difference between R&D invested according to the location of the HQ and R&D performed in the country according to the location of inventors. On the other site, countries like Italy present a positive balance; meaning R&D investment in the country proxied by inventors' location (of top m1000 EU+UK companies) is higher than the one based on the location of companies headquartered in the country. Outside the EU+UK, the US is by far the country with the highest share of R&D invested by EU+UK companies.

Figure 3.5 goes a bit deeper for the countries where there is a negative difference between R&D invested according to the location of the HQ and R&D performed in the country according to the location of inventors. Each of the four quadrants shows the estimated percentage distribution by country of the R&D invested by companies headquartered in the respective countries. For example, while 77.1% of R&D investment by Germany companies is actually done in Germany, this is 25.5% for R&D investment by UK companies in the UK, 31.9% for Dutch companies in the Netherlands, and a mere 1.5% for Irish companies in Ireland.

While this methodology is based on several assumptions and invites to exercise caution when interpreting the results, the data for The Netherlands or Ireland reflect the fact that many companies locate their headquarters there but locate the bulk of their activities (including R&D) elsewhere.

Figure 3.5 – R&D by location of inventors – distribution by country.

Note: Data available for 104 out of 212 German companies (accounting for 95.2% of total R&D by German companies in 2019), 75 out of 280 (70.5% of the R&D), 24 out of 49 Dutch companies (86.3% of the R&D) and 18 out of 35 Irish companies (87.6% of R&D).
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Box 3.1 – Comparison of R&D figures for the top 1000 EU+UK sample against territorial statistics.

As explained in Box 1.1, R&D figures from the *Scoreboard* and territorial statistics are directly comparable only at the global level, where cross-border inward and outward R&D balance each other out. However, as shown in Chapter 1, companies' patent portfolio can be used to estimate the actual location of their R&D activities, therefore allowing us to analyse companies' R&D data from a territorial perspective. The main figures of this comparison are as follows (€ bn):

- Latest available R&D territorial statistics (2018) for the EU

- Total R&D expenditure (GERD) =	295.1
- Funded by the public sector =	87.3
- Higher education	3.6
- Private non-profit sector	3.0
- Total R&D funded by the business enterprise sector (BES-R&D incl. inward R&D flow)	**192.2**

- Figures from the 2019 *Scoreboard* for the EU sample (2018 data)

- Total R&D by the top 1000 EU+UK = €184.2bn, of which performed within the EU	145.1
- EU's inward R&D from foreign controlled companies	42.2
- Total R&D funded by the *Scoreboard* companies in the EU	**187.4**

This means that the R&D figures of the *Scoreboard* are equivalent to **63% of total R&D** expenditure in the EU, and **97% of the total R&D financed by companies**.

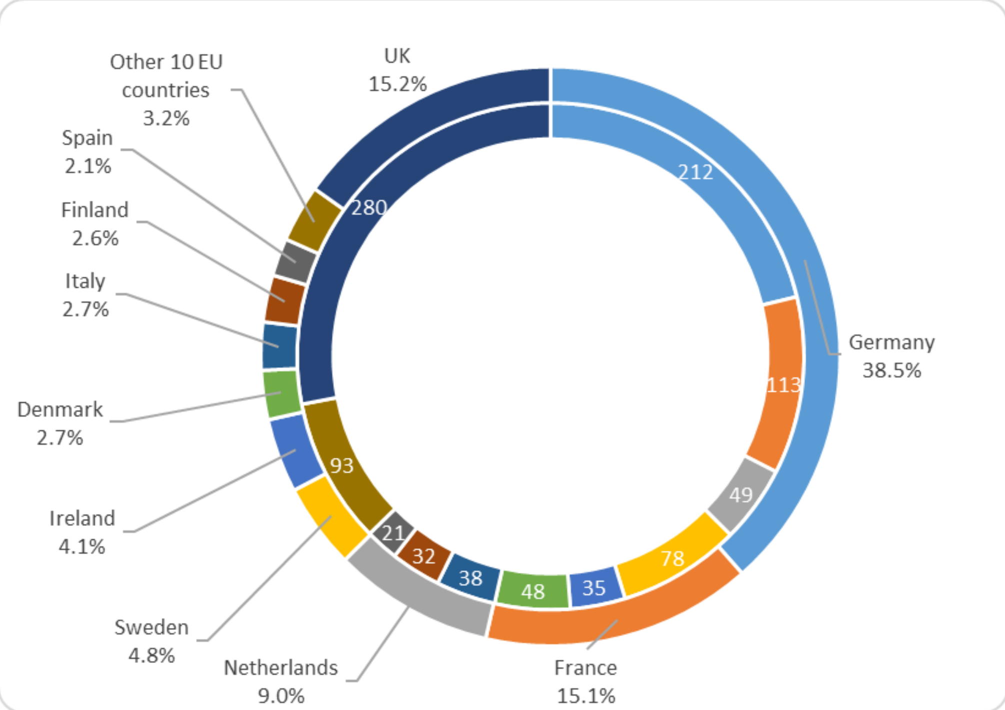
Sources: Latest figures reported by Eurostat including most countries reporting R&D, extracted on 26/11/2020. GERD, from all funding sources and performed in all sectors. BES-R&D, performed in all sectors and funded by the business enterprise sector, including inward R&D from foreign controlled companies operating in the EU.

The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

3.3 Top 1000 EU+UK investors in R&D – Main financial indicators

Figure 3.6 presents the distribution of R&D in 2019 by country for the top 1000 EU+UK sample. The predominance of German companies (already noted in Chapter 2) is replicated in the extended top 1000 EU+UK sample, where one of every five companies is headquartered in Germany. Altogether they account for 38.5% of total R&D. France and the UK have similar shares in R&D investment, but the UK does it with more than double the number of companies. These three countries together represent 68.6% of R&D in the top 1000 EU+UK sample.

Figure 3.6 – R&D by country in the top 1000 EU+UK sample.



Note: Inner circle shows the number of companies per country, the outer circle the percentage of R&D investment by country.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

This is basically the same percentage of R&D which companies located in these three countries make up of the top 542 EU+UK companies in the top 2500. Table 3.1 shows the main economic indicators and their changes compared to last year for the top 1000 EU+UK sample, split between the top companies (also in the global 2500 list) and the "bottom" part of the list.

Table 3.1: Main economic indicators for top 1000 EU+UK sample.

	EU		UK	
	TOP	**BOTTOM**	**TOP**	**BOTTOM**
Number of firms	421	299	121	159
R&D in 2019, €bn	188.9	5.7	32.0	2.8
One-year change, %	5.6	2.7	9.0	-0.7
Net Sales, €bn	4819.1	462.4	1263.2	93.3
One-year change, %	2.2	1.3	-2.3	5.2
R&D intensity, %	3.9	1.2	2.5	2.8
Operating profits, €bn	424.3	22.7	147.7	9.1
One-year change, %	-6.7	-16.0	-13.9	9.3
Profitability, %	9.0	5.0	11.7	10.0
Capex, €bn	319.1	21.1	72.7	8.7
One-year change , %	9.1	8.7	2.1	16.9
Capex / net sales, %	6.7	4.9	5.8	10.5
Employees, million	16.79	1.65	2.66	0.35
One-year change, %	0.2	0.9	-0.2	1.4
RD per employee	11228.4	3325.7	12001.0	7794.7
Market Cap, €bn	4607.9	373.6	1431.1	110.0
One-year change, %	-3.7	-3.9	-1.0	-1.8

Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The overall tendencies (increase in R&D, negative operating profit and market capital growth) as shown in Table 3.2 are as already explained in Chapter 2.

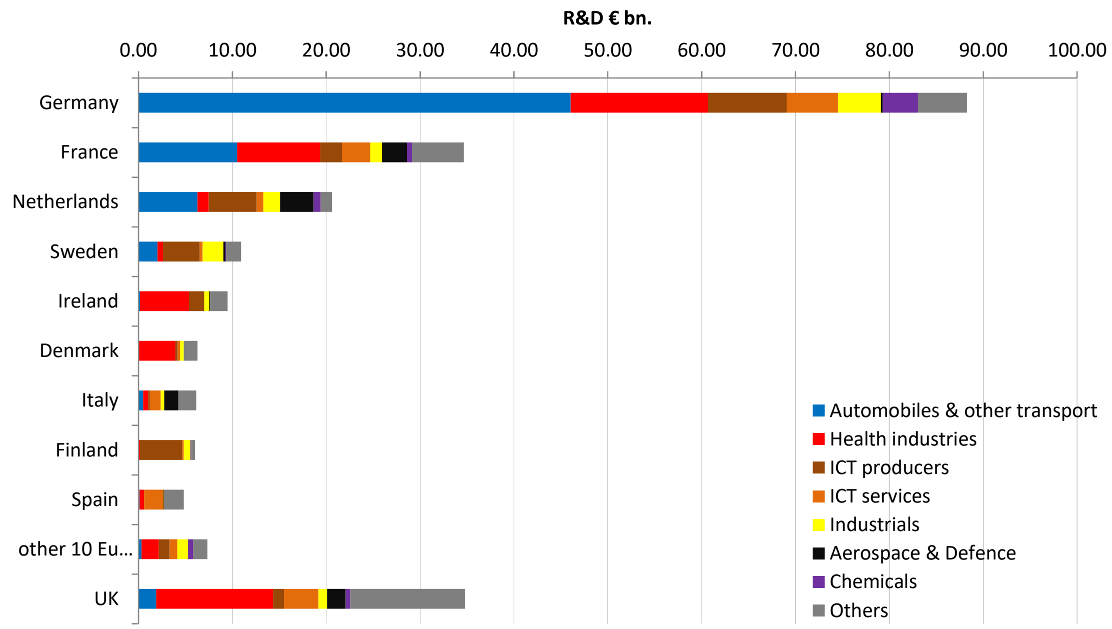
Table 3.2 Main economic indicators for TOP 1000 EU + UK – selected countries.

	Germany	France	Netherlands	Sweden	UK
No of firms	212	113	49	78	280
R&D in 2019, €bn	88.3	34.7	20.6	10.9	34.8
One-year change, %	4.6	8.4	8.2	10.3	8.2
Net Sales, €bn	1964.1	1142.5	478.8	229.6	1356.5
One-year change, %	2.9	-0.4	1.5	5.8	-1.9
R&D intensity, %	4.5	3.0	4.3	4.7	2.5
Operating profits, €bn	109.6	107.9	38.7	26.1	156.8
One-year change , %	-17.3	4.5	-23.0	16.4	-12.9
Profitability, %	5.7	9.5	8.1	11.6	11.6
Capex, €bn	114.5	90.2	21.5	9.9	81.5
One-year change , %	5.9	11.6	8.5	10.1	3.5
Capex / net sales, %	5.9	7.9	4.5	4.3	6.1
Employees, million	6.97	4.41	1.38	0.82	3.00
One-year change, %	0.7	0.5	1.0	-0.4	0.0
RD per employee	12659.4	7841.5	14968.0	13216.2	11516.8
Market Cap, € bn	1105.7	1196.8	524.3	239.0	1541.1
One-year change, %	-10.5	1.4	-1.1	-7.0	-1.1

Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The view provided by country and sector aggregation as reported in Figure 3.7 gives some useful insights into the landscape of R&D investment in the EU + UK

Figure 3.7 – R&D by country and by sector.



Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

As seen in Chapter 2, R&D in the EU is performed mainly by companies in the “Automobile and parts” (29.6% of the total R&D) and “Health industries” (21.7% of the total R&D, a quarter of it done by UK-based companies) sectors. What emerges from Figure 3.7 is that the German Automobile sector alone invests more in R&D than all *Scoreboard* companies located in the UK. The same holds true for all *Scoreboard* companies located in France, or any other EU country. To put it differently, R&D investment in Europe is driven by German carmakers.[60]

However, when we compare the sector composition of the top 542 EU+UK companies to the lower-ranked 468, an interesting pattern emerges. In the ICT services sector, there are more companies at the bottom than at the top (the opposite is true for all other sector). This can be read as a weak signal of the increasing presence of infant or midget ICT services firms (in terms of R&D invested) that could benefit from some policy interventions aimed at fostering their growth, in order to later swell the EU ranks in a sector where Europe’s competitors (the US and China) are better positioned. This applies to both the EU and the UK. The UK has more firms at the bottom in the Health, Industrial and Others sector groups, which may be another weak signal of companies in need of support to grow.

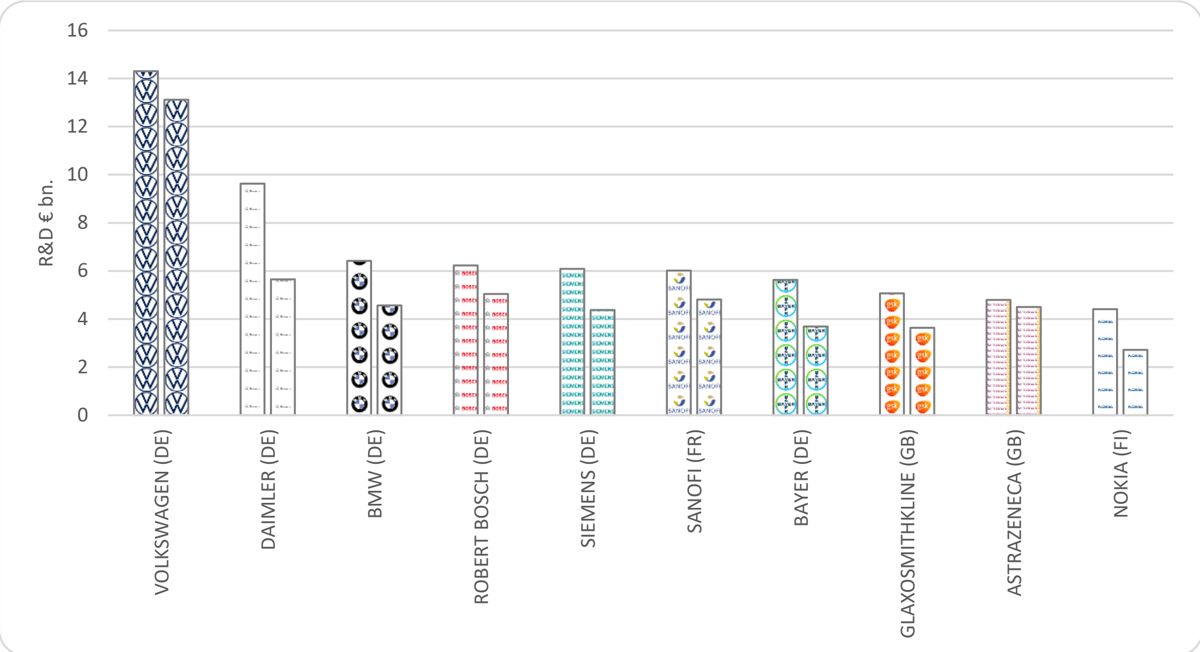
3.4 Top 1000 EU+UK R&D entry-exit - comparison 2014-2019 (Scoreboard 2015-20)

As shown already, the first four of the top 10 companies investing in R&D in the top 1000 EU+UK sample are German “automobile and other transport” firms. There are two other German companies in the top 10: Siemens, under “ICT producers“, and Bayer, under “health industries”. There is also one French and two UK companies under the branch of “health industries” (Sanofi, GSK, and AstraZeneca), and one Finnish “ICT producers” company (Nokia) (see Figure 3.8).

In Figure 3.8 below, two bars represent each company: with the left-hand bar showing R&D investment in 2019, while the right-hand bar shows R&D investment in 2014. All companies in the top 10 (that invested 31% of the total R&D of the top 1000 EU+UK sample in 2019) increased their R&D investment since 2014. Volkswagen, the first R&D investor worldwide in 2014, is one of the companies in the top 10 that has shown the smallest increase in R&D investment, by only 9%. Nokia (now 10th; 13th in 2014) is the only new entry into the top 10 in the top 1000EU+UK sample (at the expenses of Ericsson, which was 9th and is now 15th). The continuous but rather modest increases of R&D investments are the reason why EU and UK companies are overtaken by more ambitious investors in the ranking of companies worldwide.

[60] For a deeper dive into the activity of the car industry, see Chapter 7 in Hernández, H., Grassano, N., Tübke, A., Amoroso, S., Csefalvay, Z., and Gkotsis, P.: The 2019 EU Industrial R&D Investment Scoreboard; EUR 3 0002 EN; Publications Office of the European Union, Luxembourg, 2020, ISBN978-92-76-11261-7, doi:10.2760/04570, JRC118983

Figure 3.8 – Top 10 companies investing in R&D headquartered in the EU+UK – comparison 2019-2014 (Scoreboard 2020-2015).



Note: for each company, the bar on the left represents 2019 R&D investment, the bar on the right 2014 R&D investment.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The entire sample is characterised by a certain stability. Comparing this year's sample with the top 1000 EU + UK list of last year, we see that only 87 companies entered or exited the ranking, representing 8.7% of firms but a mere 1.3% of total R&D investment in 2019. Having said this, it is clear that the UK is characterised by a more dynamic business environment among firms which invest in R&D, given the higher numbers of entries and exits compared to the EU. The distribution of these companies by country and by sector is shown in Table 3.3.

As in the case of the top 2500 (see Chapter 1), the companies that went out of the ranking did so either because they were involved in a merger or acquisition, or because they were already outside the rankings and did not invest enough R&D in 2019 to enter it. The three biggest companies to exit the ranking fall under the first category. ARRIS INTERNATIONAL PLC (ranked 68th in the EU+UK last year) has been bought by CommScope; SKY LIMITED (ranked 95th) is now a subsidiary of Comcast; and GEMALTO N.V. (ranked 125th) was purchased by Thales Group in April 2019, and is now operating as Thales DIS.

As for the new entries, as seen in Chapter 1, they may be companies that just started making their R&D figures available, or companies resulting from some split, demerger or spinoff. The three highest ranked new entries are companies resulting from operations of this kind. DELPHI TECHNOLOGIES (ranked 101st) is the result of a spin-off from Aptiv; DYSON JAMES GROUP LIMITED (117th) is the heir of DYSON HOME TECHNOLOGIES LIMITED and the outcome of ownership restructuring; and LINDE PLC (188th) was formed by the merger of Linde AG of Germany (founded in 1879) and Praxair (founded in 1907 as Linde Air Products Company), which was finalised in October 2018.

Table 3.3 Entry-Exit compared to last year.

Sector	Exit		Entry	
	EU	**UK**	**EU**	**UK**
Aerospace & Defence	0	0	0	2
Automobiles & other transport	1	3	0	1
Chemicals	4	0	2	2
Health industries	9	14	11	12
ICT producers	5	6	2	1
ICT services	5	8	4	8
Industrials	2	1	3	2
Others	17	12	14	23
Total	**43**	**44**	**36**	**51**

Country	Exit	Entry
Belgium	3	2
Denmark	1	5
Finland	3	0
France	5	6
Germany	14	8
Greece	1	1
Italy	1	0
Ireland	0	4
Luxembourg	3	2
Netherlands	3	0
Malta	2	1
Spain	1	1
Sweden	6	6
Total EU	**43**	**56**
UK	44	51
Total	**87**	**87**

Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

If we look at the past 5 years, we can see more entries-exits. Table 3.4 compares the current top 1000 EU+UK sample with the top 1000 EU28 sample of 5 years ago. 674 companies are present in both rankings, which means that in total 326 companies left and 326 new companies entered the ranking). While the 674 companies accounted for 92.6% of R&D in 2019, the new 326 companies accounted for 7.4% of R&D in 2019. The three top new entries are companies that entered the ranking for three different reasons. Ferrari (ranked 49th) became an independent company again after splitting from FCA group in 2014; it went public in 2015 and entered the rankings the following year. SCHAEFFLER (ranked 55th), a company founded in 1946, had its first trading day on the Frankfurt Stock Exchange in October 2015, meaning that it had to start making its annual report publicly available, and it entered

the Scoreboard ranking the following year. SPOTIFY (ranked 568th) is a “real” new company: founded in 2001, it entered the ranking since *Scoreboard* 2016 edition.

Table 3.4 Entry-Exit compared 2014-2019 (Scoreboard 2015-2020).

	Exit		Entry	
Sector	**EU**	**UK**	**EU**	**UK**
Aerospace & Defence	6	0	4	1
Automobiles & other transport	9	8	15	3
Chemicals	4	4	4	3
Health industries	30	20	56	39
ICT producers	19	19	15	4
ICT services	27	30	22	28
Industrials	26	6	16	3
Others	77	41	55	58
Total	**198**	**128**	**187**	**139**

Country	**Exit**	**Entry**
Austria	6	11
Belgium	11	9
Cyprus	1	0
Czech Republic	2	0
Denmark	4	19
Finland	14	3
France	34	32
Germany	49	47
Greece	2	1
Ireland	4	12
Italy	14	6
Luxembourg	7	5
Netherlands	15	16
Poland	1	1
Portugal	2	1
Romania	1	0
Slovenia	4	0
Spain	5	4
Sweden	22	20
Total EU	**198**	**187**
UK	128	139
Total	**326**	**326**

Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

As for the companies that exited the ranking, the reason for the disappearance of two of the three companies ranked highest in 2015 is that they were acquired by other *Scoreboard* companies: ALCATEL-LUCENT (ranked 17th) was acquired by Nokia; SHIRE PLC (ranked 53rd) has been acquired by Takeda Pharmaceutical in 2019. The reason for the disappearance of the SOCIÉTÉ GÉNÉRALE (ranked 79th) is less clear, but is probably due to not reporting R&D activities anymore.

UK companies and companies operating in the diverse “Other sector” dominated both the annual and the 5-year entry-exit dynamics, whether we look at it by country or by sector. Unpacking the “Other sector”, the most dynamic ICB 3 sectors are “Real Estate Investment & Services” and “Business Support Services”.

The new entries in 2019 accounted for 1.3% of 2019 R&D, and all the new entries compared to five years ago accounted for only 7.4% of 2019 R&D. While this may appear small in the overall top 1000 EU+UK R&D landscape, it is possible that some of the entrants have the capacity to grow, not least because 47 of the 87 entrants in the last year and 163 of the 326 entrants over the last five years are in R&D intensive sectors.

Of the companies that are present in both rankings, and of the five that made the biggest leap forward in the rankings, four are biotech companies. These companies are ARGENX (Netherlands, moved from 900th to 215th), ASCENDIS PHARMA (Denmark, from 765th to 177th), CELLECTIS (France, from 924th to 337th), ADAPTIMMUNE THERAPEUTIC (UK, from 823th to 290th), while S&T (Austria, from 647 to 178) is an ICT producers company. Of those five that saw the biggest fall in the ranking, three are Aerospace companies. These five companies are STANDARD LIFE (UK, Others-Life insurance, from 390th to 911th), RWE (Germany, Others- Gas, Water & Multiutilities, from 103rd to 602nd), CHEMRING (UK, Aerospace & Defence, from 471st to 941st), LATECOERE (France, Aerospace & Defence, from 458th to 882nd) and SENER GRUPO DE INGENIERIA (Spain, Aerospace & Defence, from 272nd to 691st). In the case of RWE the fall is probably due to an asset swap deal made with E.ON (which jumped from 416th to 226th).

CHAPTER 4: THE EU'S POSITIONING ON GREEN INVENTIONS

This chapter analyses patenting trends for green technologies, using patent families as proxy for inventions.[61] The chapter looks at patenting by companies, universities and government non-profit organisations domiciled in the 27 EU Member States (EU), in comparison to those domiciled in the other major economies, namely China (CN), Japan (JP), South Korea (KR), the United States of America (the US) and the rest of the word (RoW). The analysis reveals the share of green innovative activity and compares the level of specialisation in green technologies between major economies, their tendency for patents to be internationally protected, and their focus on distinctively green technological areas. This chapter also highlights the EU's strengths and champion innovators and their international collaboration activity, and provides insights into green innovation by EU Scoreboard companies and their subsidiaries. Finally, special attention is paid to the EU's positioning on green technologies for industry in general, and energy-intensive industries in particular.

4.1 Share of green inventions in patenting activity

This section analyses the global green activity of companies, universities, and government non-profit organisations, using green inventions[62] as the indicator, detailed by country where they are based, to indicate how green the innovative activity is in each of the major economies.

Between 2000 and 2016, the global share of green inventions, defined as the number of green inventions over the total number of inventions, increased from 4% to 10% in 2011, before steadily decreasing to 7% by 2016 (Figure 4.1, left). The 2009-2010 financial crisis had an impact on the green share of overall inventions[63,64,65]. While the crisis had an adverse impact on all inventions, it had an outsize impact on technological areas associated with both physics research and electricity. These account for about 50% of all inventions produced between 2000 and 2016 and, crucially, the electricity sector is closely associated with green technologies. Almost all technology areas had returned to pre-crisis levels by 4 years later, but the number of inventions increased at a higher rate for non-green technologies. This implies that the recovery from the previous financial crisis was not as 'green' as it could have been. The current focus on a 'green' recovery from the COVID-19 crisis could help avoid a similar trend in the current economic environment.

In the post-crisis period, the EU is second among major economies in terms of patenting activity in green technologies as a share of all inventions (at 9.5%), behind South Korea with 10.3% (Figure 4.1, right). The private sector (applicants categorised as companies) accounts for 82% of global green inventions. In Japan, 97% of green inventions are produced by the private sector, while this share is 89% in the US and 87% in the EU. In China, the private sector only contributes 65%, implying a bigger

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[61] This analysis is based on a different methodology than that used in SB2019 (see Box 5.1). This chapter extends Chapter 6 of SB2019 by: (i) considering the patenting activity of companies, universities and government non-profit organisations (the previous focus was on Scoreboard companies, especially those headquartered in the EU); (ii) analysing the whole spectrum of green technologies, including climate change mitigation technologies, such as technologies for adaptation, waste recycling and others (see Box 5.1).

[62] See explanation in box 4.1

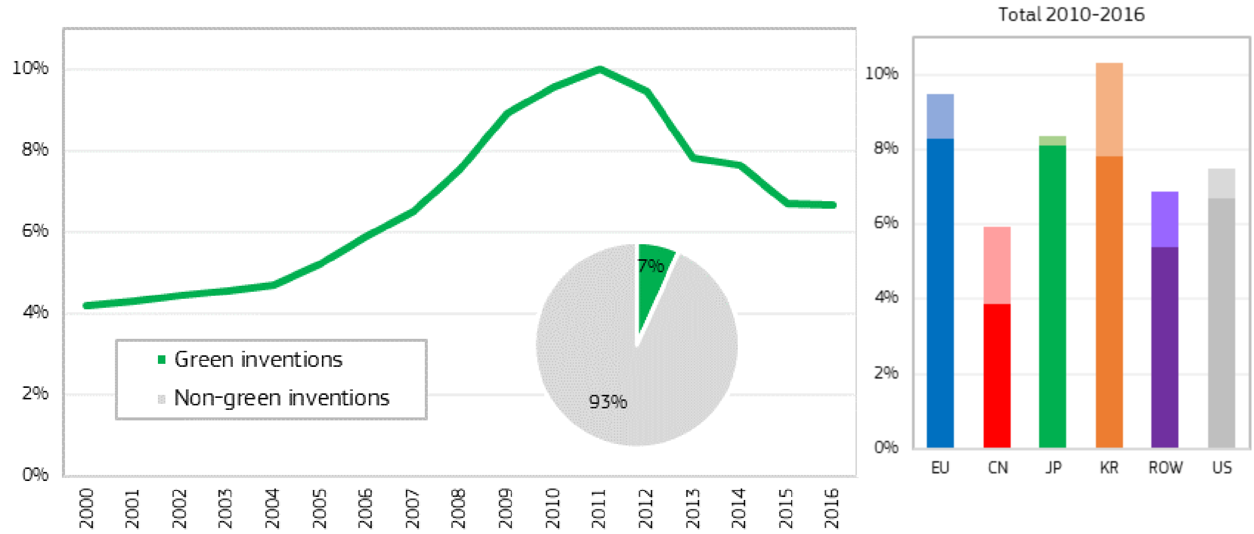
[63] WIPO (2010). World intellectual property indicators, 2010. Geneva, Switzerland: World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/intproperty/941/wipo_pub_941_2010.pdf.

[64] Gishboliner, M. (2013) The Impact of Financial Crises on Patenting Activity. Patent Law Seminar University of Haifa Law School

[65] Benoliel, D., & Gishboliner, M. (2015). The effect of economic crises on patenting activity across countries. Chi.-Kent J. Intell. Prop., 14, 316.

role in green inventions for other sectors, such as universities and government or non-profit organisations.

Figure 4.1: Share of green inventions.



Note: On the left: annual trend and average share in the period 2000-2016 (pie chart). On the right: share of green inventions for major economies in the period 2010-2016. Dark colours represent the share of green inventions produced by companies only.
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

Box 4.1 – Methodology

Patenting trends presented in this section have been produced following the well-established methodology developed by the JRC[66,67,68] to derive indicators of global innovative activity in clean energy technologies[69]. Patent data is retrieved from PATSTAT 2019 Autumn Edition, the worldwide patent statistical database created and maintained by the European Patent Office (EPO), and processed to increase the accuracy and completeness of the dataset[70]. The analysis is run up to 2016, since data for more recent years is not yet complete[71], and it is restricted to Climate Change Mitigation Technologies (CCMTs). CCMTs – referred to as **green technologies** in the context of this study - are identified through the Y02 and Y04 schemes of the Cooperative Patent Classification (CPC), that includes the following subcategories:

Adaptation	Y02A	Technologies for adaptation to climate change
Buildings	Y02B	CCMTs related to buildings
CCS	Y02C	Carbon capture storage (CCS), sequestration or disposal of greenhouse gases
ICT	Y02D	CCMTs related to information and communication technology (ICT)
Energy	Y02E or	Reduction of greenhouse gas emissions, related to energy generation, transmission distribution
Production	Y02P	CCMTs in the production or processing of goods
Transport	Y02T	CCMTs related to transportation

[66] Fiorini A., Georgakaki A., Pasimeni F., Tzimas E. (2017) Monitoring R&I in Low-Carbon Energy Technologies, JRC105642
[67] Pasimeni F., Fiorini A., Georgakaki A. (2019) Assessing private R&D spending in Europe for climate change mitigation technologies via patent data, *World Patent Information*
[68] Pasimeni F., Fiorini A., Georgakaki A. International Landscape of the Inventive Activity on Climate Change Mitigation Technologies. A patent analysis, *Energy Strategy Reviews* (forthcoming)
[69] SETIS Research & Innovation data: https://setis.ec.europa.eu/publications/setis-research-innovation-data
[70] Pasimeni F. (2019) SQL query to increase data accuracy and completeness in PATSTAT, *World Patent Information*
[71] Pasimeni F., Georgakaki A. (2020) Patent-Based Indicators: Main Concepts and Data Availability, JRC121685

Box 4.1 ctd. – Methodology

Waste	Y02W	CCMTs related to wastewater treatment or waste management
Systems	Y04S	Systems integrating technologies related to power network operation, communication or information technologies, i.e. smart grids

The JRC methodology uses **patent families** as a proxy for **inventions**. Patent families include all documents relevant to a distinct invention, including patent applications to multiple jurisdictions as well as those following regional, national and international routes. Statistics are produced based on applicants only (as the owners of the patent and, thus, directly financing R&D activities) and considering different categories of applicants, namely companies, universities and government non-profit organisations. If there are multiple documents per invention, and when more than one applicant or technology code is associated with an application, fractional counting is used to apportion effort between applicants or technological areas, thus preventing multiple counting. An invention is considered to be of **high-value** when it contains patent applications to more than one office, as this entails longer processes and higher costs, and thus indicates a higher expectation of the prospects in international markets.[72,73]. Within a patent family, only patent applications protected in a country different to the residence of the applicant are considered as **international**. High-value considers EU countries separately, while for international inventions European countries (EPO Members) are viewed as one macro-category. For example, a patent family protected in two EU countries (e.g. Germany and France) is considered high-value, while a patent application by a French applicant to the German patent authority (or to the EPO) is not considered international. A **granted invention** only sums the fractional counts of the patent family related to granted patent applications.

Fractional counting is also used to quantify international collaborations in patenting activity. Co-inventions are calculated based on a matrix of all combinations among co-applicants, for inventions that have been produced by at least two entities resident in two different countries. Shares of co-inventions in the same country are not considered[74].

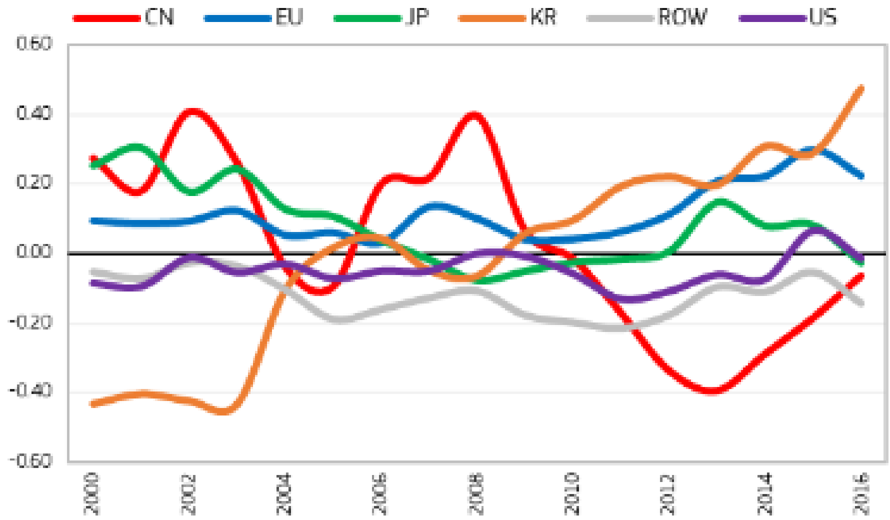
The analysis of EU Scoreboard companies focuses on the companies headquartered in the EU. The portfolio of inventions of these companies includes the inventions produced by all subsidiaries, irrespective of their location. The matching of subsidiaries to applicant names in PATSTAT currently covers 70% of the EU Scoreboard Companies, which, however, account for 90% of R&D investments.

The specialisation index (Figure 4.1) shows the relative importance of green inventions among other technologies within a country's portfolio, compared to the global average. The index is calculated by dividing a country's share in green inventions over the global share, as shown in Figure 4.1. A positive specialisation index means that patenting entities in this country develop more green inventions in their portfolio than the global average, hence there is more focus on green technologies. Propensity to patent changes among countries and over time, depending on domestic and international priorities. The EU is the only major economy with a positive specialisation index throughout the 2000-2016 period. South Korea has constantly increased its level of specialisation from 2009 onwards. In 2000, Japan had the highest specialisation index for green inventions, which after a period of decline through to 2008, has become positive again in recent years. China has fluctuated over time. From 2010 to

[72] Dechezleprêtre, A., et al., (2011) Invention and transfer of climate change–mitigation technologies: a global analysis. *Review of environmental economics and policy*.
[73] Dechezleprêtre, A. et al., (2015) Invention and International Diffusion of Water Conservation and Availability Technologies. *OECD Environment Working Papers, No. 82*.
[74] Pasimeni, F., Letout, S., Fiorini, A., Georgakaki, Monitoring R&I in Low-Carbon Energy Technologies, An improved methodology and additional indicators JRC117092, 2020 (forthcoming)

2016, the specialisation index for China was negative, although it is recovering rapidly. The US has always had negative specialisation in green technologies.

Figure 4.1: Specialisation index: share of green inventions for major economies compared to the global share.



Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

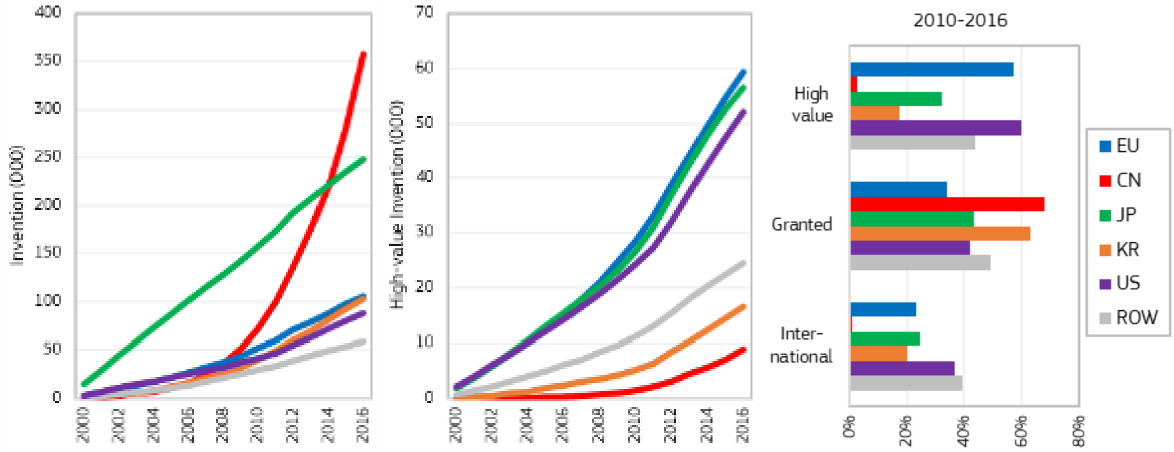
The specialisation index compares the prominence of green technologies within each country's portfolio, and not performance in absolute terms, where the standings may be different, as shown in Figure 4.2. Taking into account filing in all IP Offices, patenting entities resident in China have the highest cumulative number of green inventions, followed by Japan (Figure 4.2 left). On average, between 2000 and 2016, China increased the number of green inventions by 34% per year, indicating no significant impact from the previous economic crisis. However, these figures are skewed by domestic incentives to patent, provided by both central and local governments in China, as well as by the different patenting procedures in place in China[75,76]. Green technologies developed by Chinese applicants are mostly only protected in the Chinese market. Chinese patenting entities also have the highest share of green inventions approved (68%, Figure 4.2 right), mostly due to the incentivising policy framework established in the country. To eliminate the effect of these incentives and IP practices, we look at high-value and international inventions as an alternative to compare the activity of major economies[77].

The EU and the US are the global leaders in high-value inventions related to green technologies, those protected at least in two different patent authorities (Figure 4.2 centre). From 2000 to 2016, the patenting entities domiciled in the EU have produced around 60000 high-value green inventions, about 6 times more than China. The EU and the US have the highest share of high-value inventions,

[75] Preziosi, N et al. (2019) China – Challenges and Prospects from an Industrial and Innovation Powerhouse, EUR 29737 EN, Publications Office, Luxembourg, 2019, ISBN 978-92-76-02997-7, doi:10.2760/445820, JRC116516.
[76] China Power Team. "Are Patents Indicative of Chinese Innovation?" China Power. February 15, 2016. Updated August 26, 2020. Accessed September 11, 2020. https://chinapower.csis.org/patents/
[77] High-value inventions are patent families including patent applications filed at least in two different patent authorities, and international inventions only include patent applications filed in patent authorities distinct from the country of residence of the patent applicant. EU national patent authorities are considered as distinct for high-value inventions, while they form a single geographical area for international inventions.

which, between 2010 and 2016, accounted for about 60% of all their output in green inventions (Figure 4.2, right). South Korea (17%) and Japan (32%) have similar shares, while, in contrast, only 3% of Chinese inventions are of high-value (Figure 4.2, right). The low Chinese performance in relation to high-value green inventions can partly be explained by the fact that the internal market is big enough to enjoy the benefit of domestic patent protection. However, often Chinese inventions in green technologies are not of the same quality as those protected in other IP jurisdictions (e.g., in comparison with EU wind technologies[78]), and thus face difficulties in being protected in foreign markets.

Figure 4.2: Green inventions trends.



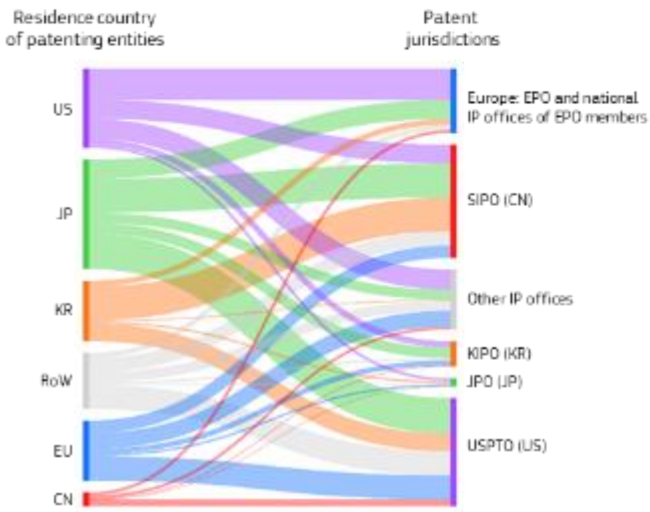
Note: Cumulative trend of green inventions (left), high-value green inventions (centre), and share in the period of 2010-2016 of high-value, granted and international inventions (right) for major economies over their total number of green inventions.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The international indicator in Figure 4.3 above looks at the performance of the EU, discounting interactions in the broader European context[79]. The indicator is lower than the high-value count as it only applies to the part of the invention protected outside the applicants' resident country. The flow of international inventions in Figure 4.3 shows the residence country of patenting entities on the left, and the jurisdictions where their international green inventions are protected on the right[80]. Between 2010 and 2016, the Chinese patent office is the most important target (30%), closely followed by the US (28%). In 2000, only 6% of international green inventions were protected in China, while in 2016 the share had reached 40%. While the US maintains the same share of international green inventions protected in its jurisdiction, the share of foreign green inventions protected in Europe has decreased

[78] Ydersbond, I.M., Korsnes, M.S. (2016) What drives investment in wind energy? A comparative study of China and the European Union, *Energy Research and Social Science*, vol. 12, pp. 50-61
[79] This also means European Countries not part of the EU but part of the EPO
[80] These are: State Intellectual Property Office of the People's Republic of China (SIPO), Korean Intellectual Property Office (KIPO), Japan Patent Office (JPO) and United States Patent and Trademark Office (USPTO). For Europe we consider the European Patent Office (EPO) and the national offices of the 38 EPO members: Albania (AL), Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), Former Yugoslav Republic of Macedonia (MK), France (FR), Germany (DE), Greece (EL), Hungary (HU), Iceland (IS), Ireland (IE), Italy (IT), Latvia (LV), Liechtenstein (LI), Lithuania (LT), Luxembourg (LU), Malta (MT), Monaco (MC), Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), San Marino (SM), Serbia (RS), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH), Turkey (TR), United Kingdom (UK).

from 28% in 2000 to 16% in 2016. Applicants from all major economies protect the majority of their international green inventions in the US, except for South Korea, which protected around 56% of its international green inventions exclusively in China. Europe is the most important market for the US, considering that 39% of US international green inventions are protected in European countries only. Japan is the second most important country targeting the European market. In contrast, Europe is not the most important market for countries such as China and South Korea. China is the third most important market for both the EU and the US patenting entities, while these two countries also mutually address their respective jurisdictions at a similar level. Rather than suggesting missed opportunities, this may indicate the difficulty for the EU and US of entering the Chinese market, where foreign companies face unfair competition, an uneven playing field and unequal treatment compared to domestic actors, and where the enforcement of IP rights is notoriously difficult.[81,82,83]

Figure 4.3: International flow of green inventions in the period 2010-2016.



Note: International flow of green inventions produced by entities resident in major economies (left) and protected in foreign patent authorities (right) in the period 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

4.2 Green inventions across technology sectors

This section provides a comparison of the trends in green inventions across different technology sectors for major economies, based on green inventions by resident companies, universities and government non-profit organisations for the period 2010-2016.

The matrix in Figure 4.4 shows the dispersion of the nine subcategories of green technologies across the broad technological sectors used to categorise innovative activity. Green subcategories (in columns) relate to the patent classification of climate change mitigation technologies (Box 4.1): technologies related to adaptation (Y02A), buildings (Y02B), CCS (Y02C), ICT (Y02D), energy (Y02E), production (Y02P), transport (Y02T), waste (Y02W) and systems (Y04S). Technology sectors (in rows) are identified via the following CPC classes: Chemistry; Metallurgy (CPC class C), Electricity (H), Fixed

[81] European Union Chamber Commerce (2018), Business Confidence Survey 2018. European Business in China. Beijing.
[82] American Chamber Commerce (2018), 2018 China Business Climate Survey Report, The American Chamber of Commerce in the People's Republic of China. Beijing.
[83] EU Delegation to China, IPR in China: Guidance for Researchers Why IP matters

Constructions (E), Human Necessities (A), Mechanical Engineering (F), Operations; Transporting (B), Physics (G) and Textiles; Paper (D).

Green technology development in the Chemistry and Metallurgy sector has the highest share (22%), followed by Electricity (21%), Mechanical Engineering (20%) and Operations and Transportation (18%). It should be noted that the development of these technologies is often undertaken by companies from other sectors. Technology sectors are predominantly associated with one of the nine different subcategories of green technologies. For example, more than half of the 7% of green inventions in Human Necessities, are technologies for adaptation to climate change. Green inventions related to transport account for about a third of green inventions in the Operations and Transportation technology sector, green inventions in Production mostly relate to Chemistry and Metallurgy, Waste to Textiles and Paper, Transport and Energy to Mechanical Engineering and Energy to Electricity.

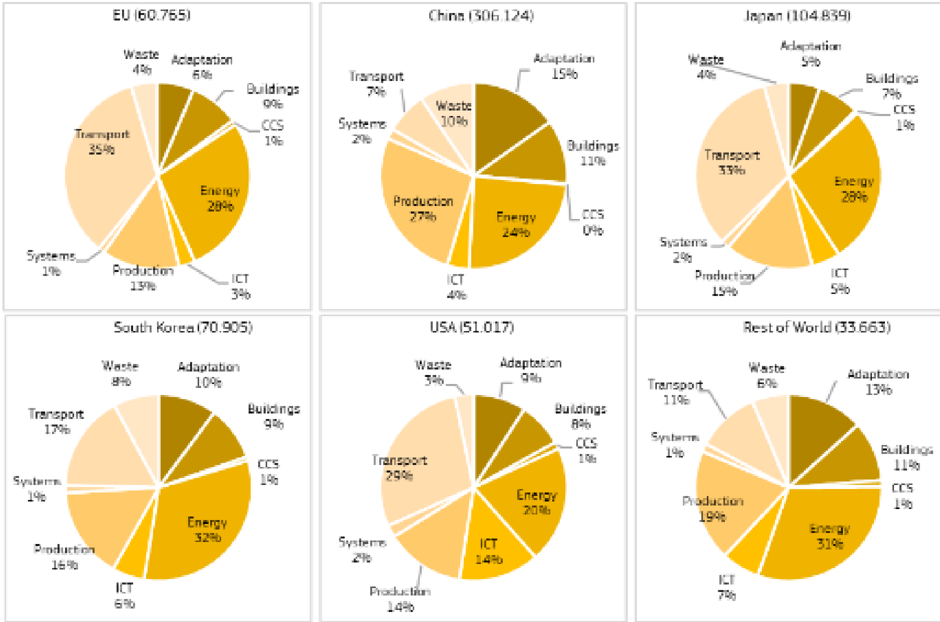
Figure 4.4: Matrix of patent applications.

	Adaptation	Buildings	CCS	Energy	ICT	Production	Systems	Transport	Waste	
Chemistry; Metallurgy	3.3%	0.3%	0.4%	4.2%	0.0%	9.6%	0.0%	0.7%	3.5%	22%
Electricity	0.2%	3.1%	0.0%	7.9%	2.5%	3.3%	0.9%	2.7%	0.2%	21%
Fixed Constructions	10%	0.5%	0.0%	0.5%	0.0%	0.2%	0.0%	0.1%	0.3%	3%
Human Necessities	4.2%	0.2%	0.0%	0.3%	0.0%	15%	0.0%	0.1%	0.3%	7%
Mechanical Engineering	13%	2.6%	0.2%	6.3%	0.0%	17%	0.0%	7.9%	0.2%	20%
Operations; Transporting	15%	0.4%	0.7%	2.5%	0.0%	4.2%	0.3%	6.3%	2.0%	18%
Physics	0.9%	0.7%	0.0%	2.4%	16%	16%	0.6%	0.8%	0.2%	9%
Textiles; Paper	0.0%	0.1%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	0.3%	1%
	12%	8%	1%	24%	4%	22%	2%	19%	7%	

Note: Share of patent applications labelled simultaneously with CPC codes related to technology sectors (rows) and subcategories of green technologies (columns).
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

Figure 4.5 shows the difference in the composition of the green invention portfolios of patenting entities domiciled in major economies, broken down by subcategory. The EU and Japan have the highest share of total number of green inventions related to transport (35% and 33% respectively). China ranks first for the share of green inventions related to Production (27%), Adaptation (15%) and Waste (10%). Energy is the one subcategory that accounts for 20% or more in all countries. In this subcategory, South Korea has the highest share in its portfolio (32%). The US ranks first in terms of the share of green inventions related to ICT in its portfolio (14%).

Figure 4.5: Green inventions split by subcategory for major economies – total 2010-2016.



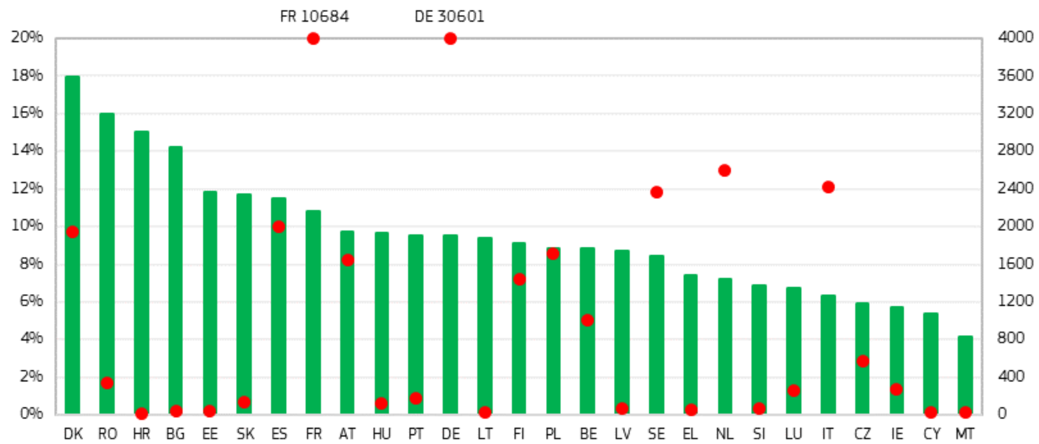
Note: Total number of inventions in brackets.

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

4.3 EU: National and regional performances

In this section, we focus on the green innovative activity of the patenting entities resident in the 27 EU Member States. Denmark is the EU Member State with the highest share of green inventions over total inventions (18%) in its national portfolio, followed by Romania, Croatia and Bulgaria with shares above 12%, although they produced a very small number of inventions (26, 16, and 26, respectively) between 2010 and 2016 (Figure 4.6). Germany ranks first for total number of green inventions (over 30000), followed by France (over 10000). The Netherlands, Italy, Sweden and Spain follow at a distance (over 2000 inventions).

Figure 4.6: Share and total number of green inventions for the 27 EU Member States - 2010-2016.

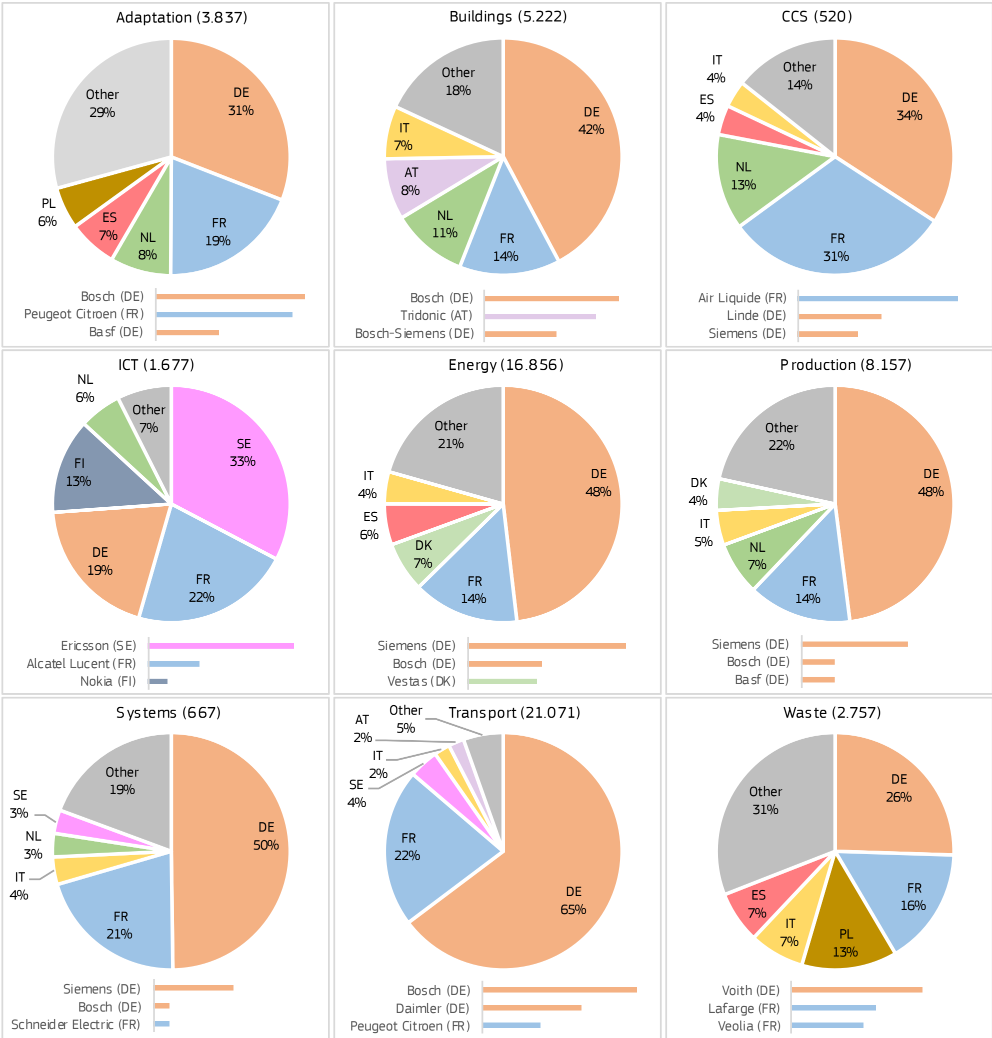


Note: Share of green inventions for the 27 EU Member States (bars coloured in green, left axis) and the total number of green inventions (dots in red, right axis) in the period 2010-2016.

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

The dominance of Germany and France is evident across all green technological areas. These two countries rank first and second respectively in all but one subcategory and account for 50% or more of total inventions (Figure 4.7). The exception is green inventions related to ICT (solutions for greening other technologies, such as home appliances or ICT for transport), where Sweden ranks first, and, together with Finland and the Netherlands, accounts for more than 50% of the green inventions produced in this subcategory. Italy appears seven times among the top five EU countries in the nine subcategories. The Netherlands follows with six. Poland ranks third in terms of green inventions related to waste, thanks to the effort of several universities and research organisations.

Figure 4.7: Green inventions in subcategories split by EU countries - 2010-2016.



Note: Total number of inventions in brackets. At the bottom, the top three EU companies for each subcategory are shown.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

The EU's regional performance for green inventions shows a very fragmented picture (Figure 4.8, left). Patenting entities resident in North-Central EU regions are the most active. Two regions in Germany (Stuttgart and Upper Bavaria) and the Parisian Region in France produced more than 7000 inventions between 2010 and 2016, accounting for 14% of total EU green inventions.

Among the top 10 EU regions, five are in Germany, with regions of France, Sweden, Denmark, Finland and the Netherlands completing the picture. Major industrial players that located in these regions (Figure 4.8 right) determine their high number of green inventions.

Figure 4.8: Regional distribution of green inventions and top industrial players - 2010-2016.

Nuts region		Inventions	Major industrial players
Stuttgart	DE11	7752	Bosch, Daimler, BMW and Audi
Parisian Region	FR10	7572	Saint-Gobain, Renault, Peugeot, SNECMA, Air Liquide, Valeo
Upper Bavaria	DE21	7097	Siemens
Stockholm Region	SE11	1239	Ericsson and Scania
Tübingen	DE14	1203	ZF Friedrichshafen
Braunschweig	DE91	953	Volkswagen
Midtjylland	DK04	944	Vestas
Helsinki-Uusimaa	FI1B	908	Nokia
North Brabant	NL41	882	Philips
Düsseldorf	DEA1	841	Evonik

Note: Regional distribution of green inventions in the 27 EU Member States (left) and top industrial players resident in the top 10 EU regions based on number of green inventions (right), in the period 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

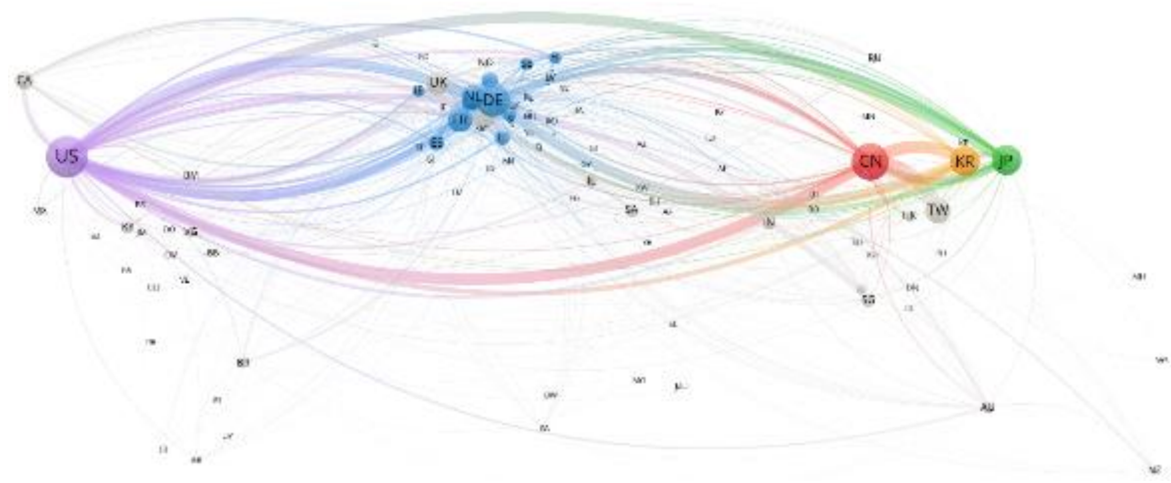
4.4 International green alliances

The network of international alliances shows a highly interconnected world in relation to co-production of green inventions (Figure 4.9). The network is built by fractional counting of all combinations among co-applicants for inventions that have been produced by at least two entities resident in two different countries, hence co-inventions in the same country are not considered. The nodes of the network in Figure 4.9 are the countries of residence of patenting entities. Their size of the nodes represents the total number of co-inventions by resident entities, while the thickness of the links is proportional to the number of co-inventions produced by two nodes.

Europe has a very dense network of collaboration among countries, mostly because collaboration is facilitated by close geographical proximity among national territories. East Asian countries, namely China, Japan, South Korea and Taiwan, have strong mutual collaborations. The US is the world leader both in terms of number of international partners, and number of international co-inventions in green technologies (Figure 4.10). 38% of these co-inventions are produced with EU partners, 13% with Japan (representing 34% of Japanese co-inventions) and 14% with China, while 32% involve other international partners. China ranks second in terms of international green co-inventions, 63% of those being with other Asian neighbouring countries: Taiwan (28%), South Korea (23%) and Japan (12%). 20% of Chinese international collaborations are with the US and 10% with EU Member States. These international co-inventions with China make up the majority of collaborations for Taiwan and Hong Kong (86% and 82% respectively).

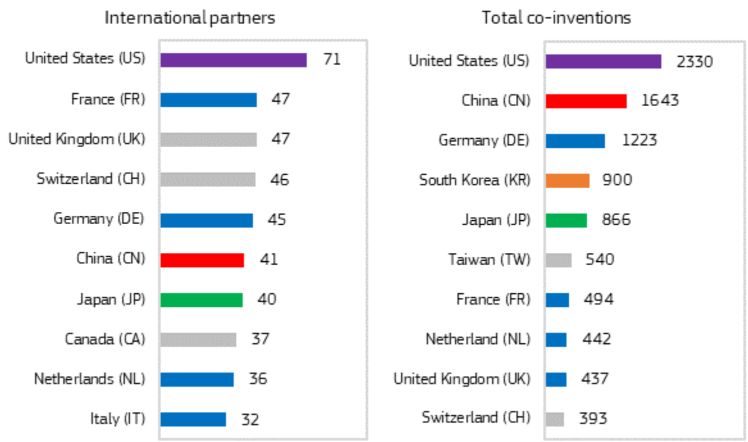
The United Kingdom is third in terms of international partners, however its international co-inventions are highly focused on US (39%) and EU (23%) partners. France and Germany are the two EU countries with the highest number of international partners and co-inventions. France and Germany respectively have 40% and 25% co-inventions with other EU countries, 18% and 24% with the US and 2% and 9% with China. Given its geographical proximity, France has 16% of the total co-inventions with Switzerland. 65% of international green co-inventions produced by the Netherlands are with the US and 20% with other EU countries. EU Member States generate 33% of co-inventions in green technologies through Intra-EU connections, 29% with the US and only 6% with China.

Figure 4.9: Green alliances network - 2010-2016.



Note: network of green co-inventions among countries worldwide. Total 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Figure 4.10: Green alliances top countries - 2000-2016.



Note: top 10 countries with the highest number of international partners (left) and with the highest number of international green co-inventions. Total 2000-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

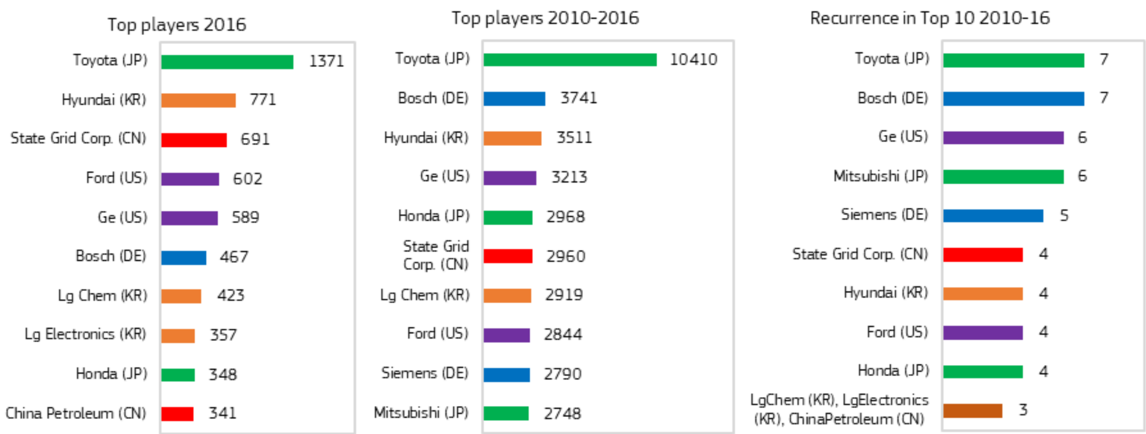
4.5 Top international players and EU Scoreboard Companies

This section narrows the analysis of green inventions down to the activity of the private sector only, that is to patent entities categorised as a company. We then focus on the green innovative activity of the Scoreboard companies headquartered in the 27 EU Member States, which, however, may include green inventions developed by foreign subsidiaries.

Figure 4.11 shows the top-performing companies in 2016, the top-performing companies cumulatively for the 2010-2016 period, and recurrence in the Top 10, indicating sustained levels of activity over the period. Toyota was the top producer of green inventions, both in 2016, and for the period 2010-2016. Bosch and Toyota are both ever-present in the Top 10 over the 7 years examined. Bosch and Siemens are the only two EU players among the Top 10 companies. Ford and GE are the top US companies. The State Grid Corporation and China Petroleum are the top Chinese players among the top producers of green inventions.

The Top 10 companies with the highest annual number of green inventions are mostly active in the transport sector. Toyota, Hyundai, Ford, GE, Bosch and Honda, on average, produced about 77% of their green inventions with a focus on Transport. State Grid Corp., LG Chem and LG Electronics focus mostly on green inventions related to Energy, although with a lower share on average (45%). 83% of green inventions produced by China Petroleum relate to applications in industry (production or processing of goods).

Figure 4.11: Top industrial players producing green inventions.



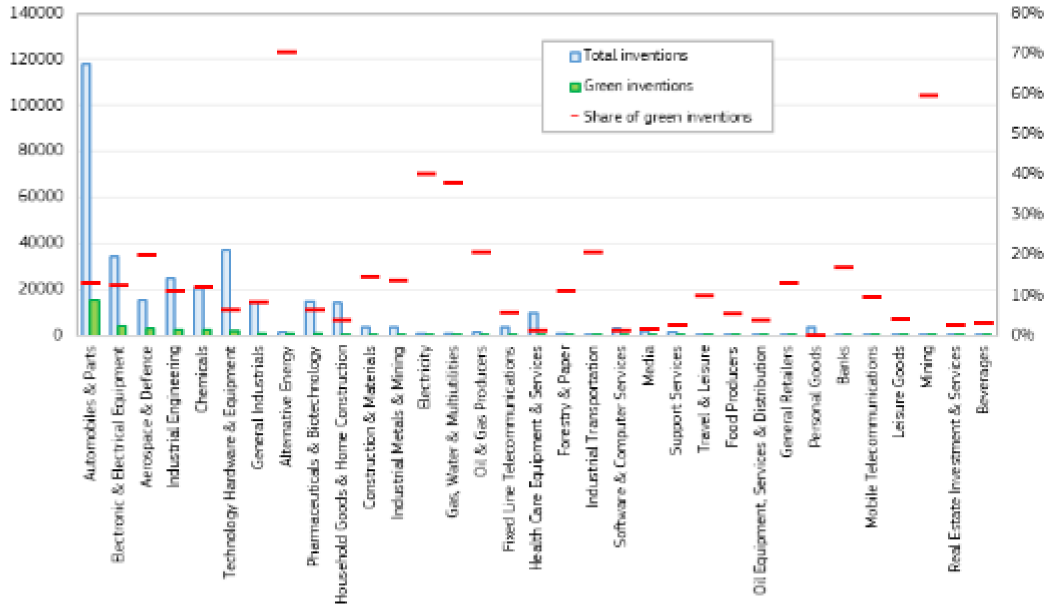
Note: Top 10 in 2016 (left), Top10 for 2010-2016 (centre) and recurrence of appearance in the annual Top 10 in 2010-2016 (right).
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

To analyse the green patenting activity of the EU Scoreboard companies, we summed the green inventions of subsidiaries by parent company. Hence, the portfolio of inventions of EU Scoreboard companies includes inventions produced by all subsidiaries, irrespective of their location. Figure 4.12 shows that companies belonging to the alternative energy sector have the highest share of green inventions, about 70%, but over a lower number of total inventions compared to other sectors. Other energy-related ICB sectors, namely Electricity, Gas, Water & Multiutilities and Oil & Gas Producers also

produce a relatively high share of green inventions, also among low comparative number of inventions. Companies whose main ICB sector of activity is not directly related to energy, such as Industrial Transportation, Construction & Materials, and Aerospace & Defence produce about 20% of green inventions.

The quantity of green inventions produced by the ICB sector depends on the overall size of the portfolio of inventions. Accordingly, Automobiles & Parts is the EU ICB sector that produces the highest number of inventions, and 13% of these (nearly 16000 between 2010 and 2016) are related to green technologies. Electronic & Electrical Equipment (over 4000), Aerospace & Defence (over 3000) and Industrial Engineering (nearly 3000) are the other ICB sectors that produce the highest number of green inventions in the EU.

Figure 4.12: EU *Scoreboard* companies' invention activity by ICB sector - 2010-2016.



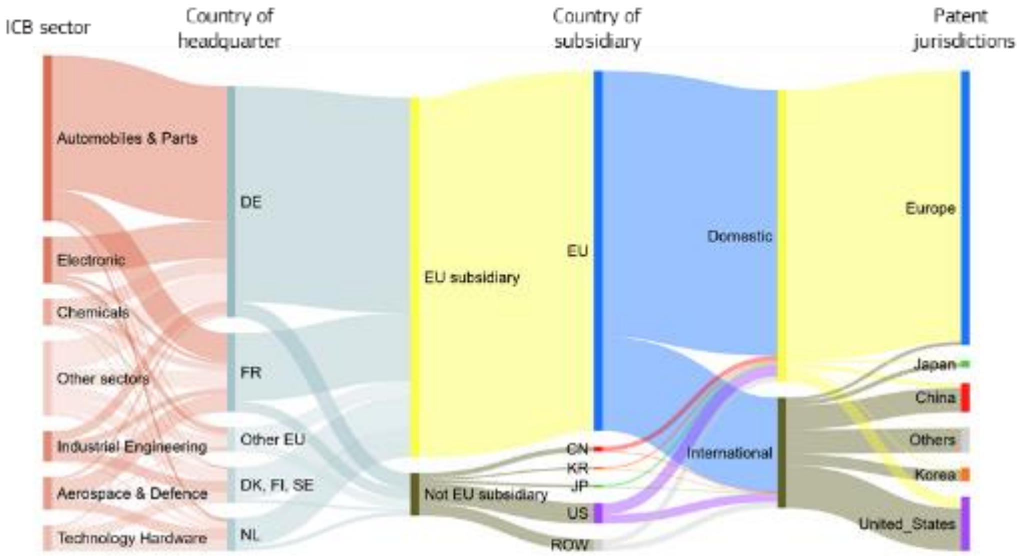
Note: Share of green inventions by ICB sector for EU Scoreboard companies (red, right axis), total inventions (blue, left axis) and total green inventions (green, left axis), in the period 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Figure 4.13 illustrates the breakdown of green inventions by EU Scoreboard companies from 2010 to 2016. It shows the number of green inventions in relation to: the ICB sector of the parent company (1st column); the country where the parent company is domiciled, that is, the location of its headquarters (2nd column); the country where subsidiaries are domiciled (3rd and 4th columns); and the patent jurisdiction where the intellectual property of the EU Scoreboard companies and their subsidiaries is protected (5th and 6th columns). Around 41% of green inventions are produced by Scoreboard companies belonging to the Automobiles & Parts ICB sector, of which 81% are from companies domiciled in Germany and 17% from French companies. 67% of green inventions produced by the Aerospace & Defence and Technology Hardware sectors belong either to companies domiciled

in the Netherlands or in France. 57% of green inventions are produced by Scoreboard companies resident in Germany, and 20% by companies resident in France.

Overall, 89% of green inventions by EU Scoreboard companies are produced by EU subsidiaries. Of the 11% produced by subsidiaries located in countries outside the EU, 48% are produced by subsidiaries in the US. 62% of green inventions produced by foreign subsidiaries are owned by EU Scoreboard companies domiciled in Germany and in France. About 89% of green inventions produced by foreign subsidiaries of EU companies domiciled in China, Japan and South Korea are then protected under the respective home jurisdictions. Only 3% of these green inventions are protected back in Europe. This is a signal indication of the R&D internationalisation needed to exploit opportunities in the host country or to access the respective internal market. In contrast to Asian subsidiaries, American subsidiaries of EU Scoreboard companies only protect 57% of their green inventions in the US, protecting 14% of these inventions back in Europe, and the rest in China, Japan and other international jurisdictions. This indicates that R&D internationalisation may also be motivated by the need to exploit the technological knowledge and capability necessary to access other markets, including the European market. Three quarters of green inventions produced by EU subsidiaries are protected in Europe. Of those targeted abroad, 42% are protected in the US, 23% in China and 21% in other international jurisdictions.

Figure 4.13: EU *Scoreboard* companies' green inventions by ICB sector - 2010-2016 - details.



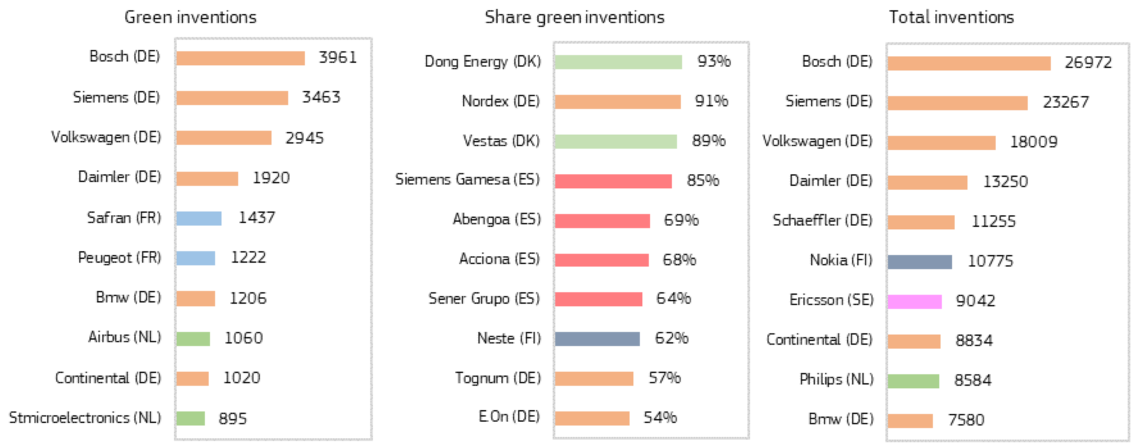
Note: Green inventions of EU Scoreboard companies by ICB sectors (1st column), country of headquarters (2nd column), country where subsidiaries are domiciled (3rd and 4th columns) and patent jurisdictions (5th and 6th columns targeted, 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Four EU countries are represented in the Top 10 list of EU Scoreboard companies with the highest share of green inventions. Dong Energy, in the Electricity sector, Nordex and Vestas, both belonging to the Alternative Energy ICB sector, are the EU SB companies with the highest share of green inventions in their portfolio, with 90% or more. Four Spanish companies, Siemens Gamesa, Abengoa, Acciona and Sener Grupo follow, with a share of green inventions between 64% and 85%.

Companies from just three EU countries make up the Top 10 list of EU Scoreboard companies with the highest number of green inventions: six from Germany (including the top four) and two each for

France and the Netherlands. In terms of total inventions, seven out of the Top 10 EU Scoreboard companies are domiciled in Germany.

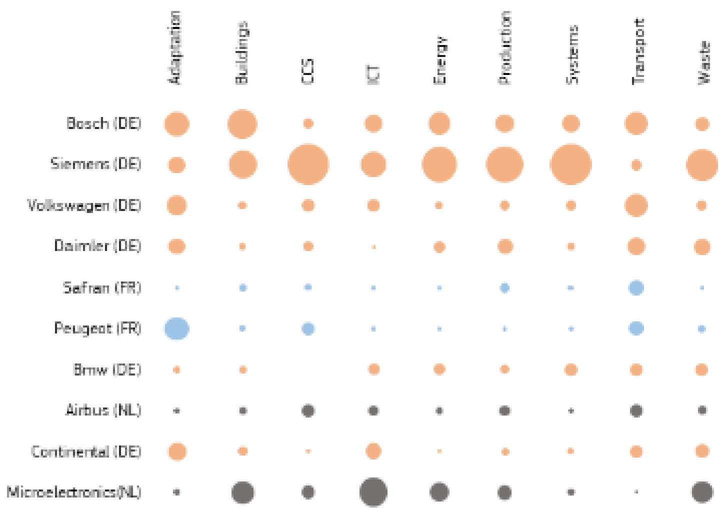
Figure 4.14: Top EU Scoreboard companies in green and total inventions - 2010-2016.



Note: Top EU Scoreboard companies in term of share of green inventions (left), total number of green inventions (centre) and total inventions (right), 2010-2016.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Among the EU Scoreboard companies, the Top 10 companies alone (Figure 4.15) produce 71% of the inventions related to green technologies in Transport, and 37% related to Energy. In five out of the nine green technology subcategories, Siemens ranks first among the Top 10 EU *Scoreboard* companies. It is the top producer of green inventions related to CCS, Energy, Production, Waste and Systems. Bosch ranks first in Adaptation, Buildings and Transport, while ST Microelectronics is first in ICT.

Figure 4.15: Top EU Scoreboard companies for total number of inventions detailed by green technology subcategories - 2010-2016.



Note: Bubble size represents the share of inventions within each subcategory.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

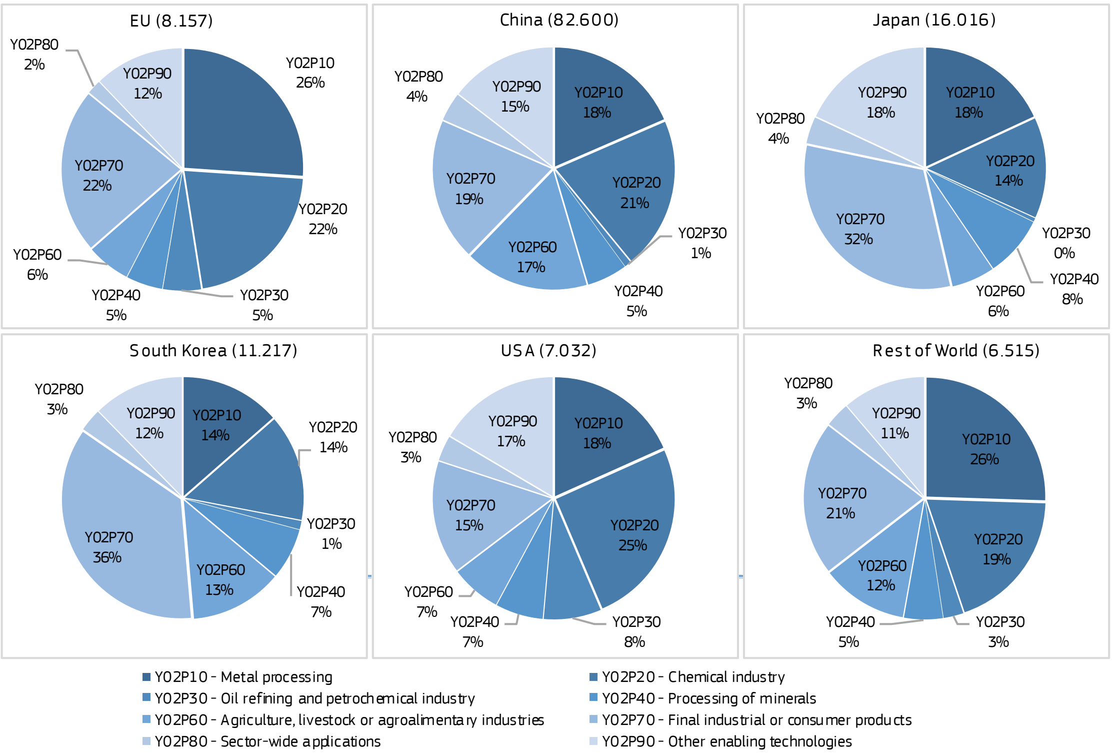
4.6 Focus on industry

The decarbonisation of energy intensive industries, such as cement, metal processing, chemicals and petrochemicals, will be key for the EU to reach its climate goals, and the innovative capacity of EU market leaders will be crucial for the industry to remain competitive while doing so. This section provides an overview of the EU's positioning in green inventions applicable to industry, the share of inventions in relevant technology areas for the EU, and major economies and top companies innovating in these industries.

Patents in green technologies for energy-intensive industries

In the period 2010-2016, inventions in production or process of goods accounted for 13% of all EU activity in green technologies (Figure 4.5). This is similar to other major economies, with the exception of China, which puts increased effort in this area, even if it is only targeting its internal market. EU patenting entities produce a higher share of green inventions for metal processing, chemical industries and finished industrial and consumer goods than those in other major economies. Oil refining and petrochemicals is also prominent (the US also having a strong focus here), along with general enabling technologies (Figure 4.16).

Figure 4.16: Green inventions split by subcategory of green technologies related to production for major economies – 2010-2016



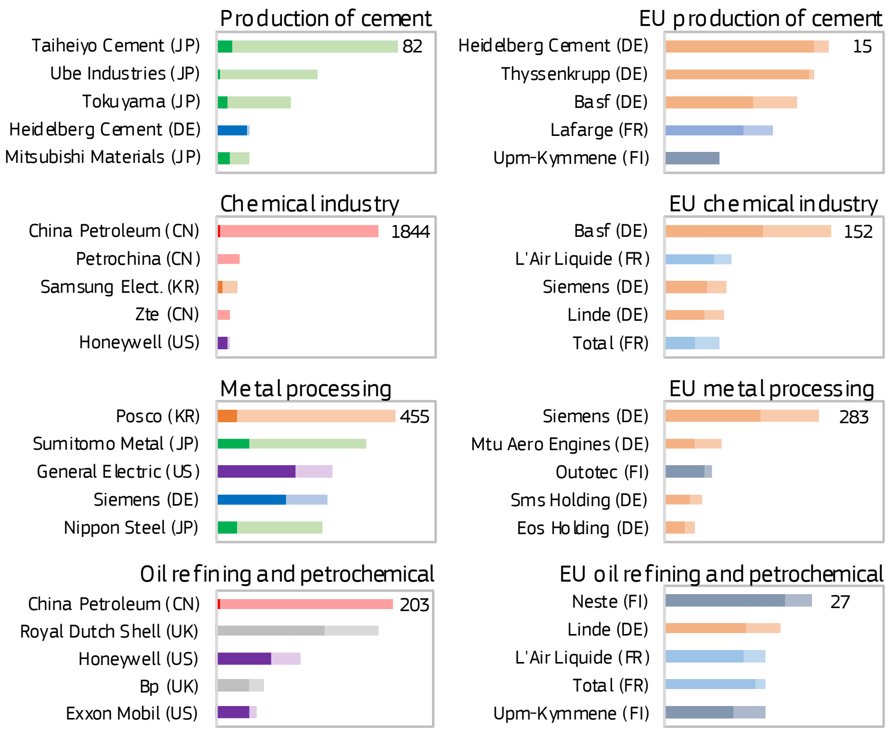
Note: Total number of inventions in brackets.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Asian economies produced the greatest absolute number of inventions. However, EU and US companies protect a larger share of their inventions outside their home IP office and market. The EU is in the lead along with Japan for high-value inventions.

In the EU, Scoreboard companies and their subsidiaries account for around a third of the patenting entities. However, activity is highly concentrated with the major actors, meaning that they account for up to three quarters of the total number of inventions, depending on the technological area. In addition, the EU Top 10 account for up to half the total number of inventions.

Figure 4.17 shows the performance of the Top 5 companies in green inventions for energy-intensive industries, in terms of total and high-value inventions (in darker shade). As discussed in the previous sections for all green inventions, companies from Asia have a strong inward focus, protecting a number of inventions only in their own market. The following overview of EU top performers is based on high-value patents.

Figure 4.17: performance of the Top 5 companies in green inventions for energy-intensive industries - 2010-2016.



Note: Positioning of the top international (left) and EU (right) players in green inventions relating to: production of cement, the chemical industry, metal processing, and oil refining and petrochemicals. The dark shading signifies the share of high-value inventions.
Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

Green inventions related to the production of cement

EU cement firms lead globally in high-value green inventions. However, the relevant patenting activity in the sector is rather low, suggesting that development of green technologies has a minor role in their R&I portfolio. Additionally, a small proportion of inventions in these technologies seems to be protected in more than one IP office. The technological areas receiving most attention related to the cement industries are geopolymers, belite cements, and CCS, the latter being the area with the largest number of high-value patents. Within the EU, Thyssenkrupp, HeidelbergCement and Fives are the companies most active in energy efficiency measures, though their portfolios are smaller than those

of the leading Japanese companies. The same actors, joined by Areva and Lafarge, feature in terms of integrated production plants, an area dominated by European interests. Thyssenkrupp, Lafarge and Linde also feature in the area of fuels from biomass and waste, but activity is very low compared to other areas. With regard to CCS, the EU has a strong position, as in the case of metal processing, through Thyssenkrupp, Vinci, Lafarge, L'Air Liquide, BASF, Stora Enso, and HeidelbergCement.

Green inventions related to the chemical industry

The EU and US are in the lead in terms of cumulative high-value green inventions for the chemical industry. Since 2014, the EU has overtaken the US in high-value inventions per year, though numbers for both are decreasing. Activity is more even across the top actors in these technologies, and more sustained throughout recent years. In a further breakdown of activities, BASF is the most prominent EU company in energy efficiency measures. Siemens, L'Air Liquide, ThyssenKrupp, STMicroelectronics and Linde all feature with patents addressing technologies for energy recovery, which is another area where the EU has a strong position and interest. Siemens is the strongest EU firm in patent development on renewable energy sources along with Toshiba, with a portfolio of high-value inventions three times the size of the other companies in the Top 10. Linde is the top EU company in patenting activity relating to reducing GHG emissions in the chemical industries, with L'Air Liquide also featuring in the Top 10.

Green inventions related to the processing of metals

While Asian firms lead in total inventions, EU and US firms have more high-value green inventions related to metal processing. As explained in previous sections, EU and US companies tend to have a more outward focus and protect more inventions in foreign markets, also targeting each other's markets. The top 3 – General Electric (US), Siemens (EU) and United Technologies (US) – have been constantly increasing their high-value patent portfolio since 2012, and are much more active than the rest. There are three EU companies in the Top 10 for high-value inventions, however only Siemens has a portfolio comparable to the leading actor General Electric. Focusing on EU champions in green technologies for metal processing, EU companies lead with regard to increasing process efficiency through reducing waste and recovering material streams. The top EU firms are Outotec, Siemens, and SMS Holdings. Siemens leads in cumulative inventions in CCUS technologies, where the EU has a strong position, with recent activity from Linde and Danieli. Siemens and Danieli are also the top EU companies in CO2 avoidance using hydrogen. Patenting activity on electrolysis is very low globally; in the EU, Salzgitter, Voest-Alpine and Outotec have filings. The EU also leads in patenting to increase the efficiency of electric conversion processes through Thyssenkrupp, Siemens and SKF. General Electric, Mitsubishi, Linde, L'Air Liquide, Siemens and POSCO are the only groups patenting technologies for renewable energy sources or cogeneration with other industries.

Overall, EU companies have a strong presence in patenting activity related to green inventions for energy-intensive industries, with companies such as BASF, Siemens, Thyssen Krupp and L'Air Liquide being prominent in more than one area. This shows both the interest and capacity of major EU companies to innovate in this area, but also that the proximity of technologies and processes makes green technologies relevant across a number of energy-intensive industries. This is especially apparent in the chemical and petrochemical sectors, with major oil and gas companies featuring in both.

4.7 Key points

- The global share of green inventions in overall patenting activity is 7%. The EU is second, behind South Korea, among major economies for green inventions (9.5% of all inventions).
- The EU has a high degree of specialisation in green inventions, and is the global leader in high-value green inventions, which account on average for about 60% of all green inventions.
- China is the most important target country for the protection of green inventions, followed by the US. Europe is the most important market for the US.
- There is a high concentration of innovative activity within the top corporate R&D investors. The Top 10 EU-headquartered Scoreboard companies account for 71% of inventions in Transport and 37% in Energy. In energy-intensive industries, the ten best-performing Scoreboard companies from the EU account for up to half of the patenting activity.
- There is evidence of a highly interconnected world in the co-production of green inventions. EU Member States generate one third of green co-inventions through intra-EU connections, another third with the US and very few with China.
- The majority of green inventions by EU Scoreboard companies are produced by EU subsidiaries. Internationalisation of the remaining R&D activity aims to exploit opportunities in the host country of subsidiaries or to access the respective internal market, and exploit foreign technological knowledge and capability for the European market.
- The 2009-2010 financial crisis had a negative impact on global patenting trends. Activity returned to pre-crisis levels 4 years later, but green inventions did not recover at the same rate as other technological areas, making the recovery from the previous financial crisis was not as "green" as it could have been. The current focus on a ‘green’ recovery from the COVID-19 crisis, could help avoid a similar trend in the current economic environment.

CHAPTER 5 – SUSTAINABILITY DISCLOSURE AND REPUTATION OF TOP R&D INVESTORS

Achieving a sustainable EU economy will require collaborations and actions by all actors and all sectors of our economy. The 17 SDGs of the UN's 2030 Agenda set out a framework and priorities for local and global partnerships to bring peace and prosperity to people and the planet.[84] At the EU policy level, making the economy sustainable and climate-neutral by 2050 is at the core of the European Green Deal.[85] The European Commission remains committed to the 2030 Agenda through transformative policies including the Industrial Strategy for Europe[86].

R&D is recognised as key driver and critical success factor in leveraging the transition towards sustainability[87], e.g. by building on EU scientific and technological knowledge to develop solutions for green and inclusive growth. The Agenda for Sustainable Development and the EU growth strategy explicitly recognize the transformative power of research and innovation (R&I) for achieving sustainable competitiveness and for driving just and inclusive transitions for all.

The SDGs are both challenges and opportunities for developing business-led solutions and technologies that contribute to green transformations and sustainable recoveries. The business sector has a key role to play in tackling sustainability challenges. First, as part of the solution, i.e. industries developing technologies and solutions to tackle environmental problems. Second, as part of the problem, i.e. industry's large share of the climate and environmental burden. Here, R&D&I become ever more crucial in the transition of our economy, society, and planet to secure a sustainable future that ensures the wellbeing of our citizens. This is reflected in the notion of prosperity, where growth is coupled to sustainability and the potential impact on future generations.

EU policies and legislative and regulatory initiatives with the ability and intent to change patterns and to promote sustainable practices in Europe exist already, in particular in the climate and waste management areas (such as the Renewable Energy Directive, the passenger car CO2 Regulation and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment). In this chapter, this is reflected in the high scores of SDGs disclosure and reputational performance of most of the EU Scoreboard companies across sectors. It is also indicated by the high scores of the chemical, automobile and transport and industrials sectors which are subject to internal market policies and legislation. The scale and ambition of such policies is increasing to deliver Europe's share in terms of the SDGs and climate mitigation goals, gathered under the overarching principles of the Green Deal. The implementation of new and existing EU policies and legislative initiatives that interact with companies behaviour and business strategies offer positive spillovers, such as access to R&D and elevating environmental standards. It is clear that to meet global targets for environmental protection, and wider goals for sustainable development, strategies for integration of environmental and social concerns across policy bounds and at global scale are needed.

[84] Transforming our world: the 2030 Agenda for Sustainable Development: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

[85] 'A European Green Deal': https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[86] Delivering on the UN's Sustainable Development Goals – A comprehensive approach, Staff Working document SWD(2020) 400 final of 18.11.2020

[87] 6th Reflection Paper on a Sustainable Europe by 2030 and https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf

Increased corporate transparency represents an opportunity for going above industry standards and reporting publicly on sustainability performance including climate change initiatives and social practices.

In support of further participation from the private sector in financing sustainability, the Commission has developed the sustainable finance policy, where the EU taxonomy for sustainable activities will constitute a unified classification system for sustainable economic activities, together with the EU green bond standard, methodologies for low-carbon indices, and metrics for climate-related disclosure.[88] The Commission has established a list of environmentally sustainable activities by defining technical screening criteria for each environmental objective via delegated acts[89]. The first draft delegated act on climate change mitigation and climate change adaptation was published for feedback on 20 November 2020 for stakeholder consultation.[90] Following adoption, the first company reports and investor disclosures using the EU Taxonomy are due at the start of 2022. For four other environmental objectives, the EU taxonomy should be established by the end of 2021 and will apply by the end of 2022. Further development of the EU taxonomy will take place via a new platform on sustainable finance.[91]

While the financial reporting aspect of sustainability under the EU taxonomy will be captured in future Scoreboard editions, a systematic understanding of companies' commitment to sustainability is still lacking.[92] This chapter shows the first results of a pilot exercise which characterises, via a big-data approach, the sustainability disclosure and reputation of Scoreboard companies in relation to a selection of Sustainable Development Goals (SDGs).

This approach provides novel type of evidence by establishing scores on the disclosure and reputation of top R&D-investors with regard to sustainability. It is based on quantitative analysis which exploits novel SDGs' scoring at the company level, integrating both data and information in terms of disclosed environment, social and governance (ESG) strategies and companies' societal and environmental impacts (see Box 5.1 below).

This provides a new angle on progress made in targeting green, just and inclusive transitions by leveraging inter alia R&I investments and capabilities (see Box 5.2 on the important role of R&D in achieving sustainability goals). The related evidence can also inform sectoral benchmarking on the multidimensional ladder of sustainable competitiveness. The SDGs disclosure and reputation scoring presented in this chapter does not replace or affect the indicators used by the European Commission to capture sustainability. It tests a specific approach to capture sustainability of corporate R&D investors as disclosed and perceived, also as a complement to the existing reporting on sustainability undertaken by some companies. This could also contribute to the efforts to monitor the progress towards sustainable development at the local and global scales.

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[88] https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_en

[89] The activities and criteria considered are based on the recommendations of the Technical Expert Group (TEG) on Sustainable Finance published in March 2020

[90] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

[91] https://ec.europa.eu/info/publications/sustainable-finance-platform_en

[92] Companies' SDG-related reporting shows awareness and strategic acknowledgement, but lacks directionality and specificity https://www.pwc.com/gx/en/services/sustainability/sustainable-development-goals/sdg-reporting-challenge-2018.html

The first section of the chapter presents thematic SDG disclosure and reputation scores by industrial groups of top investors in R&D. The second section looks at the selected SDG disclosure and reputation scoring across the world's major regions for selected industries.

Box 5.1 - SDG scores: methodology

The data on SDG scores is collected by Covalence SA[93] and relates to Environment, Social and Governance (ESG) issues, sustainability, Corporate Social Responsibility and business ethics. The data is articulated in two dimensions: disclosure and reputation.

Disclosure covers ESG data published by companies and is both quantitative (ESG indicators from Refinitiv, formerly Thomson Reuters, such as CO2 emissions, water consumption, etc.) and qualitative (sustainability-related corporate communications).

The reputation dimension covers qualitative data published by companies' stakeholders such as governments, international organisations, NGOs, the media and other third-party sources. This data is composed of narrative content (e.g., web pages, articles, texts) and may have a positive or negative valence, translating either compliments or criticisms.

The data is first classified according to 50 criteria inspired by the Global Reporting Initiative (GRI).[94] It is then recoded with hundreds of both disclosure and reputation indicators. Each selected indicator is normalised into a 0-100 scale. Finally, these indicators are classified into SDGs and for each of the 17 SDGs, an average is calculated using the disclosure and the reputation indicators, producing the final SDG scores, which also range from 0 to 100. A score of 50 represents a neutral value: if for a given SDG a company scores above 50, it means it positively contributes to that SDG. Conversely, a score below 50 means that a company is not doing enough and/or has a bad reputation.

5.1 Top investors in R&D and SDGs: scores by sector

This section examines the performances of top investors in R&D across selected sectors and selected thematic SDGs as a first test of the chosen approach. In recent years, companies have shown a growing interest in aligning their strategies with the SDGs through sustainability reporting and impact measurement. This endeavour underlines the relevance of SDGs and the need for understanding how they guide the developments of new business models, technologies and solutions, as well as enabling more sustainable growth and shareholder value. Industrial innovations in particular are instrumental in the transition towards sustainable production, innovation and work systems.

The chapter focusses on corporate scores for selected SDGs considering both the nature of our sample (large R&D-intensive firms), the sectors represented and their potential for resolving specific societal issues reflected in existing SDG targets.

[93] Covalence SA, based in Geneva (Switzerland) since 2001, is specialised in Environmental, Social and Governance (ESG) research and ratings. For more information, please visit https://www.covalence.ch/.
[94] https://www.globalreporting.org/

The following goals are very relevant for industrial action and are included in the analysis presented here: SDG 7 (Affordable and clean energy); SDG 8 (Decent work and economic growth), SDG 9 (Industry, innovation and infrastructure), SDG 12 (Sustainable consumption and production) and, SDG 13 (Climate Action).

Table 5.1 presents the performance of top industrial R&D investors for the five SDG disclosure and reputation scores across represented sectors. While not the whole set of companies in the *Scoreboard* could be matched, the sample examined in this chapter includes more than 1500 Scoreboard companies operating respectively in the industries of health, ICT-related, Industrials, Transport, Chemicals and Aerospace & Defence. Table 5.1 shows that the SDG disclosure and reputation scores differ across industries, which vary in the way their technological development strategies and R&I activities are deployed. Overall, companies from the Chemicals and Transport sectors show the highest scores on the five SDGs. Conversely, top investors in R&D that operate in ICT services and Health industry have relatively lower SDGs scores as compared to the whole sample. As explained below, this may be due to the high level of regulation affecting the Chemical and Transport sectors.

Table 5.1: Average SDG disclosure and reputation scores by sector and SDG – 2019

	top 2500				
	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION
Aerospace & Defence (34)	51.2	53.9	46.6	44.0	44.4
Automobiles & other transport (119)	56.7	56.2	51.1	51.4	50.3
Chemicals (81)	60.9	58.8	53.4	54.9	52.5
Health industries (328)	34.1	43.9	32.6	32.8	33.4
ICT producers (281)	50.6	55.7	44.8	45.7	42.4
ICT services (213)	37.6	44.8	34.6	35.0	35.0
Industrials (171)	56.6	55.6	49.2	47.3	47.1
Others (356)	54.8	57.0	47.3	48.9	48.7
Total (1583)	48.0	52.2	42.9	43.3	42.6

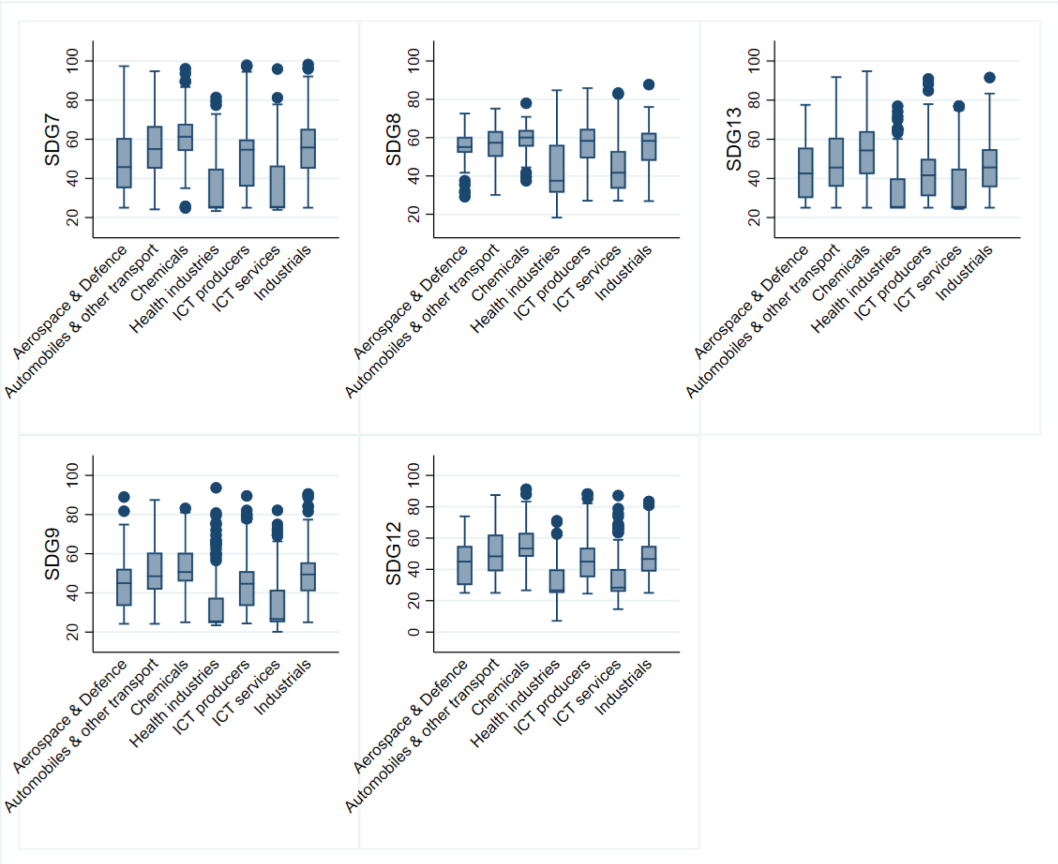
Note: data refers to 1583 companies for which data are available, representing 86.4% of the R&D invested by the all sample in 2019 (the percentages of representation of R&D2019 by region are: 84.0% for EU, 95.6% for US, 94.7% for Japan, 52.9% for China, 88.2% for RoW).
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The SDG disclosure and reputation scores of the investors in R&D align to a greater extent with SDG 7 and SDG 8 than the other SDGs. Innovative firms are instrumental in designing and producing sustainable energy solutions through clean energy research and promoting affordable, modern, resource-efficient technologies and low-carbon energy infrastructure (SDG7). The issues at stake are major ones if one considers that energy accounts for about 60% of total greenhouses emissions and that by 2030, the global rate of improvement in energy efficiency should double.

Looking closely at the individual sectors' SDG disclosure and reputation scores for the target SDG 7, the scores point to the higher performances of R&D investors from the Chemicals, Transport and Industrials industries, respectively, as compared to the Health and ICT services industries. Besides sectorial characteristics and dedicated corporate strategies, this greater alignment may result from specific sectoral environmental regulations or formal "rules of the game". These rules define the institutional framework that guides or incentivises companies to adopt sustainable products and practices to manage human resources, innovation and supply chains networks, and waste, as well as in the design, production and commercialisation of their novel product offerings.

While employment and conditions depend on many factors, *Scoreboard* companies that often rely upon global production, distribution and innovation networks are on the forefront with regard to strategies affecting SDG 8 on conditions for reaching full and productive employment and decent work for all. Here again their disclosure and reputation could be decisive with regard to improving economic productivity and diversification opportunities, as well as for protecting labour rights and the principles of 'equal pay for work of equal value'.

Figure 5.18 Boxplots of the five SDGs, by sector



Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

The boxplots in Figure 5.1 help better capture the dispersion patterns of corporate SDG disclosure and reputation beyond average sectoral scoring. A boxplot is a standardised way of displaying the distribution of data. The "box" part of the graph shows the three quartiles (first quartile or 25th percentile, median or 50th percentile, and third quartile or 75th percentile). The lines extending from the boxes ("whiskers") indicate the variability outside the upper and lower quartiles. The spacing between the different parts of the boxplot indicates the degree of dispersion (spread) and skewness in the data. The dots outside the whiskers show outliers.

As Figure 5.1 demonstrates, the dispersion of SDG disclosure and reputation scores within sectors is high, suggesting important variations in company-specific disclosure practices and/or their qualitative social and environmental impacts. The figure also suggests that the dispersion of SDG disclosure and

reputation scores is more pronounced in the Health and ICT industries, especially when looking at SDG 9 and SDG 12. The former relates to the efforts to modernise industries, develop resilient infrastructures, and encourage innovation, SDG12 insists on innovative solutions and models that yield advances in decoupling economic growth from environmental degradation.

The next section looks at the SDG disclosure and reputation scores of Scoreboard companies by main sector of operations and country of corporate headquarters.

5.2 Top R&D investors and the SDGs: scores by sector and geographic area

Section 2 gives a finer picture by accounting for geography-specific factors in the comparison of the SDG disclosure and reputation scores of Scoreboard companies. Besides voluntary reporting, governments may also set up legislative frameworks for companies to report on their SDG, which may affect both their disclosure and reputation scores. In this latter case, differences in legislation or regulatory frameworks may lead to significant heterogeneities in corporate disclosure practices and compliance levels.

Table 2 reports the average of SDG disclosure and reputation scores by sector and world region according to the Scoreboard companies active/headquartered there. Scoreboard companies based in the EU and Japan present higher SDG scores for all sectors as compared to their US- and China-based corporate investors in R&D. Looking at each of the five SDGs, European companies' disclosure and reputation scores align to a greater extent with the objectives of enhancing economic growth and opportunities for decent work (SDG 8). European companies distinguish themselves by working towards increasing the shares of renewable energies and energy efficiency (SDG 7). This may also reflect greater integration or alignment with the European Green Deal and its mission to achieve a climate-neutral economy by 2050.

Scoreboard companies in Chemicals industries from the EU, Japan and the US respectively report higher disclosure and reputation scores for SDG 7, SDG 8 and SDG 12. Only the two former groups of companies score better on targets related to enabling green transitions, jobs and growth by taking climate action (SDG 13). On SDG9, EU and Japanese companies score on average higher than their US and Chinese counterparts. Specifically for the EU, companies score high in SDG9 in sectors like Automobiles, Chemicals and Industrial, sectors that are in the focus of the Green Deal. These sectors are also subject to EU policies and the regulatory framework, which improves also the transparency. With respect to SDG 12, the higher disclosure and reputation score of EU- and Japan-based companies that operate in Chemicals and Transport industries may suggest an increasing strategic integration of targets or missions related to environmental practices and sound environmental management of chemicals and wastes, as well as to the reduction of waste generation through prevention, reduction, recycling and reuse (SDG 12), in the EU also supported by legislative and regulatory requirements. Notably, target 12.6 (SDG 12) encourages companies, "especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle" [95].

[95] See the facts and targets associated with SDG 12 at https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

Table 2: SDG scores by sector and geographical area

	EU				
	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION
Aerospace & Defence (8)	57.8	59.0	52.7	50.7	51.5
Automobiles & other transport (23)	62.6	61.9	56.1	57.6	58.9
Chemicals (15)	72.5	63.3	60.3	60.3	61.0
Health industries (46)	43.7	54.2	40.7	39.4	41.3
ICT producers (35)	60.6	60.6	51.4	50.4	47.9
ICT services (21)	55.1	60.6	47.1	48.6	49.4
Industrials (46)	62.3	61.4	54.0	51.4	51.1
Others (83)	65.7	61.8	53.2	55.5	56.2
Total EU (277)	59.9	60.2	51.2	51.3	51.6

	US				
	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION
Aerospace & Defence (13)	46.4	50.8	42.3	39.4	40.0
Automobiles & other transport (33)	51.1	53.1	48.3	44.6	41.1
Chemicals (24)	56.6	57.2	50.6	49.2	45.1
Health industries (210)	29.5	38.6	29.1	28.9	29.0
ICT producers (111)	44.6	50.7	40.8	39.7	37.0
ICT services (134)	33.0	40.8	31.1	31.1	31.3
Industrials (38)	49.9	50.4	46.5	41.8	41.9
Others (86)	47.1	53.9	45.3	43.9	42.4
Total US (649)	38.8	45.5	36.7	35.7	34.8

	Japan				
	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION
Automobiles & other transport (24)	65.5	59.5	56.5	63.4	61.3
Chemicals (23)	59.4	57.8	52.0	56.1	53.8
Health industries (16)	48.4	57.9	42.9	49.4	46.6
ICT producers (42)	60.1	60.0	53.1	57.2	48.8
ICT services (7)	49.9	55.4	49.1	48.9	42.3
Industrials (35)	59.9	54.3	50.8	50.9	47.8
Others (68)	56.1	56.7	47.4	51.7	48.9
Total Japan (215)	58.1	57.4	50.3	54.2	50.2

	China				
	7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION
Aerospace & Defence (2)	35.0	47.9	29.2	35.8	37.5
Automobiles & other transport (16)	47.2	48.1	41.3	37.5	38.2
Chemicals (2)	30.0	49.0	27.1	38.3	32.5
Health industries (18)	36.7	50.4	34.0	38.7	38.6
ICT producers (27)	44.7	55.2	38.0	42.0	39.6
ICT services (17)	36.2	41.9	34.2	31.7	31.6
Industrials (21)	47.1	50.0	40.1	40.9	42.3
Others (45)	41.4	49.2	36.3	39.1	38.7
Total China (148)	42.0	49.6	37.0	38.8	38.4

Note: data refers to 1583 companies for which data are available, representing 86.4% of the R&D invested by the all sample in 2019 (the percentages of representation of R&D2019 by region are: 84.0% for EU, 95.6% for US, 94.7% for Japan, 52.9% for China, 88.2% for RoW).
Sources: *The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

US- and EU-based Scoreboard companies in Health industries have lower disclosure and reputation scores with respect to SDG 12. A similar pattern is observed for US- and China-based companies with their main activity in the ICT services sector. As compared to their peers, Japan-based companies perform above the country-sector averages for SDG 12 and SDG 13, with the exception of companies focusing on the Chemicals industry.

EU- and Japan-based companies have above-average SDG performance when considering the five selected SDGs all together. EU- and Japan-based firms have closer SDG disclosure and reputation scoring, while US- and China-based top investors in R&D present average scores that are below 50. Conversely, the values for EU-based and Japan-based companies are consistently above 50 for the cross-sectorial average. A closer look at EU-based firms in the Aerospace and Defence industries suggests that they are well aligned both in terms of disclosure and reputation. This is illustrated by relatively higher scores on the five SDGs for the group of EU-based firms operating in the Aerospace and Defence industries, as compared to their US- and China-based counterparts respectively.

Box 5.2 - The important role of R&D in achieving sustainability goals

Figure 5.2 reports the estimated effects (with 95% confidence interval whiskers) of past R&D investment on the five SDGs, using regression analysis. Results show that, controlling for company size and capital expenditure, investment in R&D in a given year has a positive effect on the following year's SDG scores.

Figure 5.2: Estimated effect of R&D investment on SDGs

Sources: The 2020 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I

In the 2019 *Scoreboard* we summarised the important role of R&D in achieving 12 of the UN's 17 sustainability goals. In the following sections, we concentrate on highlighting new developments in each of these areas and explaining how some of the technology trends in Section 1 above link closely to the sustainability goals. Unfortunately, the coronavirus pandemic has temporarily slowed or reversed progress in several of these areas, but 2021 should see further advances being made.

Box 5.2 ctd.- The important role of R&D in achieving sustainability goals

The 12 sustainable development goals where R&D is key to progress are:

1. **Zero hunger (UN goal #2):** A major R&D advance here is the use of the Crispr-Cas9 gene editing technique to accelerate the improvement of food crops[96] and enhance the productivity of farm animals. This allows higher food production and the use of less fertile land to feed an expanding world population without the need for more farmland and the destruction of more rain forest.
2. **Good health & wellbeing (UN goal #3):** In Section 1.2 above, we outlined the rapid progress being made in developing new drugs using the tools of advanced biotechnology. Lives are being saved and the impact of chronic diseases mitigated by new drugs to treat cancers, autoimmune diseases and many other serious conditions, and progress is being made in treating intractable neurological diseases such as dementia and Parkinson's disease. R&D is also improving diagnosis and medical devices which are enhancing wellbeing by extending active life spans. And 2020 has seen rapid progress in developing treatments and vaccines for the COVID-19 virus which has had serious effects on health and wellbeing in 2020.
3. **Quality education (UN goal #4):** The Coronavirus pandemic has forced major changes in education, with remote teaching becoming vital for many institutions during the pandemic[97] and many multinational organisations helping people to discover online learning resources[98]. Conference and event organisers have also had to use online communication technologies. Experience with such methods is stimulating R&D on improving them, and should give a boost to the use of AI for personalised education & training, and help develop new ways of lowering costs and bringing the best educators to wider audiences.
4. **Clean water & sanitation (UN goal #6):** About 4 billion people experience severe water scarcity for at least one month of the year, and by 2040 one in four of the world's children under 18 will be living in areas of extremely high water stress[99]. Agriculture uses over 70% of freshwater, and new farming techniques such as hydroponics can reduce the amount of water needed to grow crops by as much as 90%[100]. And the supply of fresh water in many areas can be increased by efficient desalination technologies, since 97% of available water resources are contaminated by salt. Older thermal desalination techniques are being replaced by newer membrane processes such as reverse osmosis and electrodialysis.
5. **Affordable & clean energy (UN goal #7):** The major role for R&D here is in developing sources of clean energy with costs comparable to or lower than fossil fuels. In chapter 1 we outlined the shorter-term options such as improving the efficiency and lowering the cost of wind turbines, solar power and the associated energy storage. In the longer term nuclear fusion may offer a new source of energy. Transport will use much more clean energy as R&D improves batteries, supercapacitors and hydrogen fuel cells to power vehicles of all kinds from cars to trains and aircraft.
6. **Decent work & economic growth and no poverty (UN goals #1 and #8):** The coronavirus pandemic has set back this goal, with OECD unemployment likely to rise to 10-12% by end 2020, negative GDP growth for 2020 and an additional 70-100 million people worldwide pushed into extreme poverty in 2020[101]. History shows that technological revolutions do lead to more jobs, as experience with the transitions from agriculture to manufacturing to services in advanced economies shows. This is likely to happen in the new industries enabled by AI, biotech, new materials and processes and green jobs & industries.

[96] https://www.nature.com/articles/s43016-020-0051-8
[97] https://www.ft.com/content/bae2a4b2-5fa1-11ea-b0ab-339c2307bcd4
[98] https://ec.europa.eu/education/resources-and-tools/coronavirus-online-learning-resources_en
[99]https://www.unwater.org/water-facts/scarcity/#:~:text=With%20the%20existing%20climate%20change,et%20al.%2C%202015).
[100]https://www.nps.gov/articles/hydroponics.htm#:~:text=Less%20water%3A%20Hydroponic%20systems%20use,and%20drain%20to%20the%20environment.
[101] https://www.worldbank.org/en/topic/poverty/brief/projected-poverty-impacts-of-COVID-19

Box 5.2 ctd. - The important role of R&D in achieving sustainability goals

7. **Industry, innovation & infrastructure (UN goal #9):** The aim of this goal is resilient infrastructure, sustainable industrialisation and increased innovation. The EU R&D Scoreboard is a key tool for raising awareness of the importance of R&D and innovation, and for enabling lagging companies to understand the need to raise the intensity of their R&D investments towards the level of the best companies in their sectors. The technology trends outlined in Section 1 above suggest that changes in infrastructure will be needed to accommodate technological changes such as electric vehicle refuelling sites, city landing sites for VTOL electric aircraft, energy efficient buildings and the likely changes triggered by the coronavirus pandemic such as in retail (because of an accelerated trend towards online shopping) and office working (to possibly smaller distributed offices and more home working). And new sustainable companies will grow in sectors such as clean energy and transport, biotechnology, AI, quantum computing and new materials.
8. **Sustainable cities & communities (UN goal #11):** The coronavirus has done serious harm to the economies of many cities but, as it is controlled, air quality will be improved by widespread use of electric vehicles (see Section 1.3 above) and the development of energy-efficient buildings (towards the goal of zero net energy). An example is the United Therapeutics building in Maryland, one of the world's largest zero net energy commercial buildings[102].
9. **Responsible consumption & production (UN goal #12):** Progress here requires more efficient use of resources and design for recycling. Product & process R&D and accurate in-process measurement are improving product designs and manufacturing processes to ensure quality with lower material content, minimisation of waste and maximum recyclability. Moreover, technologies are being developed to produce green hydrogen from waste[103]. More large companies are joining the RE100 initiative which aims to use 100% renewable electricity. A total of 263 companies are now signed up, compared to 90 last year[104].
10. **Climate action (UN goal #13):** R&D has a major role to play in reducing greenhouse gas emissions by developing cost-effective electric vehicles and aircraft and more efficient clean energy generation (see 1.3 above for examples). Agriculture accounts for about one quarter of global greenhouse gas emissions. This will increase, as food demand is expected to rise by 56% from 2010 to 2050[105]. Action to improve farm productivity (e.g. using biotech – see #1 above) and livestock & fertiliser management will help, but increased consumption of plant-based 'meats' (which require one-twentieth of the land needed for animal meat) and innovative farming techniques such as green vertical farming which can release 70% less CO2 than open field farming[106].
11. **Life below water (UN goal 14):** Demand for fish is increasing rapidly, so fish farming is becoming increasingly important so that conventional fishing can remain sustainable. Indeed, aquaculture now provides half of all fish used for human consumption[107], and that proportion is rising. Biotech R&D is vital in helping to improve the quality and quantity of fish reared in aquaculture and their food productivity. Biotech uses genetic modification and other techniques to enhance desirable traits and increase disease resistance and enables more efficient use of feed. Illegal fishing is reduced by remote monitoring systems.
12. **Life on land (UN goal #15):** With world consumption of resources expanding, it is important not to over-extract minerals or damage the environment and to conserve landscapes and riverscapes and preserve biodiversity. Several of the other goals listed above are highly relevant to this one such, as 1 and10 (more efficient farming and plant-based meats to reduce land use and deforestation and preserve biodiversity), 9 (more efficient use of resources) and 5 and 8 (reduced pollution and clean energy replacing fossil fuels and minimising the need for fossil fuel extraction). Moreover, satellite observation can help to monitor pollution events and rain forest destruction.

[102] https://qz.com/1771906/the-innovative-design-of-one-of-the-worlds-largest-net-zero-buildings/
[103] https://www.rechargenews.com/transition/its-much-cheaper-to-produce-green-hydrogen-from-waste-than-renewables/2-1-801160
[104] https://www.there100.org/
[105] https://www.wri.org/blog/2020/08/us-agriculture-emissions-food
[106] https://www.greenforges.com/blog-index/how-different-types-of-agriculture-impact-on-c02-emissions#:~:text=Based%20on%20the%20results%20from,the%20amount%20of%20food%20waste.
[107] https://www.fisheries.noaa.gov/topic/aquaculture

5.3 Key points

- This chapter explores an SDG-related indicator of corporate disclosure and reputation to shed light on the practices of top investors in R&D on the pathways to sustainability. The aim is to develop it further and to benchmark them by considering both the well-known ESG compliance scores and their societal and environmental impacts, as appreciated by external stakeholders or third parties.
- The top investors in R&D from the Chemicals (with the exception of China) and Transport sectors score relatively better on the selected SDGs – SDG 7, SDG 8, SDG 9, SDG 12 and SDG 13 –, while ICT services and Health industry tend to have lower scores for the selected SDGs.
- European and Japanese Top investors in R&D show higher SDG scores as compared to US- and China-based investors for the selected SDGs.

ANNEX 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[108] with a 3 % headline target for intensity of research and development (R&D)[109]. R&D investment from the private sector plays also a key role for other relevant European initiatives such as the Industrial Policy[110], Digital Agenda and New Skills for New Jobs flagship initiatives.

The project "Global Industrial Research & Innovation Analyses" (GLORIA)[111] supports policymakers in these initiatives. 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 *Scoreboard* identifies main industrial players in key industrial sectors, analyse their R&D investment and economic performance and benchmark EU companies against their global counterparts.

This report describes and analyses the Scoreboard data and provides additional information on the positioning of Scoreboard companies in relation to other key indicators of relevance for industrial innovation policy and industrial R&D positioning. The annual publication of the *Scoreboard* intends 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[112]. 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[113]. **Therefore, the *Scoreboard* R&D figures are comparable to BES-R&D data only at the global level.**

108 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.

109 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).

110 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.

111 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 R&I R&I 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).

112 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.

113 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

The *Scoreboard* data are primarily of interest to those concerned with private sector R&D investments and positioning and benchmarking company commitments and performance (e.g. companies, investors and policymakers). 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%[114] 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 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.

- **Policy-makers, government and business organisations** can use R&D investment information as an input to industry and R&D assessment, policy formulation or other R&D-related actions such as R&D tax incentives.
- **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.

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

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).

114 According to latest Eurostat statistics.

ANNEX 2 - METHODOLOGICAL NOTES

The data for the 2020 *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 2019 fiscal year accounts, although due to different accounting practices throughout the world, they also include accounts ending on a range of dates between late 2018 and mid-2020. 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 another 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[115] 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 to 1.4 describe two typical levels of the industrial classification applied in the *Scoreboard*.

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

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)

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 are 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. Indeed, for US companies, the GAAP accounting standards are always used because they are the official, audited ones, however non-GAAP results may give a more realistic view of true R&D investments.

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; ii) different companies' information systems for measuring the costs associated with R&D processes; iii) different countries' fiscal treatment of costs. Some companies view a process as an R&D process while other companies may view the same process as an engineering or other process.

Interpretation

There are some fundamental aspects of the *Scoreboard* which affects the interpretation of the data. The focus on R&D investment as reported in group accounts means that the results do not indicate the location of the R&D activity. The *Scoreboard* indicates rather 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 only at the group and the at global level.

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. In contrast, 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, i.e. the aggregate of the 2500 companies R&D investment can be compared with the global total BES-R&D.***

Further, the *Scoreboard* collects data from audited financial accounts and reports. In contrast, BES-R&D typically takes a stratified sample, covering all large companies and a representative sample of smaller companies. An additional difference 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 because value added data is not available at a micro-level

Sudden changes in R&D figures may arise because a change in company accounting standards. For example, the first time adoption of IFRS[116], 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. By allocating all companies to a single sector, the R&D of diversified companies is allocated to one sector only leading to overstatement of R&D in that sector and under-statement of it in other sectors.

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 2019* as shown in Table A2.1[117]. 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

[116] 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/).

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

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.

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 that 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.

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 (31.12.2019). 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 depreciated by 2%, 3% and 5% against the US dollar, the Japanese Yen and the pound sterling respectively. 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 overstated because the 'benefits' of their overseas investments due to the appreciation of the US dollar against the Euro (from $1.15 to $1.12). Conversely, the R&D growth rate of US companies is partly understated due to the 'losses' 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, 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. Moreover, mergers between companies in the scoreboard allows other companies to enter such that over time the amount of BES-RD data the top 2500 comprises should increase.

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. In some cases where company are headquartered in countries for fiscal reasons with little R&D or other activity in that country, a misleading impression may be received.

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)[118].

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[118] 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

Table A2.1. Euro exchange rates applied to *Scoreboard* data for companies reporting in different currencies (as of 31 Dec 2019).

Country	As of 31 Dec 2018	**As of 31 Dec 2019**
Australia	$ 1.62	**$ 1.60**
Brazil	4.44 Brazilian real	**4.52 Brazilian real**
Canada	$ 1.56	**$ 1.47**
China	7.81 Renminbi	**7.85 Renminbi**
Czech Republic	25.73 Koruna	**25.41 Koruna**
Denmark	7.46Danish Kronor	**7.50 Danish Kronor**
Hungary	321.54 Forint	**331.13 Forint**
Hong Kong	8.97 HKD	**8.75 HKD**
India	79.94 Indiana Rupee	**80.06 Indiana Rupee**
Iraq	1351.35 IQD	**1333.33 IQD**
Israel	4.29 Shekel	**3.88 Shekel**
Japan	126.9 Yen	**122.55 Yen**
Mexico	22.54 Mexican Peso	**21.17 Mexican Peso**
New Zeland	1.71 NZD	**1.67 NZD**
Norway	9.95 Norwegian Kronor	**9.86 Norwegian Kronor**
Poland	4.30 Zloty	**4.27 Zloty**
Russia	79.55 Rouble	**69.54 Rouble**
Saudi Arabia	4.29 SAR	**4.21 SAR**
Singapore	1.56 SGD	**1.51 SGD**
South Africa	16.48 ZAR	**15.76 ZAR**
South Korea	1277.14 Won	**1298.70 Won**
Sweden	10.26 Swedish Kronor	**10.45 Swedish Kronor**
Switzerland	1.13 Swiss Franc	**1.09 Swiss Franc**
Taiwan	$ 35.19 New dollar	**$ 33.82 New dollar**
Turkey	6.03 Turkish lira	**6.68 Turkish lira**
UK	£ 0.9	**£ 0.86**
US	$ 1.15	**$ 1.12**
United Arab Emirates	4.21 Dirham	**4.13 Dirham**

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

application of international accounting standards at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002R1606:EN:HTML).

ANNEX 3 – COMPLEMENTARY TABLES

Table A3.1 – Main statistics for the 2020 *Scoreboard* sample of 2500 world companies aggregated by industrial sectors (top 15 sectors, ICB 3-digits).

Rank	Sector	R&D in 2019, € bn	1-year change, %	Net Sales, € bn	1-year change, %	R&D intensity, %	Operating profits, € bn	1-year change , %	Profitability, %	Employees, million	1-year change, %
1	Pharmaceuticals & Biotechnology	166.8	10.0	1043.9	7.5	15.4	143.1	12.8	14.7	2.7	2.0
2	Software & Computer Services	142.7	20.6	1212.6	11.2	11.8	186.7	-0.9	15.4	3.4	6.7
3	Technology Hardware & Equipment	139.6	8.9	1557.1	0.3	9.0	195.0	-17.8	12.6	3.8	8.5
4	Automobiles & Parts	132.7	1.9	2749.4	-1.0	4.8	115.4	-22.5	4.3	7.5	-3.0
5	Electronic & Electrical Equipment	68.9	6.3	1352.1	1.8	5.1	113.9	-19.8	8.5	5.5	1.4
6	Industrial Engineering	32.5	6.4	996.4	3.9	3.3	89.5	-3.8	9.1	3.6	1.4
7	Chemicals	23.1	-3.2	964.9	-4.3	2.4	86.0	-23.7	9.0	1.8	-2.6
8	Aerospace & Defence	20.6	4.3	518.4	6.4	4.0	46.6	-7.5	9.1	1.6	3.2
9	General Industrials	20.4	0.5	672.1	0.1	3.0	48.7	34.6	7.4	2.2	3.5
10	Construction & Materials	19.2	20.3	1048.9	9.8	1.8	70.4	5.6	6.7	3.1	2.2
11	Health Care Equipment & Services	18.9	9.3	495.1	8.1	3.8	43.3	14.5	8.8	1.6	4.6
12	Leisure Goods	16.5	3.5	269.6	-1.1	6.1	25.3	-0.5	9.4	0.7	1.4
13	Banks	11.4	5.6	351.7	0.4	3.2	90.3	-14.9	25.7	1.6	-0.7
14	Oil & Gas Producers	9.9	5.2	2725.5	-3.3	0.4	304.2	-23.8	11.2	1.8	-2.2
15	Household Goods & Home Construction	9.0	3.5	360.6	4.6	2.5	35.3	34.9	9.8	1.2	0.4
Total 38 industries		**904.7**	**8.9**	**21039.9**	**1.9**	**4.3**	**2060.1**	**-10.2**	**9.9**	**55.8**	**1.3**

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I.

The analysis of chapter 3 applies an extended sample of 1000 companies based in the EU. It consists of 542 companies included in the world R&D ranking of top 2500 companies and additional 458 companies also ranked by level of R&D investment. The composition by country and industry of the top 1000 EU+UK sample is presented in the table A3.2 below.

Table A3.2 Distribution of the sample of 1000 companies based in the EU+UK by country and industry.

Industry	Country codes																			
	AT	BE	CZ	DE	DK	ES	FI	FR	GR	HU	IE	IT	LU	MT	NL	PL	PT	SE	SI	GB	Total
Aerospace & Defence				3		1		5			1	1			2			1		10	24
Alternative Energy				3	2			1													6
Automobiles & Parts	4			19		1	1	6			1	4			3			4		5	48
Banks		2		4	2	1			1		2	2			2		2	2		4	24
Beverages		1			1															1	3
Chemicals	2	2		14			2	2					2		3			3		10	40
Construction & Materials	2	2		5	1	4	2	3			2				1			2		4	28
Electricity	1	1	1	1		2	1	1				2					1	1		2	14
Electronic & Electrical Equipment	3	3		16	2		2	8			3	4			3			4		12	60
Financial Services				4				1										3		4	12
Fixed Line Telecommunications				1	1	1		1				1			1					1	7
Food & Drug Retailers					1										1					3	5
Food Producers	1			2	1		2	3			2				4					7	22
Forestry & Paper							3											1		2	6
Gas, Water & Multiutilities	1			2	1			3				2								3	12
General Industrials	1	1		12	1		1	1			1	1	1		3			3		6	32
General Retailers		3		5		1		1									1			7	18
Health Care Equipment & Services	1	2		11	6		1	3			3				1			3		13	44

Industry	Country codes																			
	AT	BE	CZ	DE	DK	ES	FI	FR	GR	HU	IE	IT	LU	MT	NL	PL	PT	SE	SI	GB	Total
Household Goods & Home Construction				5	1		1	2				1	1		1			1	1	3	17
Industrial Engineering	4	1		32	2	2	7	7			2	7	2		4			12		10	92
Industrial Metals & Mining	2	4		4		1	1	1					2		1			2			18
Industrial Transportation				1	1			3	1			2						1		2	11
Leisure Goods					2											1		1		2	6
Life Insurance											1									2	3
Media	1							6												7	14
Mining													1					2		2	5
Mobile Telecommunications	1	1		2																2	6
Nonequity Investment Instruments					1																1
Nonlife Insurance				2				1												1	4
Oil & Gas Producers	1					1	1	1				1								3	8
Oil Equipment, Services & Distribution								1			1		1		1						4
Personal Goods				4				2				5	1							3	15
Pharmaceuticals & Biotechnology	1	6		15	13	4	2	23		1	12	5			10		1	14	1	53	161
Real Estate Investment & Services	1			6	3								1							11	22
Software & Computer Services	1			20	4	2	4	18					1		3	1		7		46	107
Support Services	1	1		11				3			2		1					2		24	45
Technology Hardware & Equipment	3	2		5	2		1	5	1		1				5			7		8	40
Tobacco																		1		1	2
Travel & Leisure	1	0	0	3	0	0	0	1	0	0	1	0	0	1	0	0	0	1		6	14
Total	33	32	1	212	48	21	32	113	3	1	35	38	14	1	49	2	5	78	2	280	1000

Source: *The 2020 EU Industrial R&D Investment Scoreboard*, European Commission, JRC/DG R&I

ANNEX 4 – ACCESS TO THE FULL DATASET

The 2020 *Scoreboard* comprises two data samples:

- The world's top 2500 companies that invested more than €34.7 million in R&D in 2019.
- The top 1000 R&D investing companies based in the EU with R&D investment exceeding €9.2 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 link provide access to the page where the two *Scoreboard* data samples containing the main economic and financial indicators and main statistics

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