



THE 2021 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

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Contact information

European Commission - Joint Research Centre

Directorate Growth and Innovation - Knowledge for Finance, Innovation & Growth Unit

Edificio Expo; c/ Inca Garcilaso, N° 3

E-41092 Seville (Spain)

Tel.: +34 954488318, Fax: +34 954488300, E-mail: jrc-B7-SECRETARIAT@ec.europa.eu

Any comments can be sent by email to: jrc-b7-iritec@ec.europa.eu

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THE 2021 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

Foreword by Commissioner Mariya Gabriel

This year's EU Industrial R&D Investment Scoreboard reports on companies' R&D investments in 2020, providing a snapshot of a particularly challenging year when the COVID-19 pandemic hit our societies and economy. The Scoreboard reflects the impact in various industrial sectors.

In the EU and worldwide, businesses in the Health and ICT sectors continued to increase their R&D investments. However, for the first time in 10 years, EU companies decreased their overall R&D investments. This is due mainly to the impact of the pandemic and reduced R&D investments in sectors such as the Automotive, Aerospace & defence industries and their large share in overall EU private R&D investments that year. Despite lowering their R&D investment, EU companies in the Automotive sector still account for the largest share in this sector globally and invest considerably more than their US and Chinese counterparts.

The Scoreboard also shows the strong position of the EU in developing green technology in Energy-Intensive Industries. Top R&D investing companies are increasingly focusing their R&D efforts on technologies that

will contribute to achieving the green transition with EU companies among the leaders. With the ambitious targets of the European Green Deal and the Digital Compass, this is not 'business as usual'. Given the new wave of deep tech innovation, Europe's companies have a critical role by investing in research and innovation.

The industrial competitiveness focus of the EU's research and innovation programme Horizon Europe, including the partnerships, and the swift establishment of national Recovery and Resilience Plans under the NextGenEU programme, show the EU's ambition to reinvigorate our industrial base and offer concrete support. The renewed European Research Area and the forthcoming Innovation Agenda will prompt investments in innovation, starting with the co-creation of transition pathways and ERA industrial technology roadmaps.

This report serves as a 'call to action' for industry to invest in the recovery. We have seen in the past that those who prepared for the future succeeded. I hope that this report inspires many actions for a stronger and competitive industry in Europe.

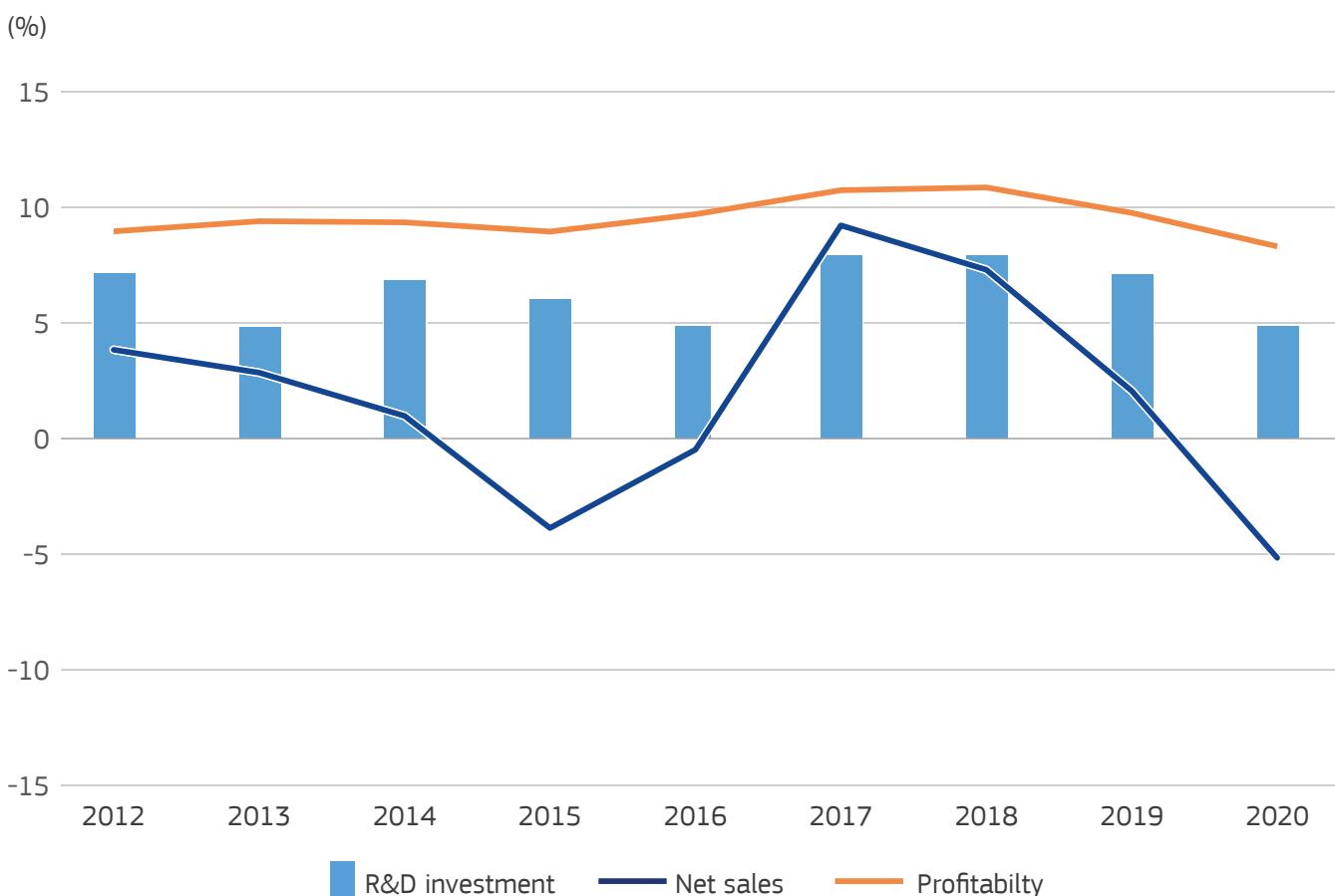
Executive Summary - Key findings

1 Global business sustained its R&D investments in 2020 despite being hit hard by the pandemic

Despite the Covid-19 pandemic, global investment in R&D continued to increase significantly in 2020 for the eleventh consecutive year. The 2500 Scoreboard companies invested €908.9bn in R&D, 6.0% more than in 2019, an increase which is rather lower than that of the previous year (9.2%). Unlike R&D investment, most other financial indicators were negatively affected by the pandemic, particularly operating profits, net sales

and capital expenditures. This indicates that, overall, the major R&D investing companies decided to protect their R&D investment despite falling sales and profits in order to maintain and develop their competitive position to be able to take advantage of the post-crisis upturn and its associated opportunities. This ongoing increase in R&D investment is in contrast to the overall decrease of 1.9% following the Great Recession in 2008-2009.

Figure S1: Global top R&D investing firms trends in R&D growth, net sales growth and profitability 2011-2020.



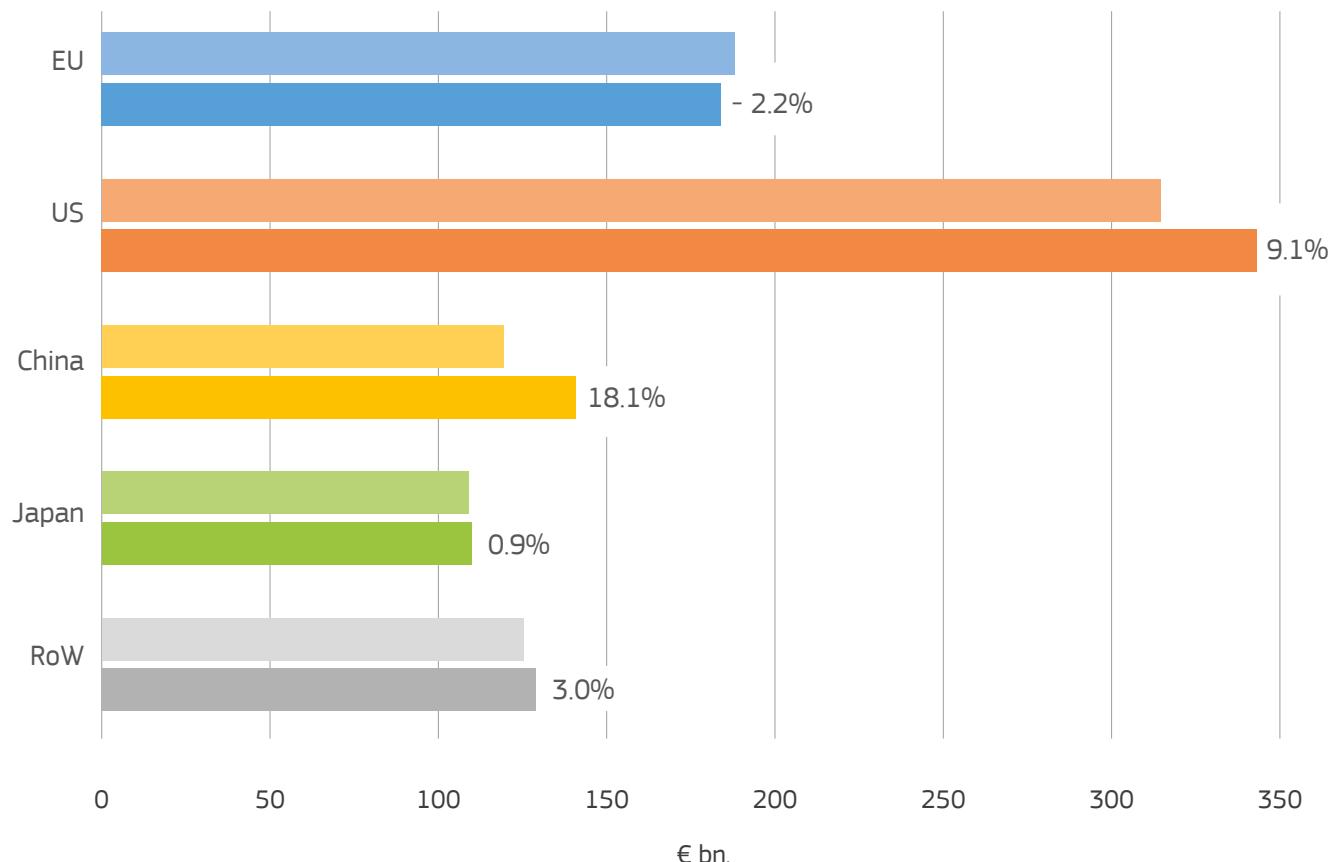
Note: Growth rates for the three variables computed on 1771 out of the 2500 companies for which data on R&D, Net Sales and Operating Profits are available for the entire period 2011-2020. These companies represent 87.3% of R&D, 87.6% of Net Sales and 88.7% of Operating Profits of the total sample in 2020.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Companies based in the US and China showed the largest R&D growth figures (9.1% and 18.1% respectively). This is not surprising since the US has a large proportion of ICT and Health companies that were not affected by the pandemic and China has a particularly large share of ICT companies. In contrast, EU companies R&D investment fell by 2.2% which broke the positive trend observed over the past years (6.0% increase in the prior year). Japanese companies increased R&D

by a modest 0.9% and the RoW group by 3.0%. The performance of the RoW companies was driven by R&D increases from companies mainly based in Taiwan (10.0%) and South Korea (4.2%). See Figures S1 and S2.

The share of global R&D investment for EU and US companies decreased slightly to 20.3% and 37.8% respectively whereas that of the Chinese companies continued to increase significantly, reaching 15.5%.

Figure S2: R&D investment level and growth rate 2019-2020 by region/country.



Note: Growth rates have been computed for 399 EU, 776 US, 597 Chinese, 292 Japanese, and 427 RoW companies for which data are available for both 2019 and 2020. Pale colour=2019; darker colour=2020.

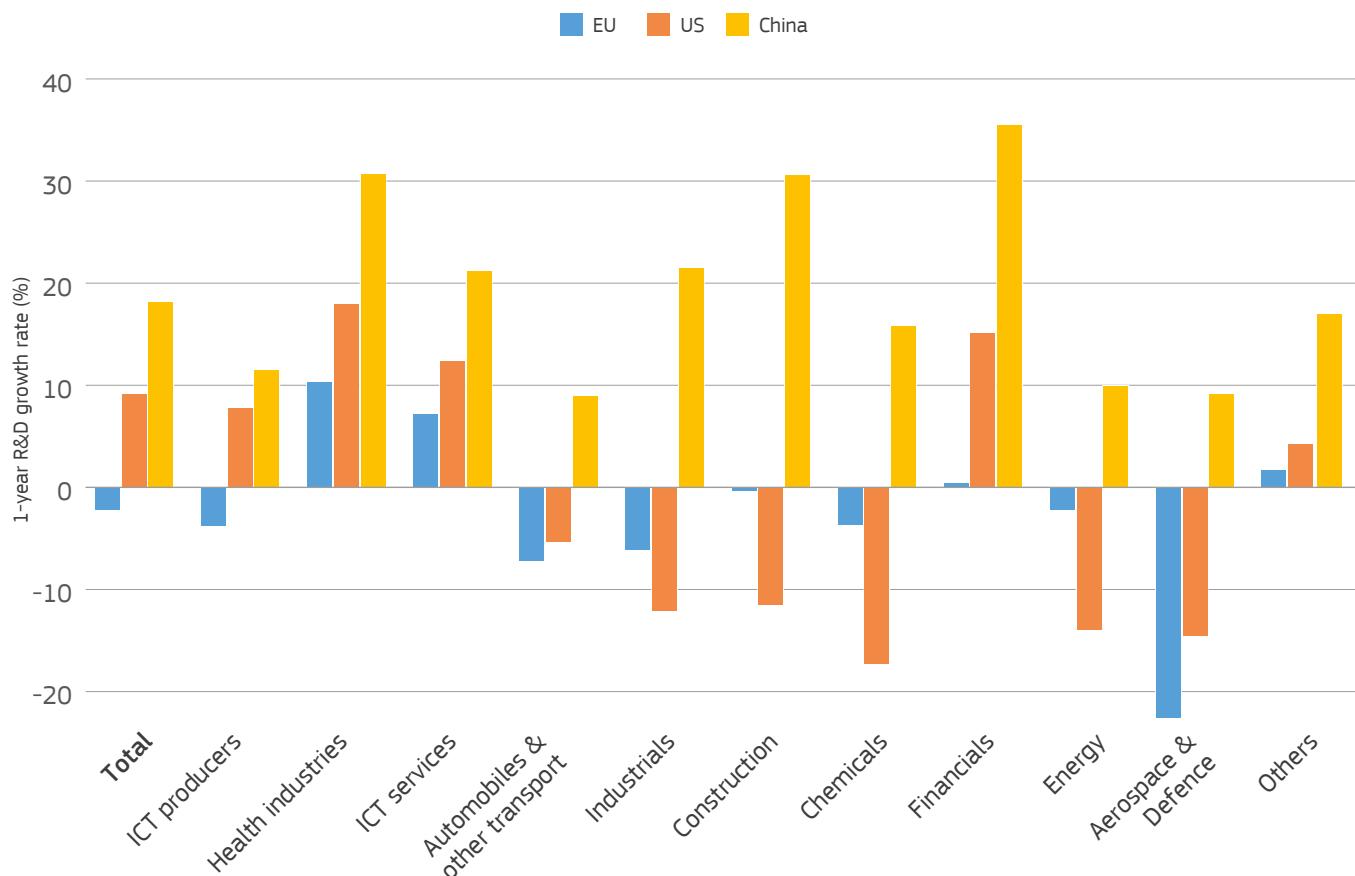
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD

2 The effect of the pandemic further boosted the fast-growing ICT services and Health industries while hitting the Automotive¹ and Aerospace & defence sectors hard

Global R&D growth was driven by the ICT services sector (15.5%), followed by the Health and ICT producers sectors (12.8% and 5.7% respectively). Most other sectors showed a decrease in R&D investment,

particularly those hit hard by the crisis, i.e. Aerospace & defence (-17.0%) and Automotive (-4.3%). The Chemicals sector reduced R&D by 3.4%, continuing the negative trend observed in the past few years. See Figures S3.

Figure S3: R&D investment growth 2019-2020 by sector and selected region/country.



Note: R&D 2020 growth rates have been computed for 399 EU, 776 US and 597 Chinese companies for which data are available for both years 2019 and 2020. Sectors ordered from left to right in terms of overall R&D investment in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

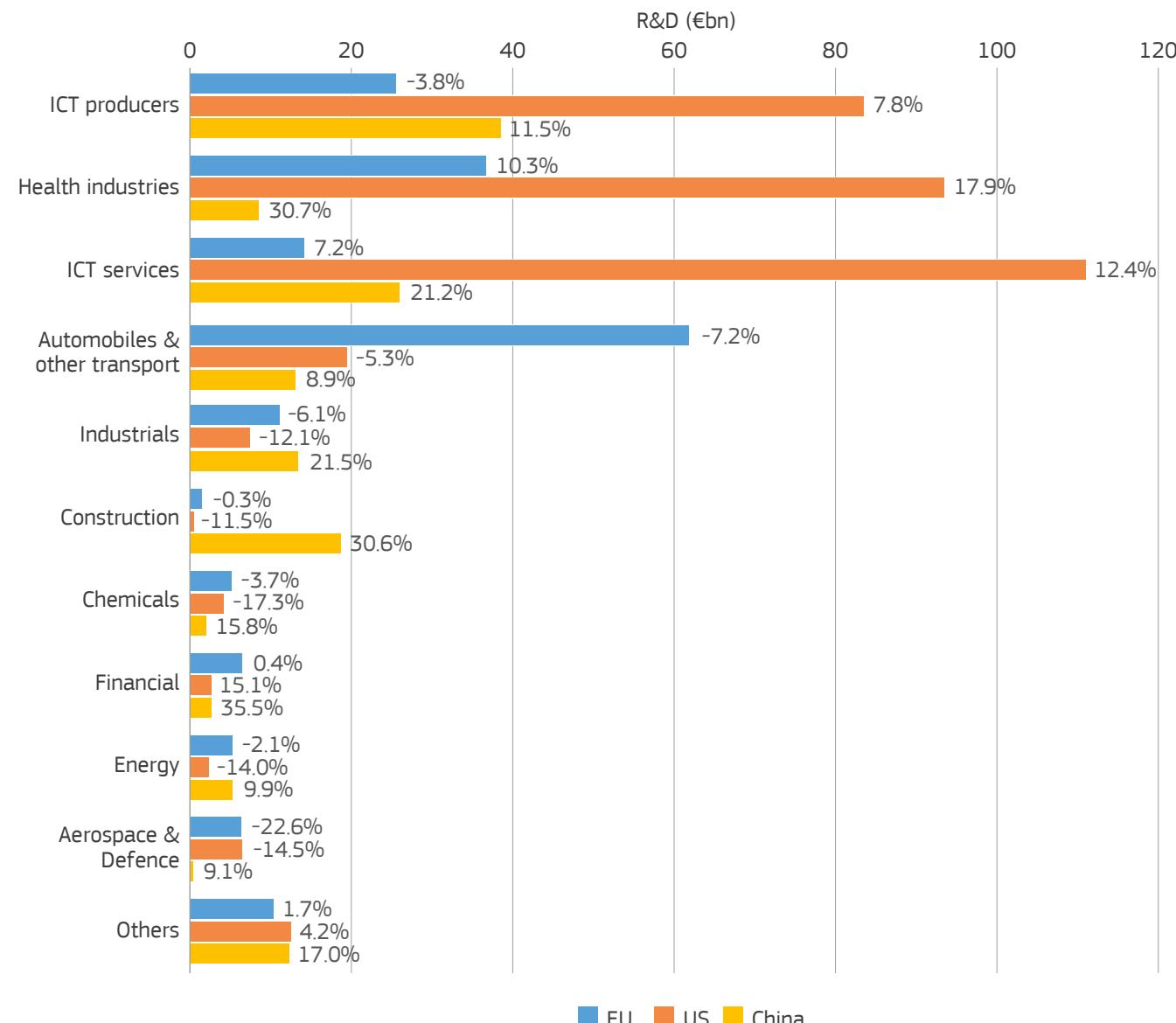
¹ Automotive is a short name for the Automobiles & other transport sector that comprises the Automobiles, Auto parts, Commercial Vehicles & Trucks and Tires subsectors.

3 The R&D specialisation of companies held back R&D investment of the EU group

The Automotive sector, the largest R&D sector in the EU accounting for 34% of total EU R&D, held back the overall R&D investment of the EU group since it decreased R&D investment of 7.2%. Most other sectors also experienced reduced R&D investment; these include Aerospace &

defence (-22.6%), Chemicals (-3.7%), Industrials (-6.1%) and ICT producers (-3.8%). Only two sectors showed positive R&D growth in the EU sample; Health (10.3%) and ICT services (7.2%), but the latter sector only accounts for 7.6% of the EU's R&D. See Figures S4 and S5.

Figure S4: R&D investment in 2020 by region/country and sector group and one-year growth rate.



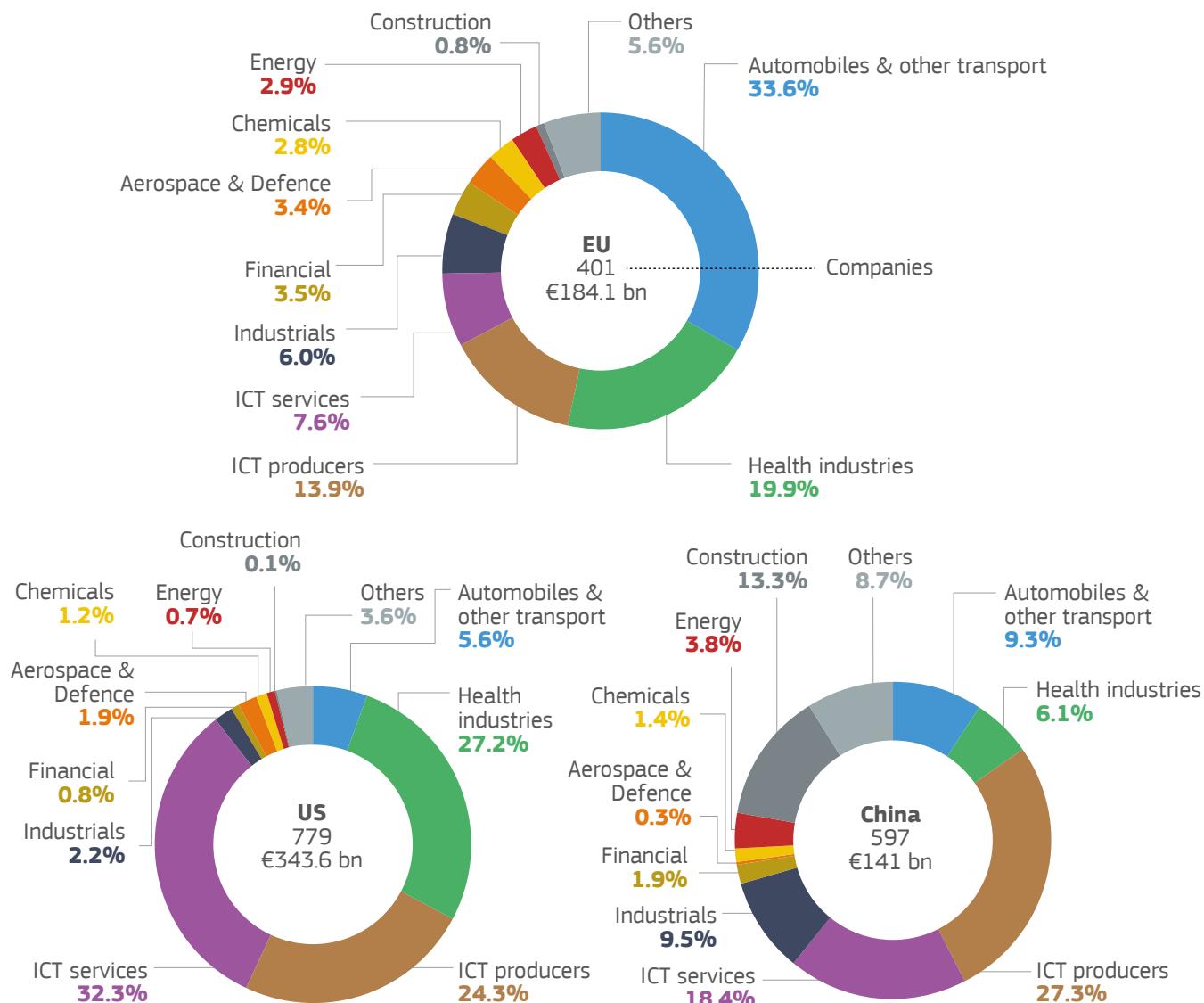
Note: R&D 2020 growth rates have been computed for 399 EU, 776 US and 597 Chinese companies for which data are available for both years 2019 and 2020. Sectors ordered from top to bottom in terms of overall R&D investment in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

In terms of countries, the largest R&D decreases were shown by companies from France (-8.0%), Italy (-13.7%) and Finland (-9.0%) mostly due to the performance of companies such as RENAULT, PEUGEOT², VALEO, SANOFI, SAFRAN, LEONARDO³ AND NOKIA. Germany, the largest R&D investor in the EU, showed only a small decrease in R&D (-0.3%) due to the balance between

the strong performance of its Health and ICT companies and the reduction of its Automotive companies. Other countries in the EU whose companies showed positive R&D growth were Denmark (6.0%), Belgium (10.3%) and Austria (12.4%), driven by the good performance of their top R&D investors NOVO NORDISK (DK), UCB (BE) and AMS⁴ (AT).

Figure S5: Share of R&D investment in 2020 by region/country and sector group.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

² PEUGEOT merged in 2020 into the STELLANTIS group comprising the Italian-American conglomerate Fiat Chrysler Automobiles. In 2020, the figures of PEUGEOT were still reported separately.

³ LEONARDO changed its R&D reporting in 2020, reflecting better the self-funded part of R&D, therefore showing an 'apparent' considerable decrease of R&D respect to previous years.

⁴ R&D increase of AMS in 2020 is due to the acquisition of the German company OSRAM whose R&D in the previous year was much higher than the AMS's R&D.

4 The ongoing global technology race is reshaping the R&D specialisation patterns of the main world regions

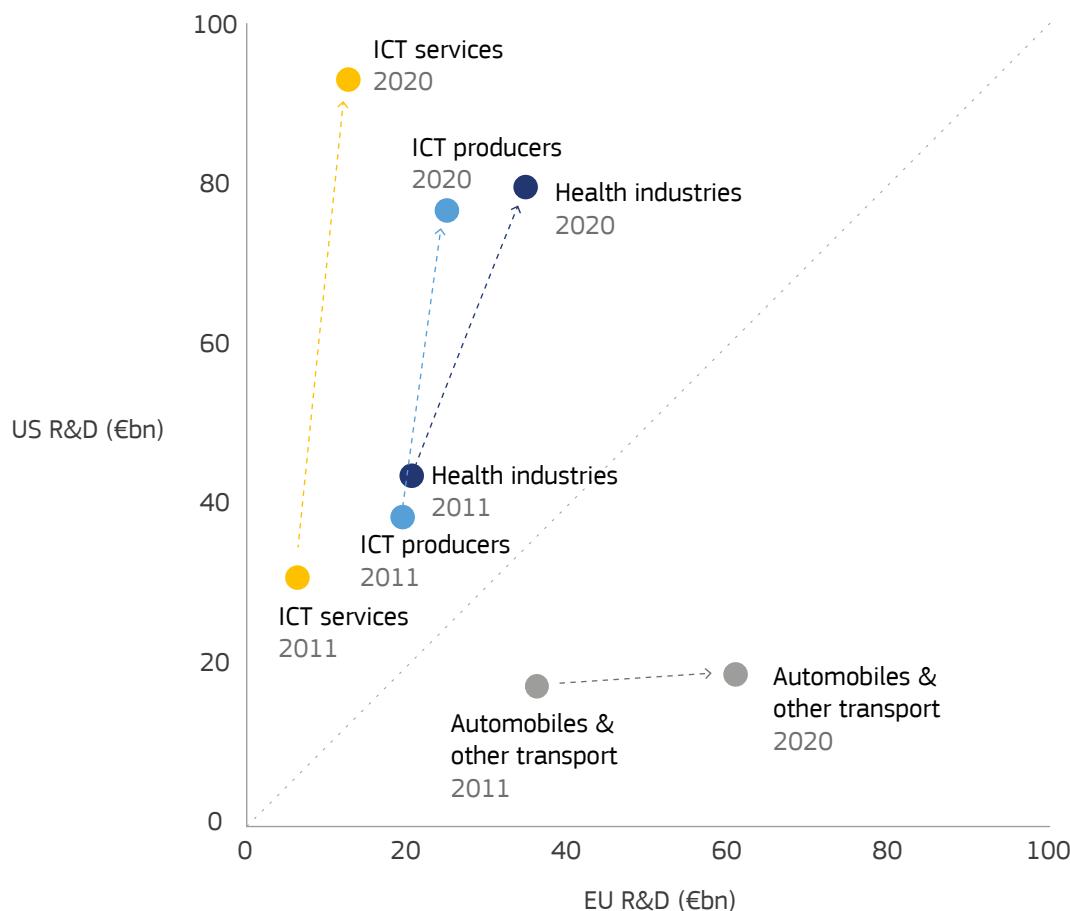
The ongoing technology race intensified over recent years, with US and Chinese companies increasing sharply their R&D investments and EU companies following behind. R&D investment is increasingly concentrated in four major sectors accounting for 77.4% of global R&D in the Scoreboard: ICT producers (22.9%), Health industries (20.8%), ICT services (18.6%) and Automotive (15.2%).

Consistent R&D trends over the past 10 years have changed substantially the R&D specialisations of world regions with the EU maintaining a stable sector mix of R&D investment, including a heavy reliance on

the Automotive sector while the US and China have increased their specialisation in ICT sectors with the US also increasing its proportion in Health.

Ten years ago, EU companies were investing in R&D twice as much as their US counterparts in the Automotive sector but half in the Health and ICT producers sectors and 5 times less in the ICT services sector. This sectoral specialisation has sharpened over the last 10 years as in 2020 EU companies invested 3.2 times more than their US counterparts in the Automotive, 2.5 times less in Health, 3.3 times less in ICT producers and 7.9 times less in ICT services. See Figure S6.

Figure S6: R&D investment in 2011-2020, comparison of selected sectors in the EU and US.



Note: Data refers to 504 (EU:154, US:350) of the 813 companies (EU:190, US:623) in the four sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 89.7% of the R&D in 2020.

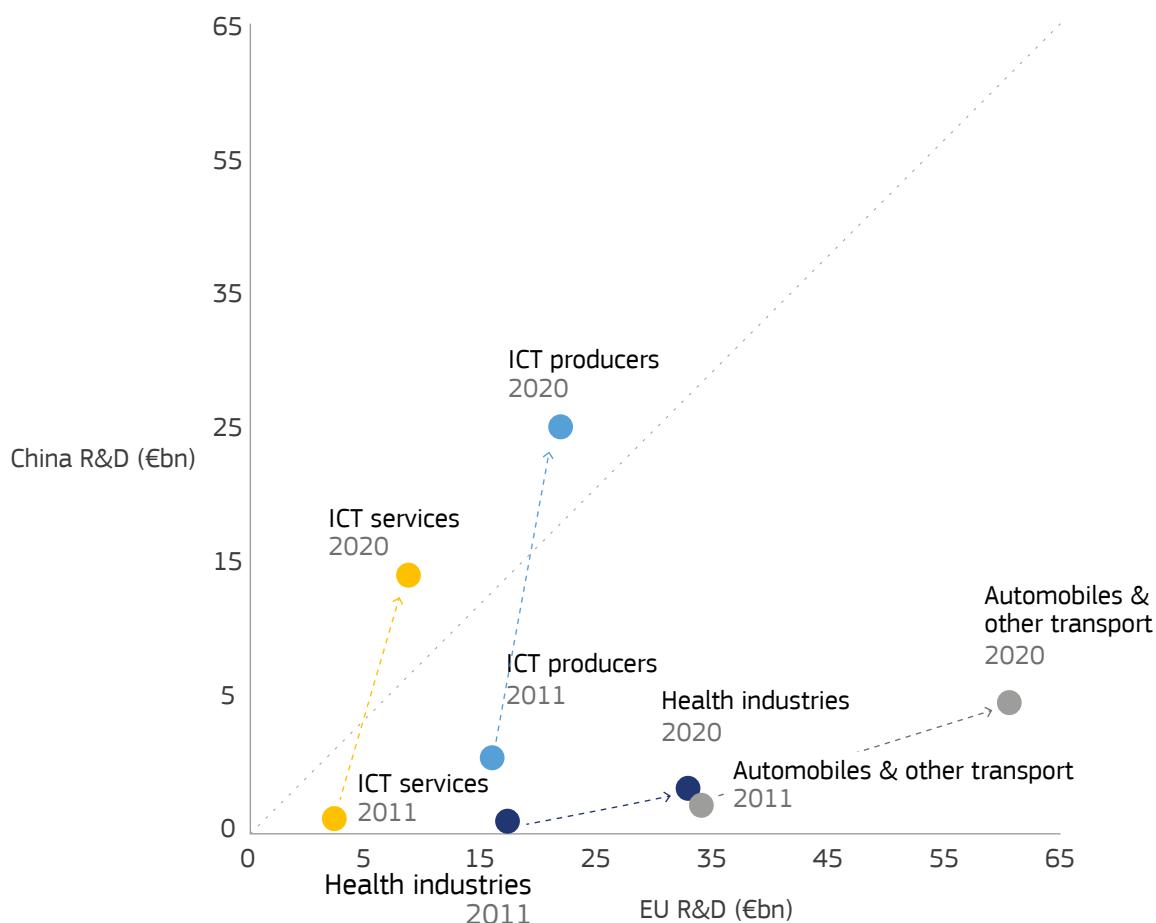
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.



In 2011, the EU invested more than China in all the four major R&D sectors. Since then, R&D investment of Chinese companies operating in ICT sectors has grown considerably with the result that in 2020, Chinese companies invested in R&D almost twice as

much as their EU counterparts in ICT services and 42% more in the ICT producers sectors. By contrast, the EU increased its lead in the other two sectors, reaching a level of R&D investment 5 times larger in Automotive and 4.3 times larger in Health sectors. See Figure S7.

Figure S7: R&D investment in 2011-2020, comparison of selected sectors in the EU and China.



Note: Data refers to 360 (EU:154, CN:206) of the 516 companies (EU:190, CN:327) in the four sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 89.0% of the R&D in 2020.

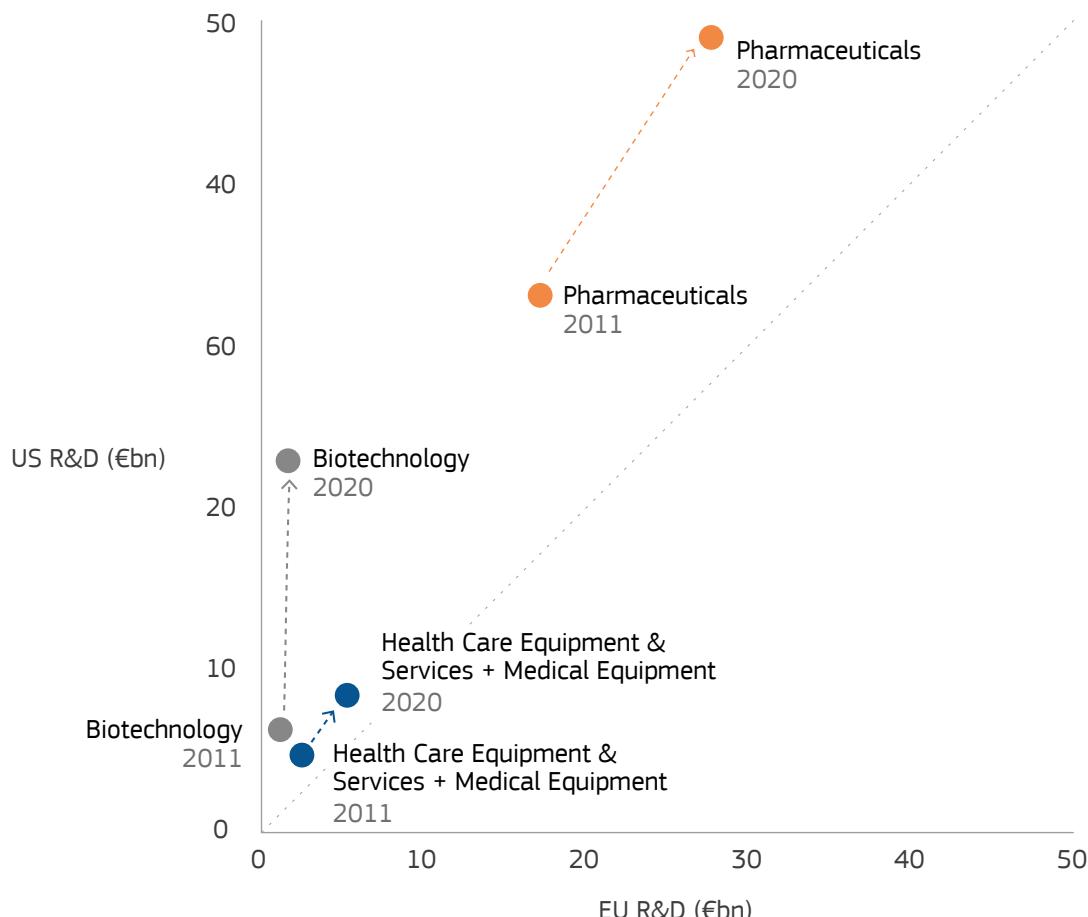
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

The differences between the EU and its competitors have been analysed in more detail at the subsector level, see in Figure S8 the breakdown of the Health sector for the EU-US sample and in Figure S9 the breakdown of the ICT sector for the EU-China data.

In Health, the main EU-US gap is due to pharmaceuticals and biotechnology subsectors with clear differences between these two subsectors. In pharmaceuti-

cals, EU companies grew R&D at a slightly higher pace than their US counterparts but their overall level of R&D remains well behind that of the US companies (half the US level of R&D investment). In biotechnology, the R&D growth of the US companies was remarkably higher; in 2020 they outperformed their EU counterparts in terms of R&D investment (11 times larger) and number of companies (166 vs 20) and, to a lesser extent, with higher R&D intensity (30.6% vs 26.5%).

Figure S8: R&D investment in 2011-2020, comparison of the Health sector in the EU and US - details.



Note: Data refers to 179 (EU:57, US:122) of the 350 companies (EU:72, US:278) in the Health sector group in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 87.6% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

In the ICT sector, the main EU-China differences are in the Software & computer services and Technology hardware & equipment subsectors. Over the past decade, Chinese companies in these subsectors, starting from a low base, overtook the level of R&D investment of their EU counterparts.

These findings reveal important policy challenges for the EU:

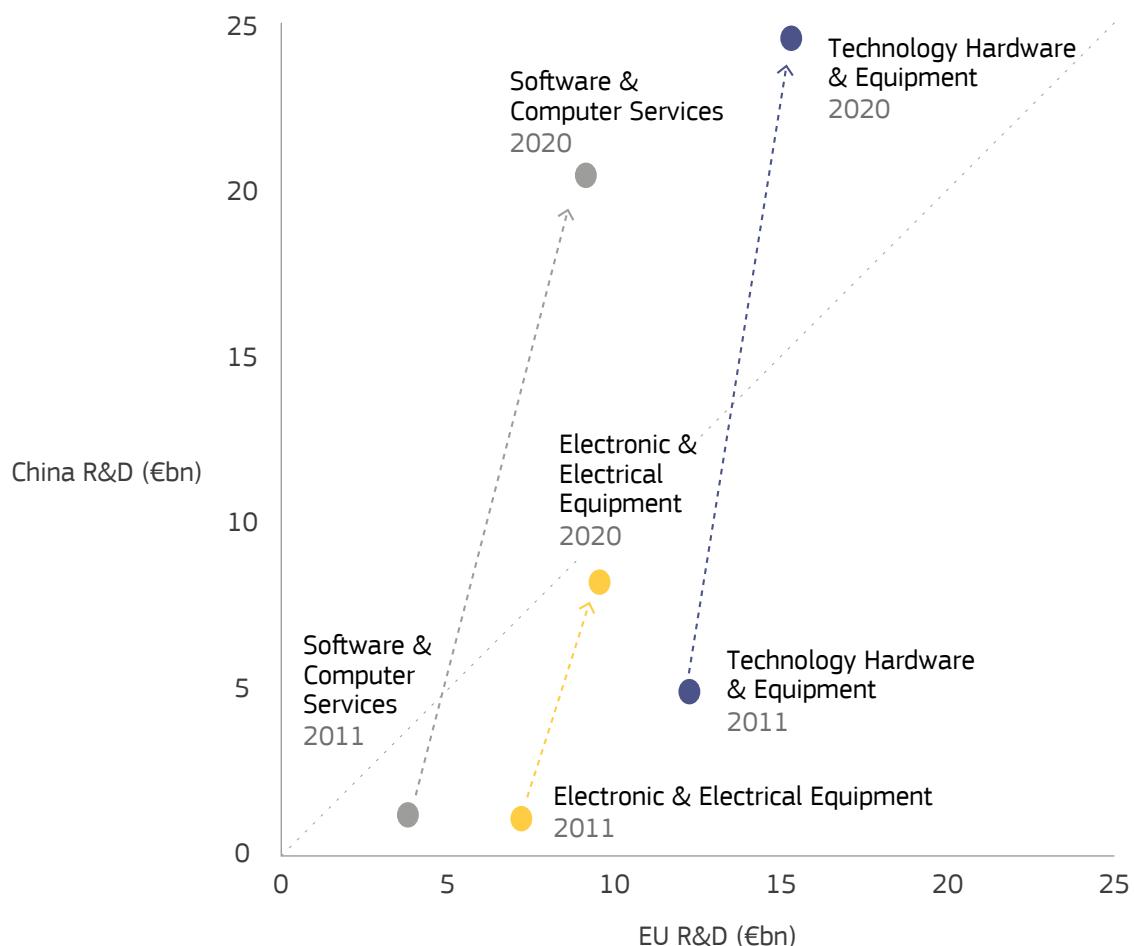
To keep the leadership in the Automotive sector that is facing a double challenge from the required transformation to electric mobility and the increasing integration of digital technology.

To rebuild a strong Health sector with increasing focus on biotechnology that increasingly underpins the development of new drugs.

To catch-up in ICT technology, reversing the trends observed over the past decade, to bring the benefits of digital technologies to the whole economy and particularly to exploit their great potential to help solve environmental problems.

To ensure a strategic autonomy in key technology sectors, keeping in-house critical market segments to guarantee the security of supply and stability of essential supply chains.

Figure S9: R&D investment in 2011-2020, comparison of the ICT sector in the EU and China - details.



Note: Data refers to 196 (EU:60, CN:136) of the 273 companies (EU:73 CN:200) in the ICT services and ICT producers sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 88.2% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.



5 The R&D intensity gap of the EU against its main competitors is largely structural and mostly due to a few high-tech sectors

The difference in industrial structure are also illustrated by the R&D intensity differences between regions. A closer look in terms of structural factors (relative size of sectors) and intrinsic factors (R&D intensity differences within sectors) shows that most of the EU gap against competitors is due to structural factors and that this has both sharpened and been exacerbated by the effects of the pandemic.

Table S1 shows the distribution of the EU-US R&D intensity differences in terms of structural and intrinsic factors for the major sectors by R&D. The figures indicate that the overall EU-US gap is mostly due to

structural factors (-3.05 out of -3.61 percentage points) and due to the Health (-1.18), ICT producers (-1.32) and, more particularly, due to ICT services (-1.67). It also shows the surplus of the EU in both structural and intrinsic terms for the Automotive sector and a smaller surplus for the aggregate of all other sectors.

The implication for EU policy is that dealing with a structural gap calls for specific targeted industrial and innovation policies to increase the number and size of EU companies in high R&D-intensity sectors while recognising that existing individual companies are close to their rivals with regard to R&D intensity levels.

Table S1: EU-US R&D intensity differences for the main industries broken-down into structural and intrinsic terms in 2020.

	EU		US		EU-US R&D intensity differences		
	R&D (€million)	R&Dint (%)	R&D (€million)	R&Dint (%)	Structural	Intrinsic	Total
Automobiles & other transport	61794.2	6.0	19406.7	4.4	0.58	0.37	0.96
Health industries	36686.5	12.1	93441.5	12.4	-1.18	-0.02	-1.20
ICT producers	25504.5	9.4	83524.8	9.9	-1.32	-0.03	-1.35
ICT services	14071.4	4.7	111001.5	13.1	-1.67	-0.56	-2.23
Rest of sectors	46044.6	1.8	36188.0	2.4	0.54	-0.34	0.20
Total	184101.4	4.2	343562.4	7.8	-3.05	-0.57	-3.61

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

6 High-tech companies are taking over more positions in the global R&D ranking and thus replacing companies from traditional sectors

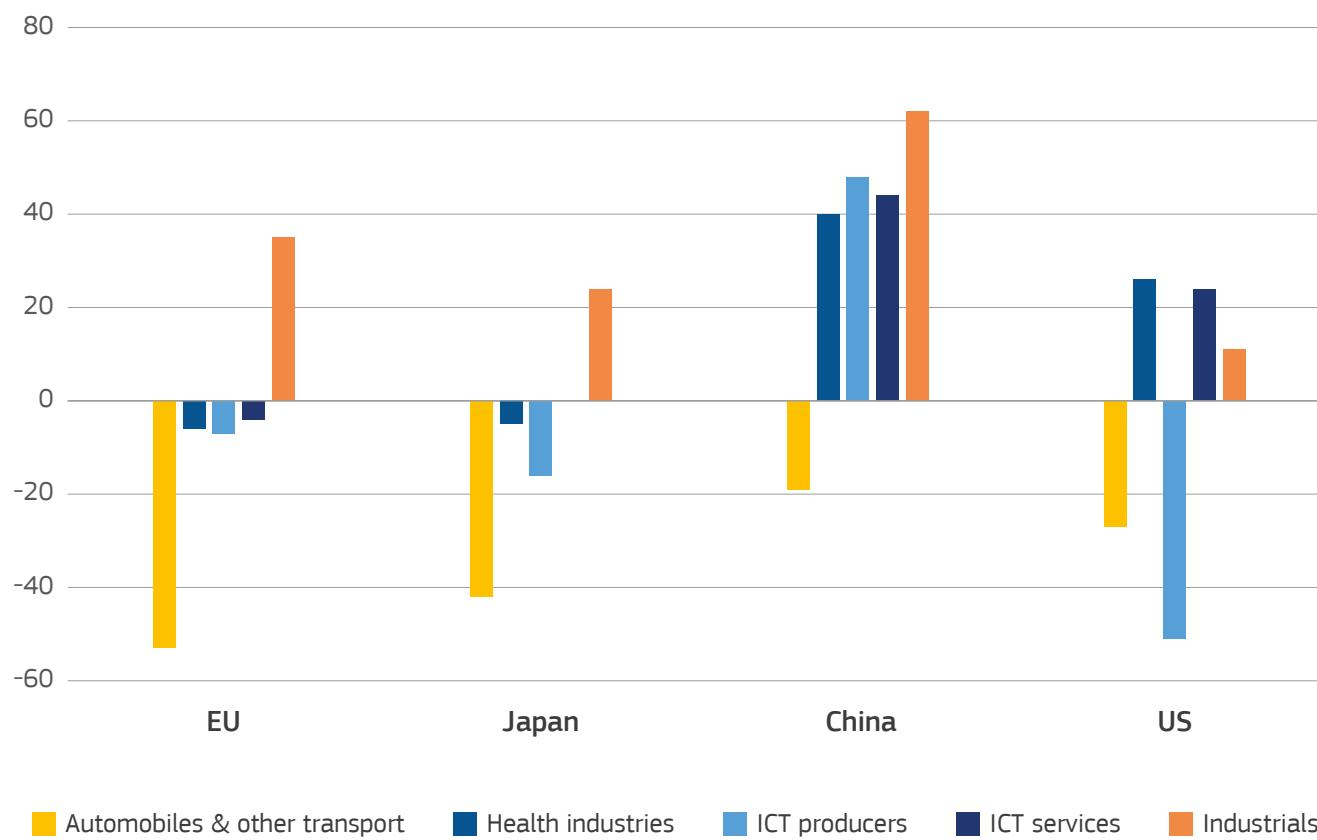
Structural changes are also reflected in the rapidly changing composition of the global R&D ranking. The most important development between the 2016 and 2021 Scoreboards in the global R&D ranking is the presence of more high-tech companies and in higher positions. These firms are mainly from China and the US, at the expense of more "traditional" sectors, mainly from the EU and Japan (See Figure S10).

The US presence increased in two of the key sectors, i.e. Health industries and ICT services and decreased

in two. The EU presence in all four key sectors decreased, slightly in ICT and Health, more in Automotive, and increased in a group of low and medium-tech industries such as Industrial metals, Industrial engineering, Industrial transport, Containers & packaging. Chinese firm presence increased in four of the five sectors.

Similar to the EU, Japan's number of companies increased in medium-tech industrial sectors and decreased in Automotive, ICT producers and Health.

Figure S10: Main changes of presence (number of companies) of the main geographic regions between the 2016 and 2021 Scoreboards.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

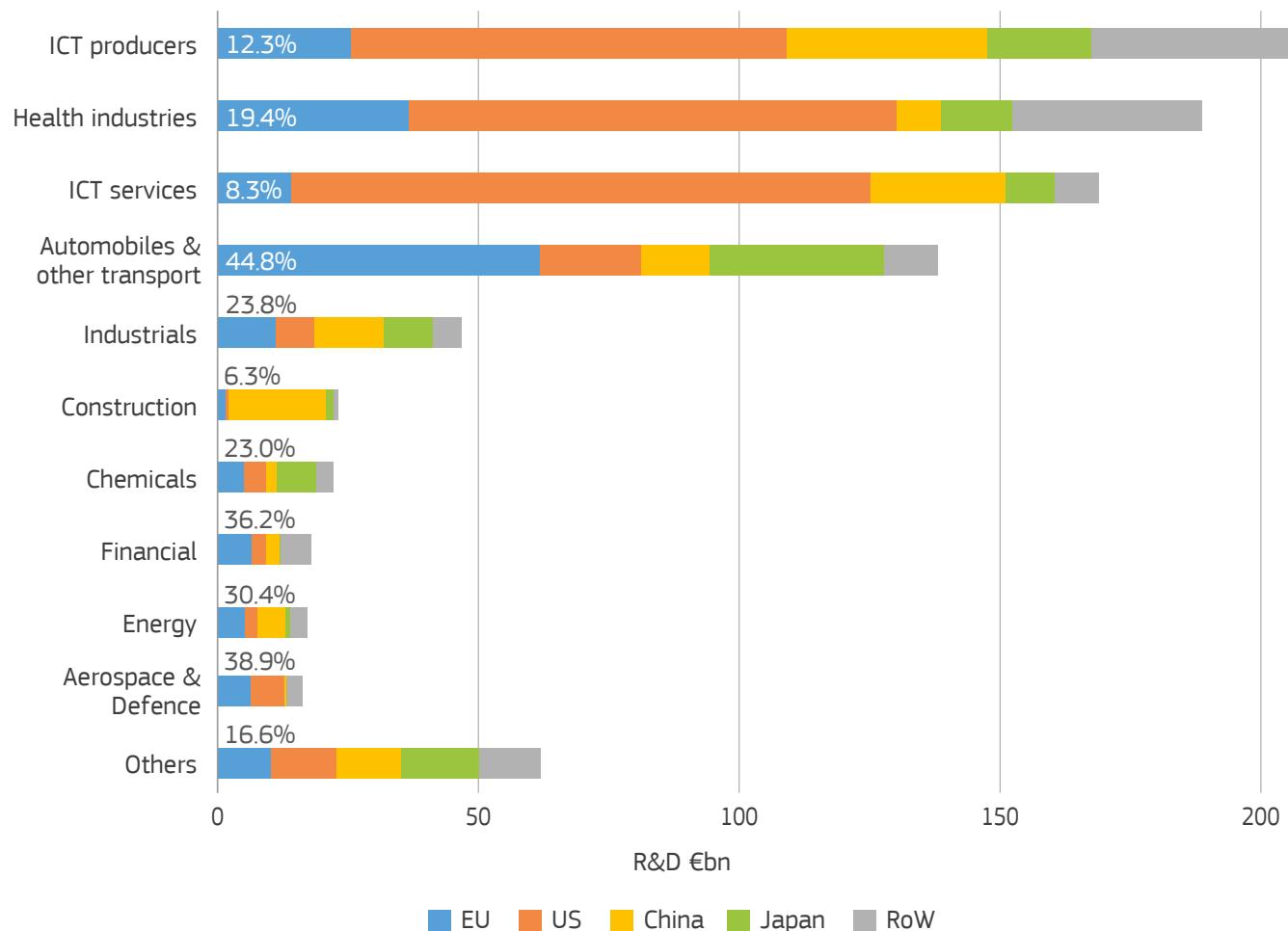
7 The actual location of companies' activities reveals EU's opportunities to improve investment attractiveness for key segments of the value chain

The Scoreboard shows the strengths of the industrial base of the EU which has a more balanced mix of companies. In terms of specialisation, as shown in Figure S5, the EU sample presents a broader diversification especially compared to the US whose R&D investment is concentrated in a few high-tech sectors. In terms of share of global R&D, as shown in Figure S11, EU companies also have a significant weight in key industrial sectors, e.g. Automotive, Aerospace & defence and Chemicals sectors and compared with

the Chinese sample, the EU group has 30% more overall R&D investment.

In addition, the ownership structure of the Scoreboard shows a broader worldwide distribution of EU companies and their subsidiaries. For example, out of 201 countries where the Scoreboard's parent companies have subsidiaries, the EU has at least one company in 195 countries compared with 176 for the US, 149 for Japan and 142 for China.

Figure S11: Share of R&D investment in the global R&D ranking for main sectors and regions.



Note: Percentages reported represent the shares of EU companies R&D in each sector
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Moreover, the analysis of the inventor location of the patents of Scoreboard companies shows that EU companies are more likely than their counterparts to source R&D inputs from abroad. Table S2 presents, for the overall sample and for four major R&D sectors, the share of patents whose inventors are located in the company's headquarter region and the shares of patents located in other regions (obtained through their subsidiaries, foreign affiliates or partnerships). These data show a higher patenting activity abroad of the EU companies, 27.5% of their patents have inventors located abroad compared with

18% for the US and 12.1% for China. Similar patterns are observed for the Health and ICT sectors but Automotive, where the EU is world leader, shows a balance between high patent activity of EU companies at home and high patent activity in the EU by foreign controlled companies.

These results indicate the potential opportunity for the EU to improve its R&D capability and reinvigorate its industrial base, in line with the priorities of the new industrial and innovation EU policy, particularly in the context of the digital and green transitions.

Table S2: Distribution of companies' patents according to the location of inventors: share of patents within the headquarter region (blue) and shares located in other regions.

Overall sample (all sectors)

		Inventor Location				
		EU	US	China	Japan	RoW
HQ	EU	72.5%	17.7%	1.1%	1.2%	7.5%
	US	5.6%	82.0%	1.7%	0.5%	10.1%
	China	3.5%	5.8%	87.8%	0.3%	2.5%
	Japan	3.0%	14.2%	0.9%	77.1%	4.7%

Sector's detail

Health Sector		Inventor Location				
		EU	US	China	Japan	RoW
HQ	EU	56.0%	32.2%	0.4%	0.7%	10.7%
	US	6.1%	83.6%	2.1%	0.2%	8.0%
	China	4.3%	7.4%	84.3%	0.1%	4.0%
	Japan	5.4%	34.8%	0.4%	46.6%	12.9%



ICT producers		Inventor Location				
		EU	US	China	Japan	RoW
HQ	EU	67.3%	19.0%	3.2%	0.4%	10.1%
	US	7.0%	75.5%	2.8%	1.2%	13.6%
	China	3.6%	9.0%	82.4%	0.6%	4.5%
	Japan	2.9%	8.5%	0.8%	86.4%	1.4%

ICT services		Inventor Location				
		EU	US	China	Japan	RoW
HQ	EU	72.8%	13.0%	1.8%	0.0%	12.4%
	US	2.6%	86.3%	0.8%	0.3%	10.0%
	China	0.0%	4.2%	95.4%	0.0%	0.4%
	Japan	3.0%	25.3%	6.2%	55.8%	9.7%

Automobiles & other transport		Inventor Location				
		EU	US	China	Japan	RoW
HQ	EU	79.0%	14.1%	0.7%	2.1%	4.1%
	US	12.0%	78.2%	1.2%	0.4%	8.2%
	China	11.0%	6.1%	82.0%	0.5%	0.3%
	Japan	1.9%	14.2%	0.0%	79.7%	4.2%

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

8 A patent analysis reveals the positioning of the EU in green technology for energy intensive industries

The report includes a patent analysis on green inventions⁵ addressing the production or processing of goods for eight Energy Intensive Industries (EI), Cement, Ceramics, Chemicals, Fertiliser, Glass, Lime, Oil-Refining and Steel over 2010-2018.

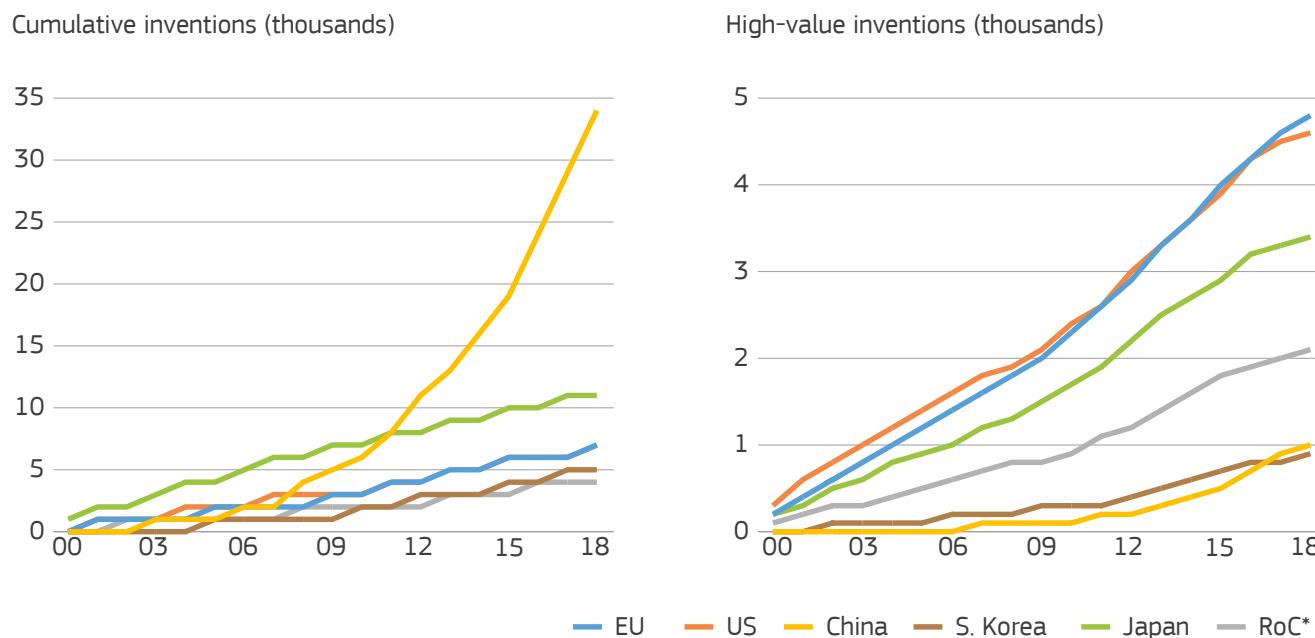
The results show a steady growth of green patents over the considered period with the EU showing the highest specialisation index (amount of green patents as a share of total patents within the region's portfolio).

The group of EU companies is runner-up in the race to develop green technology from several perspectives. In terms of share of high-value patents⁶ (57%) close behind the US (58%), regarding the share of number of inventions protected internationally (23%) behind the

US (33%) and as to the share of EEI inventions relevant for the production or processing of goods (35%) close behind the US (37%).

Regarding the green patents relevant for the specific EI, the EU shows specialisation for Oil-Refining and Lime and has the second highest share of green invention within its portfolio for Oil-Refining and Steel. The Chemicals sector accounts for 38% of green inventions in EI in the EU. Japanese Scoreboard companies lead the inventive activity in green inventions for the Cement industry and are very prominent in the glass sector. Chinese and South Korean Scoreboard companies top the list in Ceramics and Chemicals. EU Scoreboard companies lead the global ranking in Fertilisers and Lime industries. See Figure S12.

Figure S12: Trends in energy intensive industry inventions.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

*Note: Cumulative inventions (left), high-value inventions (centre), and share of high-value, granted and international inventions (right) for major economies in the period of 2010-2018.

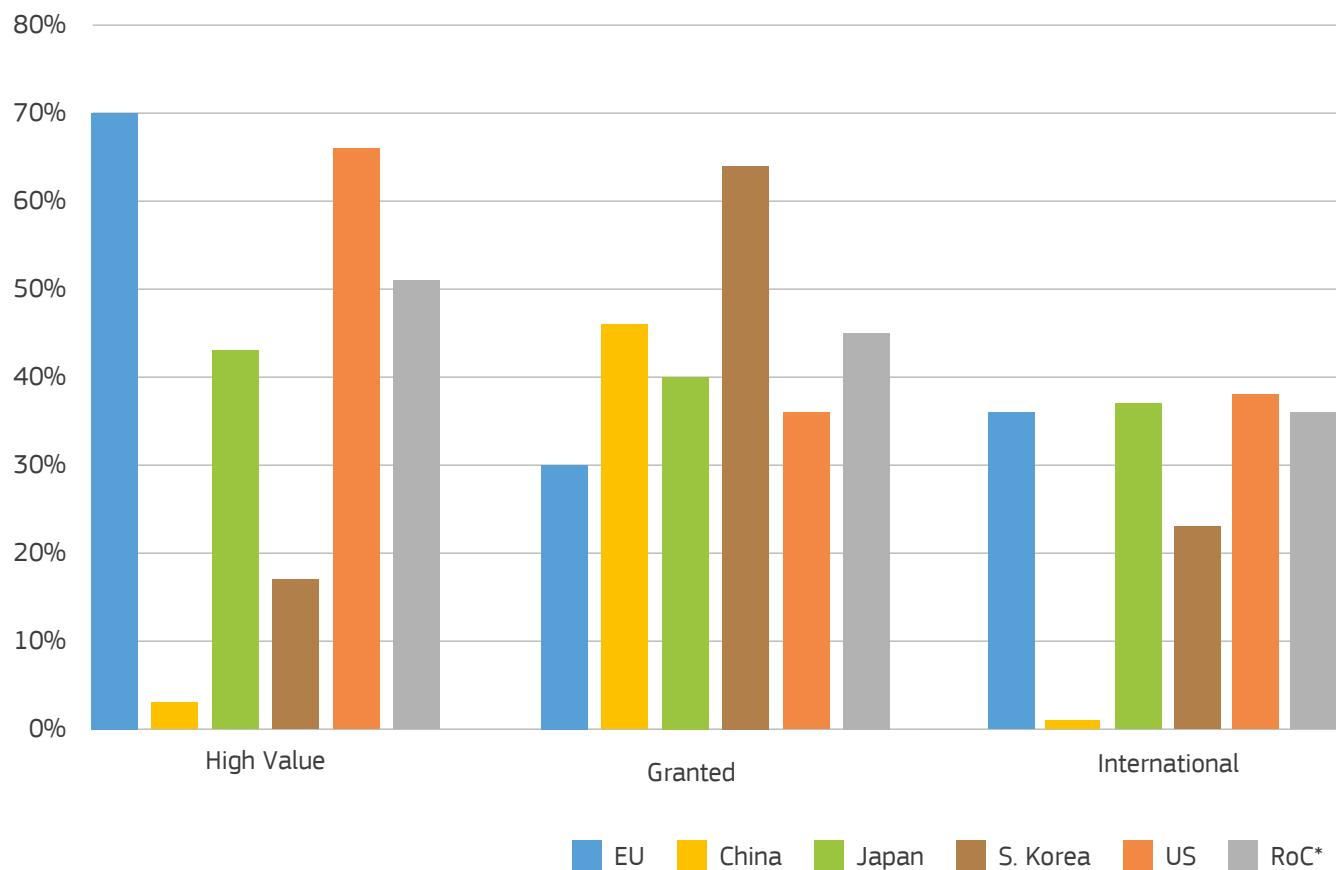
⁵ According to the definition of the Cooperative Patent Classification (CPC), Y02 patent classes regarding climate change mitigation technologies. EPO/USPTO partnership.

⁶ It is considered high-value invention when it contains patent applications in more than one office.



Share of high-value, granted and international inventions.

2010-2018



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

*Note: RoC means "Rest of Countries"

9 Top R&D investors are increasingly improving their practices on the pathway to achieve UN's sustainable development goals (SDGs).

The report includes a follow-up of the analysis presented in the 2020 Scoreboard, aimed at investigating the sustainability behaviour of the top R&D investors, based on extended and updated coverage and deeper analysis on companies' key performance indicators.

The SDGs practices of the top R&D investors have improved over the period 2016-2020, with EU

companies having a comparative advantage in the Energy and Chemicals sectors. There is also a clear association between attention to SDGs and R&D investment for top R&D investors in Energy intensive industries, particularly with respect to SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth) and SDG 15 (life on land). See Figure S13.

Figure S13: Scores for selected SDGs for EU and non-EU companies.

	EU (Environmental)			Non-EU (Environmental)		
SDG #6: Clean water & sanitation	59	55	48	57	52	45
SDG #7: Affordable & clean energy	72	76	59	62	63	50
SDG #12: Responsible consumption & production	61	58	51	58	52	46
SDG #13: Climate action	61	63	52	54	57	45
SDG #14: Life below water	53	50	46	55	48	43
SDG #15: Life on land	62	57	57	58	53	51

	EU (Socio-economic)			Non-EU (Socio-economic)		
SDG #3: Good health & well-being	54	54	50	53	50	45
SDG #5: Gender equality	57	58	56	49	51	49
SDG #8: Decent work & economic growth	66	65	62	62	60	56
SDG #9: Industry, innovation & infrastructure	61	58	51	56	51	46

	Chemicals	Energy	Other sectors	Chemicals	Energy	Other sectors

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.



INTRODUCTION THE 2021 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

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 and to provide an R&D investment database that companies, investors and policymakers can use to compare individual company performances against the best global competitors in their sectors.

The 2021 edition of the Scoreboard reports on the 2500 companies that invested the largest sums in R&D worldwide in 2020. These companies, with headquarters in 39 countries, and more than 800k subsidiaries all over the world, each invested over €36.5 million in R&D in 2020. The total investment across all 2500 companies was €908.9bn, an amount equivalent to 90% of the world's business-funded R&D.

The top 2500 includes 401 companies based in the EU, accounting for 20% of the total, 779 US companies (38%), 597 Chinese companies (16%), 293 Japanese companies (12%) and 430 from the rest of the world (RoW, 14%). The RoW group comprises companies from the UK (105), Taiwan (86), South Korea (60), Switzerland (57) and companies based in a further 15 countries.

This report analyses companies' R&D investments, patent portfolios and other financial performance indicators over recent years, focusing on the comparative performance of EU companies and their global counterparts. Moreover, it includes a patent-based analysis showing the positioning of EU companies in green technology for energy intensive industries, and a study exploring the role of the Scoreboard companies in achieving the UN's sustainable development goals (SDGs).

In 2020, the pandemic hit global business hard causing a significant drop in companies' sales, profits and capital expenditures. Overall R&D investment was sustained by increases in sectors positively affected by the crisis, namely ICT services and Health industries. However, most other sectors decreased R&D investment, particularly the transport-related industries that have been most strongly affected by the lockdown.

The results of this report highlight the challenges and opportunities facing the EU as it seeks to improve its R&D capability and reinvigorate its industrial base, in line with the priorities of the new industrial and innovation EU policy, particularly in the context of the digital and green transitions.

The report is organised as follows. Chapter 1 provides an analysis of the top R&D investors in 2020 by country and sector, while Chapter 2 analyses trends over time, comparing the EU performance against its main competitors. Chapter 3 looks deep into the EU, enlarging the sample beyond the top 2500 R&D investors to the EU top 100 R&D investors in 2020. Chapter 4 analyses Climate Change Mitigation Technologies for Energy Intensive Industries (EII) while Chapter 5 digs deeper into the compliance of top R&D investors with the UN's sustainable development goals. The Annex section contains the methodological notes, some extra tables, and information on how to get access to the data.



CHAPTER 1

A PICTURE OF PRIVATE R&D INVESTMENT IN 2020

1.1 The economic context and technological trends in 2020

1.1.1 The economic context

The economic environment for Scoreboard companies in 2020 has been dominated by the effects of the Covid-19 pandemic on world economies. The virus has caused more economic disruption than the financial crisis of 2008/09; the IMF in April 2020 expected global GDP to contract by 4.9% making it the worst recession since the Great Depression and far worse than the financial crisis of 2008/09⁷. The OECD estimates that the impact on jobs has been ten times worse than during the financial crisis. In September 2020 the OECD predicted that global GDP would fall by 4.5%, a drop unprecedented in recent history⁸ with 2020 falls in GDP for all OECD countries but not China (a large economy but not an OECD country). The IMF's October 2020 outlook projects global growth at -4.4% with an increase to +5.2% for 2021 provided there is persistent social distancing with the rate slowing to +3.2% for the medium term⁹. The IMF noted that the pandemic has prompted unprecedented fiscal actions amounting to \$11.7 trillion, around 12% of global GDP.

Restrictions imposed by governments to reduce the rates of transmission of the virus and to reduce the death rate have had very serious effects on several

industries – the travel industry, aerospace, cruise lines, hotels, and the hospitality, entertainment and events sectors in particular. The increase in homeworking and restrictions on travel have seriously affected the transport sector with much reduced air and train travel, reduced car usage and large drops in the sales of cars and of fuel. Global car sales were down 24.6% for first half 2020 and are expected to be down 20% for the full year compared to last year¹⁰. The US Energy Information Association (EIA) estimates that global demand for liquid fuels in 2020 will be 9.3% below 2019¹¹. Although the price has bounced back in 2021, reduced demand for oil in 2020 led to a sharp drop in crude oil prices, which the EIA quotes as around \$41 for Brent crude in 2020 compared to \$64 in 2019 with a forecast of a recovery only to \$47 in 2021¹². Although many industries have suffered because of the pandemic, some have seen increased demand. These include video conferencing applications, video streaming (Netflix and others), Amazon and other online shopping sites and online deliveries from supermarkets. A sign of the times is that the market cap of Florida-based NextEra Energy, a solar and wind energy company, surpassed the market cap of ExxonMobil in early October 2020¹³.

⁷ <https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/>

⁸ <http://www.oecd.org/newsroom/building-confidence-crucial-amid-an-uncertain-economic-recovery.htm>

⁹ <https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020>

¹⁰ <https://www.spglobal.com/ratings/en/research/articles/200917-global-auto-sales-forecasts-hopes-pinned-on-china-11651519>

¹¹ http://www.oecd.org/newsroom/building-confidence-crucial-amid-an-uncertain-economic-recovery.htmhttps://www.eia.gov/outlooks/steo/report/global_oil.php#:~:text=EIA%20forecasts%20that%20global%20consumption,than%20in%20the%20September%20STE0.

¹² <https://www.eia.gov/outlooks/steo/#:~:text=EIA%20forecasts%20that%20global%20consumption,million%20b%2Fd%20in%202021>

¹³ <https://wwwaxios.com/renewable-energy-giant-surpasses-exxonmobil-in-value-8f615d7c-c81b-4042-8f41-a8d747d572ba.html>



ExxonMobil was the world's largest public company by market cap as recently as 2013. Moreover, the market caps of both are dwarfed by the market caps of the large US tech companies Alphabet, Amazon, Apple, and Microsoft (which have increased still further during the pandemic). However, overall most industries have suffered from the virus and unemployment has risen. The OECD unemployment rate rose from 5.2% in February 2020 to 8.0% in June and only dropped to 7.7% in July despite government support schemes for many industries. However, Euro area unemployment rose to 7.9% in July from 7.7% in June. Global youth unemployment in July was twice as high as for over 25-year olds. Almost all OECD countries have adopted measures such as furlough schemes to protect employment as substantial parts of their massive financial stimulus packages. The July 2020 OECD employment outlook projected an unemployment rate of 10% at the end of 2020, up from 5.3% at end 2019 and as high as 12% should a second wave of virus hit most countries¹⁴. A jobs recovery is not expected until after 2021.

Interest rates and inflation

Central banks have taken what action they can to mitigate the serious economic effects of the virus crisis. However, as interest rates were already very low central banks had much less room for manoeuvre than at the time of the financial crisis. The US Federal Reserve cut its interest rate to near zero in mid-March 2020 and started a bond-buying programme. The Fed funds rate is now 0-0.25% and the Fed has indicated that this rate is likely to be held through 2023¹⁵. The ECB's deposit facility rate in 2020 remained at -0.5% (it was

reduced to that in 2019) and it has a pandemic emergency bond-buying programme of 1.35trn euros. The euro has risen against the US\$ and reached \$1.19 in September 2020 which makes life more difficult for EU exporters and reduces the value of returns from overseas activities. The Bank of Japan has maintained its overnight interest rate at -0.1% and has capped its 10-year bond yields at 'around zero'. Despite these very low global interest rates there are companies carrying more debt than they should because of their virus-depressed home economies.

PWC have combined various sources of data to make best estimate inflation predictions for 2020 and 2021¹⁶. The global projection is for inflation at 1.5% in 2020 rising to 2% in 2021. Country projections range from 2.2% for China in 2020 (2% for 2021) down to the US at 0.8% (2% for 2021), 0.3% (1%) for the Eurozone and 0.1% (0.3%) for Japan. However, these predictions have proved to be optimistic and the OECD in September 2021 predicted the rate of inflation in the G20 only to fall to 4.5% at end 2021 and then 3.5% at end 2022.¹⁷

Overall, companies encountered an economic environment in 2020 that combines both threats and opportunities, with big sectoral differences. 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 Scoreboard enables investors to see which companies increased R&D in this way (or maintained it) and which reduced R&D to shore up profits.

1.1.2 The key technological developments

The pandemic accelerated two important technological trends – the rapid growth of biotechnology and AI (artificial intelligence)/advanced software – that were already ongoing in the years before.

Firstly, biotechnology has been in the news because of the virus and the vaccines developed to fight it. The typical timeframe to develop a new vaccine has in the past been 5-10 years¹⁸. However, the 2019 virus pan-

¹⁴ <http://www.oecd.org/employment-outlook/2020/>

¹⁵ <https://english.kyodonews.net/news/2020/09/7a0814876e0e-update1-us-fed-projects-near-zero-rate-to-continue-through-2023.html#:~:text=The%20U.S.%20Federal%20Reserve%20indicated,term%20goal%20of%202%20percent.>

¹⁶ <https://www.pwc.com/gx/en/issues/economy/global-economy-watch/projections.html>

¹⁷ <https://www.bbc.co.uk/news/business-58638224>

¹⁸ <https://coronavirus.jhu.edu/vaccines/timeline>



demic required much faster vaccine development and, incredibly, two new Covid-19 vaccines were developed and approved by developed country regulators in just under a year. The genome of the virus was first published in January 2020 and three different vaccines (developed by Pfizer/BioNTech, Moderna and AstraZeneca/Oxford University) were first approved by a developed country (the UK) regulator in December 2020 (Moderna in early January 2021). The technologies used were mRNA (Pfizer/BioNTech and Moderna) and viral vector carrier (AstraZeneca/Oxford). This rapid vaccine development was only possible because both the mRNA and viral vector platforms had been studied for many years so a solid basis of science was available as a firm foundation on which to build the new Covid-19 vaccines. The timescale for development was compressed by using overlapping trials and rolling regulatory approval procedures. This represented a step change in innovation for the sector. The key breakthrough in mRNA science was made by Katalin Kariko and Drew Weissman at the University of Pennsylvania in 2005¹⁹ and their technology was licensed to both BioNTech and Moderna for use in those companies' vaccines and other treatments. Beyond Covid, Moderna's new drug pipeline includes mRNA-based vaccines for Cancer, Influenza, Zika and others together with mRNA treatments for cancer and autoimmune diseases. There have been other vaccine advances too with an example being GSK's new malaria vaccine approved in 2021 which should save the lives of hundreds of thousands of children in Africa and elsewhere.

While Covid-19 vaccines are important, effective treatments are also needed for those suffering from the virus. Some existing drugs have been re-purposed to treat Covid-19 such as Gilead's Remdesivir²⁰ (originally developed for Ebola) which has been approved for emergency use in 50 countries. Moreover there are now several pipeline drugs that have been devel-

oped specifically for Covid-19 with AstraZeneca's AZD7442 being the first non-vaccine antibody combination shown by a clinical trial to offer long-lasting protection (greatly reduces the chance of developing Covid-19) from symptomatic and severe disease.²¹ The Phase III trial showed a 77% reduction in the risk of developing symptomatic Covid-19 and AstraZeneca has applied to the FDA for emergency use authorisation²². In addition, US Merck has developed the first anti-viral pill shown in clinical trials to reduce hospitalisations and deaths by half for those infected with Covid-19.²³ This was first approved in late 2021. Pfizer has recently reported a clinical trial where its pill reduced hospitalisations by nearly 90%.

Other advances in biotechnology for health include immunotherapies for a wide range of cancers, many based on monoclonal antibody technology. For example, Merck's Keytruda (pembrolizumab) is now approved to treat 17 different cancers including non-small cell lung cancer, Hodgkin lymphoma, melanoma and advanced gastric, kidney, liver, colorectal & cervical cancers. Substantial advances are also being made with drugs to treat serious autoimmune diseases such as rheumatoid arthritis, psoriasis, diabetes and MS. Early successes are also being reported for neurological diseases such as Alzheimer's and Parkinson's with the first new drug for Alzheimer's for 18 years being approved by the FDA in 2021 (Biogen's Aducanumab).

Biotechnology is also important for the agriculture and food industries. Genetic modification is making crops and farm animals more productive and disease resistant with crops able to withstand harsher conditions such as drought and poorer soil. Progress is also being made with animal-free 'meat' either grown in the laboratory or made from plants. Singapore has already approved cultivated meat for human consumption and European start-ups such as Ivy Farm in

¹⁹ <https://www.pennmedicine.org/news/news-releases/2020/december/penn-mrna-biology-pioneers-receive-covid19-vaccine-enabled-by-their-foundational-research>

²⁰ <https://www.gilead.com/purpose/mission-and-core-values>

²¹ <https://www.astrazeneca.com/media-centre/press-releases/2021/azd7442-prophylaxis-trial-met-primary-endpoint.html>

²² <https://www.astrazeneca.com/media-centre/press-releases/2021/azd7442-request-for-emergency-use-authorization-for-covid-19-prophylaxis-filed-in-us.html>

²³ <https://www.aljazeera.com/news/2021/10/1/mercks-covid-pill-cuts-deaths-hospitalisations-by-50-report>



the UK are making it. Major companies such as Nestle are already selling meat-free ‘meats’ such as its Vrimp seafood salad.²⁴

Important advances are being made in other multi-disciplinary areas such as bioelectronics and biophysics. Examples include proton arc therapy, which provides radiotherapy to cancers while minimising the dose given to normal surrounding tissue. Another is miniaturisation such as the leadless pacemaker that can be inserted directly into the heart via a transcatheter,²⁵ AI is being used in health applications such as in diagnostics and epidemiology. For example, a major study of diagnoses from imaging showed that AI diagnosed correctly in 87% of cases vs. 86% for medical professionals.²⁶

The virus pandemic has resulted in large numbers of people working from home, communicating remotely to avoid business travel, using online learning technologies, greatly increasing online purchasing and taking out entertainment subscriptions in place of going out to entertainment venues. This has been of great benefit to the big technology companies such as Alphabet, Amazon, Apple, Facebook, Microsoft, Netflix and smaller companies such as Zoom. For example, Amazon’s sales for 2020 were up 37.6% over 2019 to reach \$386.1bn while Microsoft’s 2020 sales were up 17.5% to \$168.1bn and Zoom’s sales for the year to end January 2021 were up 4.3 times to \$2.7bn. In contrast, sectors such as travel, hospitality, entertainment, events & exhibitions, non-food retail and personal services all suffered falling sales and profits.

The pandemic has accelerated several technology trends that were already underway. A major one is cloud computing where Amazon is the market leader followed by Microsoft and Alphabet (Google) – this trend is driven by companies’ desire to shift their computing online to the cloud so employees can access data from home. This also saves the company money. Consumer behaviour is changing, probably permanently, to benefit tech companies with social media platforms gaining new audiences, customers getting used to online ordering of groceries

and many other products previously bought on the high street and spending more time on their smartphones (including gaming).

Edge computing is a new technology enabling computation to be done closer to data storage systems. Bridging the gap between data and computation reduces long distance communication, increases process speed and ties in with the increased use of cloud computing. Human augmentation is another growing technology where technology enhances cognition, perception and action. An example is Intuitive Surgical’s da Vinci robotic surgery system, which is in wide use in hospitals. Other health applications of computer technology include patient records and diagnostics.

A new advance in quantum computing by a team at the University of New South Wales²⁷ has enabled larger quantum computers with many more qubits by removing the on-chip control wires. Although there are engineering challenges to be overcome before we have quantum computers with one million qubits, this advance is an important step since we now have a way to control the large numbers of qubits needed. Larger quantum computers will have important applications in cybersecurity & cryptography, materials & drug development, finance and advanced manufacturing. There are many private specialist quantum computing companies and the first of these – IonQ – was listed in New York in 2021. IonQ is already running development applications for customers and expects a 9-fold increase in revenue from 2024 to 2026 as customers start to use quantum computing applications in their day-to-day operations. Quantum computing should enhance the abilities and capabilities of computational modelling, particularly in biotech.

Road transport is the first area where the transition to electric vehicles is already underway. However, existing lithium-ion batteries set limitations on both range and fast charging ability. For this reason, R&D is being accelerated on solid-state batteries. For example, Ford & BMW are funding Solid Power (a private company which is expected to go public) which

²⁴ <https://www.theguardian.com/business/2021/oct/06/vrimp-shrimp-nestle-faux-seafood-seaweed>

²⁵ <https://www.medtronic.com/us-en/transforming-healthcare/tiny-medtech-big-benefits.html>

²⁶ <https://www.medicalnewstoday.com/articles/326460#AI-on-a-par-with-healthcare-professionals>

²⁷ <https://newsroom-unsw-eduau/news/science-tech/missing-jigsaw-piece-engineers-make-critical-advance-quantum-computer-design-notaGE>



hopes to have its solid-state battery commercialised in 2026²⁸ and Volkswagen are funding QuantumScape's solid-state battery programme. Then there is Sila Nanotechnologies' next generation lithium battery, which uses a silicon-composite material to make a battery with 20% higher energy density than existing designs.²⁹

For converting heavier vehicles such as coaches, heavy trucks and trains to zero emissions, Hydrogen is likely to be a better bet. For example, Hyzon (a subsidiary of Horizon Fuel Cell) now offers trucks of up to 50 tonnes with a range of 400-600km per fill³⁰. The main issue for hydrogen-powered cars, coaches and trucks is the need for better infrastructure – more hydrogen filling stations and cheaper catalysts for fuel cells. JCB has developed a hydrogen combustion engine which is a conventional engine fuelled by hydrogen instead of diesel. The prototype 4.8 litre hydrogen engine develops the same power as its diesel equivalent but the exhaust only emits water³¹.

Hydrogen-powered aircraft using hydrogen turbines, hydrogen fuel cells or a combination of the two are being actively explored with the world's first successful hydrogen-powered passenger aircraft demonstration flight being from Cranfield, UK in September 2020 – a Piper M-class converted to hydrogen by Zero-Avia, a US company with US and UK sites. In addition, Vertical Aerospace (a Bristol, UK company) now has 1,350 orders from major companies worth £4bn for its silent electric air taxis with a range of 120 miles. Rolls-Royce has built an electric aircraft that it plans to use to set a new electric airspeed record of over 300mph. Moreover, Rolls' batteries, motors and power distribution technology are on the futuristic, multirotor CityAirbus demonstrator made by Airbus. Airbus has also designed three concept hydrogen-powered passenger aircraft to carry 100-200 passengers up to 2,000 miles³².

Ships are another significant source of emissions so it is encouraging that Maersk, the world's largest shipping company, will have its first vessel running on carbon-neutral methanol in 2023. In addition, Maersk has a dual fuel engine under development, which will be capable of running on green ammonia³³. The company is collaborating on building Europe's largest plant for producing green ammonia. Domestic boilers are another area where hydrogen can be used to reduce emissions and achieve lower carbon emissions. Most modern gas boilers can be run with 20% hydrogen in the natural gas supply but prototypes have now been developed that will run on pure hydrogen. It is clear that hydrogen will play an important role in mitigating climate change. There are three ways of producing hydrogen with different environmental impacts. The first is 'gold' hydrogen from hydrogen gas reservoirs underground such as in Mali where Canadian company Hydromax is drilling wells. The second is 'turquoise' or 'blue' hydrogen produced from natural gas using renewable electricity – the output is hydrogen and carbon black³⁴ or hydrogen and carbon captured CO₂. The third is 'green' hydrogen produced by the electrolysis of water using renewable electricity (hydro, wind or solar) – preferably excess electricity produced at times of low demand or high wind speed to make 'green' hydrogen. At present about 5% of hydrogen is produced by electrolysis with about 95% produced from natural gas.

The exploitation of new technologies depends in part on the ease of formation of new companies and the availability of funding to help them grow (venture capital or VC funding). VC funding is particularly important since it supports higher risk projects that can be unattractive to many established companies. In 2020, there were over 500 VC deals worth a total of over \$7bn just for renewable energy projects. The OECD publishes total VC funding by country for each year³⁵. In 2020, the US has a vast lead with \$135.6bn followed by the UK (\$3.19bn), Canada (\$3.01bn), S. Korea

²⁸ <https://www.spglobal.com/marketintelligence/en/news/insights/blog/bank-ma-revival-market-disruption-warning-venture-capital-funding-soars>

²⁹ <https://silanano.com/>

³⁰ <https://hyzonmotors.com/vehicle/heavy-duty-trucks/>

³¹ <https://www.fwi.co.uk/machinery/technology/jcb-hydrogen-fuelled-combustion-engine-examined>

³² <https://physicstoday.scitation.org/doi/10.1063/PT.3.4632>

³³ <https://www.maersk.com/news/articles/2021/02/23/maersk-backs-plan-to-build-europe-largest-green-ammonia-facility>

³⁴ https://spectra.mhi.com/achieving-net-zero-what-is-turquoise-hydrogen?utm_source=google&utm_medium=cpc&utm_campaign=layer1&utm_content=hydrogen&gclid=EAIalQobChMldq3_oPP8glVpO_tCh2BVghiEAAYAiAAEgJ_GPD_BwE

³⁵ https://stats.oecd.org/Index.aspx?DataSetCode=VC_INVEST



(\$2.58bn), Japan (\$2.5bn), France (\$2.3bn) and Germany (\$2.2bn) where the figures for the US and Japan are for 2019 since no 2020 figures were available at the time of compilation. The ease of forming start-up companies is also important and CEOWORLD magazine published its 2021 ranking of the most start-up friendly countries based on responses from 195,000 CEOs³⁶. The top three are the US, UK and Canada as in the VC funding ranking followed by Israel, India and Germany. The US's #1 rank in VC and start-ups helps

to explain its strong position in R&D for the R&D-intensive sectors of ICT and healthcare in the Scoreboard. Many US biotech and ICT companies start off with VC funding and then grow much larger and enter the Scoreboard. In some countries government funding is used to grow companies through their difficult early stages and even to accelerate growth rates when they have become much larger – an example is Huawei which has benefited from state-backed investment to the tune of \$75bn.³⁷

1.2 Industrial R&D landscape

This section presents the main characteristics of the 2021 Scoreboard, focussing on the geographical and sectoral distribution of the top 2500 R&D investors. It also delves deeper into an analysis of where R&D is performed using data on subsidiaries and patents. The top 2500 global companies each invested more than €36.5 million in R&D in 2020³⁸, accounting altogether for a total of €908.9bn;

this is a 6.0% increase on their investment in the previous year³⁹. The 2500 companies in the sample invested more in R&D in total than in 2019, although growth was at a slower pace (compared to the 2020 Scoreboard sample, where growth was 8.9%). This growth rate compares with that predicted using an early sample dataset in June 2021 (where 3.9% R&D growth was forecast).⁴⁰

1.2.1 Geolocation of companies and their R&D activity by headquarters

The top 2500 Scoreboard includes companies from 39 countries of which 17 are Member States of the EU. The total R&D of these 2500 companies accounts for over 90% of global business-funded R&D (see Box 1.2). The 2500 companies include companies based in the US (779), China (597), the EU (401), Japan (293), UK (105), Taiwan (86), South Korea (60), Switzerland

(57), Canada (26), India (25), Israel (21) and a further 12 countries (see Table 1.1 and Figure 1.1). The most significant change compared to last year is once again the increase in the number of Chinese companies (+61 companies). The US has registered a small increase (+4), while the EU (-20) and Japan (-16) have seen a decrease in the companies in the top 2500⁴¹.

³⁶ <https://ceoworld.biz/2021/04/26/most-startup-friendly-countries-in-the-world-2021/>

³⁷ <https://www.wsj.com/articles/state-support-helped-fuel-huaweis-global-rise-11577280736>

³⁸ The Scoreboard is based on information taken from the companies' latest published accounts. For most companies, these correspond to calendar year 2020, 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 2021, and a small number for which only the accounts up to the end of 2019 were available. Therefore, we should refer to the data of the last available year as 2020/21, those of the previous one as 2019/20 and so on. However, for most companies the last available year corresponds to calendar year 2020, the previous year to the calendar year 2019 (and so on). For reasons of clarity and consistency, we decided to refer to the last available year as 2020, the previous year as 2019 (and so on).

³⁹ The 2020 Scoreboard reported R&D for the top 2500 companies as €904.2bn in 2019, which will make for an increase of 0.3% (not 6.0%). The reason for the apparent discrepancy is exchange rates. The US\$ appreciated from 1€=\$1.12 at end 2019 to 1€=\$1.23 at end 2020. If the 2020 Scoreboard R&D is expressed at 2019 Scoreboard exchange rates, the total R&D for the 2500 companies is €953.4bn, which will represent a 5.4% increase (the remaining 0.6% difference to get to the 6.0% figure of this year is explained by entry-exit of companies). See details on exchange rates in Annex 2 – Box A2.1 and Table A2.1.

⁴⁰ See Grassano, N. and Hernandez Guevara, H., The impact of Covid19 on top R&D investors: first insight into 2021 EU Industrial R&D Investment Scoreboard data, European Commission, 2021, JRC125712

⁴¹ The geolocation of companies is based on where they have their HQ. This can cause some over (under) statement for some countries (like for example the Netherlands or Ireland) where there can be companies that are registered there but whose principal activities are carried out elsewhere. See paragraph 1.2.2 for and chapter 3 for a discussion on the difference between location of R&D as of HQ and location of R&D as of location of the inventors.

Table 1.1: Distribution of companies and R&D by country.

EU	No. companies	R&D (€bn)	non-EU	No. companies	R&D (€bn)
Germany	124 (124)	86.94	US	779 (775)	343.56
France	66 (68)	32.02	China	597 (536)	140.95
Netherlands	34 (38)	18.96	Japan	293 (309)	111.06
Sweden	34 (32)	11.61	South Korea	60 (59)	33.43
Ireland	27 (28)	7.17	Switzerland	57 (58)	29.01
Denmark	29 (32)	6.20	UK	105 (121)	28.93
Finland	15 (16)	5.15	Taiwan	86 (88)	19.13
Italy	21 (24)	4.94	India	25 (29)	4.37
Spain	14 (14)	4.45	Canada	26 (30)	4.27
Belgium	13 (14)	3.19	Australia	11 (11)	2.88
Austria	14 (16)	1.75	Israel	21 (22)	2.69
Luxembourg	4 (7)	1.10	Norway	11 (10)	1.21
Portugal	2 (3)	0.16	Saudi Arabia	1 (2)	0.62
Slovenia	1 (1)	0.15	Turkey	7 (6)	0.55
Hungary	1 (1)	0.15	Singapore	6 (6)	0.54
Poland	1 (1)	0.10	Brazil	5 (5)	0.37
Malta	1 (1)	0.04	Further 6 countries	9 (11)	1.20
Total EU	401 (421)	184.1	Total	2099 (2079)	724.8

Note: Figures between brackets are the number of companies comprised in the previous 2020 Scoreboard.

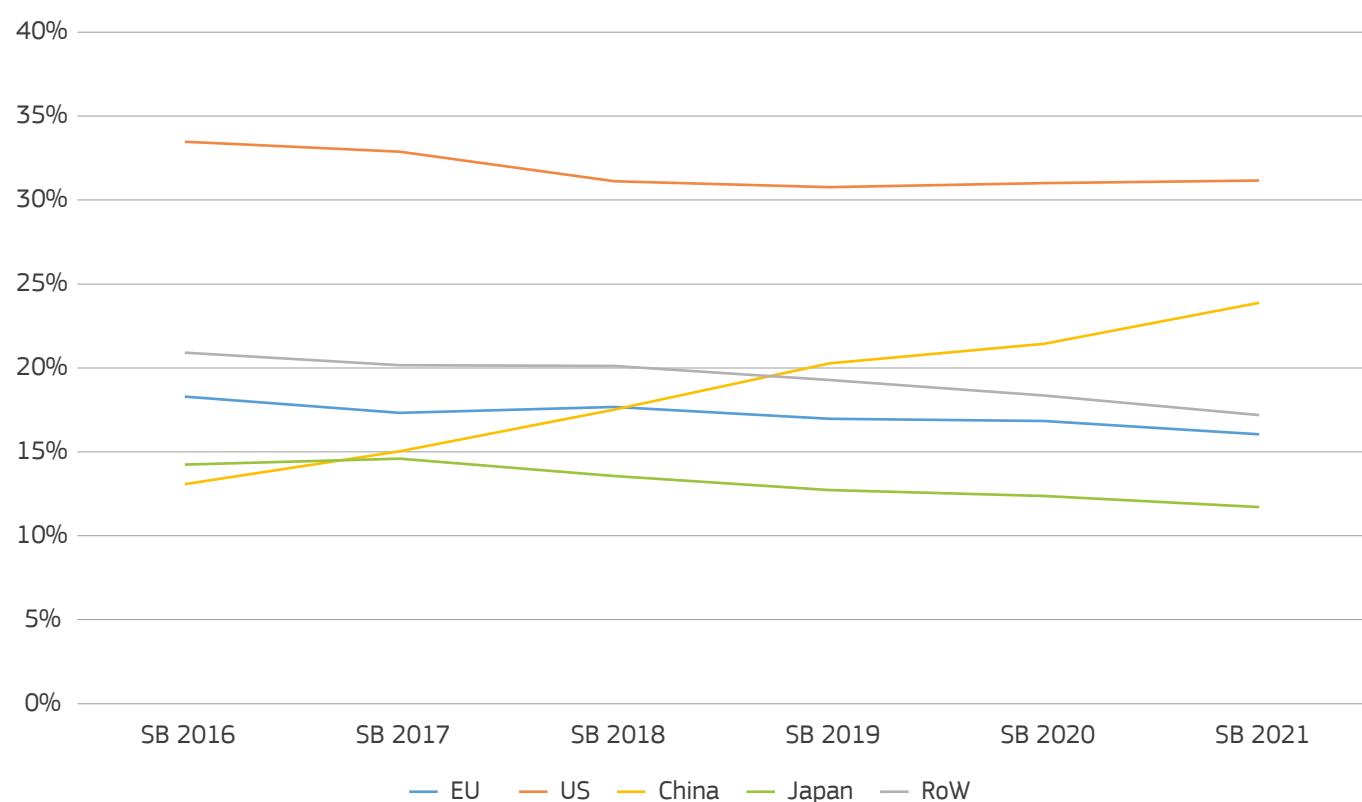
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



The US is the country with the greatest number of top investors in R&D worldwide (779 companies), followed by China (597) and the EU (401). As for the last Scoreboard, China is second only to the US in terms of number of companies in the R&D ranking and it is consolidating its advantage over the EU.

Even if the UK were still in the EU, China would still have been second in the ranking (597 vs 506). China first overtook the EU-27⁴² in terms of number of companies for the 2018 edition of the Scoreboard and the gap has been increasing since then every year, as shown in figure 1.1.

Figure 1.1: Share of companies in the Scoreboard by region – 2016 to 2021 editions.



Note: Data from Scoreboard (SB) editions 2016 to 2021.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 1.2 maps the world's top R&D investing companies by country, considering the location of their headquarters. As observed in past editions of the report, R&D investment is very concentrated.

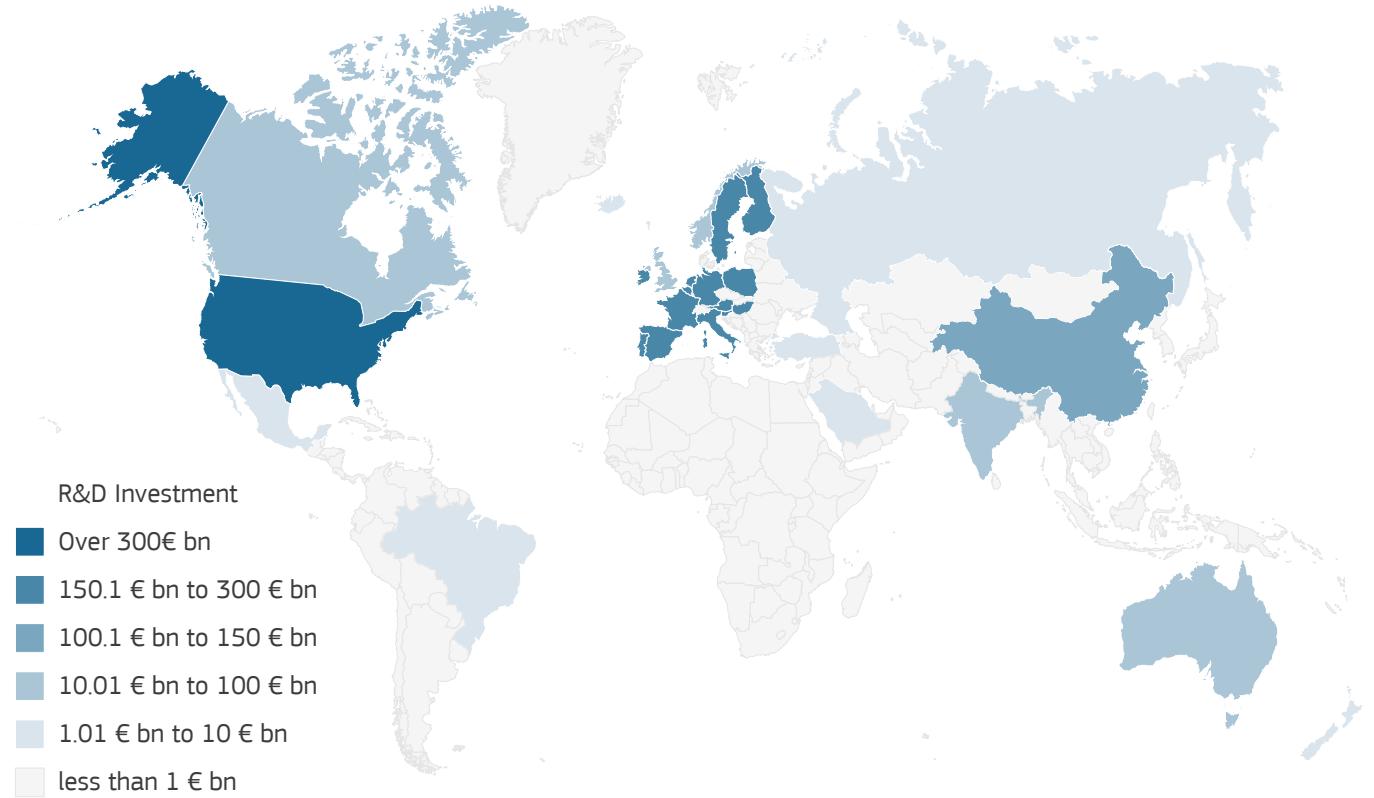
Companies headquartered in the top five countries in terms of R&D investment (US, China, Japan, Germany and South Korea) account for 78.8 % of

the R&D (last year it was 77.6% when France was in the top 5 instead of South Korea) and 74.1% (last year 72.5%) of the companies in the sample. Taking the EU as a single entity, the four major economies (US, EU, China and Japan) account for 82.8% of the R&D and 85.8% of the number of companies (last year they accounted for 84.0% of the companies and 88.8% of the R&D).

⁴² In this report, when we refer to the EU we always refer to the EU-27. Data from past Scoreboard (where UK companies where part of the EU) have been recodify to include in the EU group only companies headquartered in one of the EU-27 Member States.



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



Note: colour darkness proportional to R&D investment in 2020 by companies headquartered in the country.
The EU is considered as a single region, only member states where at least one company is headquartered are highlighted.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The top 2500 companies investing in R&D own just under 800,000 subsidiaries⁴⁵, of which around 307000 are corporate subsidiaries⁴⁴. While the companies' headquarters (HQ) are located in 40 different countries, there is at least one subsidiary of a Scoreboard company in 201 countries/territories, which is slightly more than the sample of last year (197). It should be noted that not all subsidiaries necessarily carry out R&D. The distribution of corporate subsidiaries is represented in Figure 1.3.

30.2% of the subsidiaries belonging to Scoreboard companies are located in the US, which is the economy where the relative majority of subsidiaries are. The EU (22.4%) and China (14.0%) follow, mirroring the

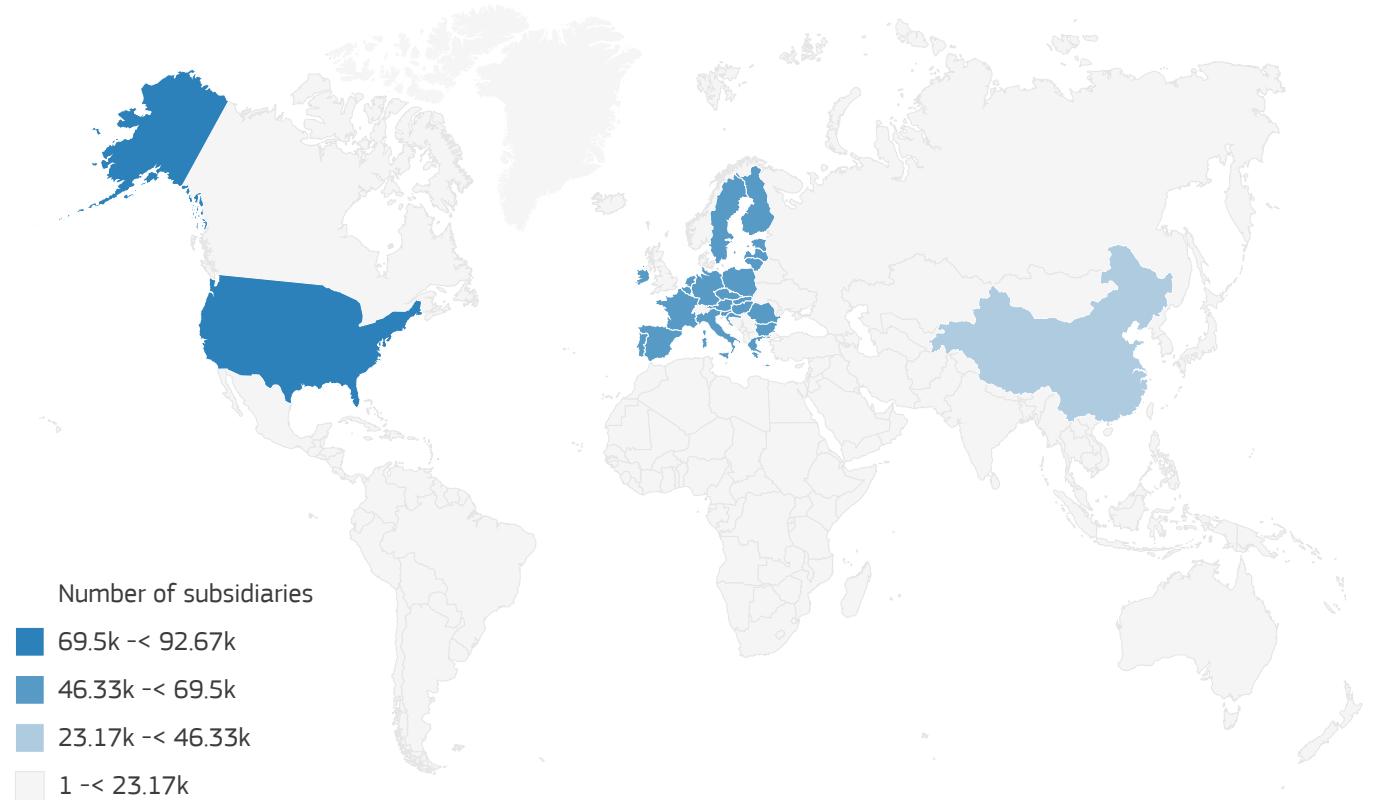
distribution observed in last year's sample. The top five countries (out of 201 countries/territories) in terms of number of subsidiaries (US, China, UK, Germany and France) host 56.1% of the subsidiaries. This percentage rises to 69.5% if we take the first ten economies. Therefore, subsidiaries, rather like headquarters, are quite concentrated.

The distribution of the number of corporate subsidiaries of Scoreboard companies across the five world regions/countries considered is shown in Figure 1.4. Companies headquartered in the EU are those owning the relative majority of subsidiaries (31.6%), located in 195 different countries. US companies follow closely, owning 29.3% of the subsidiaries, located in 176 countries, while

⁴³ Data on ownership structure is provided by Bureau van Dijk (BvD) and refers to the subsidiaries owned by Scoreboard companies with a share of 50.1% or more.

⁴⁴ 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.

Figure 1.3: 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 2317 companies (accounting for 97.3% of R&D in 2020) for which subsidiary data is available.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Chinese and Japanese companies control a similar share of subsidiaries (11.5% each) located in a similar number of countries (142 and 149 respectively).

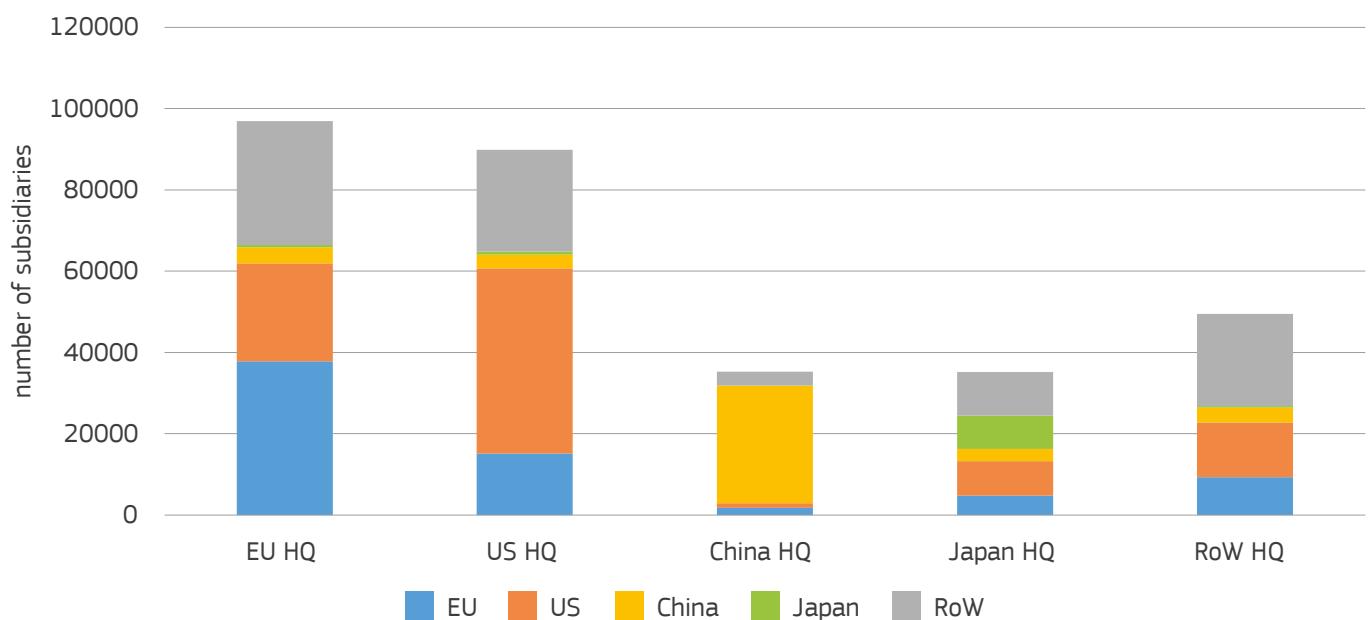
Subsidiaries owned by EU companies (EU HQ) are mostly located in the EU (39.0%) and in the US (24.9%), while half of those owned by US companies also located in the US (50.6%), but there is a relevant share also in the EU (16.9%). The vast majority of Chinese-owned subsidiaries are located in China (81.7%), while Japanese companies have a slightly lower share of domestic subsidiaries (i.e. located

in the same country as the HQ) than subsidiaries located in the US (respectively 23.3% and 23.8%). This data indicates that Japanese companies are more internationalised, in the sense that they have more foreign subsidiaries representing a higher share of their subsidiaries than their counterparts.

As for the overall number of subsidiaries, their location across the different economies considered is similar to that reported last year, which means the industrial structure of top R&D investors has remained stable (at least for 2020) notwithstanding the COVID-19 crisis.



Figure 1.4: Distribution of the number of subsidiaries by region.



Note: Data refers to 2286 companies (accounting for 97.1% of R&D of the sample in 2020) for which subsidiary data is available. Countries included in RoW are: South Korea; Switzerland; UK; Taiwan; India; Canada; Australia; Israel; Norway; Saudi Arabia; Turkey; Singapore; Brazil; Liechtenstein; United Arab Emirates; New Zealand; Russia; Iceland; Mexico.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

1.2.2 Geolocation of companies and their R&D activity by inventor

Assigning a company to the country where it has its headquarters does not necessarily give an accurate picture of the actual location where the R&D or other industrial activity is actually performed. This is especially true in the case of multinational companies such as those included in the 2021 Scoreboard. To try to approximate the actual location where the R&D is performed, we use as a proxy 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 2016-2018⁴⁵. We exploit this information to approximate a redistribution of 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 approximation assumes *inter alia* that the amount of R&D invested to generate a patent does not vary from

technology to technology, that the propensity to patent does not vary by technology and company and that the success rate of R&D is comparable across companies.

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 companies with HQ located in another country, and the outward flow is the R&D funded by local companies (with HQ in the country) but performed abroad. 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.

⁴⁵ We consider patent family applications.



Figure 1.5a shows the geographic distribution of the R&D applying patent data for the five groups of Scoreboard companies.

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Figure 1.5a shows the geographic distribution of the R&D applying patent data for the five groups of Scoreboard companies.

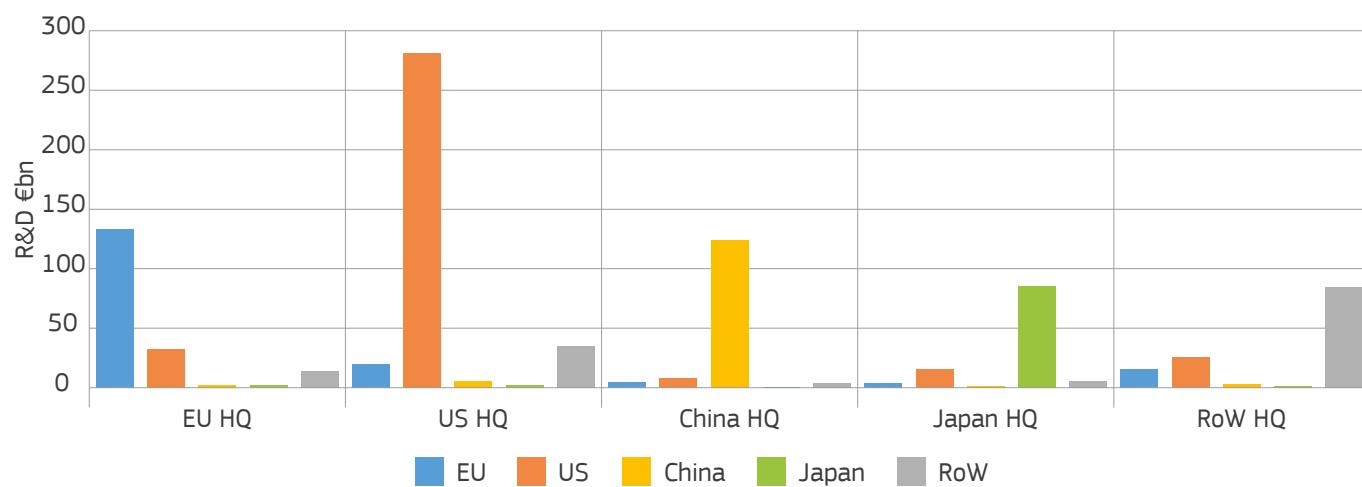
In all the four economies considered, the companies headquartered there performed the vast majority of

their R&D in the home territory. Chinese companies do 87.9% of their R&D in China, US companies do 82.0% of their R&D in the US, Japanese companies do 77.1% of their R&D in Japan and EU companies do 72.5% of their R&D in the EU. This means EU companies perform the highest share of their R&D outside the home region.

For the EU, Japan and (to a lower extent) China, the majority of the R&D not performed at home is done in the US. This indicates the relative attractiveness of US R&D ecosystems and markets. The EU is the region where US companies invest the more in R&D (outside the US).

Figure 1.5b digs deeper into this by comparing the sector distribution of the R&D resulting from the HQ location and the sectoral distribution of R&D estimated from inventors’ locations. The differences between the two can be positive (if the volume of R&D invested by foreign companies in the country/region - inward flow- is higher than the volume of R&D invested by local companies outside the country/region – outward flow) or negative (if it is the other way round).

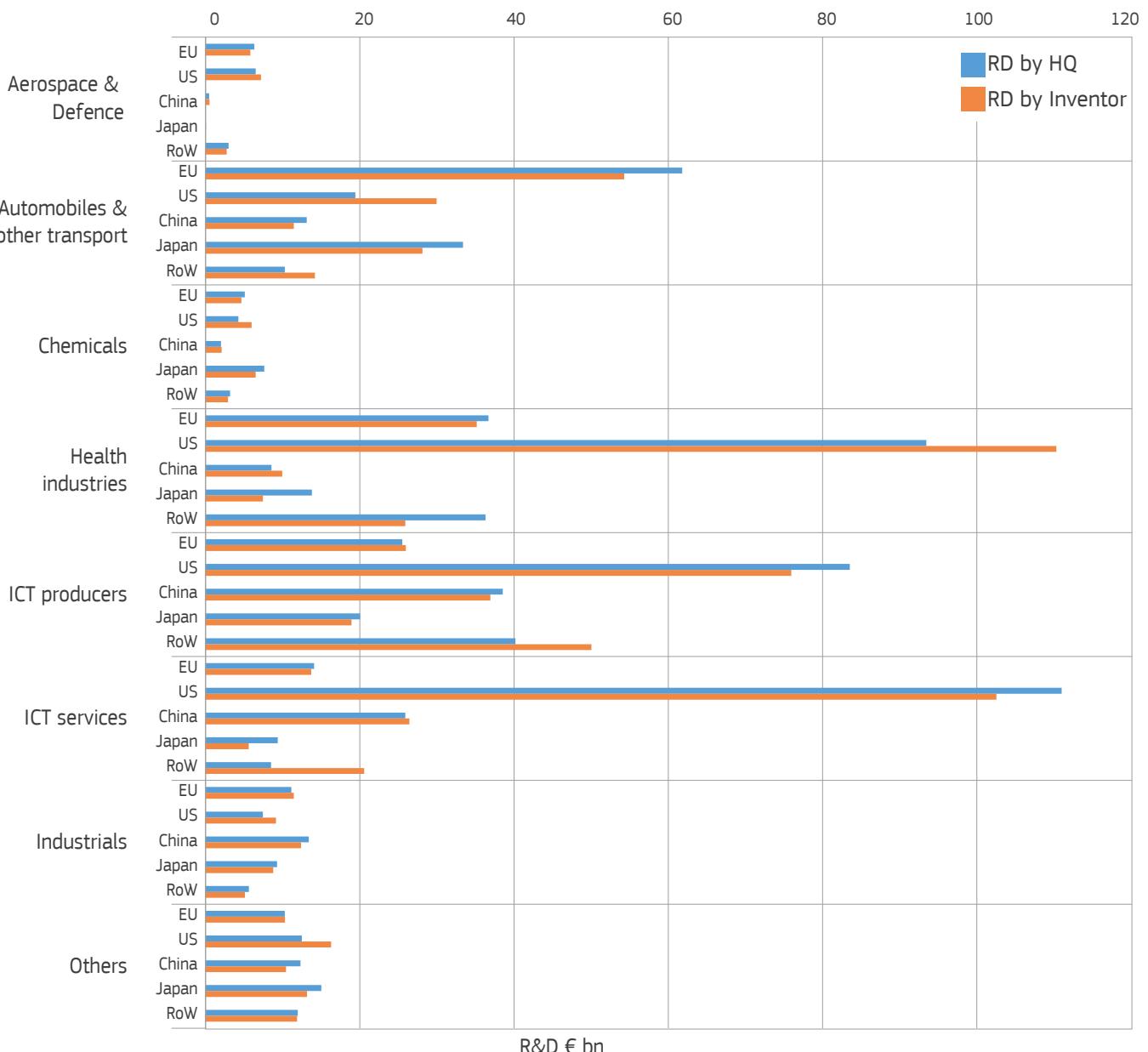
Figure 1.5a: Distribution of R&D by location of inventors for main regions.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁴⁶ The methodology used to estimate the R&D is performed based on where the inventors’ of patents belonging to the company are located is based on several assumptions. For example, it assumes the entire R&D translates into patents, not taking into account possible R&D failures and other ways to protect IPRs, like for example industrial secrets. In addition, it assumes the R&D effort needed to produce one patent is uniform across sectors and technologies. It also assumes that the propensity to patent does not vary by technology or company. These are strong assumptions that needed to be taken into account when reading the result. For a full explanation of the methodology and its limitations, 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/contenttype//publication//reports//1568800313//Estimating%20territorial%20business%20R&D%20expenditures.pdf>

Figure 1.5b: Distribution of R&D by sector: location by headquarters (HQ) vs location by inventors.



Sources: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The most significant differences are the deficits for the Automobile & other transport⁴⁷ sector in the EU together with the ICT services and ICT producers sectors in the US while the health sector in the US shows a surplus.

This picture, as for the overall results emerging from the general analysis of flows, is slightly different from that reported in the analysis last year. If this is a new pattern or not remains to be seen in the future.

⁴⁷ In this report we refer to the "Automobile & other transport" sector also as the "Automotive" sector, "Automobiles" sector or the "Automobile and o.t." sector.

1.2.3 Sectoral classification of companies

Multinational companies are by definition companies with activities and affiliates located in different countries. However, most also operate in multiple sectors, which makes the assignment of a company to a specific sector a difficult task. In the Scoreboard we assign a company to 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)⁴⁸. The distribution of companies by sector according to the ICB and grouped in broad macro-sectors is reported in table 1.2.

Table 1.2: Industrial classifications applied in the Scoreboard: 11 industrial groups.

Industrial Sector	Sector classification ICB4 digits	N. of firms	R&D 2020 (€ bn)	R&D intensity (%)	% of total R&D	R&D per firm (€ million)
Aerospace & Defence	Aerospace; Defence	43	16.3	4.0	1.8	378.0
Automobiles & other transport	Auto Parts; Automobiles; Commercial Vehicles & Trucks; Tires	184	138.0	5.0	15.2	749.8
Chemicals	Commodity Chemicals; Specialty Chemicals	125	22.1	2.7	2.4	176.8
Construction	Building Materials & Fixtures; Construction and Materials; Heavy Construction	67	23.1	2.1	2.5	344.8
Energy	Alternative Energy; Alternative Fuels; Conventional Electricity; Electricity; Exploration & Production; Gas Distribution; Gas, Water & Multiutilities; Integrated Oil & Gas; Multiutilities; Oil & Gas Producers; Oil Equipment & Services; Oil Equipment, Services & Distribution; Renewable Energy Equipment; Water	82	17.4	0.7	1.9	212.0
Financial	Banks; Financial Services; Full Line Insurance; Insurance Brokers; Investment Services; Life Insurance; Real Estate Holding & Development; Real Estate Investment & Services; Real Estate Services; Reinsurance; Specialty Finance	67	18.0	2.8	2.0	268.2
Health industries	Biotechnology; Health Providers; Medical Equipment; Medical Supplies; Pharmaceuticals	525	188.7	12.4	20.8	359.5
ICT producers	Computer Hardware; Electrical Components & Equipment; Electronic Equipment; Electronic Office Equipment; Semiconductors; Telecommunications Equipment	458	207.8	7.4	22.9	453.6

⁴⁸ <http://www.ftse.com/products/downloads/ICBStructure-Eng.pdf>



Industrial Sector	Sector classification ICB4 digits	N. of firms	R&D 2020 (€ bn)	R&D intensity (%)	% of total R&D	R&D per firm (€ million)
ICT services	Computer Services; Internet; Software; Mobile Telecommunications	355	168.8	8.7	18.6	475.5
Industrials	Aluminium; Containers & Packaging; Diversified Industrials; Delivery Services; Industrial Machinery; Iron & Steel; Nonferrous Metals; Transportation Services	274	46.8	2.5	5.1	170.8
Others*	Beverages; Food & Drug Retailers; Food Producers; Forestry & Paper; General Retailers; Household Goods & Home Construction; Leisure Goods; Media; Mining; Personal Goods; Support Services; Tobacco; Travel & Leisure	320	62.0	2.4	6.8	193.7
Total		2500	908.9	4.8	100.0	363.5

Note: * Sectors in the "Others" group are presented at ICB-3 digits level. R&D intensity is defined as R&D over Net Sales.

Source: The 2021 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG R&I.

As last year, Health has the highest number of companies in the 2500 company sample, accounting for 21.0% of the companies and 20.7% of the R&D. It is followed by ICT producers (18.4% of the companies and 23% of the R&D) and ICT services (14.2% of the firms and 18.6% of the R&D). The Automotive sector represents 15.1% of the R&D, but only 7.3% of the companies. This distribution (and concentration of R&D in the four largest macro sectors) is very similar to the sample analysed last year.

Table 1.3a and 13b disaggregate the figures (of number of firms and R&D investment) by region, illustrating a familiar specialisation pattern: This shows US firms leading in ICT (both services and producers) and Health, and the EU firms leading in Automotive. This sectoral specialisation explains why the EU has been hit harder by the COVID-19 crises, compared to the other regions. This aspect will be analysed in details in Chapter 2.

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

Industry	EU	US	China	Japan	RoW	Total
Aerospace & Defence	10 (23.3%)	13 (30.2%)	5 (11.6%)	(0%)	15 (34.9%)	43 (1.7%)
Automobiles & other transport	38 (20.7%)	35 (19%)	45 (24.5%)	36 (19.6%)	30 (16.3%)	184 (7.4%)
Chemicals	16 (12.8%)	25 (20%)	28 (22.4%)	34 (27.2%)	22 (17.6%)	125 (5%)
Construction	8 (11.9%)	4 (6%)	35 (52.2%)	13 (19.4%)	7 (10.4%)	67 (2.7%)
Energy	28 (34.1%)	8 (9.8%)	18 (22%)	12 (14.6%)	16 (19.5%)	82 (3.3%)
Financial	26 (38.8%)	9 (13.4%)	13 (19.4%)	1 (1.5%)	18 (26.9%)	67 (2.7%)
Health industries	72 (13.7%)	278 (53%)	72 (13.7%)	33 (6.3%)	70 (13.3%)	525 (21%)
ICT producers	48 (10.5%)	120 (26.2%)	129 (28.2%)	53 (11.6%)	108 (23.6%)	458 (18.3%)
ICT services	32 (9%)	190 (53.5%)	81 (22.8%)	10 (2.8%)	42 (11.8%)	355 (14.2%)
Industrials	66 (24.1%)	34 (12.4%)	89 (32.5%)	49 (17.9%)	36 (13.1%)	274 (11%)
Others	57 (17.8%)	63 (19.7%)	82 (25.6%)	52 (16.3%)	66 (20.6%)	320 (12.8%)
Total	401 (16%)	779 (31.2%)	597 (23.9%)	293 (11.7%)	430 (17.2%)	2500

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 of firms by region is highlighted. The total in the final column shows the number of firms in the sector, with the share of the total number of firms between brackets. The total in the final row shows the number of firms in the region, with their overall share of the sample in brackets.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&l.

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

Industry	EU	US	China	Japan	RoW	Total
Aerospace & Defence	6.3 (38.9%)	6.5 (40%)	0.4 (2.8%)	0 (0%)	3 (18.4%)	16.3 (1.8%)
Automobiles & other transport	61.8 (44.8%)	19.4 (14.1%)	13.1 (9.5%)	33.4 (24.2%)	10.3 (7.4%)	138 (15.2%)
Chemicals	5.1 (23%)	4.2 (19.2%)	2 (9%)	7.6 (34.4%)	3.2 (14.4%)	22.1 (2.4%)
Construction	1.5 (6.3%)	0.5 (2.1%)	18.7 (81.1%)	1.5 (6.3%)	1 (4.3%)	23.1 (2.5%)
Energy	5.3 (30.4%)	2.3 (13.4%)	5.3 (30.6%)	1.1 (6.5%)	3.3 (19.1%)	17.4 (1.9%)
Financial	6.5 (36.2%)	2.7 (15.3%)	2.7 (15.1%)	0.1 (0.3%)	6 (33.2%)	18 (2%)
Health industries	36.7 (19.4%)	93.4 (49.5%)	8.5 (4.5%)	13.8 (7.3%)	36.3 (19.2%)	188.7 (20.8%)
ICT producers	25.5 (12.3%)	83.5 (40.2%)	38.5 (18.5%)	20 (9.6%)	40.2 (19.3%)	207.8 (22.9%)
ICT services	14.1 (8.3%)	111 (65.8%)	25.9 (15.3%)	9.4 (5.5%)	8.5 (5%)	168.8 (18.6%)
Industrials	11.1 (23.8%)	7.4 (15.9%)	13.4 (28.6%)	9.3 (19.8%)	5.6 (12%)	46.8 (5.1%)
Others	10.3 (16.6%)	12.5 (20.1%)	12.3 (19.8%)	15 (24.2%)	11.9 (19.3%)	62 (6.8%)
Total	184.1 (20.3%)	343.6 (37.8%)	141.0 (15.5%)	111.1 (12.2%)	129.2 (14.2%)	908.9

Note: The figures in brackets show each sector's regional percentages of R&D investment in the sector. The cell representing the higher sectoral R&D by region is highlighted. The total in the final column shows the total R&D invested in the sector, with the share of the total R&D between brackets. The total in the final row shows the R&D invested by firms headquartered in the region, with their overall share of R&D investment in brackets.

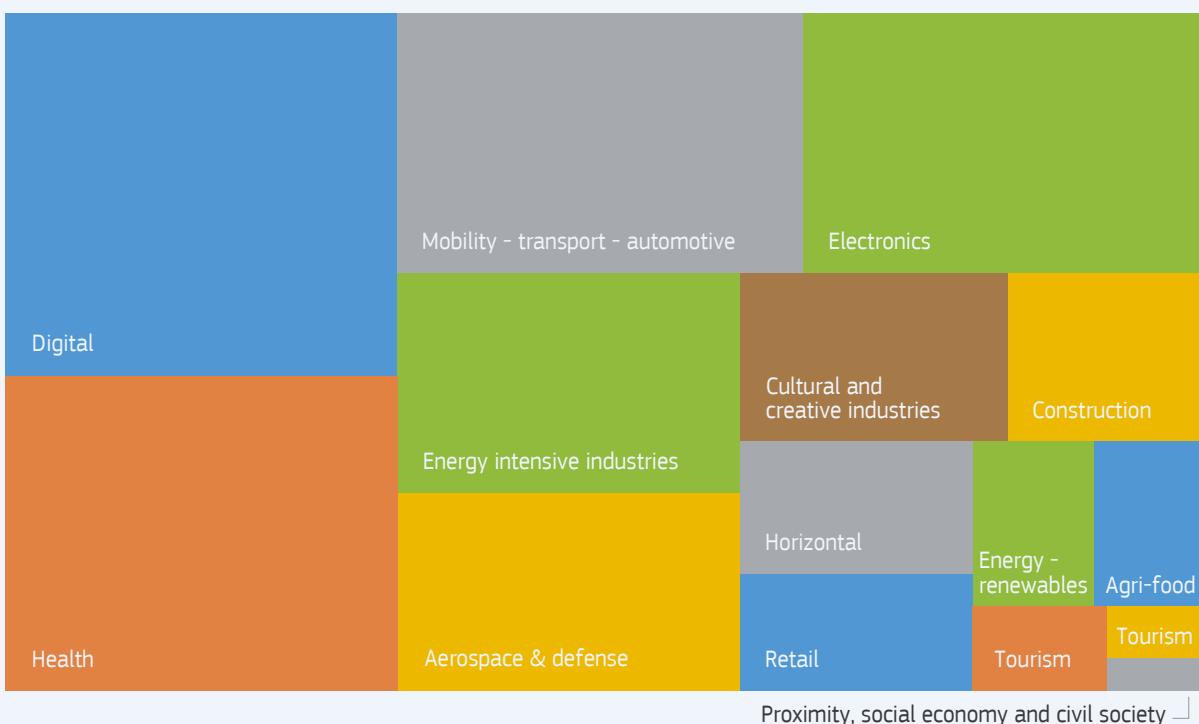
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&l.

Box 1.1: Looking at the *Scoreboard* from an ecosystem perspective.

In the Scoreboard the analysis is done by grouping companies in macro sectors based on the ICB classification. An alternative way of looking at it could be to follow the ecosystem approach introduced by the report entitled "A new Industrial Strategy for a green and digital Europe", launched by the European Commission in March 2020.

Using the correspondence between ICB codes and ecosystems (via NACE code) and fractionally counting R&D for companies belonging to ICB sectors falling in more than one ecosystem, it is possible to have a look at how the Scoreboard would look like from an ecosystem perspective (Figure B.1).

Figure B.1: R&D investment 2020 by ecosystem.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Not surprisingly, the majority of R&D is concentrated in the digital, health, mobility and electronics ecosystems (accounting for about 64% of the total). Also in line with the analysis done using ICB sectors, the two ecosystems registering a negative R&D growth in 2020 are mobility and tourism (although tourism is a very small sector in terms of R&D in the Scoreboard, only 1.4% of the total).

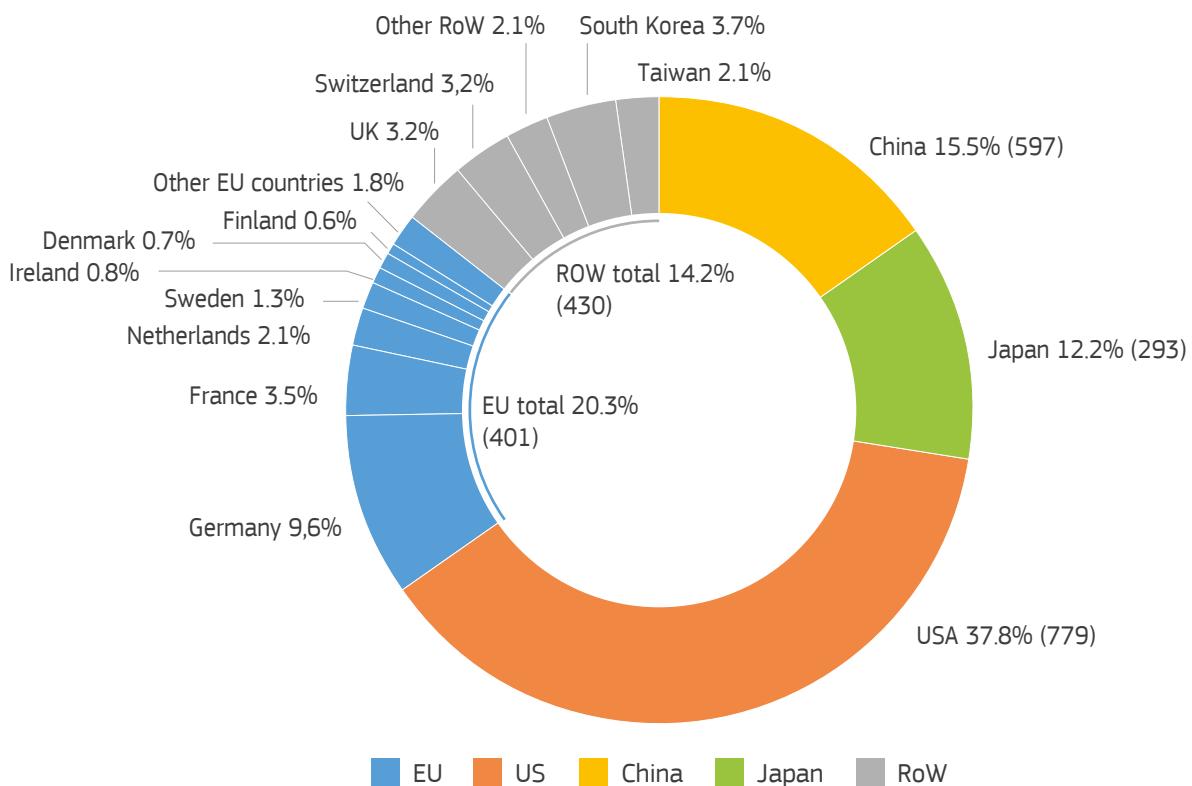
The conversion from ICB to Ecosystem via NACE codes is not straightforward. Some NACE codes fall in more than one ecosystem and some ecosystems overlap. We used value added as a weighting for NACE codes falling into multiple ecosystem and rescaled weights to sum up to 1. Further analysis is needed to check the accuracy of conversions from ICB codes to ecosystems.

1.2.4 R&D investments by world region and industrial sector

Despite COVID-19, the overall level of R&D investment increased in 2020 by 6.0% compared to 2019 (see Table 2.1). 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). However, some

small changes can be seen: as noted in past editions of the Scoreboard, we observe a constant growth of China's R&D at the expense of the EU and Japan. 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 average R&D investment per company.

Table 1.6: R&D investment by region and country.



Note: between brackets the number of companies per country/region.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

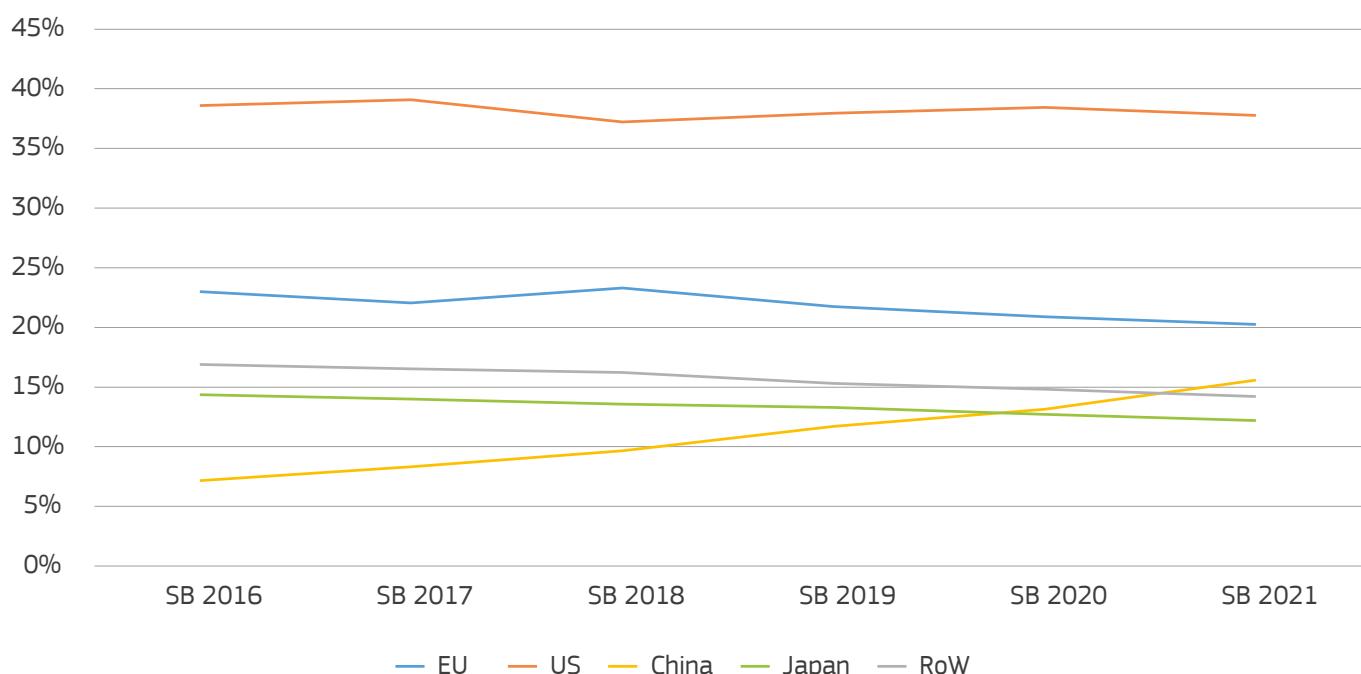
While China has overtaken the EU in terms of number of companies (as seen in section 1.2.1) it has not (yet) overtaken the EU in the cash amount invested in R&D. EU companies invested €184.1bn of R&D in 2020, compared with €141.0bn for Chinese companies. The US remains first, with €343.6bn, while Japan is behind both the EU and China with €111.1bn. Figure 1.7 reports the trends of R&D shares by region in the

Scoreboard since the 2016⁴⁹ edition. China has more than double the share in the current sample compared to Scoreboard 2016 and is a clear third behind the US and the EU. The US has consistently hovered around 38% but the EU share has decreased to 20.3% (from 23.0% in 2016). If the trends of the past 6 years continue, China will surpass the EU in total R&D in two to three years.

⁴⁹ In order to have a five years (and six Scoreboard) windows to appreciate a trend in the data.



Figure 1.7: Share of global R&D investment by region – 2016 to 2021 editions.



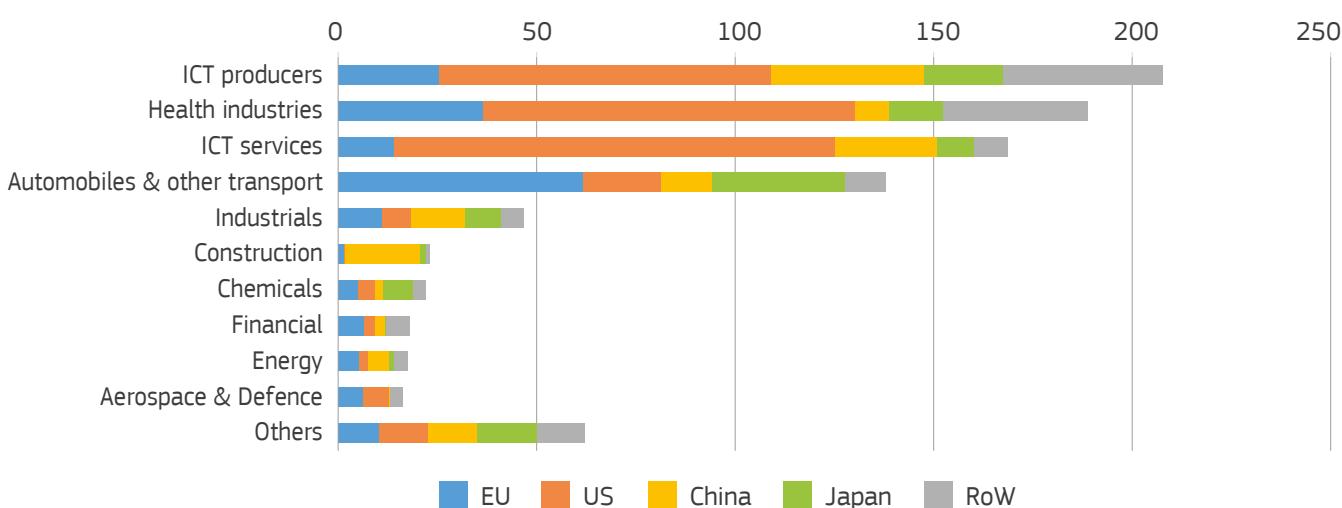
Note: Data from Scoreboard (SB) editions 2016 to 2021.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

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 43.7% of R&D investment in 2020 (43.5% in 2019). Figure 1.8 presents R&D shares by sector and region.

Figure 1.8: R&D investment by region and sector in €bn.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



The ICT services sector has consolidated its position as third largest sector in terms of share of R&D at the expenses of the Automotive sector. This consolidation has been supported by the opportunities presented by the COVID-19 pandemic, which has favoured

ICT-related activities over the Automotive sector. This confirms the sector shift already observed in the past edition of the Scoreboard: high-tech sectors are progressively widening the gap with mid- and low-tech sectors.

Box 1.2: Comparing R&D figures from the *Scoreboard* with territorial statistics

R&D figures used in the Scoreboard are conceptually different from, but complementary to, those provided by statistical offices. Following the Frascati manual⁵⁰, 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; 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) in the country. While, at the global level, the Scoreboard and BES-R&D figures are comparable, the former is lower because it excluded R&D whose source of funding is public and it does not include all private companies.

To illustrate the coverage of the Scoreboard R&D figures, we compare the latest available territorial statistics (2019) with the R&D data from the 2020 Scoreboard (company data for 2019). This comparison shows that the amount of R&D investment by the top 2500 companies (€904.2bn) is equivalent to 60% of the total expenditure on R&D worldwide (GERD, €1497.4bn) and to more than 90% of the R&D expenditure financed by the business sector worldwide (BES-R&D, €990.8bn).

Note: Latest figures reported by Eurostat including most countries reporting R&D, extracted on 4/11/2021. GERD, from all funding sources and performed in all sectors. BES-R&D performed in all sectors and funded by the business enterprise sector.
Sources: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁵⁰ See <https://www.oecd.org/sti/inno/frascati-manual.htm>

1.3. Scoreboard 2021: main changes and entry-exit analysis

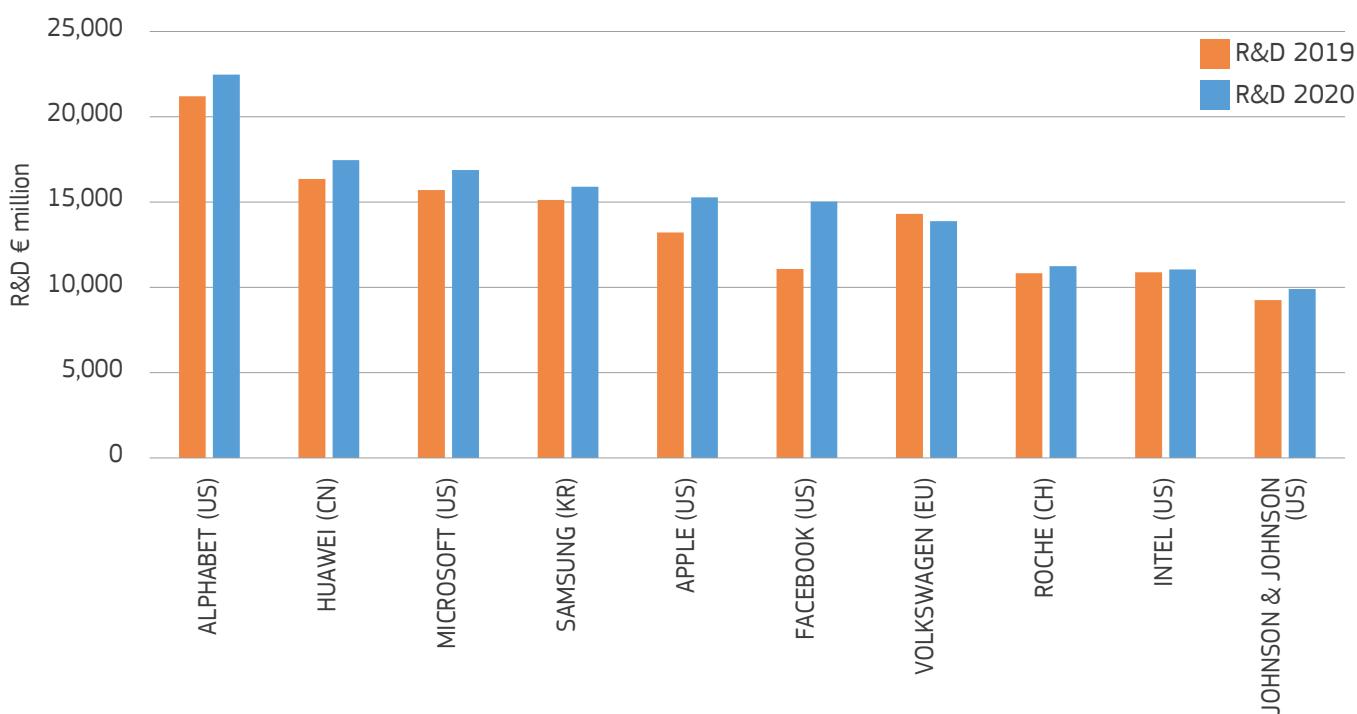
Top 10 year-on-year

The ranking of the top 10⁵¹ investors in R&D has registered no new entry⁵². In addition, the top five companies are the same as last year, with a single change in their order: Microsoft and Huawei interchanged places (2nd and 3rd); the Chinese company now occupies now the 2nd place behind Alphabet (Figure 1.9).

The total R&D investment of the top 10 companies was €149.1bn, which represents a nominal increase of 8.1% compared to last year's €138bn⁵³ (Table A3.1, Appendix). The highest growth is registered by Facebook (35%),

followed by Apple (15%). Recent acquisitions made by these companies may have also played their role in these impressive growth rates⁵⁴. Volkswagen was the only company in the top 10 whose R&D investment fell. In contrast, the total growth of the 2500 Scoreboard companies' investment was 5.6%, meaning a global increase of €47.9bn. Nearly one quarter (23%) of the increase of R&D investment of the total Scoreboard comes from these top 10 investors. The 16.4% R&D investment share of the top 10 in the total Scoreboard is surprisingly high and slightly up on last year's 16%.

Figure 1.9: Top 10 R&D investors in SB2020 and SB2021.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁵¹ There is one large R&D-investing company absent from the Scoreboard – this is Amazon, which unfortunately only records a combined figure for 'Technology and Content' investment in its accounts. Since no information is given on how to extract the technology (R&D) component, it is not possible to include Amazon in the Scoreboard. However, using statements in Amazon's accounts over the past few years we estimate that Amazon's R&D is a little larger than Alphabet's so Amazon should probably have been #1 in both 2021 and 2020.

⁵² Ranking of the top 50 companies is provided in Figure A.3.1 in the Appendix

⁵³ Figures in € referring to previously published scoreboards such as SB2020 or SB2016 have been recalculated with the exchange rates used for the present, 2021 Scoreboard – see the methodological note A2.1 for further insights.

⁵⁴ <https://www.bbc.com/news/business-56178792> and <https://www.techwyse.com/blog/infographics/facebook-acquisitions-the-complete-list-infographic/>



US companies and the ICT sector dominate the landscape of the top 10: of these 10 companies, six are from the US, and one each from Switzerland, China, South Korea and the EU. Three-quarters of the

top 10 are from the two ICT related sectors, which together, invested a total of €114bn (77% of the total investments of the top 10). Within ICT, services and producers have roughly equal shares.

Top 10 in the latest 5 years

The list of top 10 companies is only slightly different when considering a longer time span (Table 1.4). Comparing the 2021 and the 2016 Scoreboards, a core of 8 companies feature in both Scoreboards. There were two “exits” – Toyota (11th in 2021) and Novartis (19th in 2021) and two “entries” – Facebook (29th in

2016) and Apple (11th in 2016). The share of R&D of the Top 10 in the Total Top 2500 was only 14.1% in 2016, pointing also towards the steady concentration of R&D over time. The exit/entry dynamics shows the relative increase of the importance of both the US as well as the ICT sectors. Alphabet, Huawei, Apple

Table 1.4: Top 10 investors in R&D in SB2021 and SB2016.

Rank-SB2021	Rank-SB2016	Company	Country	Sector	R&D-2020 € million (SB2021)	R&D-2015 € million (SB2016)	CAGR, %
1	4	Alphabet	US	ICT services	22,470	11,050	15.3
2	8	Huawei	CN	ICT producers	17,460	9,467	13
3	5	Microsoft	US	ICT services	16,882	10,624	9.7
4	2	Samsung	KR	ICT producers	15,895	11,080	7.5
5	11	Apple	US	ICT producers	15,282	8,186	13.3
6	29	Facebook	US	ICT services	15,033	4,824	25.5
7	1	Volkswagen Ag	DE	Automobiles	13,885	13,672	0.3
8	7	Roche Holding Ag	CH	Health	11,247	9,176	4.2
9	3	Intel Corp	US	ICT producers	11,047	10,382	1.2
10	9	Johnson & Johnson	US	Health	9,909	7,412	6
18	6	Novartis	CH	Health	7,114	7,335	-0.6
11	10	Toyota	JP	Automobiles	8,620	8,159	1.1
Total Top 10					149,109	98,357	8.7
Total top 2500					908,875	695,963*	5.5
Share of Top 10 in Total Top 2500, %					16.4	14.1	

Note: *recalculated figure – see note 53

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

and Facebook are the most dynamic R&D performers in this 5-year period. This is shown by the relatively high 5-year CAGR of their R&D investments. On the other hand, both European companies present in the

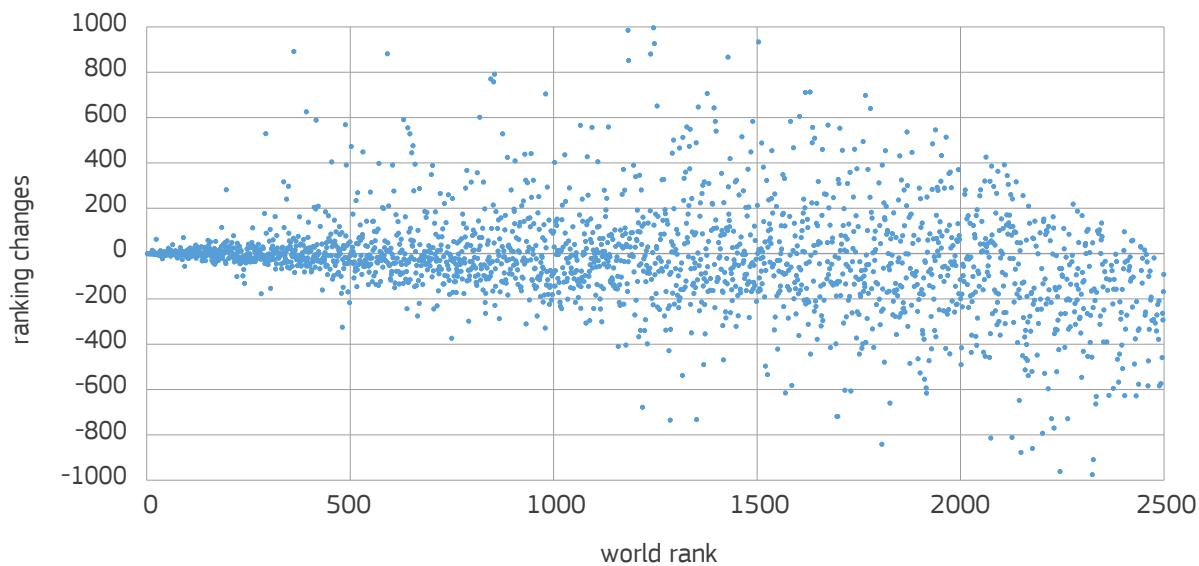
top 10 of the 2021 Scoreboard show a much more modest increase of R&D between 2016 and 2021 with Volkswagen's CAGR only barely positive.

Top 2500 year-on-year

The set of those top 2500 R&D investors appearing in both the 2020 and 2021 Scoreboards consists of 2271 companies. This set invested a total of EUR867.8bn in 2021, i.e. 95.4% of the total Scoreboard. It is clear that changes in the rankings are smaller near the top of the ranking and gradually increase towards the bottom (Figure 1.10). The two lowest quintiles (i.e. between 1500 and 2500) have only a few companies with small

changes to their rankings – there are visibly fewer dots on the horizontal axis in this part of the chart. In contrast, the top 500 points are on the axis or close to it indicating relatively little change. We computed also the average changes in position (Table A3.2, Appendix); these are smallest in the upper parts of the ranking, despite the presence of outliers, and gradually increase down towards the bottom.

Figure 1.10: Distribution of ranking change between SB2020 and SB2021.*



Note: for better visibility, the extreme outliers have been removed. See the text for discussion.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.3 in the Appendix lists the extreme outliers. From among the largest rises and falls we mention China Evergrande (China, Automobile & other transport) that has risen 2,140 places (currently 242nd) by investing €683 million this year after €38 million. According to its 2020 financial report⁵⁵, the company has massively

increased its R&D expenditure on new energy vehicles. However, based on the accounts there were no significant acquisitions during 2020. The other extreme outliers involve lower ranked companies with lower amounts of R&D invested. Further to these cases, we analysed the most important changes in the top quintile

⁵⁵ <https://www1.hkexnews.hk/listedco/listconews/sehk/2021/0429/2021042902969.pdf>



of the ranking. We observed that, apart from a few cases (2 or 3 companies), there are no major changes in the top 100 group of companies that account for ca. 50% of the total R&D invested by the 2500 firms included in the Scoreboard. Concerning the top 500, we identified four main groups of companies: large drops in the ranking without dropping out of the first quintile, fallouts followed by a large drop, entry into the top 500 from other quintiles, and ranking improvements within the first quintile. These are discussed below.

Larger drops within the top 500 quintile

The first company from the 2020 ranking with a significant drop in ranking was Leonardo S.p.A., the Italian aerospace, defence and security company, which significantly reduced its R&D activity spending only €560 million in 2020 as opposed to the €1.6bn in 2019. This company lowered its ranking by 176 positions, to become only the 281st largest investor in 2020. Another “falling star” is Dupont de Nemours, Inc. which lost 130 positions (down from the 110th place in the previous year) because of a drastic decrease of its R&D investment. This was due to the divestment of DowDuPont into three separate companies and is explained in DuPont’s form 10-K of December 2020 as due to “productivity actions as well as the absence of R&D costs previously allocated to the materials science and agriculture businesses” (DuPont de Nemours, Form 10-K, December 31, 2020, p.38)⁵⁶. Another company that reduced its R&D and fell by 324 positions after being the 156th in SB2020 is United Therapeutics (US). According to their financial report, this reduction was due to a one-off up-front payment of \$800 million⁵⁷.

Exits from the top 500

Exits from the top 500 consist of companies from the bottom third of the top 500 of Scoreboard 2020 and there are 51 such companies, 16 from the US, 10 from the EU, 9 from Japan, and 5 from China. Sector-wise they are more evenly distributed, except for ICT (the largest sector in the Scoreboard), which is “represented” by 13 of the 51 companies (services and producers). 40 companies

fell into the second quintile of Scoreboard 2021 and the remaining 11 dropped out of the Scoreboard. The most notable companies in these groups are Bombardier (Canada, aerospace) falling by 374 positions to 750th place, Sohu.com (China, ICT) falling by 275 places to 666th position and Visteon (US, automobiles), positioned in 792nd place after a falling by 298 places. The reasons behind these changes vary from one company to another. For example, the decline in R&D spending by Bombardier may be linked to the company’s restructuring and disposing of its most R&D intensive programs⁵⁸. However, companies do not necessarily disclose the reasons behind changes in their R&D. The complete list of fallouts is in Table A3.4 of the appendix.

Entry into the top 500

Out of the 51 entries into the top 500, 14 companies are included in the Scoreboard for the first time and a further 37 entered into the first quintile after an increase in their ranking positions from Scoreboard 2020 (Table A3.5, Appendix). They are situated mostly in the lower half of the top 500, and they mainly come from the second quintile of the previous year’s Scoreboard (32 companies). 23 of them are headquartered in China, 15 in the US and 8 in the EU (DE and NL, FR, SE). Unlike the previous group (i.e. companies that fell out of the top 500), companies entering the first quintile are active mainly in ICT (20 firms) and in health industries (9 enterprises), the latter clearly stemming from the impact that the Covid pandemic had on this industry. Apart from the outliers mentioned earlier, the most notable changes were registered by Novavax (US, health industries), which almost quintupled its R&D investment (ca. €400 million in 2021) as a response to the Covid-pandemic and it therefore rose by 893 places to 361st place; China State Shipbuilding Corporation (CSSC) tripled its R&D (€368 million) because of its merger with China Shipbuilding Industry Company (CSIC) in 2019 and its strategic plans⁵⁹ and gained 627 positions in the scoreboard, to 392nd place; and Chinese truck manufacturer Faw Jiefang that improved its ranking by 590 positions to 416th place because of a threefold increase in R&D investment⁶⁰.

⁵⁶ [https://s23.q4cdn.com/116192123/files/doc_financials/2020/ar/DuPont-2020-10-K-\(Final\).pdf](https://s23.q4cdn.com/116192123/files/doc_financials/2020/ar/DuPont-2020-10-K-(Final).pdf)

⁵⁷ https://s1.q4cdn.com/284080987/files/doc_financials/2020/q4/UTHR-10-K-2020-vFINAL-2-23-21.pdf

⁵⁸ <https://globaladvantageconsulting.com/what-is-behind-bombardiers-decline-in-rd-spending/>

⁵⁹ <https://www.iiss.org/blogs/military-balance/2020/09/china-shipbuilding-merge>

⁶⁰ <https://sg.news.yahoo.com/state-owned-faw-jiefang-pledges-061053762.html>

Ranking improvements within the top 500

179 companies in the top 500 improved their ranking positions. Somewhat more than half of them (95 companies) were in the upper part of the quintile already last year (SB2020). Their year-on-year R&D investment has typically (on average) grown by 20-21%. This emphasizes once more the relative concentration of R&D expenditures in companies situated in the upper reaches of the Scoreboard, in this case the top 100 that invests ca. 52% of the total Scoreboard R&D. The most notable rises in ranking were by ICT companies, such as L3Harris Technologies (US, 283 positions up reaching 195th place), China United Network Communications (CN, 178 places

up to reach the 289th) as well as AMS AG (AT, 164 places up from last year's 479th). These companies have typically increased their previous year's R&D by 60-80%, except for Harris, which slightly more than tripled its prior year's investment of €270 million. The reasons include an increase in own R&D effort (all three companies), mergers (AMS AG buying OSRAM Group⁶¹), contracted R&D (L3Harris⁶²). Despite the relatively lower change in the ranking positions, Nippon Telegraph and Telephone Corporation (63 places up, to become the 23rd largest R&D investor), increased its R&D investment slightly more than threefold (3.1x) to reach €3.8bn from its already high 2019 value of €1.77bn. The increase stems mainly from increased efforts of the company⁶³.

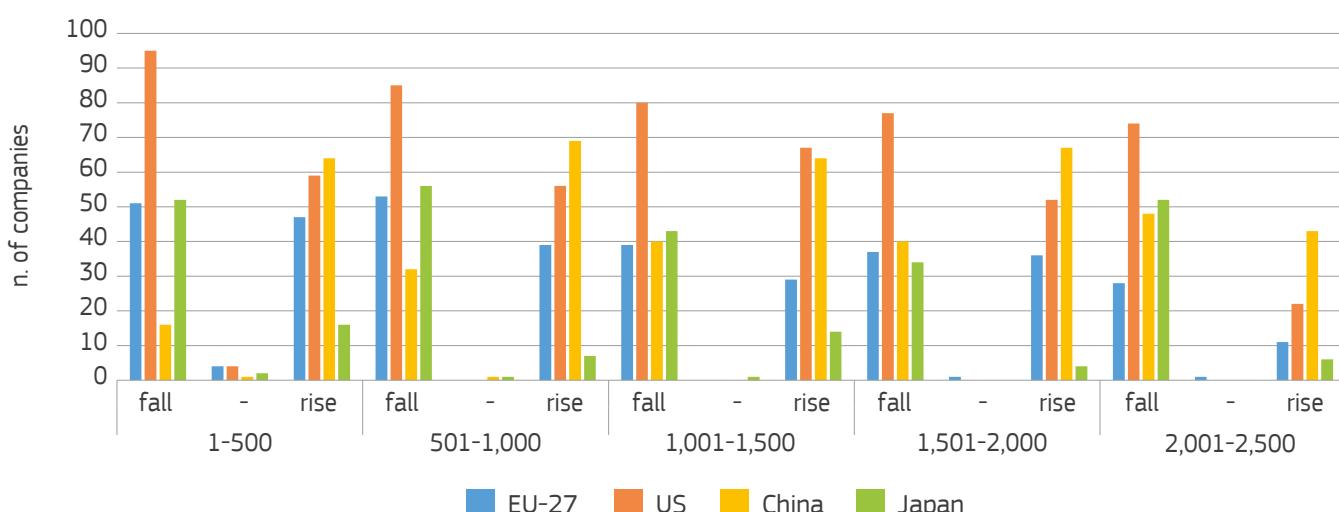
Quintile analysis: year-on-year changes

Headquarters' country

The quintile distribution of the changes in the rankings per countries shows that China managed to improve its companies' rankings in each of the quintiles at the expense of its main competitors between last year's and

this year's Scoreboards. While the US and EU companies still outnumber those of China in the top 500, the latter saw the most rises (improvements in ranking position) and the fewest drops (worsening of ranking positions) in the number of companies that have changed their rankings. (Figure 1.11a).

Figure 1.11a: Changes in the number of companies per quintile groups and regions in SB2020-SB2021 (fall=worsening of the ranking, rise=improvement of the ranking).



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁶¹ <https://ams.com/documents/20143/3749114/ENG+Gesch%C3%A4ftsbericht+ams+2020+DS.pdf/63deea0f-89c9-04c4-5713-be8452540734?t=1631521897905>

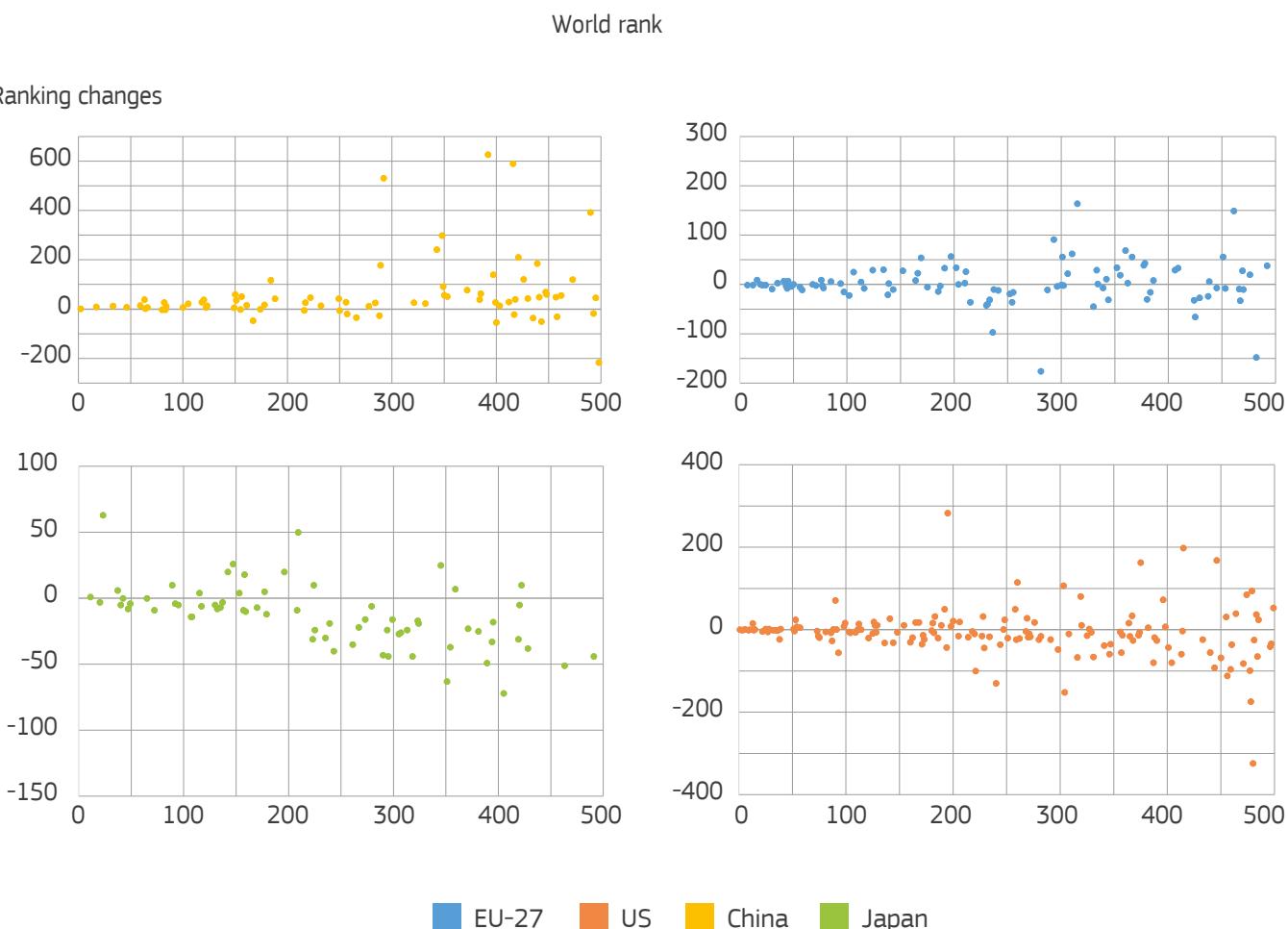
⁶² https://www.l3harris.com/sites/default/files/2021-03/L3Harris_2020_AnnualReport.pdf

⁶³ https://group.ntt/en/ir/library/annual/pdf/annual_report_20.pdf

Therefore, in terms of position change, Chinese companies have gained probably the most in the top 500 (Figure 1.11b),⁶⁴ followed by their EU counterparts. On the other hand, Japanese and US companies' rankings tend to fall or increase/change less. Ranking of companies from China looks to be the most "volatile".⁶⁵ This suggests that these companies' growth may be more dynamic than that of their competitors.

Figure 1.11b: Distribution of y-o-y ranking change in SB2020-SB2021 in the four main competitor regions – top 500.*

The possible reasons behind this evolution could be multiple: younger age and more dynamic growth phase, higher R&D capital injections from private and public sources, more lively M&A market, etc. Coupled with growing net R&D investments, this increased significantly China's importance as a top 500 R&D investing region (Figure 1.11c). One also observes from this figure that, while the top 500 saw the largest rises and falls in R&D investment, the overall changes in other cohorts are relatively low or close to zero.



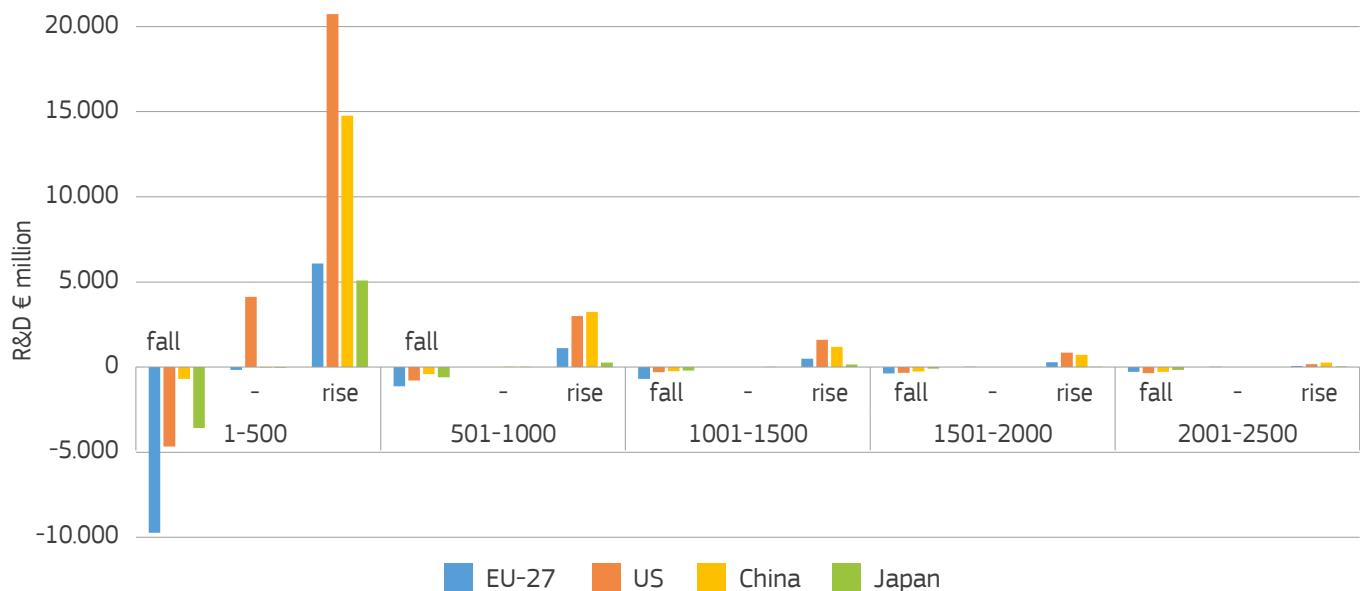
Note: *: after excluding outliers; **: the metric is only for illustration, it should not be used for computational purposes.

⁶⁴ Outliers are excluded

⁶⁵ Shown by their relatively higher standard deviation - the figures are only indicative, not for computational purposes. Overall, while Chinese, EU as well as US companies had a similar variation in the ranking change, Japanese companies saw much smaller changes. Further analysis would be needed to understand what drives (if anything at all) the Japanese case.



Figure 1.11c: Changes in the volume of R&D investments by quintile group and region in SB2020-SB2021 (fall=worsening of ranking, rise=improvement of ranking).



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The EU is the only region in the top 500 for which the increase in investments by companies registering an improvement or a stagnation of their rankings as well as new entrants did not offset the decrease of R&D by companies that worsened their ranking (Figure 1.11c top 500, and Table 1.5). US companies are still investing the largest amounts both as a whole

(€262bn) as well as average per company (€1.6bn) and they are followed by the EU, Japan and finally China⁶⁶. The latter region managed somewhat to catch up on the average investments per company (increase by €179 million of China vs. €135 million of the US), but the gap is still significant compared to either the EU or the US.

Table 1.5: Changes in the volume of R&D investments in the top 500 by ranking change type and regions in SB2020-SB2021 (fall=worsening of the ranking, rise=improvement of the ranking).

Region	fall	-	rise	entry	Total change in R&D (€ million)	Total # comps	Total R&D in SB2020 (€ million)	Total R&D/comp (€ million)	Change in R&D/comp (€ million)
China	-690	-29	14,757	1,510	15,548	87	80,433	925	179
Japan	-3,575	-36	5,078	0	1,467	70	87,405	1,249	21
US	-4,668	4,128	20,727	1,883	22,069	163	261,739	1,606	135
EU	-9,729	-165	6,093	-66	-3,867	105	156,919	1,494	-37

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁶⁶ The four economic regions represented on the graphs account for 85% of total changes (falls/rises) in the number of companies and 90% of the changes in the R&D investments.

Chinese companies improved significantly their rankings and increased their investments in other cohorts as well, mainly at the expense of its main competitors (i.e. the US and the EU) except for the very bottom 500 of the ranking. In each cohort, the number of EU companies that fell in rank is higher than those that rose. The EU showed the highest losses in the top 500 in terms of both rankings and R&D investment. In the other cohorts, the R&D investment was approximately preserved, although the drops in ranking were higher in general⁶⁷. Overall, the differences among the main competitors with respect to the average change in R&D investment per company are lower than the one in the top 500 (last column of Table 1.5): on the Scoreboard (i.e. top 2500 companies) level the EU faced an R&D investment decrease by ca. €11 million per company included without new entries.⁶⁸ The US saw an increase by €36 million, China by €38 million, and Japan by €3 million (Table A3.7, Appendix).

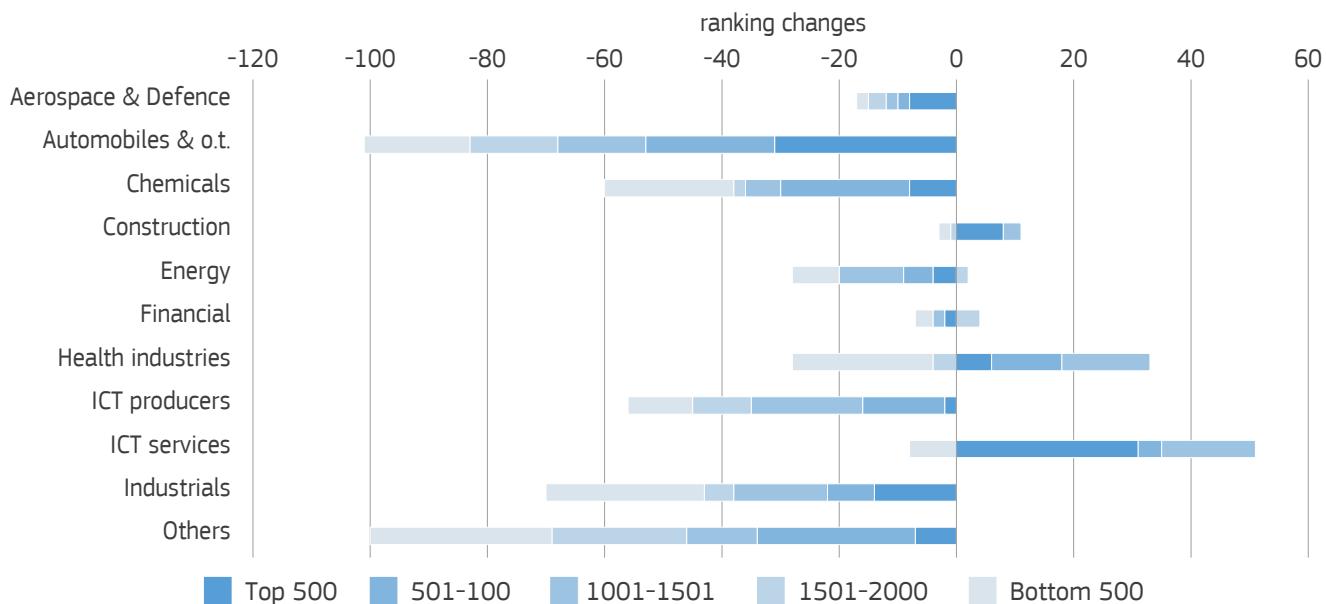
The further down we go in the ranking the higher the number of new entries, with the 2001-2500 cohort having the most (Table A3.6, appendix). This is to be expected: the lower the R&D investment the easier it is to enter

(and also to exit as we will see in the following). Chinese companies lead the number of new entries, though the highest number of new Chinese entrants are in the lowest cohort. In the top 500, there are very few new entrants and their number is evenly distributed among the three main economic regions of the Scoreboard. The number of new EU entrants is remarkably low.

Sector of activity

The quintile distribution of the changes in rankings per sector of activity show that most recent year-on-year net changes in ranking (difference between rises and falls) took place unevenly in the various sectors and various parts of the ranking quintiles (Figure 1.12). It is notable that the number of automotive firms in the top 500 fell by 30 and that in health industries the largest fall was in companies in the bottom 500. To a large extent these changes result from M&A in sectors which have been consolidating. While ICT services and health industry companies mainly increased in position, automotive, industrials, ICT producers, chemicals and ICT producers all showed drops in ranking.

Figure 1.12: Net changes in the number of companies per quintile groups and sectors of activity in SB2020-SB2021.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁶⁷ France and Germany account for the half of the changes in the EU in general.

⁶⁸ The ratio of the total change in the investment and the total number of companies included in the ranking without the new entries

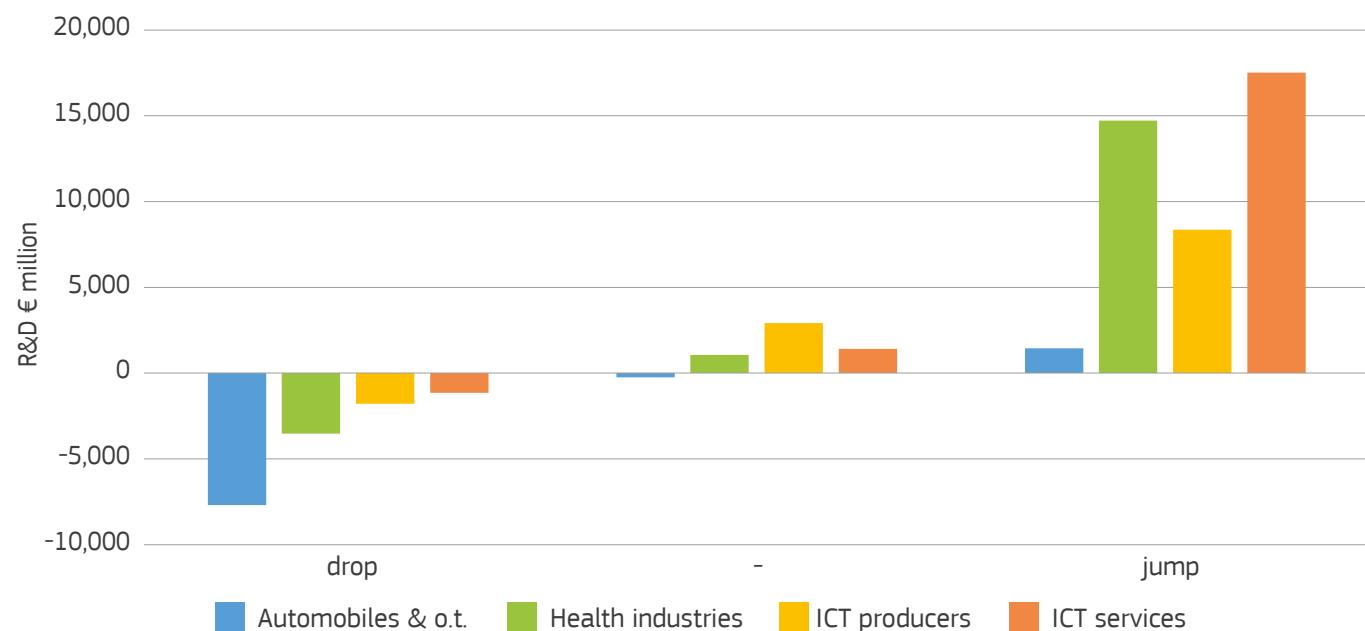


Similarly to the R&D dynamics per quintile groups and geographic regions, the top 500 saw the largest rises and falls of R&D investments, the overall changes in other cohorts are relatively low or close to zero (Figure A3.2, Appendix).

Changes in R&D investment by those of the top 500 companies worldwide that improved their rankings more than offset reductions in R&D by companies in the same quintile that worsened their rankings

in three of the four key sectors of activity: health industries, ICT producers, ICT services (Figure 1.13). In contrast, the automotive sector experienced a net loss of around €5.9bn. In the group of companies that maintained their ranking, those in the automotive sector (5 companies) slightly decreased their R&D, whereas those in the other three sectors (altogether 10 companies) still increased theirs. This will make it difficult for the automotive companies to improve their ranking for next year.

Figure 1.13: Changes in R&D in the main sectors of activity by ranking change type in the top 500.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Entries and exits in 2020-21

The number of companies that entered/dropped out of the ranking increased to 278 from last year's 233, indicating a slightly increased volatility, especially for the bottom ranks. There is a clear (logical) inverse relationship between the number of entries/ exits as well as their ranking group, i.e. the turnover is growing towards the lower quintiles. (Figure 1.14).

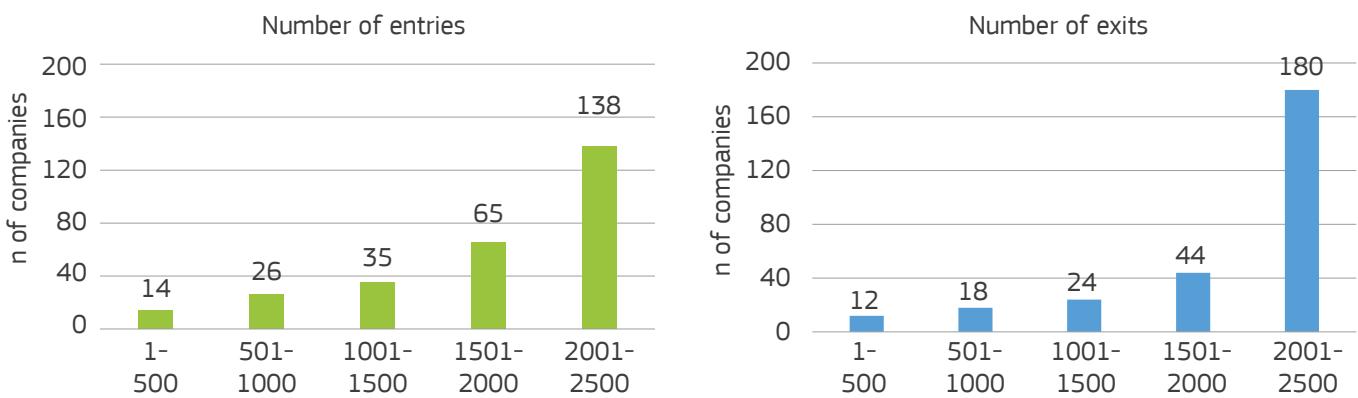
45 companies entered from below the bottom of SB2020 (places between 2,505 and 2,949), and there are 233 completely new entries compared to last year⁶⁹. Shares of "lost" or "newly acquired" R&D⁷⁰ are low; its total share was 2.3% for exits and 3.2% for entries (Figure A3.3, appendix). The highest position was 100 (Allergan, health, which was acquired by AbbVie) for the exits and 69 (Airbnb, ICT services) for the entries.

⁶⁹ Some of the "new" entrants may be returnees from Scoreboards of previous years.

⁷⁰ By "lost" R&D we mean the R&D investments linked to exiting companies, and by "newly acquired" R&D we mean the investments by entrants.



Figure 1.14: Entry/exits dynamics of the scoreboard.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Concerning geographic regions and sectors of activity, China increased, at the expense of its main competitors, its number of companies in each of the key sectors of activity. The EU managed to preserve the same number of companies in ICT services,

but dropped slightly in the other three key sectors (automotive, IC producers, health). The single figure that stands out most in table 1.6 is the net increase of 28 in US ICT services companies – this emphasises the US's strong global lead in this sector.

Table 1.6: Number of companies that entered SB 2021 and exited SB2020 by region and sector of activity.

# of companies	Exit						entries						net					
	CN	EU	JP	US	RoW	Sum	CN	EU	JP	US	RoW	Sum	CN	EU	JP	US	RoW	Sum
Aerospace & Defence				1	2	3				1	1	0	0	0	-1	-1	-2	
Automobiles & o.t.	5	5	1	1	4	16	5	1	1	3	2	12	0	-4	0	2	-2	-4
Chemicals	1	4		4	2	11	4			1	0	5	3	-4	0	-3	-2	-6
Construction		1	1		1	3	5			0	5	5	-1	-1	0	-1	2	
Energy	1	2	1	2	2	8	2	2		0	4	1	0	-1	-2	-2	-4	
Financial		2		1	0	3	4	8		1	1	14	4	6	0	0	1	11
Health industries	5	13	3	57	12	90	23	5		51	7	86	18	-8	-3	-6	-5	-4
ICT producers	13	2	3	10	8	36	17		1	8	6	32	4	-2	-2	-2	-2	-4
ICT services	6	3		12	9	30	17	3	2	40	1	63	11	0	2	28	-8	33
Industrials	10	6	5	8	5	34	14	1		2	17	4	-5	-5	-8	-3	-17	
Others	12	7	7	8	10	44	23	5	1	4	6	39	11	-2	-6	-4	-4	-5
Total	53	45	21	104	55	278	114	25	5	108	26	278	61	-20	-16	4	-29	0

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



Concerning R&D investment flows (Table 1.7), there has been an apparent significant decrease in the EU health R&D investments due to the exit of Allergan (headquartered in Ireland) because of the merger with U.S. pharmaceutical company AbbVie, the merged company is domiciled in the US⁷¹. On the other hand, despite very small movements (both gross and net) in the ICT producers sectors in the EU in terms of number of companies, the overall net R&D increased significantly (almost €1bn) with the entrance of Siemens Energy AG. Likewise in the automotive sector, where

the entry of Faurecia (automotive parts manufacturer) and the exit of five smaller manufacturers has resulted in a net increase of R&D by €839 million. The net increase of the US R&D by €5.8bn comes from the entry of Airbnb (€2.2bn) and a number of smaller players. In China, the innovative technology provider ANT Group boosted the R&D of the "Financial" sector by €1.3bn. The single figure that stands out most in table 1.7 is the net €5.8bn increase in US ICT services R&D. The second largest figure is the net €2.4bn reduction in EU health R&D.

Table 1.7: R&D "acquired" and "lost" via entries and exits (R&D € millions).

	exits (SB2020, adjusted for e/r)					
	CN	EU	JP	US	RoW	Sum
Aerospace & Defence	0.0	0.0	0.0	44.4	72.7	117.1
Automobiles & other transport	286.7	348.4	34.4	164.6	461.8	1295.9
Chemicals	67.4	245.9	0.0	131.8	452.8	897.8
Construction	0.0	38.3	34.8	0.0	32.8	106.0
Energy	104.2	147.7	35.0	317.8	104.7	709.4
Financial	0.0	89.3	0.0	32.6	0.0	121.8
Health industries	570.0	2626.8	103.8	3508.7	474.5	7283.8
ICT producers	859.9	237.2	126.1	1248.9	604.0	3076.1
ICT services	585.5	161.8	0.0	1144.6	564.9	2456.8
Industrials	489.2	305.9	188.9	295.7	187.7	1467.4
Others	484.0	677.6	248.9	301.6	735.3	2447.5
Total (exit)	3446.9	4878.9	771.9	7190.7	3691.2	19979.6

⁷¹ <https://www.biopharmadive.com/news/abbvie-deal-for-allergan-not-about-the-taxes-thanks-to-2017-law/557693/>



	entries (SB2021)					
	CN	EU	JP	US	RoW	Sum
Aerospace & Defence	0.0	0.0	0.0	0.0	59.2	59.2
Automobiles & other transport	677.5	1187.3	98.6	327.7	76.0	2367.1
Chemicals	265.5	0.0	0.0	43.9	0.0	309.4
Construction	287.3	0.0	0.0	0.0	0.0	287.3
Energy	80.0	1216.4	0.0	0.0	0.0	1296.4
Financial	1727.7	808.7	0.0	39.4	66.6	2642.5
Health industries	1353.1	257.7	0.0	3509.8	425.2	5545.7
ICT producers	1145.7	0.0	36.7	565.6	289.5	2037.6
ICT services	2274.6	166.4	155.2	6927.6	44.6	9568.4
Industrials	569.0	49.5	0.0	0.0	285.5	903.9
Others	2068.2	1682.3	43.0	222.4	349.6	4365.5
Total (entries)	10448.5	5368.4	333.5	11636.5	1596.3	29383.1

	net					
	CN	EU	JP	US	RoW	Sum
Aerospace & Defence	0.0	0.0	0.0	-44.4	-13.4	-57.9
Automobiles & other transport	390.9	838.9	64.2	163.1	-385.9	1071.2
Chemicals	198.1	-245.9	0.0	-87.9	-452.8	-588.5
Construction	287.3	-38.3	-34.8	0.0	-32.8	181.3
Energy	-24.2	1068.8	-35.0	-317.8	-104.7	587.1
Financial	1727.7	719.4	0.0	6.9	66.6	2520.6
Health industries	783.0	-2369.1	-103.8	1.1	-49.3	-1738.1
ICT producers	285.8	-237.2	-89.4	-683.3	-314.5	-1038.5
ICT services	1689.1	4.6	155.2	5783.0	-520.2	7111.7
Industrials	79.8	-256.4	-188.9	-295.7	97.9	-563.5
Others	1584.1	1004.7	-205.9	-79.2	-385.8	1918.0
Total (net)	7001.6	489.5	-438.4	4445.8	-2094.9	9403.5

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Sectors and regions: now and then

Comparing the 2016 and the 2021 Scoreboards, the dynamics of companies (number, volume of R&D invested) in the main investor regions (China, US, EU, Japan) by sectors of activity (in particular automotive, health industries, ICT services and ICT producers) were examined. The most important development in the global R&D ranking is the increased presence of high-tech companies, mainly from China, which comes at the expense of more “traditional” sectors, mainly from the EU and Japan (Table 1.8). China’s presence increased very significantly through the addition of 269 companies to the 327 included in the 2016 scoreboard (Table A3.8, appendix). Overall decreases

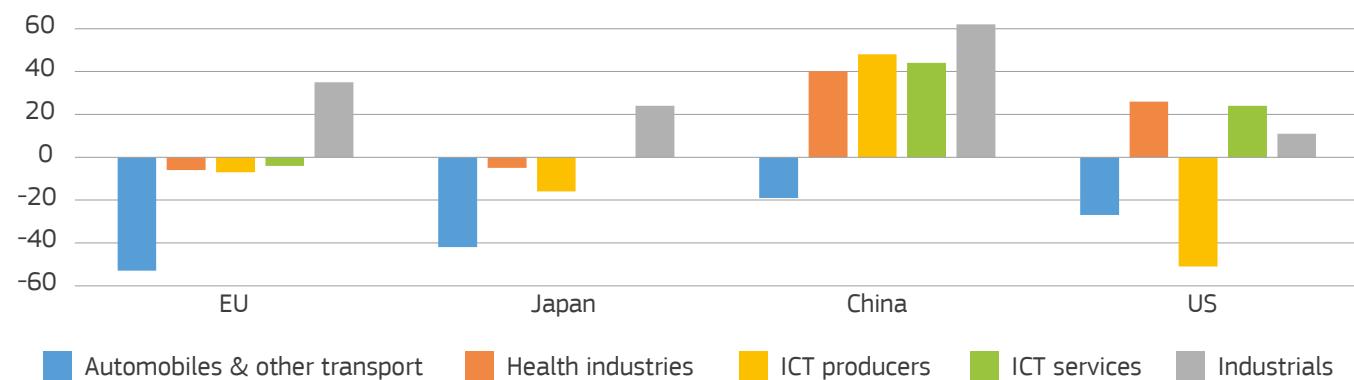
in the case of the EU, the US and Japan are of similar magnitude, but their mix is least concerning for the US, which managed to increase its presence in two of the key global sectors, i.e. health industries and ICT services, thanks to its sustained investment in software, internet and computer services technologies as well as in pharmaceuticals and biotechnology. The EU lost both R&D and number of companies in all four key sectors, slightly in ICT and health, more in automotive. However, it increased in industrial machinery and general industrials, which are two sub-sectors that encompass a number of medium-low and medium-high tech industries and some more or less knowledge intensive services – all these are included more generally in the group of “Industrials” (Figure 1.15).

Table 1.8: Net change in the number of companies by region and sector of activity between SB2016 and SB2021.

	EU	Japan	China	US	Total
Aerospace & Defence	-2	-1	0	-6	-10
Automobiles & other transport	-53	-42	-19	-27	-171
Chemicals	-3	-4	17	-10	-1
Construction	-10	-3	19	-4	-2
Energy	-2	-3	5	-5	-11
Financial	0	1	10	-2	8
Health industries	-6	-5	40	26	58
ICT producers	-7	-16	48	-51	-68
ICT services	-4	0	44	24	47
Industrials	35	24	62	11	142
Others	-4	-14	44	-14	8
Total Scoreboard	-56	-63	270	-58	0

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 1.15: Main changes of presence (number of companies) for the main geographic regions between 2016 and 2021.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The main positive change in the sectoral mix is the significant increase of the number of industrials for China, the EU and Japan⁷² as well as that of health and ICT services for the US (Table 1.9). There is practically no change in the representation of different sectors for each region: the EU is significantly underrepresented in the ICT sectors and rather overrepresented in energy, financials and industrials; the US is significantly over-represented in health and ICT services, and strongly under-represented in industrials. China is pretty much under-represented in health industries. Finally, Japan is very much over-represented in chemicals and under-represented in health and ICT services, the latter being the largest difference in proportion overall⁷³.

In contrast, the mix that takes into account R&D investment looks to be much more stable across time (Table 1.10). Despite the significant across-the-board decrease in the number of companies in the automotive sector, its share has not changed significantly in the investment mix, except for China where one observes a clear divestment and shift towards ICT producers and industrials. No major change can be observed in case of the EU. The US has somewhat shifted its investment away from the automotive sector and turned towards ICT services and health. Together with similar changes in the number of companies, the move towards higher value added R&D means that the US is most probably moving further up in the global value chains than its main geographic competitors.

⁷² In all cases at the expense of the automotive sector

⁷³ We represent, but not analyse sectors such as Aerospace & Defence or Construction –weakly represented in the Scoreboard in general.

Table 1.9: Structure of company presence in various sectors of activity by main geographic regions – no. of companies included (orange= lower than the scoreboard average, yellow= higher than the scoreboard average).

Sector, %	SB average		EU		EU		China		US	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
Aerospace & Defence	2.1	1.7	2.6	2.5	0.3	0	1.5	0.8	2.3	1.7
Automobiles & other transport	14.2	7.4	19.9	9.5	21.9	12.3	19.6	7.5	7.4	4.5
Chemicals	5	5	4.2	4	10.7	11.6	3.4	4.7	4.2	3.2
Construction	2.8	2.7	3.9	2	4.5	4.4	4.9	5.9	1	0.5
Energy	3.7	3.3	6.6	7	4.2	4.1	4	3	1.6	1
Financial	2.4	2.7	5.7	6.5	0	0.3	0.9	2.2	1.3	1.2
Health industries	18.7	21	17.1	18	10.7	11.3	9.8	12.1	30.1	35.7
ICT producers	21	18.3	12	12	19.4	18.1	24.8	21.6	20.4	15.4
ICT services	12.3	14.2	7.9	8	2.8	3.4	11.3	13.6	19.8	24.4
Industrials	5.3	11	6.8	16.5	7	16.7	8.3	14.9	2.7	4.4
Others	12.5	12.8	13.3	14.2	18.5	17.7	11.6	13.7	9.2	8.1

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table 1.10: Structure of company presence % R&D in various sectors for the main geographic regions.

R&D invested, %	SB2016					SB2021				
	EU	Japan	China	US	Total SB	EU	Japan	China	US	Total SB
Aerospace & Defence	5	0	0	3	3	3	0	0	2	2
Automobiles & other transport	35	33	18	9	19	34	30	9	6	15
Chemicals	3	7	1	3	3	3	7	1	1	2
Construction	1	1	14	0	2	1	1	13	0	3
Energy	3	1	7	2	2	3	1	4	1	2
Financial	5	0	1	1	2	4	0	2	1	2
Health industries	19	12	3	26	21	20	12	6	27	21
ICT producers	15	20	34	26	23	14	18	27	24	23
ICT services	6	4	12	24	13	8	8	18	32	19
Industrials	3	7	4	3	3	6	8	9	2	5
Others	5	14	6	5	7	6	14	9	4	7

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

1.4 Financing companies' innovation activities.

The R&D reported in the Scoreboard is the cash investment funded by the companies with their own internal resources. However, R&D and innovation can be also financed by external sources through a variety of funding tools provided by different financial intermediaries and investors.

This section describes two types of sources of financing used by the Scoreboard companies: Corporate Venture Capital (CVC) that is particularly important at early stages of the innovation cycle and Green Bonds (GBs) aimed at financing green tech activities.

1.4.1 Corporate Venture Capital

Companies' investment in promising start-ups and scale-ups is generally performed via CVC funds. Establishing and operating a CVC fund serves several strategic interests. Firstly, it can serve as a vehicle to complement the firm's internal innovation capability or widen its product portfolio⁷⁴. Investments in start-ups, and eventually their subsequent acquisition, may also serve to fix emerging internal weaknesses in the internal innovation capability of the company.⁷⁵ In addition, investing in start-ups can be a relatively low-risk approach to diversifying the product portfolio by exploring new, potentially attractive, lines of business. In both cases, it is a strategy to tap into external knowledge and review the availability of new talents. Often the economic reasoning is that it may be more efficient and economical (quicker or cheaper) to buy-in the knowledge rather than to develop it in-house. Furthermore, it preserves an 'organizational opportunity cost' since start-ups enjoy a high degree of operational agility that large firms do not always possess.

This section presents some insights on CVC investments by Scoreboard companies targeting start-ups. To this aim, we matched the top R&D investors from

the 2020 Scoreboard and their subsidiaries with the companies listed as investors on Dealroom.co (DR), a provider of funding deal data that specializes in start-up companies.⁷⁶ We identified 1557 distinct Scoreboard companies that invested in start-ups and scale-ups in the period 1999-2020.

Overall, 62% of the 2500 Scoreboard companies have invested in start-ups and scale-ups at least once in the period 2000-2020. Furthermore, 344 distinct Scoreboard Companies (22% of the matched distinct Scoreboard companies) took part in at least one start-up deal in the year 2019.⁷⁷ The majority of these are in the top tier of the Scoreboard ranking, with 55% placing in the top 20% in terms of global R&D. The above confirms the strategic value of corporate VC investments.

Figure 1.16 illustrates the number of deals and amounts invested by the 1557 entities mentioned above during the period 1999-2020⁷⁸ and shows an overall upward trend during the past two decades with some slowdowns, particularly around the times of the dotcom crash and the financial crisis.

⁷⁴ MacMillan, I. C., Roberts, E. B., Livada, V., & Wang, A. Y. (2008). Corporate venture capital (CVC) seeking innovation and strategic growth: Recent patterns in CVC mission, structure, and investment. National Institute of Standards and Technology, US Department of Commerce.

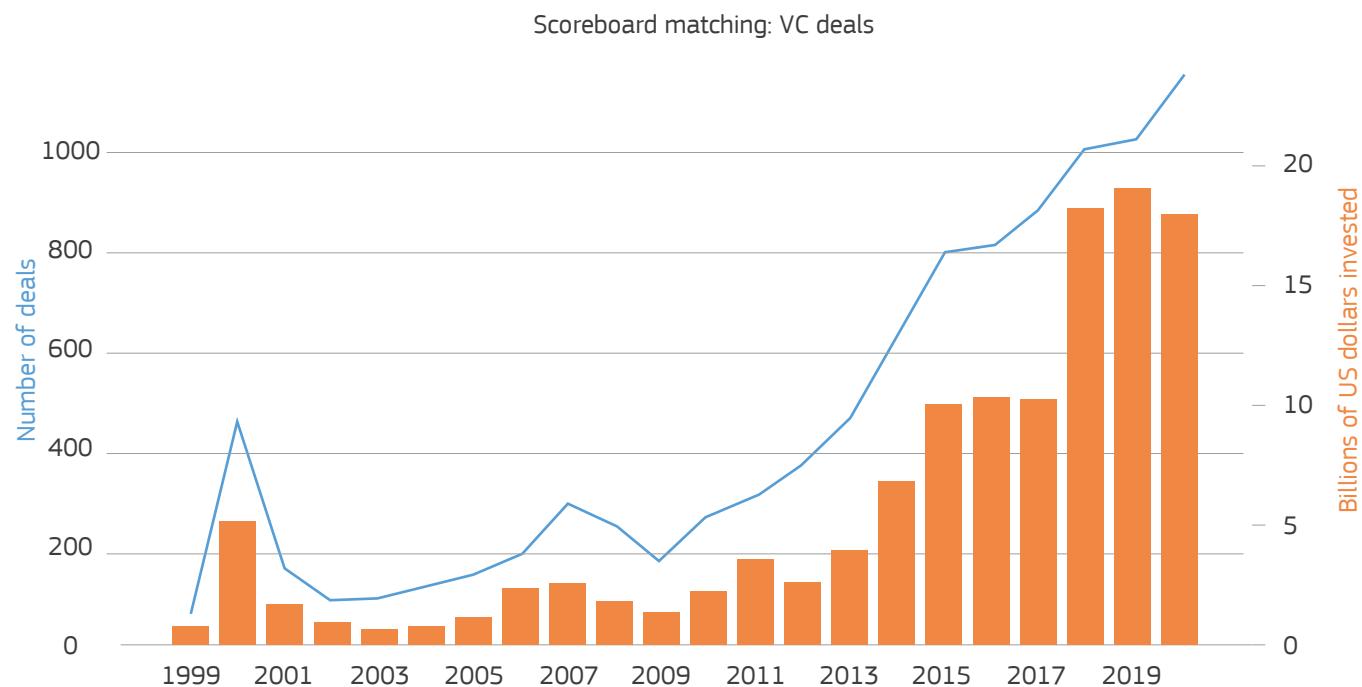
⁷⁵ Ma, S. (2020). The life cycle of corporate venture capital. *The Review of Financial Studies*, 33(1), 358-394.

⁷⁶ Some Scoreboard companies operate via subsidiaries or the mother company has several financial vehicles for investment purposes. Thus, the number of legal entities carrying the investment (3745) is higher than the Scoreboard companies we can match (1557).

⁷⁷ S2019 is the last year where we consolidated, have full coverage. For successive dates the data may be still be adjourned.

⁷⁸ In the following tables and graphs we exclude Japanese Scoreboard firm SoftBank. Softbank runs the 'Vision Fund', which is the world largest technology-focused venture capital fund with over \$100 billion in capital. The way this multinational conglomerate holding companies operates resembles largely a financial VC firm, rather than a Corporate VC. Softbank's investments in 2019, in its vast majority in Software and IT services related ventures, were in the order of magnitude of 9985,86 m€ and would distort the objective of focussing on CVC.

Figure 1.16: Number of deals (left scale) and amounts spent (histogram – right scale) by Scoreboard Companies and their subsidiaries in the period 1999-2020.



Note: funding data for the year 2020 not yet consolidated

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The first decline occurs in 2001, likely due to the bursting of the dot.com bubble. Investments also dipped, albeit not as much, during the aftermath of the 'Great Recession' in 2008. Finally, the non-consolidated data for 2020 seem to indicate a new reduction, suggesting that some investments were postponed due to the outbreak of the Covid pandemic. This would mirror the slower growth of R&D investment in 2020 as reported in chapters 1-3 and, in the case of the EU and Japan, the overall reduction in R&D expenditure. It is worth noting that the evolution of the Scoreboard company-backed CVC trend follows the same pattern as the ensemble of all VC investors during the same period.⁷⁹

To address the question of how important CVC is for Scoreboard companies, we compared the total direct R&D investment by these companies in 2019 (as per

the 2020 edition of the Scoreboard) with total CVC investment in the same year. For 2019, we identified 344 distinct Scoreboard Companies, which invested either directly or via their subsidiaries an overall amount of €16 983bn in VC-backed companies. When we compare this figure to the overall R&D investment carried out by the Scoreboard companies in the same year (which totals €916 472bn), we find that CVC investment by top R&D investors worldwide equals 1.9% of their internal R&D investment. This is a considerable amount in volume terms given the magnitude of the figures and similar to results for a similar exercise for US-based CVC investment.⁸⁰

For this purpose, Table 1.11 breaks down the total R&D investments and Corporate Venture Capital investments by sector for the year 2019.

⁷⁹ PwC Money Tree - Quarterly U.S. Venture Capital Investments 1995-2021

<https://www.pwc.com/us/en/industries/technology/moneytree/explorer.html#/type=history&category=¤tQ=Q4%202018&qRangeStart=Q1%202100&qRangeEnd=Q1%202021&chartType=bar>

⁸⁰ Ma (2020) finds that investments by CVCs affiliates with U.S. public firms account for 2-3% of US corporate R&D (with a maximum of 4.5% in the period close to the dot-com bubble).

Table 1.11: Sectoral breakdown of the comparison of total R&D investment and CVC investment by Scoreboard companies.

Sector	Total R&D investments by SB companies (€million) *	Total investments via CVC (€million)	Ratio
Aerospace & Defence	20742	55	0.3%
Automobiles & other transport	166258	3038	1.8%
Chemicals	23606	154	0.7%
Construction	19591	87	0.4%
Energy	17981	471	2.6%
Financial	17319	2151	12.4%
Health industries	188592	1616	0.9%
ICT producers	210012	3590	1.7%
ICT services	154463	4375	2.8%
Industrials	32359	131	0.4%
Others	65549	1315	2.0%
Total	916472	16984	1.9%

Note: * This column does not include CVC investments

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The breakdown by sector shows that the largest amount of CVC investment comes from ICT services, followed by ICT producers. This is not unexpected, since software and hardware producers together with biotechnology are traditionally being backed up by VC instruments. The largest fraction under the ICT services umbrella originates from the big players such as Amazon, Facebook, Google and other multinational companies.

Financial services come in fourth in terms of CVC volume and first in terms of share of investment. This is not surprising as currently one fifth of all VC (private and corporate) investments flow into this sector.⁸¹ The bulk of the investments go into new financial start-ups pursuing new business models. In fact, the two largest EU unicorns, the Swedish Klarna and the German online bank N26, are part of the financial sector. Given that the financial sector is not traditionally the strongest in undertaking R&D projects itself, it is not surprising that CVC investment amounts to 12.4% of its R&D investment, a value well above the mean.

Regarding the regional distribution, Table 1.12 shows direct R&D and CVC investment by Scoreboard companies, taking the site of the headquarters as the geographical reference.

The regional distribution is uneven, with US and Japanese companies having the highest CVC investment shares and EU firms having the lowest share. This may reflect the general trend that a venture capital culture is more extensive and mature than in the EU; with the proposition that this applies not only for the VC industry in general but also corporate VC. This is not obvious, as the strategies of very large multinationals tend to align, irrespective of the location of their headquarters.

Another explanation may have a structural component. EU has few global players in sectors like ICT services, ICT production, health industries or financial services, which account for a high number and largest amount of VC deals, while sectors like aeronautics, automotive or transport, where Europe is traditionally stronger, are less VC intensive.

⁸⁰ Own calculations, confirmed by other sources such private data provider CBinsights ('State of Venture Report' 3Q 2021)

Table 1.12: Regional breakdown of the comparison of total direct R&D and CVC investment by Scoreboard companies.

Region	Total R&D investment by SB companies (€million)	Total investments via CVC (€million)	Ratio
EU	194985	1009	0.5%
US	348723	9745	2.8%
China	120164	1727	1.4%
Japan	115139	3077	2.7%
RoW	137459	1989	1.4%
Total	916470	17547	1.9%

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

1.4.2 Green bonds

Green bonds are debt instruments issued to finance investment projects that are meant to have positive environmental or climate effects.⁸² The green bond market has experienced exponential growth since its inception in 2007. Green bonds issued worldwide were worth €31.1bn in 2014. Six years later, in 2020, the market had reached €245 billion (\$290.1bn). The projection is that \$1 trillion will be raised for environmental projects in 2023.⁸³ This indicates the potential these instruments can play a crucial role in scaling up private and public financing of the low-carbon transition.

Of the 2,250 Scoreboard companies that have issued bonds between January 2007 and September 2020, 3.8% have accessed the green bond segment during the same period. As green bond issuance is still quite limited in comparison to volumes raised with conventional securities, this reflects the very early stage of this market. Scoreboard companies have raised €74 billion through green bonds, or just 0.24% of total volume of finance obtained on bond markets. In line with the broader market dynamics, the use of green bonds by Scoreboard companies is on an upward trend. Green bond issuance in comparison to total bond issuance has been growing steadily since 2013, in terms of both contracts and volumes. The latter, expressed as

a percentage of total bond issuance, doubled in terms of volume and almost quadrupled in terms of the number of deals between 2018 and 2019 (Figure 1.17).

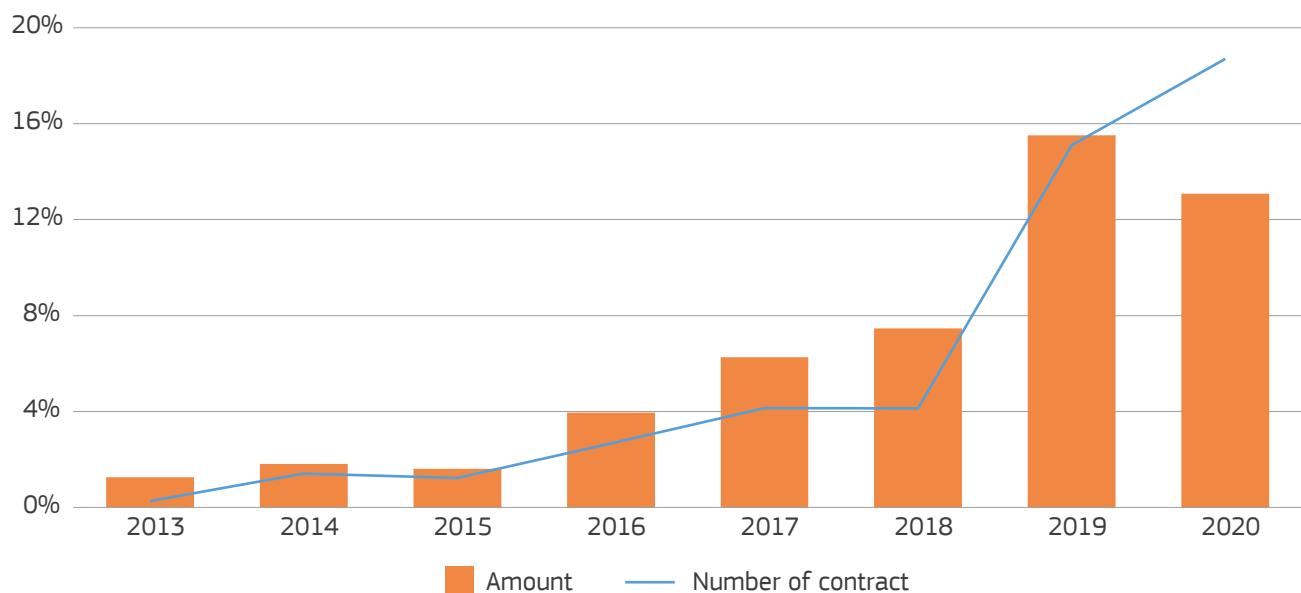
Overall, green bond issuance is concentrated in relatively few sectors. The sectoral breakdown in Figure 1.18 shows that to date, expectedly, utilities and energy companies have issued the lion's share of green volumes. Together with financial institutions and companies active in the 'Computers and Electronics' and 'Transportation' sectors, they account for roughly three quarters of funds raised on the green bond market by the group of highly innovative firms.

In the absence of a universally accepted definition of the qualifying features for green bonds, current market practice is largely informed by the Green Bond Principles (GBPs), a set of market-based voluntary process guidelines that put forward standardized procedures to encourage transparency and disclosure. Among those, there is the use of external review by issuers, which involves a wide range of services from environmental consultancy to audits on use of proceeds. As such, it is of paramount importance to signal that funds are going to finance environmental projects,

⁸² For an overview of green bonds and green bonds markets, and the JRC research in the field, see Fatica, S., Financing a sustainable recovery with green bonds, JRC Science for Policy Brief.

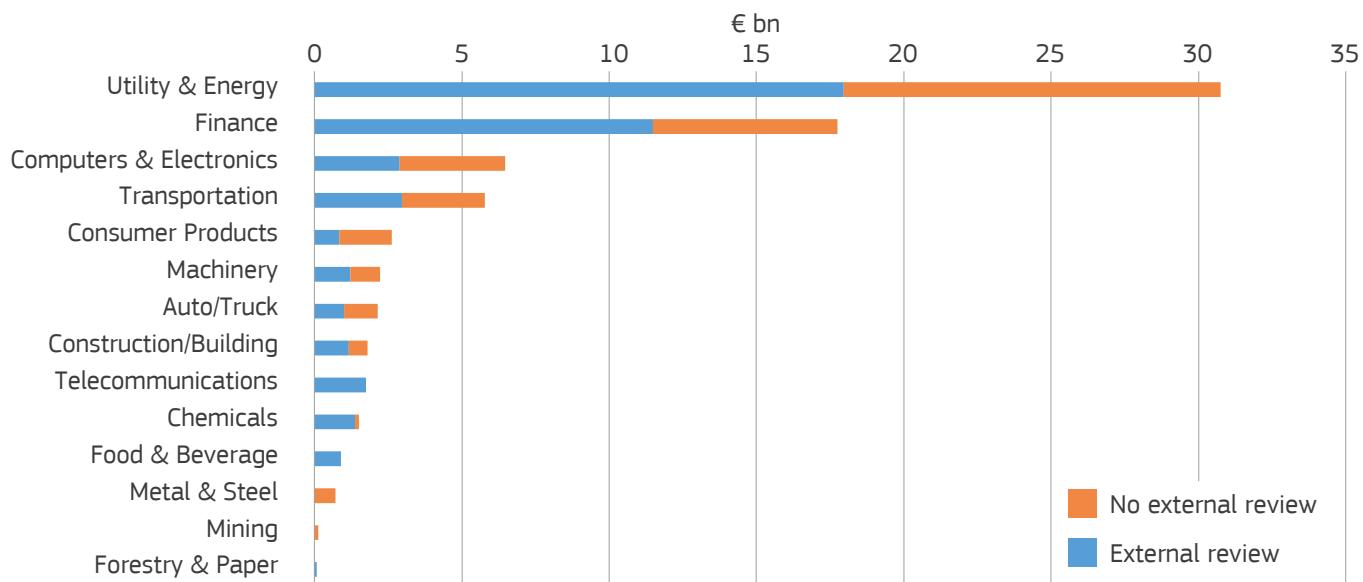
⁸³ Climate Bond Initiative, Sustainable Debt Market – Summary H1 2021.

Figure 1.17: Green bond issuance as a % of total bond issuance.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

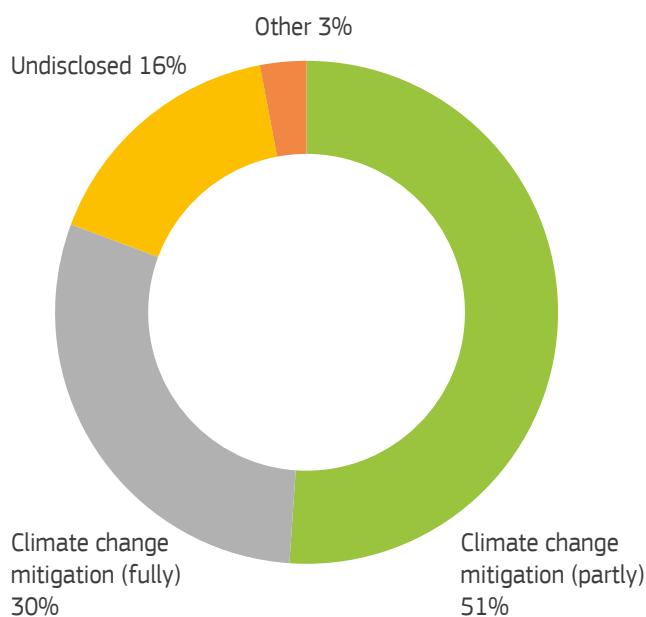
Figure 1.18: Green bond issuance across issuer sector, breakdown by use of external review.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



Figure 1.19a: Green bond issuance by scope of the project.

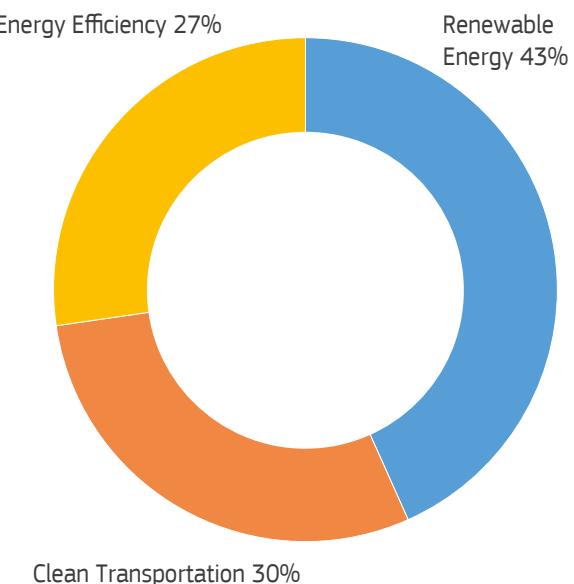


Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

thus minimizing the risk of ‘greenwashing’.⁸⁴ Figure 2 breaks down the total green amount issued according to presence of external review. Contract volumes with external review amount to roughly 58%.

Transparency and disclosure are important determinants of the success of the green bond market. In particular, the reporting of information on the use of proceeds uniquely characterises these securities compared to conventional corporate debt, including ordinary bonds. Textual analysis of the use of proceeds reports indicates that projects financed with green bonds have a strong focus on climate change mitigation (Figure 1.19a). Three out of four contracts (amounting to 80% of the funds raised) are issued for projects with the purpose of climate change mitigation, either fully or partially, i.e. in combination with projects pursuing

Figure 1.19b: Green bond financing of projects with climate change mitigation purposes, breakdown by type of projects.



other environmental objectives. Moreover, Figure 1.19b considers only projects fully devoted to climate change mitigation purposes (30% of total amounts). Among these, the majority of funds (70%, or 21% of total green bond amounts) is used to finance investment projects in the domain of renewable energy and energy efficiency.

While informative on the type and broad category of projects financed, the analysed use of proceeds reports usually do not explicitly mention the undertaking of research and innovation activities as a reason to raise green bond funding. One notable exception is the debut security issued on the green segment by Schneider Electric, a French company operating in energy management and automation, in October 2015.⁸⁵ The reported objective of this bond issue is to finance low-carbon R&D projects geared towards

⁸⁴ In our analysis, we collect the different activities of the external reviewer (second opinion, verification and certification) together. Research shows that external review has important signalling effects. Green bonds with external review benefit from an additional negative yield gap with respect to their peers without external review (see, Fatica, S., Panzica, R., & Rancan, M.: The pricing of green bonds: Are financial institutions special? *Journal of Financial Stability*, 54, 2001). Moreover, external review has been found to signal a stronger commitment towards climate-friendly investment, which results in lower total emission intensity at the company level (see, Fatica, S. and Panzica, R.: Green bonds as a tool against climate change?, *Business Strategy and the Environment*, 30(5), 2021).

⁸⁵ The green bond was issued for a total amount of €200 million with a 10-year maturity and a coupon of 1.841%



technologies that achieve superior CO₂ savings. The selected R&D projects aim at developing new technologies in the specific dimensions of energy efficiency; low-CO₂ energy production through connection of renewable energy solutions to grid; low-greenhouse gases content; low resource intensity.

The absence of a unique reference framework is still identified as one of the main barriers to the further development of the green bond market. To help scale up and raise the environmental ambitions of the market, in July 2021 the European Commission proposed a

regulation for a European green bond standard (EU-GBS), inspired by market best practice, which aims to enhance the transparency, comparability and credibility of the green bond market for both borrowers and investors. The EU-GBS explicitly states that "Green Projects can include: (...) any capital expenditure and selected operating expenditures (...) and research and development costs." As the EU-GBS emerges as the gold standard in the green bond market, issuers will have higher incentives to report the use and allocation of proceeds for intangible capital assets such as research and development.



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 describes companies' performance over the previous year, and the second part analyses the EU's performance relative to its main competitors, over the past 10 years with particular attention to selected industries.

The 2500 company sample is divided into 5 sets, according to the location of companies' headquarters: EU (401), US (779), China (597), Japan (293) and RoW (430). The RoW group comprises companies from the UK (105), Taiwan (85), South Korea (60), Switzerland (56), Canada

(26), India (25), Israel (21) and a further 12 countries. The EU group includes companies from 17 EU countries⁸⁶.

In 2020, global business sustained its level of R&D investment, continuing the trend observed in the past 10 years, despite being impacted by the pandemic that led to a significant drop in companies' sales, operating profits and capital expenditures. The positive global R&D growth was driven by sectors positively affected by the crisis, namely the Health and ICT services while most other sectors showed a considerable reduction in R&D investments, particularly the transport-related industries whose sales and profits have been strongly affected by the lockdown.

2.1 Main changes in companies' Scoreboard indicators 2019 - 2020

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

2.1.1 Worldwide picture

R&D trends

Despite the recession caused by the Covid-19 pandemic, investment in R&D continued to increase significantly in 2020 for the eleventh consecutive year. The 2500 Scoreboard companies invested €908.9bn in R&D, 6.0%

more than in 2019, albeit at a much lower pace than the year before (9.2%).

Companies headquartered in the US and China showed the largest R&D growth figures (9.1% and 18.1% respectively). On the contrary, EU companies R&D

⁸⁶ Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovenia, Spain and Sweden.

investment decreased by 2.2% breaking the positive trend observed over the past 10 years (6.0% increase in the previous period). Japanese companies increased R&D by a modest 0.9% and the RoW group by 3.0%, driven by R&D increases from companies based in Taiwan (10.0%) and South Korea (4.2%).

EU companies' share in global R&D investment decreased slightly to 20.3% (in last year Scoreboard it was 20.9%), US companies decreased their share to 37.8% while Chinese companies continued to increase significantly their share, reaching 15.5% (from 13.2% in the last Scoreboard). On the other hand, Japanese companies' share of R&D continued to shrink (12.2% from 12.7% in the past Scoreboard).

Global R&D growth was driven by the ICT services sector (16.0%), followed by the Health and ICT producers' sectors (10.5% and 5.7% respectively). Most other sectors showed a decrease in R&D investment, except for the Construction and Financial sectors. The sectors hit hard by the crisis showed substantial decreases of R&D investment, mainly

Aerospace & defence (-17.0%) and Automobiles (-4.7%). The Chemicals sectors reduced R&D by 2.8%, continuing the negative trend observed in the past few years.

Financial indicators trends

Unlike R&D investment, most other financial indicators of the 2500 companies were negatively affected by the pandemic, particularly operating profit, net sales and capital expenditure.

The operating profit of companies dropped significantly across all sectors and world regions, except for the ICT services sector that showed a slight increase of 1.6%. The sectors showing the largest drop in operating profits were Aerospace & defence (-85.1%), Automobiles (-29.8%) and Chemicals (-19.3%).

The overall net sales of the 2500 companies were €19.0 trillion, 4.6% less than the year before. Sectors that showed the largest drop in net sales were those hit hardest by the pandemic, namely Automobiles & other

Table 2.1: Main R&D and economic indicators by world region in the 2021 Scoreboard.

	EU	US	China	Japan	RoW	Total
Number of firms	401	779	597	293	430	2500
R&D in 2019, € bn	184.1	343.6	141.0	111.1	129.2	908.9
One-year change, %	-2.2	9.1	18.1	0.9	3.0	6.0
Net Sales, € bn	4420.0	4342.7	3860.2	2746.8	3582.4	18952.1
One-year change, %	-8.1	-1.0	3.8	-7.3	-10.3	-4.6
R&D intensity, %	4.2	7.8	3.6	4.0	3.6	4.8
Operating profits, € bn	263.1	513.9	278.6	142.0	356.4	1554.0
One-year change , %	-35.3	-11.4	0.0	-24.3	-30.2	-20.9
Profitability, %	6.0	12.0	7.2	5.2	10.0	8.2
Capex, € bn	275.1	244.9	287.5	200.6	285.2	1293.2
One-year change , %	-9.6	-9.6	2.8	-8.7	1.5	-4.6
Capex / net sales, %	6.6	5.6	7.5	7.3	8.1	6.9
Employees, million	16.3	10.6	13.4	8.9	7.0	56.1
One-year change, %	-1.5	0.5	4.5	-0.03	2.2	0.9
R&D per employee, €	11331.8	32407.4	10476.7	12536.5	13384.2	15554.6
Market Cap, € bn	4612.6	16029.8	4206.0	2578.6	6428.1	33855.1
One-year change, %	2.9	38.5	66.1	7.9	42.4	32.8

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

transport (-10.5%), Aerospace & defence (-10.9%) and Chemicals (-7.2%). On the other hand, sectors positively affected by the crisis showed increases in net sales, Health (4.1%), ICT services (7.7%) and ICT producers (3.0%).

Capital expenditures dropped €62.2bn worldwide by 4.6%, similar to the percentage decrease in sales, with a decrease of €62.2bn compared with an R&D increase of €51bn. This shows that overall companies tried to protect R&D at a time even as revenues were falling. As for the other

indicators, the main decrease in capital expenditures was shown by companies from the Automobiles and Aerospace sectors (-13.0% and -12.5% respectively) and from other sectors such as Industrials, Energy and Financials.

The overall number of employees of the 2500 companies increased slightly by 0.9% up to 56.0 million. The main industry that saw a drop in the number of employees was Aerospace (-10.5%) and the main sectors that increased employment were ICT services (6.3%) and Health (3.9%).

2.1.2 EU companies

The 401 EU companies are headquartered in 17 of the 27 EU countries (18 countries in 2019). Of these, companies located in three countries, namely Germany, France and the Netherlands⁸⁷, comprise the majority of companies and the R&D investment. German, French and Dutch headquartered companies are responsible for respectively 47.2%,

17.4% and 10.3% of R&D investment by all EU companies. French companies account for 17.4%, and those based in the Netherlands account for 10.3% of the EU's R&D. The latter figure overstates the R&D investment in the Netherlands as the list of Dutch companies includes some whose main operations are in other countries.

Table 2.2: Top 20 companies by R&D investment in the EU.

Company	Country	Sector	RD 2020		Net sales 2020		Employment 2020	
			(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Volkswagen	DE	Automobiles & other transport	13885,0	-2,9	222884,0	-11,8	662575	-1,3
Daimler	DE	Automobiles & other transport	8441,0	-12,3	154309,0	-10,7	288481	-3,4
Bayer	DE	Health industries	7704,0	36,9	42550,0	-8,1	99538	-4,1
Bmw	DE	Automobiles & other transport	6279,0	-2,2	98990,0	-5,0	120726	-9,8
Robert Bosch	DE	Automobiles & other transport	6044,0	-3,0	71494,0	-8,0	395000	-0,8
Sanofi	FR	Health industries	5527,0	-8,1	36041,0	-0,2	99412	-1,0
Siemens	DE	ICT producers	5020,0	-17,5	57139,0	-34,2	293000	-23,9
Sap	DE	ICT services	4447,0	3,8	27338,0	-0,8	102430	2,1

⁸⁷ Several top R&D investors, e.g., Airbus, Stellantis, STMicroelectronics, are headquartered in the Netherlands but have most of their operations in different countries.



Company	Country	Sector	RD 2020		Net sales 2020		Employment 2020	
			(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Ericsson	SE	ICT producers	3894,4	1,6	23159,7	2,3	100824	1,4
Stellantis	NL	Automobiles & other transport	3866,0	-7,8	86676,0	-21,1	191705	-3,6
Nokia	FI	ICT producers	3841,0	-12,9	21852,0	-6,3	92039	-6,4
Boehringer Sohn	DE	Health industries	3696,0	6,8	19566,0	3,0	51944	1,8
Peugeot	FR	Automobiles & other transport	3613,0	-11,0	60734,0	-18,7	204000	-2,3
Continental	DE	Automobiles & other transport	3554,8	-1,2	37722,3	-15,2	236386	-2,1
Airbus	NL	Aerospace & Defence	2959,0	-15,2	49912,0	-29,2	131349	-2,7
Renault	FR	Automobiles & other transport	2749,0	-25,6	43474,0	-21,7	170158	-5,2
Merck De	DE	Health industries	2263,0	1,1	17534,0	8,6	58096	1,9
Basf	DE	Chemicals	2149,0	-4,0	60963,0	-3,5	110302	-6,2
Asml Holding	NL	ICT producers	2068,9	12,2	13978,5	18,3	28073	12,7
Medtronic	IE	Health industries	2031,6	6,9	24543,2	4,2	90000	0,0

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

There are 14 EU companies in the global top 50 group. The top 10 includes seven German companies (VOLKSWAGEN at position 7 in the world rank; DAIMLER at 12, BAYER at 16; BMW at 19, ROBERT BOSCH at 21, SIEMENS at 30; and SAP at 35, one French company (SANOFI at 24), one Swedish (ERICSSON at 41) and one Dutch-headquartered company (STELLANTIS⁸⁸ at 43). 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. Table 2.2 below shows the main indicators for the top 20 companies in the EU group.

The 401 EU-based companies invested €184.1bn in R&D, which is a reduction of 2.2% with respect to 2019 and contrasts with the substantial increase in the year before (6%). EU companies' R&D share of 20.3% decreased slightly with respect to the previous year. The number of EU companies in the global ranking (401) is 20 less than in the 2020 Scoreboard.

Considering sectoral variations, the Health sector showed the largest R&D increase (10.3%) followed by ICT services (7.2%), but ICT services only accounts for 7.6% of the EU's R&D. Automobiles, the largest

⁸⁸ STELLANTIS is a multinational automotive company formed in 2021 based on a merger between the Italian-American conglomerate Fiat Chrysler Automobiles and the French PSA Group. Its operation is distributed in many countries in particular France, Italy, the US and Brazil.

R&D sector in the EU, accounting for 34% of the total R&D held back the overall R&D growth of the EU group since it decreased R&D investment by 7.2%. Most other sectors decreased R&D, Aerospace (-22.6%), Chemicals (-3.7%), Industrials (-6.1%) and ICT producers (-3.6%).

In terms of countries, the worst performance was shown by French companies (-7.9%) mostly due to R&D decreases in automotive companies (RENAULT, PEUGEOT and VALEO), Health (SANOFI) and Aerospace (SAFRAN). Italian and Finish companies also showed significant R&D decreases (-13.7% and -9.0% respectively), mostly due to the poor performance of their top R&D investors (LEONARDO and NOKIA). In 2020, Leonardo adjusted its R&D reporting, reflecting better the self-funded part of R&D.

Germany, the largest R&D investing country, showed only a slight decrease in R&D (-0.3%) due to the contrast between the good performance of Health and ICT companies and the poor results of its automotive companies. Other countries in the EU whose companies showed positive R&D growth were Denmark (6.0%), Belgium (10.3%) and Austria (12.4%), driven by the good performance of their top R&D investors NOVO NORDISK (DK), UCB (BE) and AMS (AT). The R&D increase of AMS in 2020 is due to the acquisition of the German company OSRAM.

Table 2.3 below shows the list of 10 companies that made the largest contribution to R&D growth in the EU sample (this page) and those that significantly held back the EU's R&D growth (next page).

Table 2.3: Companies most affecting R&D growth in the EU sample in 2020.

Companies that contributed most to the R&D growth of the EU sample

Company	Country	Sector	1-year R&D growth (%)
Bayer	Germany	Health industries	36.9
Ucb	Belgium	Health industries	22.7
Biontech	Germany	Health industries	119.2
Boehringer Sohn	Germany	Health industries	6.8
Asml Holding	Netherlands	ICT producers	12.2
Ubisoft Entertainment	France	ICT services	21.4
Spotify	Luxembourg	ICT services	32.1
Dassault Systemes	France	ICT services	26.8
Infineon Technologies	Germany	ICT producers	17.3
Ams	Austria	ICT producers	61.7

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Companies that affected most negatively the R&D growth of the EU sample

Company	Country	Sector	1-year R&D growth (%)
Volkswagen	Germany	Automobiles & other transport	-2.9
Peugeot	France	Automobiles & other transport	-11
Safran	France	Aerospace & Defence	-38.9
Sanofi	France	Health industries	-8.1
Airbus	Netherlands	Aerospace & Defence	-15.2
Nokia	Finland	ICT producers	-12.9
Leonardo	Italy	Aerospace & Defence	-62.6
Renault	France	Automobiles & other transport	-25.6
Siemens	Germany	ICT producers	-17.5
Daimler	Germany	Automobiles & other transport	-12.3

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

In line with the observed sectoral trends, the top 10 EU companies that increased the R&D growth most are from the sectors positively affected by the crisis, 4 from Health and 5 from ICT sectors. On the other hand, there were high R&D growth variations within these sectors, involving also the top R&D investors that showed poor performance i.e. SANOFI, NOKIA and SIEMENS⁸⁹. Apart from these 3 companies the other 7 companies that decreased significantly R&D are from the sectors more affected by the pandemic, Automobiles and Aerospace.

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). For example, the remarkable 61.7% increase of AMS' R&D is due to the acquisition of the German company OSRAM that reported R&D investment in 2019 substantially higher than that of AMS; the R&D decrease of SIEMENS is mostly due to the spun off company SIEMENS ENERGY in 2020.

Trends in sales, capex, profits and employees for the 401 EU companies

The main financial indicators of the EU sample of companies have been hit hard by the pandemic.

The net sales of the 402 EU companies, reaching €4.4 trillion, were 8.0% below the level of the previous year. The sectors showing the worst sales performance were Aerospace & defence (-22.4%), Automobiles (-13.1%) and ICT producers (-11.1%). Only two sectors showed growth of net sales, ICT services (4.1%) and Health (0.4%).

The overall operating profits of the EU sample had the worst performance (-35.3%) with most sectors showing a double-digit decline of profits. The sectors most affected were Aerospace (-77.4%), Industrials (-51.6%) and Automobiles (-48.3%). Only the ICT services sector showed a growth of operating profits (15.2%).

The capital expenditures of the 401 EU companies dropped significantly by 9.6%, (a decrease of €28.7bn, much larger than the R&D decrease of €4.1bn). This contrasts with the global picture where reduced capital expenditure was partially offset by increased R&D. The sectors showing the largest drop in capital expenditures were Aerospace (-19.4%), Industrials (-18.5%), Chemicals (-15.7%) and Automobiles (-14.9%).

The 401 companies based in the EU employed 16.2 million people, a slight decrease of 1.5% with respect to the year before. Employment decreased in ICT producers, Aerospace, Chemicals and Automobiles sectors and increased in Health and ICT services.

⁸⁹ In 2020, SIEMENS spun off the company SIEMENS ENERGY.



The market capitalisation of the listed companies based in the EU increased slightly by 2.9% (from 31 August 2020 to 30 August 2021).

2.1.3 Non-EU companies

Companies based in the US

The top 2500 investors in R&D worldwide include 779 US companies. Among the top 10 companies in the US sample, the top five are from the ICT industry (ALPHABET at position 1 in the world rank; MICROSOFT at 3; APPLE at 5; FACEBOOK at 6 and INTEL at 9). The following four companies are from the Health sector (JOHNSON & JOHNSON at 10, BRISTOL-MYERS SQUIBB at 13; MERCK US at 14 and PFIZER at 15). The tenth company is from Automobiles (FORD at 22). The Table 2.4 below shows the main indicators of the top 20 companies in the US group.

The R&D funded by US companies continued to be concentrated in three sectors accounting in 2020 for 83.8% of the total R&D (comprising 623 companies, 80% of the total number of US companies). These three sectors are ICT services (32.3%), Health industries (27.2%) and ICT producers (24.3%).

The 779 companies based in the US invested €343.6bn in R&D, reflecting a significant increase of 9.1% over the previous period. US companies' global R&D share reached 37.8%, somewhat lower than in the previous year.

The R&D growth of the 779 US companies was driven by double-digit figures in the Health sector (17.9%) and

Table 2.4: Top 20 companies by R&D investment in the US.

Company	Sector	RD 2020		Net sales 2020		Employment 2020	
		(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Alphabet	ICT services	22470,1	6,0	148746,7	12,8	135301	13,8
Microsoft	ICT services	16882,1	7,5	136980,0	17,5	181000	11,0
Apple	ICT producers	15281,6	15,6	223710,5	5,5	147000	7,3
Facebook	ICT services	15033,0	35,6	70055,5	21,6	58604	30,4
Intel	ICT producers	11047,2	1,5	63456,2	8,2	110600	-0,2
Johnson & Johnson	Health industries	9908,7	7,1	67300,2	0,6	134500	1,7
Bristol-Myers Squibb	Health industries	8409,3	70,9	34649,2	62,6	30250	0,8
Merck Us	Health industries	8331,0	10,5	39111,8	2,5	74000	4,2
Pfizer	Health industries	7837,2	16,1	34152,1	1,8	78500	-11,1
Ford Motor	Automobiles & other transport	5786,0	-4,1	103613,5	-18,4	186000	-2,1



Company	Sector	RD 2020		Net sales 2020		Employment 2020	
		(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Oracle	ICT services	5319,0	7,6	32987,6	3,6	132000	-2,2
Cisco Systems	ICT producers	5172,4	-3,5	40176,9	-5,0	77500	2,1
General Motors	Automobiles & other transport	5052,6	-8,8	99816,7	-10,7	155000	-5,5
AbbVie	Health industries	5037,1	14,3	37327,1	37,7	47000	56,7
Qualcomm	ICT producers	4869,2	10,7	17709,2	11,0	41000	10,8
IBM	ICT services	4696,4	7,6	59995,1	-4,6	375300	6,4
Dell Technologies	ICT producers	4298,8	-1,0	76786,0	2,2	158000	-4,2
Gilead Sciences	Health industries	4106,4	24,3	20119,8	10,0	13600	15,3
Broadcom	ICT producers	4048,6	5,8	19467,0	5,7	21000	10,5
Eli Lilly	Health industries	3455,9	16,1	19998,2	9,9	35000	4,1

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

ICT services (12.4%) and a significant R&D growth in ICT producers (7.8%). US companies reduced R&D investment significantly in the following sectors: Chemicals (-17.3%), Aerospace (-14.5%) and Industrials (-12.1%).

Companies based in the US reduced net sales slightly (-1.0%). A significant reduction of net sales in sectors such as Energy and Automobiles offset significant sales increases in ICT and Health industries. Operating profits of US companies, as for companies across most regions, were hit hard by the crisis; they dropped by 11.4% mostly due to big losses in Energy, Aerospace and Chemicals sectors.

Capex expenditures by US companies also dropped significantly by 9.6%, (a decrease of €26.1bn, comparable to the R&D increase of €28.7bn) mostly due to reductions in the Energy, Chemicals and Construction sectors. The number of employees of US companies (10.6 million) increased slightly (0.5%). The market capitalisation of US-listed companies increased substantially (38.5%) in the reference period (from 31 August 2020 to 30 August 2021).

Companies based in China

Amongst the top 2500 investors in R&D worldwide, there are 597 Chinese companies, 61 companies more than in the 2020 Scoreboard. Of the top 10 Chinese companies, four are from ICT industries (HUAWEI at world rank 2; ALIBABA at 17; TENCENT at 33 and BAIDU at 64). Five companies operate in the Construction sector (CHINA STATE CONSTRUCTION ENGINEERING at 46, CHINA RAILWAY at 59, CHINA COMMUNICATIONS CONSTRUCTION at 63, CHINA RAILWAY CONSTRUCTION at 66 and POWER CONSTRUCTION CORPORATION OF CHINA at 82). Moreover, one company is from the Energy sector (PETROCHINA at 80). HUAWEI is by far the largest R&D investor in China, making up 12.3% of total R&D in the Chinese sample. Table 2.5 below shows the main indicators of the top 20 companies in the Chinese group.

The R&D of the Chinese companies is performed mainly in the ICT producers sector (27%), followed by ICT services (19%) and the Construction sector which accounts for 13% of the total R&D.

Despite the pandemic, the 597 companies based in China invested €141.0bn in R&D in 2020, a substantial increase of 18.1% over the previous year. Chinese companies showed double-digit R&D growth in most sectors, ICT services (21.2%), ICT producers (11.5%), Health (30.7%), Construction (30.6%), except for Automobiles (8.9%). Chinese companies' share of global R&D continued to increase in 2020, reaching 15.5%.

In terms of net sales, the 597 Chinese companies also continued to show growth (3.8%) driven by

strong sales in sectors such as ICT, Industrials and Construction. Only the Energy sector reduced sales in the Chinese sample. In addition, the capital expenditure of Chinese companies continued to grow in 2020 by 2.8%, (an increase of €7.8bn, much smaller than the R&D increase of €21.6bn) sustained by significant increases in the ICT producers, Construction and Chemicals sectors despite a reduction of capital expenditures in the Automobiles and Energy sectors. The operating profits of Chinese companies stagnated in 2020, and the number of employees increased by

Table 2.5: Top 20 companies by R&D investment in China.

Company	Sector	RD 2020		Net sales 2020		Employment 2020	
		(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Huawei Investment & Holding	ICT producers	17460,1	6,7	111157,4	3,8	197000	1,5
Alibaba Group Holding	ICT services	7137,6	32,9	89449,0	40,7	251462	113,8
Tencent	ICT services	4860,0	28,3	60115,4	27,8	85858	36,5
China State Construction Engineering	Construction	3665,3	34,4	199046,1	14,2	356506	6,4
China Railway	Construction	2723,3	32,3	121553,3	14,6	288729	1,2
China Communications Construction	Construction	2462,3	60,3	77877,2	13,0	133294	7,1
Baidu	ICT services	2433,4	6,4	13352,6	-0,3	41000	8,5
China Railway Construction	Construction	2320,2	12,6	112136,9	9,7	286242	-2,6
Petrochina	Energy	1963,6	0,5	241157,6	-23,2	432003	-6,2
Power Construction Corporation Of China	Construction	1905,0	35,2	49540,4	15,6	132125	-0,3
Saic Motor	Automobiles & other transport	1866,5	1,3	87846,3	-11,7	204815	-5,3
Zte	ICT producers	1862,6	14,7	12651,3	11,8	73709	5,2
Crrc China	Automobiles & other transport	1592,7	10,0	27699,3	-0,6	164177	-0,9

Company	Sector	RD 2020		Net sales 2020		Employment 2020	
		(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Metallurgical Corporation Of China	Industrials	1526,8	24,4	49498,7	18,2	101020	2,5
Netease	ICT services	1344,7	23,4	9186,6	24,4	28239	35,8
Ant Group	Financial	1322,5	53,6	14962,8	40,7	16660	0,0
Meituan	Others	1319,9	28,9	14315,4	17,7	69205	26,8
Midea Group	Others	1261,8	5,0	32415,8	1,8	149239	10,6
China Petroleum & Chemical	Energy	1257,8	7,4	262625,2	-20,7	384065	-4,5
Lenovo	ICT producers	1055,6	9,4	49500,7	19,8	71500	13,5

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

4.5%, well above the global average. Market capitalisation of the listed Chinese companies rose by 66.1% from 31 August 2020 to 30 August 2021.

Companies based in Japan

The top 2500 investors in R&D worldwide include 293 Japanese companies. Among the top 10 Japanese companies, four are Automobile companies (TOYOTA at position 11 in the world rank, HONDA at 20, NISSAN at 40 and DENSO at 42). Two are Leisure goods companies (SONY at 37 and PANASONIC at 47), one is a Health company TAKEDA PHARMACEUTICAL at 49) and three are ICT companies (NTT at 23, HITACHI at 65 and CANON at 72). The Table 2.6 below shows the main indicators of the top 20 companies in the Japanese group.

R&D investment by the Japanese companies is mostly in the Automobile (30.0%) and ICT producers (18.0%) sectors, with a sector specialisation pattern similar to the EU, which is also led by the Automobile sector.

The 293 companies based in Japan invested €111.1bn in R&D, only 0.9% more than in the previous year. The global R&D share of Japanese companies continued

to decline (12.2% in 2020 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 the ICT services sector (mostly due to acquisitions made by the largest company in the sector, NTT), whereas the large R&D sectors in the Japanese group decreased R&D, i.e. Automobiles, Industrials and ICT producers.

Most other financial indicators of Japanese companies were hit by the pandemic. Net sales dropped by 7.3%, mostly due to a decrease in sales in the Automobiles, Energy, Construction and Industrials sectors. The operating profits, as for the other world regions, showed the largest decline (-24.3%) due mainly to ICT producers, Automobiles and Chemicals sectors.

Capital expenditures dropped by 8.7% (a decrease of €19bn, much larger than the small R&D increase of €1.0bn) mostly due to decreases in the ICT, Industrials and Automobiles sectors. The number of people employed by Japanese companies remained constant at 8.9 million and market capitalisation of the listed companies increased by 7.9% (from 31 August 2020 to 30 August 2021).

Table 2.6: Top 20 companies by R&D investment in Japan.

Company	Sector	RD 2020		Net sales 2020		Employment 2020	
		(€ million)	1 year growth rate (%)	(€ million)	1 year growth rate (%)	N of employees	1 year growth rate (%)
Toyota Motor	Automobiles & other transport	8619,8	-1,3	214011,3	-8,9	366283	1,9
Honda Motor	Automobiles & other transport	6225,2	-5,5	103570,9	-11,8	211374	-3,3
Ntt	ICT services	5566,8	214,8	93925,5	0,4	324667	1,8
Sony	Others	4129,9	5,2	70769,5	9,0	109700	-1,8
Nissan Motor	Automobiles & other transport	3959,3	-7,6	61830,0	-20,4	131461	-3,4
Denso	Automobiles & other transport	3869,1	-3,1	38821,6	-4,2	168391	-1,5
Panasonic	Others	3626,7	-11,1	52678,3	-10,6	243540	-6,1
Takeda Pharmaceutical	Health industries	3584,1	-7,4	25147,1	-2,8	47099	-0,8
Hitachi	ICT producers	2398,7	3,8	68645,0	-0,4	350864	16,5
Canon	ICT producers	2141,4	-8,8	24851,7	-12,1	181897	-2,8
Daiichi Sankyo	Health industries	1787,9	15,1	7569,1	-2,0	16033	4,5
Astellas Pharma	Health industries	1765,3	0,1	9826,1	-3,9	15455	-2,7
Otsuka	Health industries	1705,2	0,5	11188,9	1,9	33151	0,5
Mitsubishi Electric	ICT producers	1498,6	-7,9	32960,8	-6,1	145653	-0,6
Aisin	Automobiles & other transport	1493,0	-7,8	27726,3	-6,8	118359	-1,0
Softbank	ICT services	1400,8	6,6	44259,0	7,4	58786	-27,3
Sumitomo Chemical	Chemicals	1373,5	2,6	17984,4	2,7	34743	3,4
Fujifilm	ICT producers	1196,5	-3,6	17241,6	-5,3	73275	-0,9
Toshiba	Industrials	1183,2	-5,3	24019,1	-9,9	117300	-6,6
Mitsubishi Heavy Industries	Industrials	1154,4	n.a	29095,8	-8,4	79974	-2,0

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Companies based in the rest of the world (RoW)

This group comprises 430 companies from 19 countries. Most of the R&D investment is concentrated in four countries that account for 85% of the total R&D of the whole group: South Korea (25.9%), UK (24.4%), Switzerland (22.5%) and Taiwan (14.8%).

In 2020, the 430 companies of the RoW sample invested €129.2bn, 3.0% more than the year before. As for other world regions, companies operating in the ICT and Health sectors drove up the R&D growth. Main companies showing outstanding performance were SAMSUNG (5.1%), TSMC (19.8%), ASTRAZENECA (11.5%), ROCHE (3.9%) and MEDIATEK (22.4%).



Most other financial indicators of the 430 companies of the RoW were hit by the crisis, in particular operating profits (-30.2%) and net sales (-10.3%). Capital expenditures of the RoW companies increased slightly by 1.5%.

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

Table 2.7 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).

The 10 best performing companies operate in sectors positively affected by the crisis, 8 from ICT and 2 from Health. On the other hand, as for the EU sample, due to the high R&D growth variation within the sectors, the worse performing companies are from transport-related sectors and also some companies from the best performing sectors Health and ICT.

Table 2.7: Companies most affecting R&D growth in the non-EU sample in 2020.

Companies that contributed most to R&D growth in the non-EU sample

Company	Country	Sector	1-year R&D growth (%)
Facebook	US	ICT services	35.6
Ntt	Japan	ICT services	214.8
Bristol-Myers Squibb	US	Health industries	70.9
Apple	US	ICT producers	15.6
Alibaba Group Holding	China	ICT services	32.9
Airbnb	US	ICT services	181.9
Biogen	US	Health industries	75
Alphabet	US	ICT services	6
Microsoft	US	ICT services	7.5
Huawei	China	ICT producers	6.7

Companies that most negatively affected R&D growth in the non-EU sample

Company	Country	Sector	1-year R&D growth (%)
Trip.com Group	China	Others	-28,1
General Electric	US	Industrials	-17,7
Panasonic	Japan	Others	-11,1
Lyft	US	Industrials	-38,8
General Motors	US	Automobiles & other transport	-8,8
Pinterest	US	ICT services	-49,8
Dupont	US	Chemicals	-45,8
Boeing	US	Aerospace & Defence	-25,1
United Therapeutics	US	Health industries	-69,8
Uber Technologies	US	ICT services	-56,2

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

2.1.4 Large R&D changes in big companies

Most of the increases in R&D and sales in the Scoreboard are due to organic growth but some are the result of mergers & acquisitions (M&A). There are also some decreases in R&D and sales and a few of these are due to divestments. This section summarises the main M&A events affecting the top 157 companies by R&D – all those with R&D over €1bn which we term large companies. We have examined all those companies whose sales increased by more than 20% over the previous year and where there was a significant increase in R&D (see Box 2.1 below). We have also examined a few companies with

high R&D intensity where there was a smaller increase in sales but a very large increase in R&D. Finally, a few companies are highlighted with large divestments that have reduced sales, R&D or both.

Companies whose sales increased by over 20% are mentioned if they made a significant number of acquisitions even if these did not have a major effect on sales and R&D. Where a company had a rise in sales of over 20% and is not listed below, we have not found any significant acquisitions.

Box 2.1: Major company mergers, acquisitions & divestments.

M&A for large Companies with sales increases over 20%

The following companies have had substantial M&A events within their most recent two financial years which are likely to have accounted for a significant part of their sales and/or R&D increase over the previous year. Two companies are also mentioned which are in the Scoreboard but have been acquired so are no longer separate companies.

Facebook: (sales up 21.6%, R&D up 35.6%) made 8 acquisitions from Dec 2019 to Dec 2020. The largest was Kustomer for \$1bn followed by Giphy for \$0.4bn. The R&D of these acquisitions is unlikely to account for much of the 35.6% increase in Facebook's R&D to €15bn. Facebook's sales increase is mainly due to additional use of social media during the virus period.

Bristol-Myers Squibb: (sales up 62.6%, R&D up 70.9%) acquired Celgene for \$74bn in November 2019, and in 2020 Forbius and then MyoKardia (for \$13.1bn). Since MyoKardia's R&D budget for 2019 was only \$143m, the increases in sales and R&D were mainly due to the Celgene acquisition since Celgene's 2019 R&D was of order \$4.6bn. Celgene is not in the 2021 Scoreboard.

Alibaba Group: (sales up 40.7%, R&D up 32.9%) spent \$3.6bn to acquire a majority stake in SunArt hypermarkets in October 2020 which would have raised sales. Alibaba's sales also increased during the virus period for the same reasons as those of the US tech giants.

AbbVie: (sales up 37.7%, R&D up 14.3%) completed its \$63bn acquisition of Allergan in May 2020 and this accounts for its large increases in sales and R&D. Allergan is not in the 2021 Scoreboard.

Tencent: (sales up 27.8%, R&D up 28.3%) made a record number of 31 deals for games companies in 2020. Some were acquisitions, some minority stakes. Tencent like other tech companies benefited from increased sales during the virus period.

Nvidia: (sales up 52.7%, R&D up 38.7%) completed its acquisition of Mellanox in April 2020 for \$7bn. Mellanox's R&D was \$415m in 2019. In September 2020, Nvidia reached agreement with Softbank to buy



ARM for \$40bn but regulators have not yet approved this acquisition (and may not) and thus its R&D is not yet consolidated into Nvidia's figures.

Salesforce.com: (sales up 24.3%, R&D up 30.1%) completed the acquisition of Tableau for \$15.7bn in August 2019 and made six acquisitions in 2020 with the largest being SLACK for \$27.7bn followed by VLOCITY for \$1.33bn. The SLACK acquisition was agreed in December 2020 and completed in July 2021. Tableau's R&D was around \$450m in 2019 and SLACK's was \$382m in 2020. These are substantial compared to Salesforce's R&D of \$2.9bn for 2020. Slack is in the 2021 Scoreboard as #445.

AMD: (sales up 45%, R&D up 28.2%) acquired Xilinx for \$35bn in 2020. Xilinx's 2020 R&D was \$854m.

Vertex Pharmaceuticals: (sales up 49.1%, R&D up 4.4%) in 2019 acquired Exonis Therapeutics for up to \$1bn and Semma Therapeutics for \$950m.

Paypal: (sales up 20.7%, R&D up 23.6%) acquired GoPay in September 2019 and Honey Science Corporation (for \$4bn) in late November 2019 with four more acquisitions in 2021. However, the combined revenue of GoPay and Honey was only around 1% of that of Paypal.

ANT Group: (sales up 40.7%, R&D up 53.6%). ANT, an affiliate of Alibaba Group, has taken major stakes in payments companies in at least 12 Asian countries ranging from Pakistan and India to Malaysia and the Philippines. In 2019 it acquired WorldFirst of the UK.

Tesla: (sales up 28.3%, R&D up 11%) acquired Hibar Systems in 2019 and ATW Automation in 2020 but the sales increase is mainly due to the success of its Model 3 range and increasing demand for electric vehicles.

Ubisoft Entertainment: (sales up 39.4%, R&D up 21.4%) acquired Kolibri Games in 2020 but the increase in sales was mainly due to weak sales in 2019/20 and some 2019 game releases delayed to 2020/21. The increase in demand for home entertainment products during the virus period helped.

Danaher: (sales up 24.4%, R&D up 5.5%) acquired Cytiva, the biopharma business of General Electric Co in March 2020 for \$21.4bn and this accounted for most of the sales increase.

High R&D intensity companies with large increases in R&D but falls in sales

Biogen: (R&D up 75%, Sales down -6.5%). The increase in R&D was mainly due to the number of pipeline drugs in Phase III clinical trials including Aducanumab for Alzheimer's disease (approved by the FDA in 2021)

AIRBNB: (R&D up 181.9%, Sales down -29.7%). The large increase in R&D was partly due to improvements to the company's technology platform but mainly due to the stock-based compensation payable to R&D staff in 2020, the IPO year. The sales decrease was caused by the virus reducing demand for lets.

Beigene: (R&D up 48.5%, sales down -27.9%). Beigene is an early stage biopharma with R&D over four times as large as sales. The big increase in R&D is due to a series of clinical trials of pipeline drugs.

Companies with lower sales and R&D due to divestments

General Electric: (sales down -16.4%, R&D down -17.7%). GE has divested many businesses to concentrate on energy and aviation. The biopharma business was sold to Danaher in early 2020, the oilfield services business is being sold off over three years and the transportation business was merged into WABCO in 2019. Revenue is down from \$120bn in 2017 to \$80bn in 2020. GE announced in late 2021 that its remaining activities will be demerged into 3 separate companies.

Siemens: (sales down -34.2%, R&D down -17.5%). Siemens spun off Siemens Energy in 2020 and intends to sell off its remaining interest in it. Siemens Energy is to close plants to raise margins. Siemens Energy is separately listed in the 2021 Scoreboard. Siemens Healthineers (listed separately but majority owned by Siemens) acquired Varian Medical Systems in 2020.

2.2 Positioning of the EU with respect to its 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, Chinese and Japanese companies for the top 4 sectors in terms of R&D investment. These sectors account for 77.4% of total R&D in the Scoreboard and are ICT producers (23.0%), Health industries (20.7%), ICT services (18.6%) and Automobiles (15.1%).

Figures 2.1, 2.3 and 2.5 compare the sector specialisation of the EU companies with that of US, Chinese and Japanese companies respectively. The figures present the R&D investment for the four main sectors in 2011 and 2020. Each dot represents a sector that, if it is 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 its counterparts in each specific sector.

2.2.1 The EU vs the US

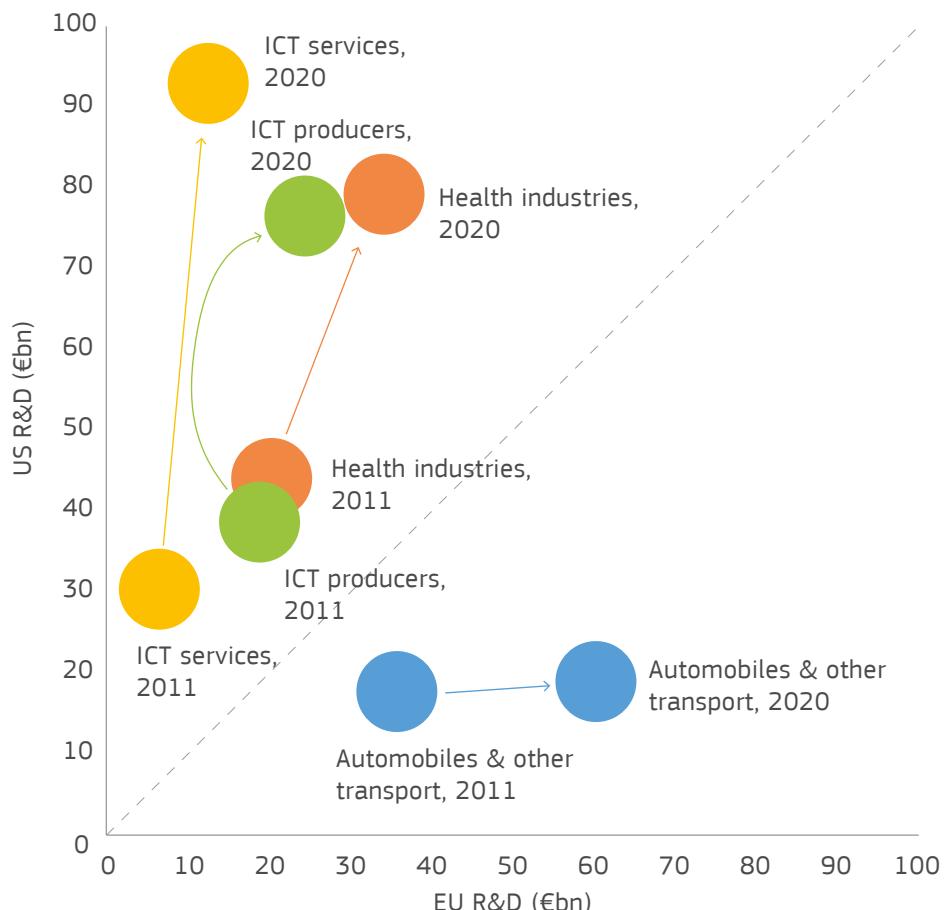
In 2011, EU and US companies showed a distinctive R&D specialisation, EU companies were investing in R&D twice as much as their US counterparts in the Automobiles & other transport sector, half as much in the Health and ICT producers sectors and one-fifth of the US in the ICT services sector.

In 2020, this specialisation pattern further diverged, EU companies invested 3.2 times more than their US counterparts in the Automobiles & other transport sector but only 40% of the US in Health sectors, 30% of the US in ICT producers and 13% of the US in ICT services sectors.

R&D intensity (R&D/Net sales) has grown in the past decade for both the EU and the US samples; however, the increase was higher for the US widening the R&D intensity gap between the EU and the US.

The average R&D investment per company has grown substantially in the two regions over the past 10 years. In the EU, it was €531 million in 2011, and grew to €729 million in 2020. In the US, it grew from €374 million to €493 million.

Figure 2.1: EU-US sector-by-sector comparison of R&D investment in 2011 and 2020.



Note: data refers to 504 (EU:154, US:350) of the 813 companies (EU:190, US:623) in the four sector groups in the two regions considered for which R&D data are available for all period 2011-2020, accounting for 89.7% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

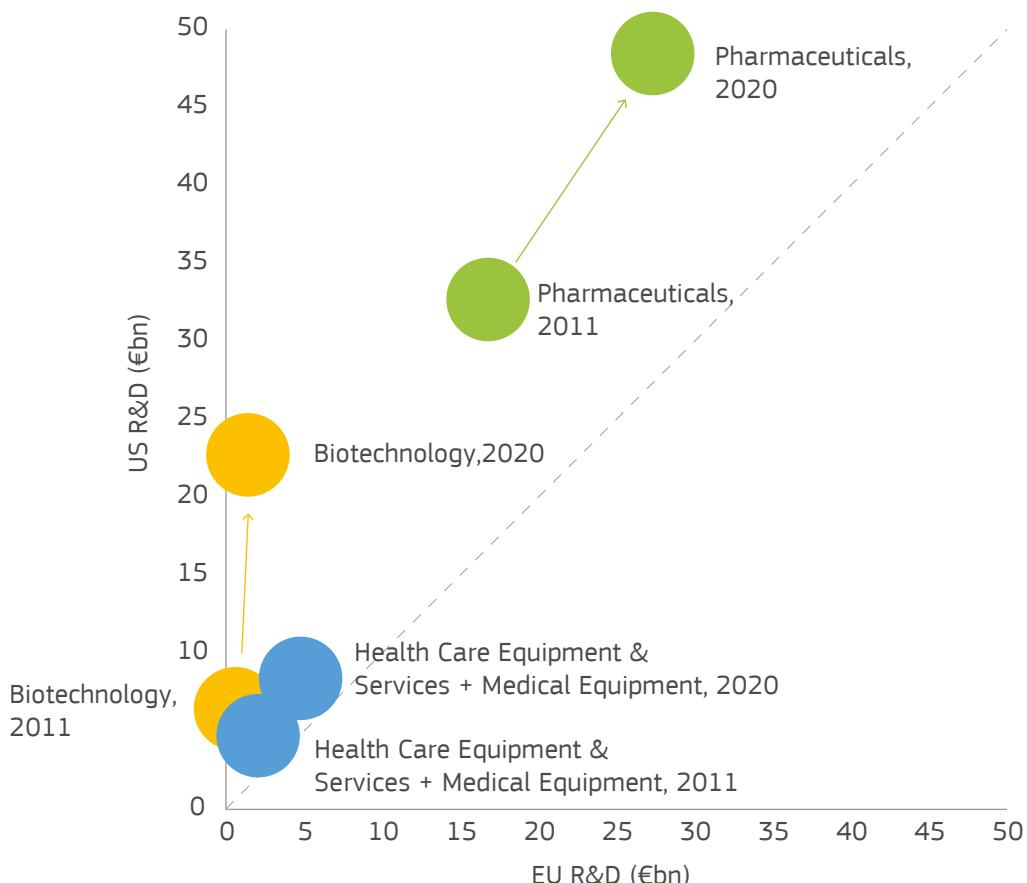
The evolution of the number of companies reflects also the different dynamics of the EU and US samples over the past 10 years and the resulting difference in terms of R&D specialisation. The number of EU companies increased by 37 (from 154 to 191) whereas the US sample increased by 273 (from 350 to 623) companies. In fact, as mentioned in chapter 1 and in previous Scoreboard editions, most of the new companies in the global R&D ranking operate in fast growing sectors such as ICT services and Health where the US dominates. For the latter, this is particularly true for the subsector of biotechnology.

Focus on the Health sector

It is interesting to breakdown the Health sector into the main subsectors (pharma, biotech and health equipment) to characterise further the EU-US differences. Figure 2.2 shows the R&D investment of the three subsectors for both EU and US companies in 2011 and 2020.

In Health, the main EU-US gap is due to the biotech subsector that grew much more rapidly than the other subsectors. In 2020, the US sample dominates in terms of R&D investment (11 times larger) and number of companies (166 vs 20) and, to a lesser extent, with higher R&D intensity (30.6% vs 26.5%).

Figure 2.2: EU-US sector-by-sector comparison of R&D investment in 2011 and 2020: focus on the Health sector.



Note: data refers to 504 (EU:154, US:350) of the 813 companies (EU:190, US:623) in the four sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 89.7% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Analysis of the EU-US difference in R&D intensity in terms of structural and intrinsic factors

The difference in R&D intensity between two regions can be stated in terms of "structural factors", resulting from differences in the sectoral composition of the economy, and "intrinsic factors", derived from differences in the R&D intensities, sector by sector (see formulation in Box 2.2). This is interesting from the policy viewpoint since different approaches are needed to tackle problems of under-investment (intrinsic differences) at company and sector level than to address problems of industrial structure.

Table 2.8 below shows the results of distributing the R&D intensity differences of the EU and the US samples of companies for the major sectors. The figures indicate that the overall EU-US gap is mostly due to structural factors (-3.05 out of -3.61 percentage points) involving the Health (-1.18), ICT producers (-1.32) and more pronounced in ICT services (-1.67).

The results show also a surplus of the EU in both structural (0.58 percentage points) and intrinsic (0.37) terms for the Automobiles sector and a smaller surplus for remaining sectors combined.



This confirms findings from past editions of the Scoreboard that show a persistent and widening gap that requires an increase of the number and size of companies in key high R&D-intensive sectors for the EU.

Table 2.8: EU-US R&D intensity differences for the main industries broken-down into structural and intrinsic terms.

	EU		US		EU-US R&D intensity differences		
	R&D(€million)	R&Dint(%)	R&D(€million)	R&Dint(%)	Structural	Intrinsic	Total
Automobiles & other transport	61794.2	6.0	19406.7	4.4	0.58	0.37	0.96
Health industries	36686.5	12.1	93441.5	12.4	-1.18	-0.02	-1.20
ICT producers	25504.5	9.4	83524.8	9.9	-1.32	-0.03	-1.35
ICT services	14071.4	4.7	111001.5	13.1	-1.67	-0.56	-2.23
Rest of sectors	46044.6	1.8	36188.0	2.4	0.54	-0.34	0.20
Total	184101.4	4.2	343562.4	7.8	-3.05	-0.57	-3.61

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

Box 2.2 Difference of R&D intensity between two regions split into structural and intrinsic factors.

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

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

where:

- X and Y refer to the world regions for which the comparison is performed;
- RDI = R&D intensity
- P is the share of sector i (in terms of production/turnover/sales) within the given world region (X or Y)

The first term on the right side of the formula is the structural factor, accounting the different shares of sectors within the compared world regions. If this term is negative, it means that the shares of R&D-intensive sectors of region Y are larger than those in region X.

The second term on the right side of the formula is the intrinsic factor, accounting for the differences in R&D intensity sector by sector. If this term is negative, it means that the R&D intensities of sectors with high share within region X are smaller than those in region Y.

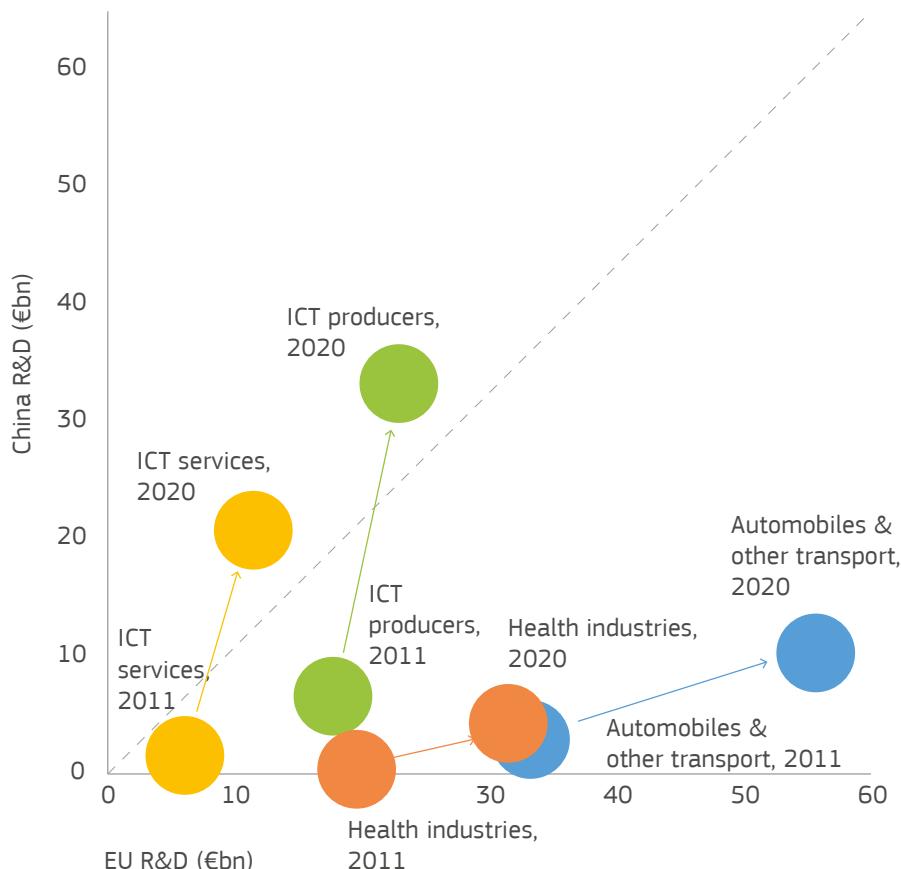
2.2.2 The EU vs China

In 2011, 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 grown considerably. The result is that in 2020, Chinese companies invested in R&D almost twice as much as their EU counterparts in ICT services and 44% more in ICT producers sectors. By contrast, the EU retained its lead in the Automobiles and Health sectors (5 and 4.3 times more R&D respectively).

The R&D intensity (R&D/Net sales) was much higher for the EU companies in 2011. It has grown in the past decade for the two samples but at much higher pace for the Chinese companies that are closing the gap with the EU in some sectors and have surpassed the EU in the ICT services sector.

The average R&D investment per company in the Scoreboard has grown significantly for both EU and

Figure 2.3: EU-China sector-by-sector comparison of R&D investment in 2011 and 2020.



Note: data refers to 360 (EU:154, CN:206) of the 516 companies (EU:190, CN:327) in the four sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 89.0% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.



Chinese samples, however in 2020 it is still much higher in the EU (€729 vs €265). This difference can be explained by the fact that the Chinese group added many more companies to these sectors than the EU (120 new companies vs 37 new EU companies).

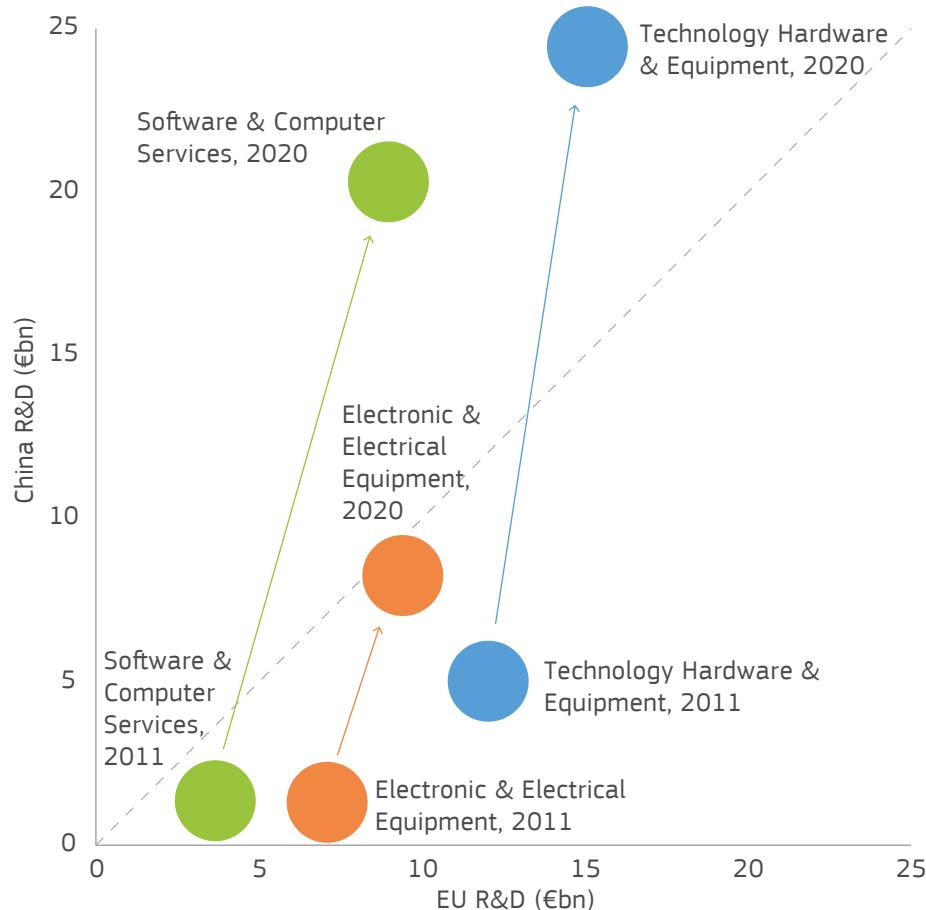
Focus on the ICT sector

It is interesting to breakdown the ICT sector into the main subsectors (Software & computer services Technology hardware & equipment and Electronic & electrical equipment) to characterise further the

EU-China differences. See in figure 2.4 the R&D investment of the EU and Chinese companies in 2011 and 2020.

In the ICT sector, the main EU-China differences are in the Software & computer services and Technology hardware & equipment subsectors. Over the past decade, these subsectors, starting from a low base, largely surpassed the level of R&D investment of their EU counterparts. The EU still shows a somewhat higher R&D investment in the Electronic & electrical equipment sector but the Chinese companies show a steadily higher annual R&D growth.

Figure 2.4: EU-China sector-by-sector comparison of R&D investment in 2011 and 2020 – focus on the ICT sectors.



Note: data refers to 197 (EU:60, CN:137) of the 273 companies (EU:72 CN:201) in the ICT services and ICT producers sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 88.2% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

2.2.3 The EU vs Japan

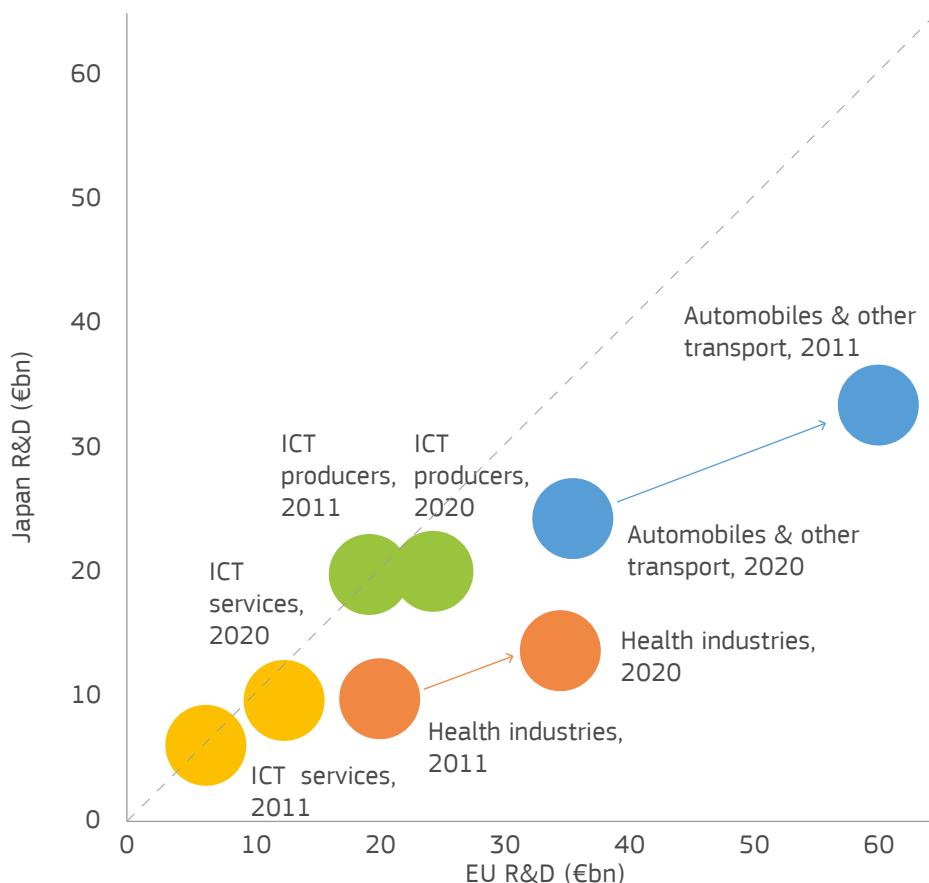
In 2011, EU companies in the Scoreboard invested more than Japan in all four major sectors under consideration.

In the Automobile sector, which represents the most important sector for both regions in terms of R&D investment, the ratio of R&D investment for the EU compared to Japan has increased from 1.4 to 1.9.

R&D intensity (R&D/Net sales) has grown in the past decade in the EU, while remaining practically the same for the Japanese companies. This has resulted in the EU having a much higher R&D intensity than Japan in 2020 (7.2% vs 5.5%).

The average R&D investment per company has grown more rapidly in the EU than in Japan. In 2020, it was €729 million for the EU companies and €580 million for their Japanese counterparts.

Figure 2.5: EU-Japan sector-by-sector comparison of R&D investment in 2011 and 2020.



Note: data refers to 283 (EU:154, JP:129) of the 322 companies (EU:190, JP:132) in the four sector groups in the two regions considered for which R&D data are available for the all period 2011-2020, accounting for 96.9% of the R&D in 2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.



CHAPTER 3

A CLOSER LOOK AT THE EU

3.1 Introduction: the top 1000 EU extended sample

This chapter aims to provide a more detailed understanding of the R&D investing landscape in EU companies. In order to do so, it relies on an extended EU1000 sample, built by adding to the 401 EU companies in the top 2500 a further 599 EU companies that invested in R&D in 2020 an amount between €36.5 million (the threshold to get into the top 2500 ranking) and €2.0 million. The lower threshold is considerably lower than that for the EU1000 sample in the 2020 Scoreboard,

which was €9.2 million. This almost five-time difference is mainly the result of the composition of the sample as 2020 was marked not only by the Covid-19 pandemic but also by Brexit. On the 1st of February 2020, the UK officially exited the EU, finalising a divorce in the making for the previous five years. With the UK no longer part of the EU, the EU1000 sample in this Scoreboard does not include UK companies.

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

The geographical distribution of the EU top 1000 companies is presented in figure 3.1. As we have seen in chapter 1, the 401 EU companies in the top 2500 ranking are located in 17 different Member States. This “top” group is augmented with other 599 companies (the “bottom” group), located in 17 different member states (14 of which also register the presence of at least one “top” company⁹⁰) to compose the full sample of the EU100 companies that we have analysed in this chapter. Overall the EU 1000 companies are located in 19 member states and invested €191.7bn in R&D in 2020.

This “top” group is augmented with other 599 companies (the “bottom” group), located in 17 different

member states (14 of which also register the presence of at least one “top” company⁹¹) to compose the full sample of the EU100 companies that we have analysed in this chapter. Overall the EU 1000 companies are located in 19 member states and invested €191.7bn in R&D in 2020.

The EU1000 companies’ R&D investment is only €7.6bn more than the €184.1bn of the top 401 companies, i.e. just 3.9% more. The slight increase in the number of Member States covered (19 against 17 covered by the “top” 401 EU companies) and R&D invested is almost identical to that registered for the EU+UK 1000 sample in the last edition of the Scoreboard. On the one hand, this illustrates again how R&D is concentrated in a

⁹⁰ Member States with at least one company in the “top” and one in the “bottom” are: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Spain, Sweden. Member State with only companies in the top are: Hungary, Malta, Slovenia. Member States with only companies in the bottom are: Czech Republic, Greece.

⁹¹ Member States with at least one company in the “top” and one in the “bottom” are: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Spain, Sweden. Member State with only companies in the top are: Hungary, Malta, Slovenia. Member States with only companies in the bottom are: Czech Republic, Greece.

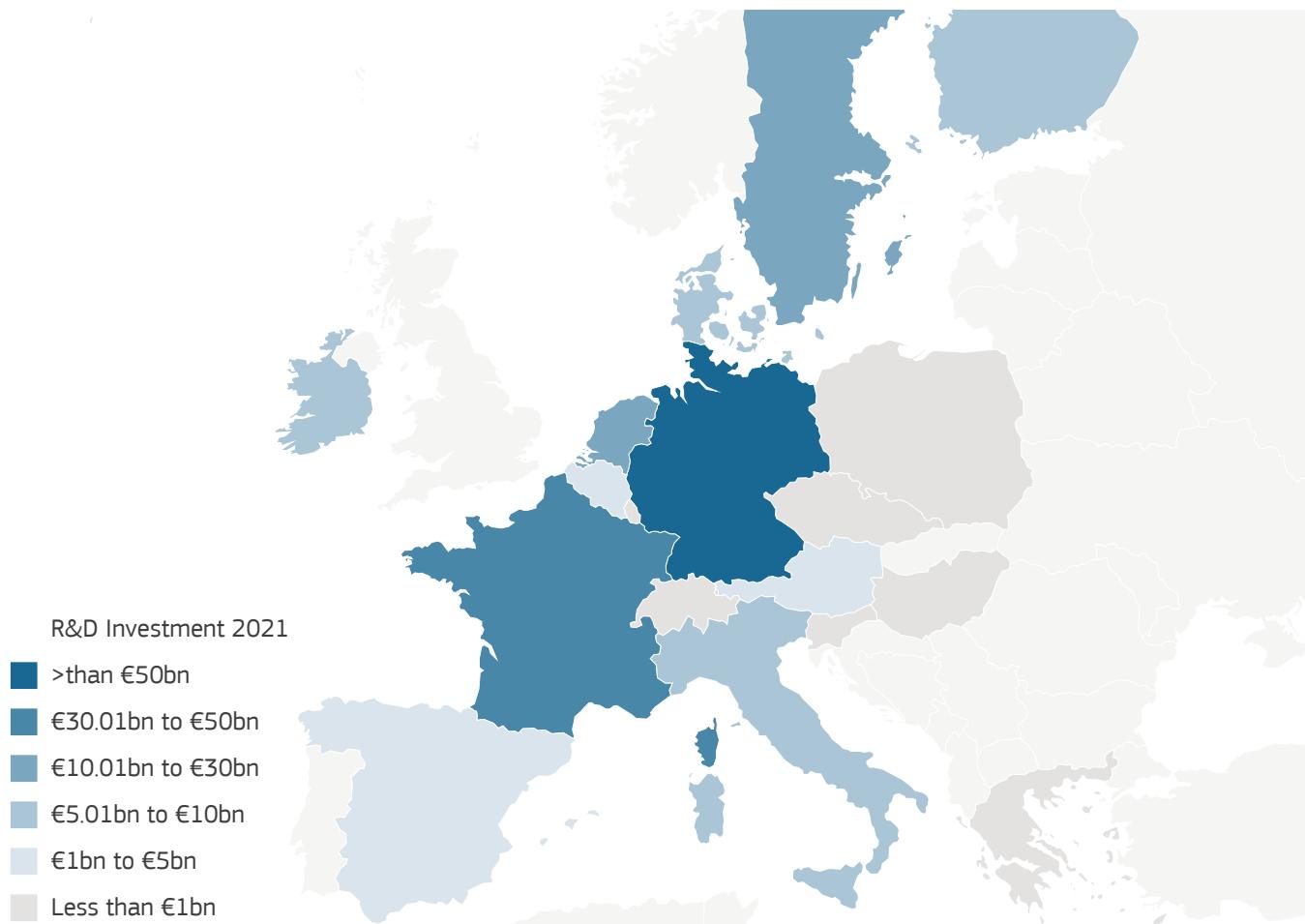
few companies and countries. On the other hand, notwithstanding the 'departure' of the 280 UK companies included last year and their replacement by 280 non-UK companies this year, the number of member states covered remained unchanged.

It should be stressed that for Member States with no representation in the EU1000, do have R&D investing firms but the R&D investing firms in these countries

either invested less than €2.0 million in 2020 or are affiliates of firms headquartered elsewhere.

While the headquarters of top R&D investors are concentrated in few countries, these companies do have a global presence via subsidiaries⁹². There is at least one corporate subsidiary⁹³ of an EU headquartered company in all Member States and in practically all the countries in the World (as reported in Figure 3.2).

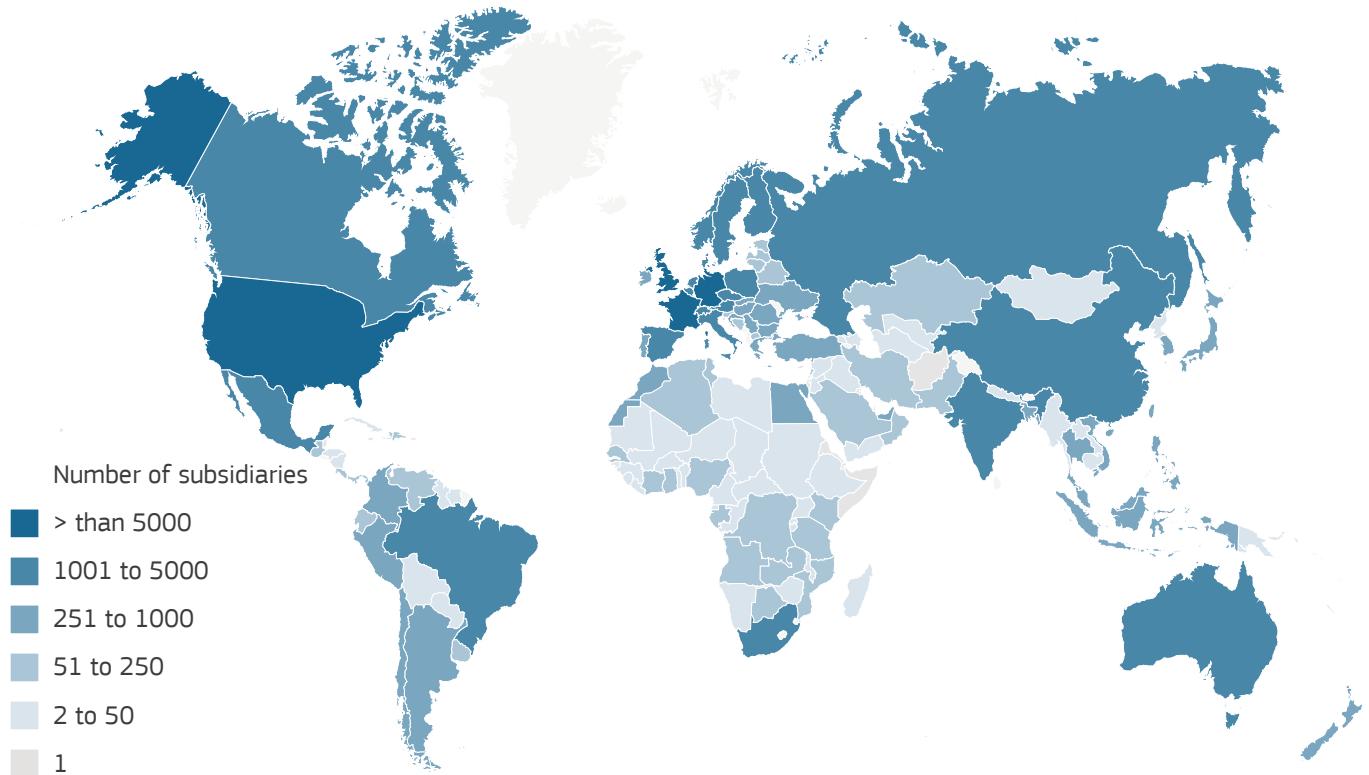
Figure 3.1: Map of the top 1000 investors in R&D by location.



⁹² These Member States are: Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania, Romania, Slovakia.

⁹³ 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 also include companies active in B2B or B2C non-financial services. If not stated otherwise, every time we refer to subsidiaries we mean corporate subsidiaries.

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



Note: colour darkness proportional to the subsidiaries in the country. Data refers to 905 companies (accounting for 94.9% of R&D in 2020) for which subsidiary data is available.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

42% of the subsidiaries of EU headquartered firms are located in the EU (especially Germany and France); while the US is the non-EU country accounting for the highest share of subsidiaries (22.5% of the total) followed by the UK with 5.0%. Other significant shares (more than 2% of the total) are registered by Canada, China and Brazil.

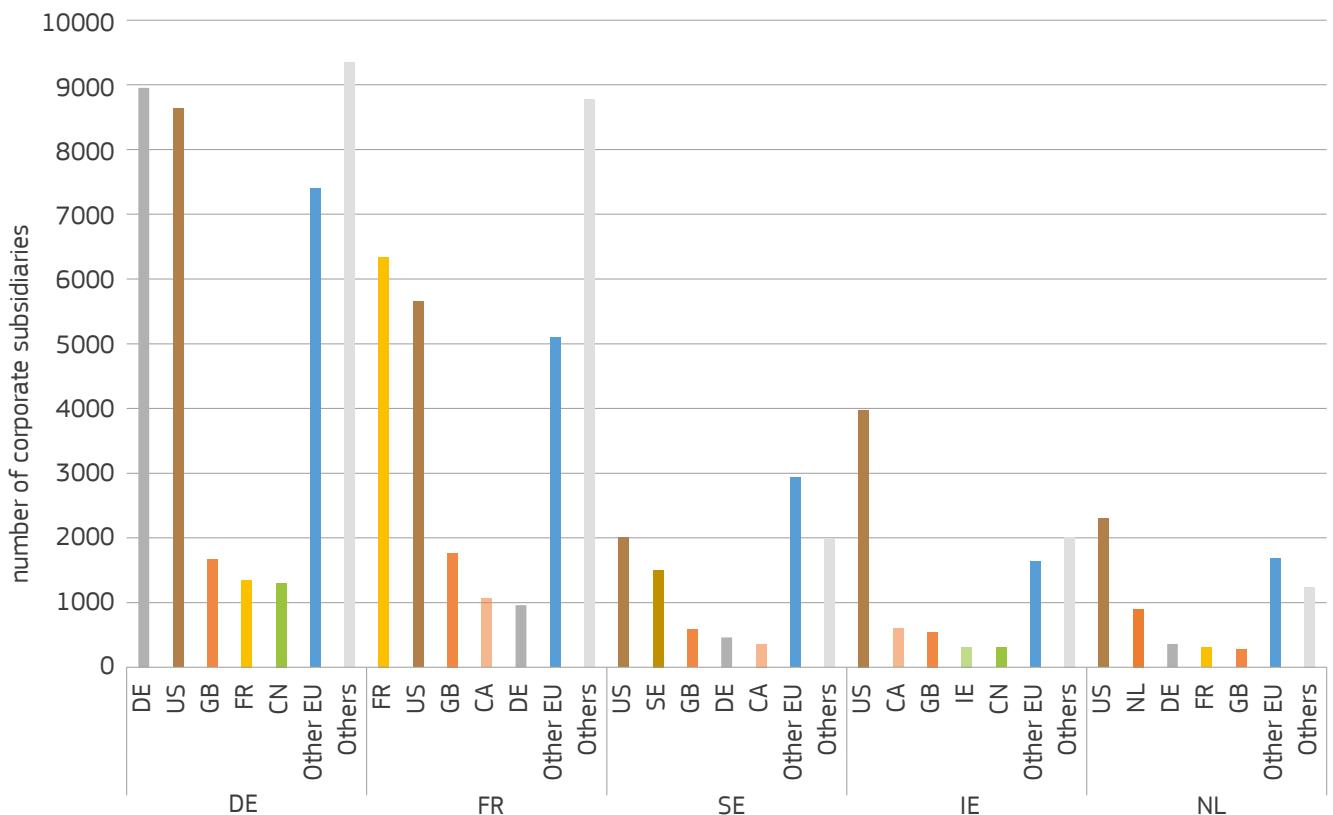
Using data on both location of HQ and location of subsidiaries for each company, we could distinguish between domestic (located in the same country), European (located in one of the other Member States of the EU), and international (located outside the EU) subsidiaries. Figure 3.3 reports the top five countries in terms of subsidiary location for the top five countries in terms of R&D invested at HQ level.

While for Germany and France, the relative majority of subsidiaries are domestic, for Dutch and Irish companies the US is the country where they have the relative

majority of subsidiaries. However, companies located in these three countries also have a significant share of their subsidiaries located in the EU. For Sweden, the largest proportion of subsidiaries is from other EU countries with the US being the next largest.

In general, there is a considerable presence of EU companies in the US (via their subsidiaries). Ireland is a particular case, with only 3% of the subsidiaries located in Ireland and 42% of the subsidiaries located in the US. The Netherlands has a similar if less pronounced profile. However, in none of the 10 top countries in terms of R&D investment (see figure 3.6) is the combined share of domestic+EU subsidiaries above 50% (the closest one is Italy with 48.8%). This suggests a high level of internationalisation of the top R&D investors located in the EU. Using the same approach, as 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 in order

Figure 3.3: Corporate subsidiaries location – details.



Note: data refers to 905 companies (accounting for 94.9% of R&D in 2020) for which subsidiary data is available. 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.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

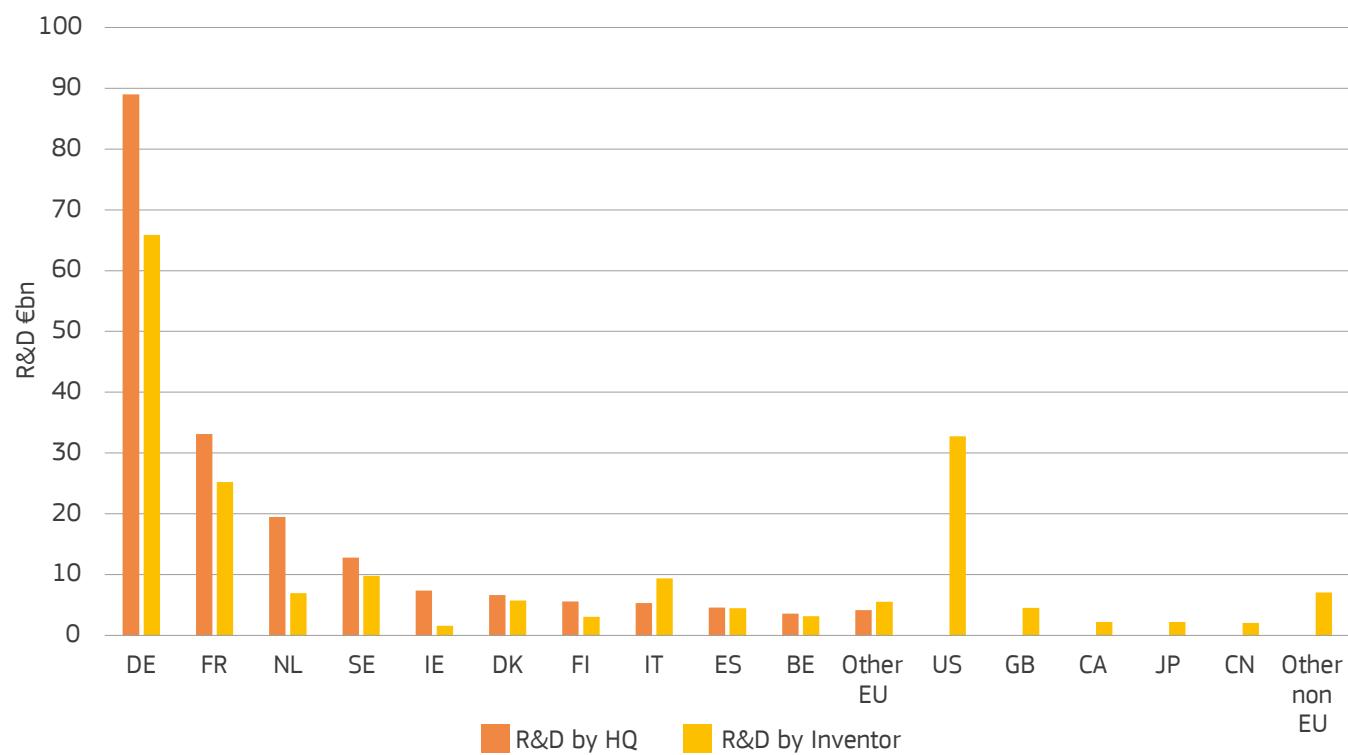
to approximate the location where the R&D is actually performed. Fig 3.4 shows this data for the top 10 countries by R&D at HQ level.

All the top 10 Member States considered (apart from Italy) have less R&D invested in their territory than the aggregate R&D reported by companies headquartered in the territory. As for the number of subsidiaries, the US is by far the country with the highest share of R&D invested by EU companies outside the EU, followed by the UK and then Canada.

Figure 3.5 delves a bit deeper for the two countries where the 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 is highest: Ireland and the Netherlands. Each quadrant reports the estimated percentage distribution by country of the R&D invested by companies headquartered in Ireland (left panel) and the Netherlands (right panel). Irish companies do 17% of their R&D in Ireland, while Dutch companies do 30% of their R&D in the Netherlands. Both countries do a substantial share of their R&D in the US (in the case of Irish companies; it is almost two/thirds). For the Netherlands, Italy and France are among the top countries where Dutch companies perform R&D. This is not surprising considering the Netherlands is where some pan-European companies like Stellantis and Airbus have their HQs.

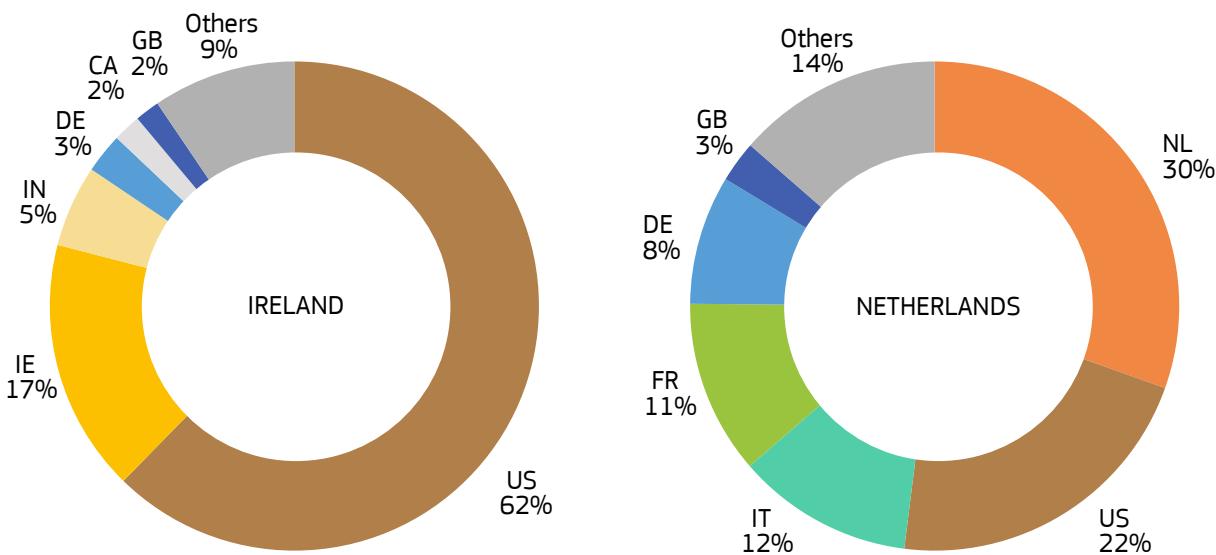
Figure 3.4: R&D location –HQ investments vs location of inventors (patents).



Note: data refers to 905 companies (accounting for 94.9% of R&D in 2020) for which subsidiary data is available. 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.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

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



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

As per last year report, the methodology used to redistribute the R&D according to the location of the inventors is based on several assumptions⁹⁴. This calls for extreme caution when interpreting the results. However, for The Netherlands and Ireland the data reflect

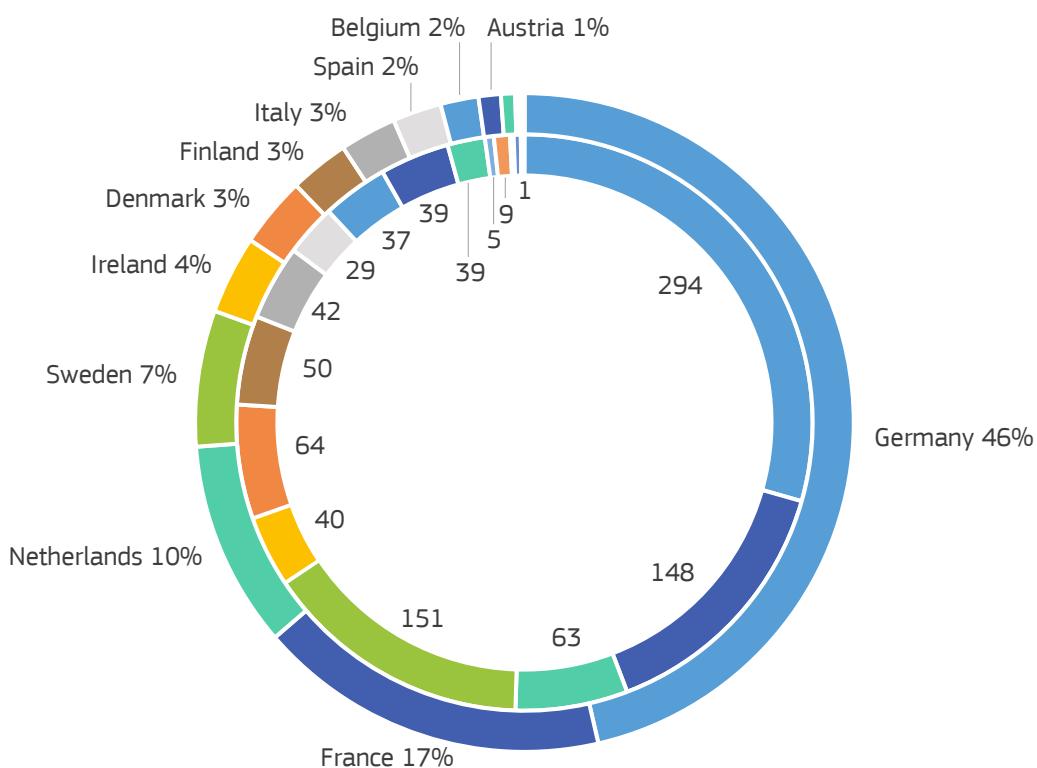
the actual situation on the ground, with many companies that have located their headquarters there for tax reasons but perform the bulk of their activities (including R&D) elsewhere.

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

Figure 3.6 presents the distribution of R&D in 2020 by member state for the top 1000 EU firms. The top three (Germany, France, and Netherlands) represent

together 50.5% of the companies and 73.8% of R&D in the top 1000 EU sample.

Figure 3.6: R&D by country in the top 1000 EU sample.



Note: Inner circle shows the number of companies per country, the outer circle the percentage of R&D investment by country.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁹⁴ The methodology used to estimate the R&D is performed based on where the inventors of patents belonging to the company are located is based on several assumptions. For example, it assumes the entire R&D translates into patents, not taking into account possible R&D failures and other ways of protecting IP such as, for example, industrial secrets, design rights and copyright. In addition, it assumes the R&D effort needed to produce one patent is uniform across sectors and technologies whereas in practice some sectors generate several times as many patents for a given amount of R&D as do others. It also assumes that the propensity to patent does not vary by technology or company. These are strong assumptions that needed to be taken into account when interpreting the results. For a full explanation of the methodology and its limitations, 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/contenttype//publication//reports//1568800313//Estimating%20territorial%20business%20RD%20expenditures.pdf>



The EU1000 is dominated by German companies, which account for almost 50% of the total R&D invested by EU headquartered firms. The new companies substituting the UK companies included in last year's sample are evenly distributed across Member States. This results in an overall distribution that is similar to the one of last year adjusted (once excluded the UK).

Table 3.1 shows the main financial performance indicators and their changes compared to last year for the top 1000 EU companies, split between the top companies (which are the 401 EU companies included in the global 2500 list) and the “bottom” part of the list.

The overall tendencies of the “top” (decrease in R&D, negative growth in all the other indicators but Market capitalisation) have been already discussed in Chapter 2. The “bottom” register the same tendencies to an even higher degree. For example, while the R&D of the top companies decreased by 2.2%, the R&D investment of the bottom decreased by 4.5%. In addition,

the companies in the bottom register a bigger decrease of profits compared to the top ones.

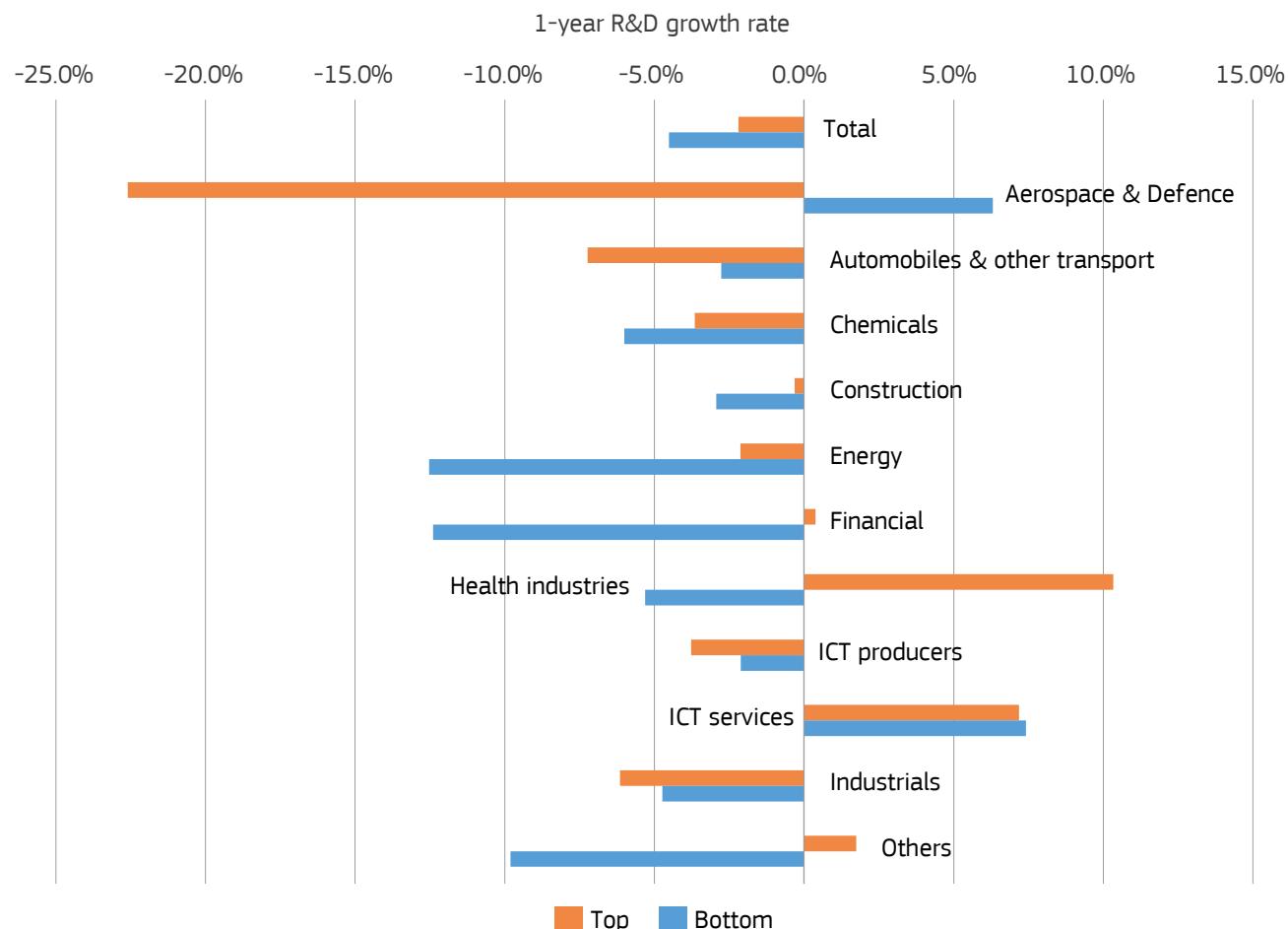
Bearing in mind that the bottom firms represent only 3.9% of the R&D of the EU1000, their negative economic performance is a signal that small EU R&D investing firms have suffered on average more than big R&D investing firms the crises generate by COVID-19. This table also indicates that the downward trend in all of these indicators was more pronounced for smaller firms. It also shows a certain pandemic effect with R&D falling by rather lower percentages than net sales and CAPEX. The difference between the fall in R&D and CAPEX indicates firms were planning for a recovery. This difference in the impact of COVID between big and small R&D investors seems to be confirmed by Figure 3.7, which compares the growth rates of R&D by sector for the top and the bottom groups. On average, bottom companies have been hit harder than top companies in the majority of sectors.

Table 3.1: Main economic indicators for top 1000 EU sample - top vis-à-vis bottom.

	EU-top	EU-bottom
Number of firms	401	599
R&D in 2020, € bn	184.1	7.6
One-year change, %	-2.2	-4.5
Net Sales, € bn	4420.0	598.9
One-year change, %	-8.1	-12.1
R&D intensity, %	4.2	1.2
Operating profits, € bn	263.1	0.3
One-year change , %	-35.3	-99.5
Profitability, %	6.0	0.21
Capex, € bn	275.1	27.9
One-year change , %	-9.6	-14.0
Capex / net sales, %	6.6	5.1
Employees, million	16.3	2.4
One-year change, %	-1.5	-8.7
R&D per employee, €	11267.9	3054.2
Market Cap, € bn	4612.6	510.4
One-year change, %	2.0	1.0

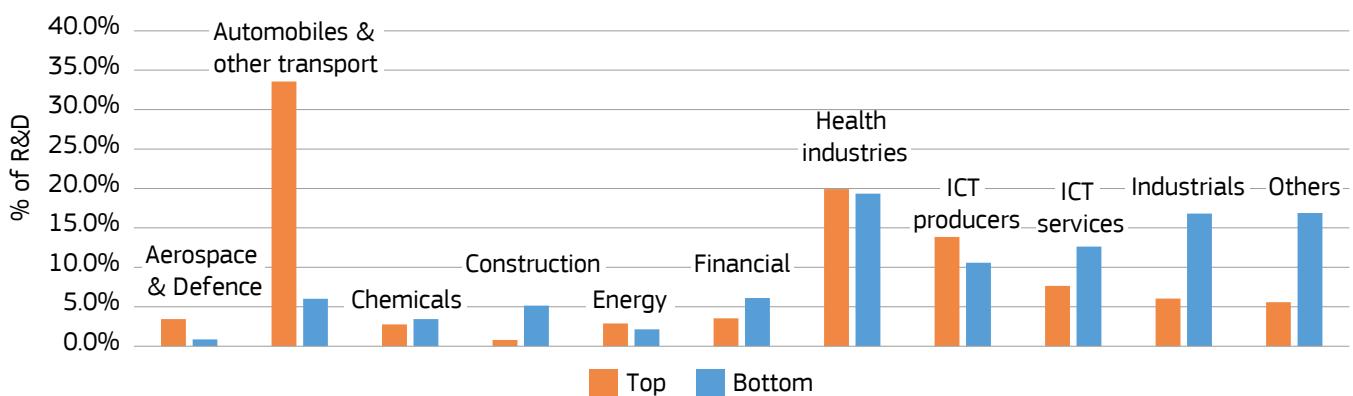
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 3.7: 1-year R&D growth rates by sector- top EU vs bottom EU.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 3.8: R&D share by sector - top EU vis-a-vis bottom EU.



Note: the percentages are the shares of R&D by sector of the top (green bars) and bottom (blue bars) groups
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Moreover, we can compare the distribution of R&D by sector for the top and the bottom groups. This is reported in figure 3.8.

Looking at the two distributions, R&D is differently distributed across sectors for the bottom firms compared to the top firms. In particular, the role of the Automobiles sector in the bottom is far less pronounced than for the top firms. The bottom firms are more focused in construction, financials and industrials. The bottom shares of R&D in ICT services and Industrials are higher than the corresponding ones of the top. Always bearing in mind the small amount of R&D the bottom group represents, the distribution of R&D by sector in the bottom group might be read as an encouraging signal of the presence of small R&D investors in a sector such as ICT services where the EU lags dramatically behind its competitors.

Table 3.2 presents the main financial indicators for the top five countries in terms of R&D investment in the EU1000 sample.

While R&D investment by German firms barely decreased, there was a sharp decrease in France. While the reduction in R&D by the Automobile sector in Germany has been partially offset by the good performance of the Health sector, this is not the case in France, where both sectors registered a decrease in R&D. The picture that emerges from aggregating the EU1000 R&D data by country and sector is similar to that discussed in chapter 2 (and reported in the previous edition of the Scoreboard): the German car industry alone invests more in R&D than every other EU country.

Table 3.2: Main economic indicators for TOP 1000 EU– selected member states.

	Germany	France	Netherlands	Sweden	Ireland
Number of firms	294	149	63	151	40
R&D in 2020, € bn	89	33.1	19.5	12.8	7.4
One-year change, %	-0.3	-8	-1.4	-1.8	-0.2
Net Sales, € bn	1912.6	1076.6	411	262.7	209.5
One-year change, %	-6.7	-12.4	-9.6	-5.5	-6.3
R&D intensity, %	4.7	3.1	4.7	4.8	3.5
Operating profits, € bn	50.5	63.3	22.5	25.3	18.8
One-year change , %	-47.8	-42.1	-38.4	-14.1	-28.9
Profitability, %	2.6	5.9	5.6	10	9
Capex, € bn	104.1	80.3	23.3	8.1	8
One-year change , %	-8.4	-9.5	13.6	-23.5	-11.2
Capex / net sales, %	5.9	7.5	5.7	3.6	3.8
Employees, million	6.9	4.7	1.4	0.9	1.3
One-year change, %	-2.5	-1.6	2.6	-2.5	-2.2
R&D per employee, €	12870.5	6972.8	14098	14424.1	5830.8
Market Cap, € bn	1247.4	1137.8	531.9	340	574.6
One-year change, %	8.9	-8.4	4.1	21	17.4

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁹⁵ Given data constraints, 700 is the largest possible sample size for EU-27 companies that can be compared between SB20 and SB21 as well as SB21 and SB16.

3.4 Entry and exit of top EU 700⁹⁵ in 2020-21

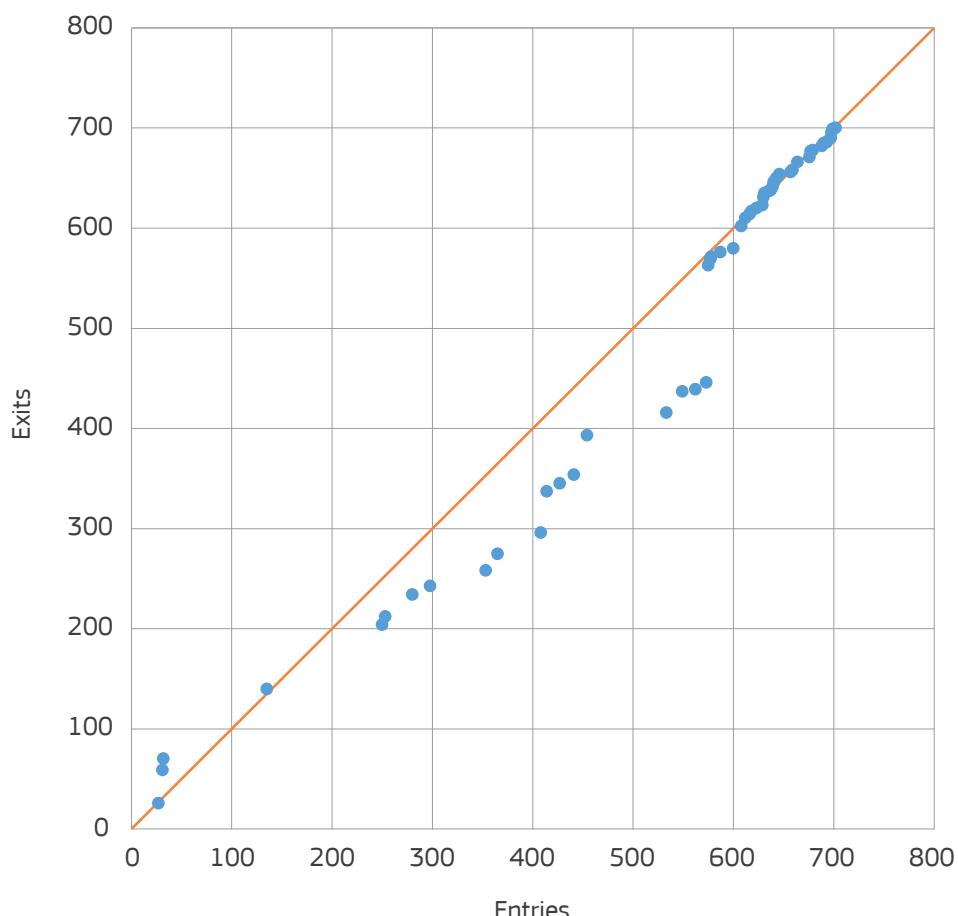
The number of companies that entered and exited the EU-700 ranking increased to 52 from last year's 43, indicating a slightly increased volatility. R&D investment of €5.1bn has been "newly acquired" through entries with €4.2bn "lost" through exits. These represent rather low shares in the total R&D invested by the top EU 700 companies: 2.2% for exits (as of Scoreboard 2020) and 2.7% for entries (as of Scoreboard 2021).

There are three notable entries. With €1.46bn invested in 2020, Geely Sweden Holdings (business support services) became the 110th largest global R&D investor (the 27th in the EU). Investing €1.19bn Fau-

recia (France, automotive parts manufacturer) is the 131st investor in Scoreboard 2021 (the 30th in the EU). Finally, Siemens Energy AG (Germany, Energy) which was spun-off from Siemens invested €1.18bn in 2020 and became the 133rd largest R&D investor company worldwide (32nd largest in the EU). The other 48 entrants invested altogether €1.63bn.

16 EU companies exited the top 2500 global, the other 36 exiting firms are below the 2500th world rank positions. In a similar way to entries, there are three exits of somewhat higher amounts. The Irish pharmaceuticals firm Allergan (investing €1.6bn in R&D in 2019) has exited

Figure 3.9: Rank of entries (horizontal axis) and exits (vertical axis) between SB2020 and SB2021 in the EU 700.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁹⁵ Given data constraints, 700 is the largest possible sample size for EU-27 companies that can be compared between SB20 and SB21 as well as SB21 and SB16.

the Scoreboard (100th position in Scoreboard 2020 (EU rank: 26) having been acquired by AbbVie. Mylan N.V. (Netherlands, pharmaceutical, R&D in 2019 of €549 million) exited from the 275th position (EU rank: 59) following its acquisition by Upjohn, Pfizer's off-patent medicine division, to form Viatris⁹⁶. The third most important EU R&D investor falling out from the scoreboard was Osram Licht (Germany, lighting solutions, R&D in 2019: €425 million) which was acquired by the Austrian sensors and sensing solutions designer AMS AG. The rest of 48 exiting companies invested altogether €1.7bn.

The first four entrants to the top EU 700, have rankings higher than their exiting counterparts (Figure 3.9). For the following 27 places, exiting companies ranked higher than entrants. Finally, for the last group of 21 companies there is no significant difference in positions between entrants/exiting firms. It is important to mention that while the first three entering companies account for 75% of the R&D invested by the 52 entrants, the corresponding share on the exiting side is only 61%. The corresponding world rankings are 110, 131 and 133 vs. 100, 275 and 337. Given that the

Table 3.3: Number of companies that entered the EU-700 in 2021 and exited the EU-700 in 2020 by Member State and sector of activity.

# of companies	exit					entries					net							
	Automobiles & other transport	Health	ICT producers	ICT services	Total	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total	
AT	1	1	2	4						1	1	-1		-1	-1	-3		
BE	2		2	4		2		1	1	4		0		1	-1	0		
DK	4		2	6					3	3		-4		1	1	-3		
FI	1			1		1		1	1	1	4	1	-1	1	1	1	3	
FR	1	1	2	1	5	1		1	1	1	3	6	1	-1	0	-1	2	1
DE	1	1	1	1	6	10		1	1	2	8	12	-1	0	0	1	2	2
EL			1	2	3									-1		-2	-1	-3
IE	2			2						1	1		-2		1		1	-1
IT			1	1		1	1				2	1	1		-1		1	1
LU									1		1			1		1		1
NL	1	2		1	4		5		1	4	10	-1	3		1	3	6	
PT				1	1										-1		-1	-1
SI				1	1										-1		-1	-1
ES				1	1										-1		-1	-1
SE	2	1	1	5	9	1	1	1	1	4	8	1	-1		-1		-1	-1
Total	16	4	5	25	52	4	10	4	8	26	52	2	-6	0	3	1	0	

Note: Other sectors for exits include: chemicals, industrials, others. Other sectors for entries include: construction, financial, industrials, others
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁹⁶ <https://en.wikipedia.org/wiki/Mylan>



top quintile of the scoreboard is the most important (see chapter 1) it can be concluded that the entry-exit dynamics of 2020-2021EU has been favourable for the EU from the largest R&D investors' point of view.

Considering companies entering and leaving the EU 700 ranking by EU Member States and their key sectors of activity, one observes a net drop in the number of companies active in health industries (by 6 companies, mainly Danish) as well as a net increase in the number of companies registered in the Netherlands (by 6 companies).

Concerning R&D investment, the large movements in ICT producers, health as well as automotive industries are due to the previously mentioned large entrants and exiting firms as well as the developments in the number

of companies active in the health industries as one observes from Table 3.3 (and Table A3.9, Appendix). However, by excluding the three main entrants and exiting companies, one observes that the net R&D flow of the rest of the companies is overall small and slightly negative with a total "loss" of €335 million (Table 3.4). While ICT producers register the highest negative figure among the sectors (€218 million), the largest decreases are observed for Denmark – exit of health companies due M&A, Austria – exit of a chemical company for the same reason. On the other hand, the Netherlands has seen the largest increase, due mainly to entries to health industries (e.g. Curevac, Immatics, Pharvaris, Lava Therapeutics, Centogene) and others (e.g. Nouryon (financial), Tennessee Acquisition Holding (financial), Heijmans (construction)). Other sectors and Member States have smaller net balances.

Table 3.4: R&D (€million) "acquired" and "lost" via entries and exits without the three main entrants and exiting firms.

	exits (adjusted for the exchange rates)					
	Automo- biles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT		13.8		17.641	130.8	162.3
BE		29.7			21.9	51.6
DK		149.5			111.1	260.7
FI		10.7				10.7
FR		10.9	197.9	64.2	17.4	290.4
DE	15.9	12.9	31.3	31.9	188.6	280.6
EL			12.7		83.0	95.7
IE		12.1			1.1	13.3
IT					10.6	10.6
LU						
NL	114.2	60.4			28.6	203.2
PT					36.3	36.3
SI					18.3	18.3
ES					9.9	9.9
SE		30.6	11.7	76.8	66.1	185.3
Total exits	130.1	330.6	253.6	190.6	723.8	1628.7



entries						
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT					20.3	20.3
BE		32.7		15.3	10.4	58.4
DK					64.2	64.2
FI	16.2		13.7	10.4	27.2	67.5
FR			11.3	63.8	230.1	305.2
DE		14.4		27.6	163.6	205.5
EL						
IE					46.2	46.2
IT	17.4	11.6				29.0
LU				16.8		16.8
NL		168.3		11.1	182.3	361.7
PT						
SI						
ES						
SE	35.6	17.8	10.8	17.9	37.1	119.2
Total exits	69.2	244.7	35.8	163.0	781.2	1294.0
net						
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT		-13.8		-17.641	-110.5	-142.0
BE		3.0		15.3	-11.5	6.9
DK		-149.5			-46.9	-196.5
FI	16.2	-10.7	13.7	10.4	27.2	56.8
FR		-10.9	-186.6	-0.4	212.7	14.9
DE	-15.9	1.5	-31.3	-4.4	-25.0	-75.1
EL			-12.7		-83.0	-95.7
IE		-12.1			45.1	32.9
IT	17.4	11.6			-10.6	18.4
LU				16.8	0.0	16.8
NL	-114.2	107.9		11.1	153.6	158.5
PT					-36.3	-36.3
SI					-18.3	-18.3
ES					-9.9	-9.9
SE	35.6	-12.8	-0.9	-58.9	-29.1	-66.1
Total exits	-60.9	-85.9	-217.8	-27.6	57.5	-334.7

Note: Other sectors for exits include: chemicals, industrials, others. Other sectors for entries include: construction, financial, industrials, others
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

3.5 Entry and exit of top EU 700 in SB2016-SB2021

The number of EU headquartered companies that entered and exited the top EU700 ranking between Scoreboard 2016 and Scoreboard 2021 was 184. R&D investment of €12bn has been “newly acquired” through entries, and €14.5bn “lost” with the exits. Despite the 26% share in the total number of companies (184/700), the shares of these entries/exits are relatively modest in terms of R&D invested by the top EU 700 companies, i.e. they amount to 8.8% for exits (as of Scoreboard 2016) and 6.3% for entries (as of Scoreboard 2021).

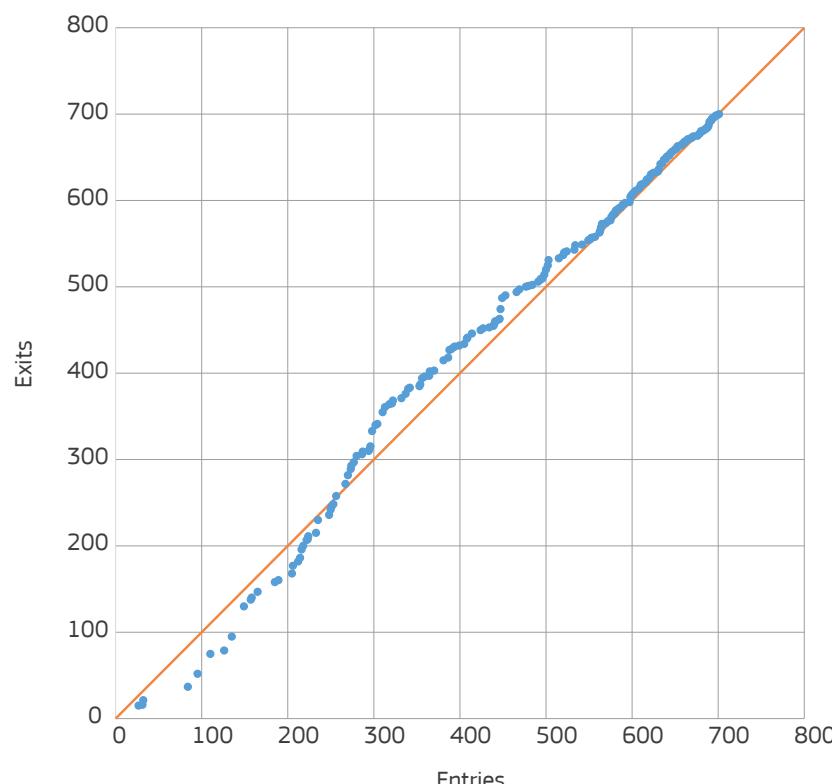
The three largest companies entered in 2020 and they are the ones discussed in the previous section (entry and exit in the top EU 700 in 2020-21). The other 181 companies that were not yet in the top EU 700 in the 2016 Scoreboards entrants invested altogether €8.14bn, ranging from €10 million to €380 million and averaging at €45 million.

Comparing the 2016 Scoreboard with the 2021 Scoreboard 77 EU companies exited from the list of top

2500 in 2017–20, and 107 from lower positions. The four largest companies present in the 2016 Scoreboard but absent from the 2021 one invested €7.8bn in total in 2015–16. These are the previously discussed Allergan (Ireland, pharmaceuticals, R&D-2015: €2.68bn) as well as Alcatel-Lucent (France, ICT producers, €2.41bn) acquired by Nokia, Exor (Italy, real estate investment & services, €1.95bn) and Unilever Group (Netherlands, food producers, €1.01bn). The other 179 exiting companies invested altogether €6.6bn, ranging from €7 million to €617 million and averaging at €36.8 million.

Concerning the entry-exit dynamics of the top EU 700, new entrants occupy slightly worse positions in the ranking (the 24th highest entrant ranked 1,166 worldwide) than exiting firms (the 24th exiting firm ranked 989 worldwide). This changes below the 24th entrant, where entrants had slightly better positions than exiting companies until the bottom 80 (ranked 549–700 in the EU 700), which had practically no differences in positions for entries and exits (Figure 3.10).

Figure 3.10: Rank of entries (horizontal axis) and exits (vertical axis) between 2016 and 2021 in the EU 700.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



Concerning companies entering and leaving the EU 700 ranking by EU MS and the key sectors of activity, one observes a net increase in the number of companies active in health industries (12 companies), mainly Irish, French and Dutch) as well as a net drop of companies in the automotive sector (7 companies, mainly German). Country-wise, while Denmark and Ireland have succeeded to strengthen their presence in the Scoreboard more than other countries, a number of Member States

have seen somewhat more of their companies dropping out than the others (Table 3.5). The highest turnover was in health industries followed by ICT services.

Concerning R&D investment the large movements in the ICT producers, Health, Automotive industries as well as in the "Other sectors" categories are due to the previously mentioned large entrants and exiting firms (Table A3.10, Appendix). However, by excluding the

Table 3.5: Number of companies that entered EU-700 in 2021 and exited EU-700 in 2016 by MS and sector of activity.

# of companies	exit					entries					net							
	Automobiles & other transport	Health	ICT producers	ICT services	Total	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total	
AT	1	1	2	3	7	1	1	1	6	9			1	-2	3	2		
BE		2		6	8		3	1	1	5	10		1	1	1	-1	2	
CZ				2	2										-2	-2		
DK		3	1	2	6		4	1	3	8	16		1	1	2	6	10	
FI			3	2	4	9	1	1	1	0	4	1	1	-2	-1	-4	-5	
FR	2	7	4	5	29	2	10	2	8	9	31	0	3	-2	3	-2	2	
DE	12	6	3	8	48	3	5	6	6	28	48	-9	-1	3	-2	9		
EL		1	1	3	5			1			1		-1	0		-3	-4	
IE		3		1	5	1	6	1		5	13	1	3	1	-1	4	8	
IT	1			7	8		2			2	4	-1	2			-5	-4	
LU			1	3	4				1	3	4		0	-1	1			
NL	2	4	3	2	16	1	7		4	8	20	-1	3	-3	2	3	4	
PL									1	1					1	1		
PT				1	1	2				1	1				-1		-1	
RO					1	1									-1	-1		
SI				2	2										-2	-2		
ES	1			3	4	1				0	1				-3	-3		
SE	1	7	1	2	28	3	7	2	2	7	21	2		1	-10	-7		
Total	20	34	16	24	90	184	13	46	16	27	82	184	-7	12	0	3	-8	0

Note: Other sectors are: Aerospace & defence, Chemicals, Construction, Energy, Financial, Industrials, Others
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



three main entrants and four main exiting companies, one observes that the net R&D investment of the rest of the companies is smaller, but not negligible except for a few combinations of Member States and sectors (Table 3.6). The overall balance is positive (€630 million) due to the positive balance of the health indus-

tries and the ICT services category. While Denmark, Germany and Ireland are the largest winners of net R&D investment, France and Spain have “lost” the most R&D, although much less than the gains recorded by the other three countries.

Table 3.6: R&D (€million) “acquired” and “lost” via entries and exits without the three main entrants and exiting firms.

	exits (adjusted for the exchange rates)					
	Automo- biles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	8.2	20.8		76.1	125.1	230.2
BE		22.8			66.3	89.1
CZ					23.9	23.9
DK		71.7		23.4	94.8	189.9
FI			34.3	31.8	119.0	185.1
FR	38.7	97.8	234.8	249.1	881.9	1502.3
DE	235.4	161.2	119.3	161.5	656.2	1333.7
EL		44.3	17.8		75.3	137.4
IE		33.3		21.3	10.0	64.7
IT	52.5				92.3	144.8
LU			8.4		71.3	79.6
NL	102.4	612.9	446.4	104.7	1086.4	2352.7
PL						
PT				100.0	27.8	127.8
RO					10.0	10.0
SI					28.2	28.2
ES	68.2				310.7	378.9
SE	6.7	256.1	13.5	43.3	315.9	635.5
Total exits	512.1	1320.9	874.6	811.2	3995.0	7513.8



	entries					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	17.6	69.0	57.8		239.4	383.8
BE		113.3	20.7	15.3	145.9	295.3
CZ						
DK		680.3	19.5	73.3	189.4	962.4
FI	16.2	12.9	13.7	13.4		56.1
FR	65.4	248.4	29.9	263.3	532.9	1139.9
DE	231.2	164.9	245.2	218.3	1163.2	2022.8
EL			10.3			10.3
IE	119.8	185.5	35.4		301.2	641.9
IT		26.4			78.2	104.5
LU				16.8	83.5	100.2
NL	159.0	233.8		366.4	693.5	1452.7
PL					104.8	104.8
PT					12.2	12.2
RO						
SI						
ES	58.8					58.8
SE	275.1	205.0	24.0	130.0	171.6	805.6
Total exits	943.2	1939.5	456.5	1096.7	3715.8	8151.7
	net					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	9.3	48.2	57.8	-76.1	114.3	153.6
BE		90.5	20.7	15.3	79.7	206.2
CZ					-23.9	-23.9
DK		608.6	19.5	49.8	94.7	772.5
FI	16.2	12.9	-20.7	-18.4	-119.0	-129.0
FR	26.7	150.6	-204.9	14.2	-349.0	-362.4
DE	-4.2	3.7	125.9	56.8	507.0	689.2
EL		-44.3	-7.5		-75.3	-127.1
IE	119.8	152.2	35.4	-21.3	291.2	577.2
IT	-52.5	26.4			-14.1	-40.2



LU		-8.4	16.8	12.2	20.6
NL	56.6	-379.0	-446.4	261.7	-392.9
PL					104.8
PT			-100.0	-15.6	-115.6
RO				-10.0	-10.0
SI				-28.2	-28.2
ES	-9.4			-310.7	-320.1
SE	268.5	-51.1	10.5	86.7	-144.4
Total exits	431.1	618.6	-418.0	285.5	-279.2
					637.9

Note: Other sectors are: Aerospace & defence, Chemicals, Construction, Energy, Financial, Industrials, Others.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



CHAPTER 4

PATENTING TRENDS IN CLIMATE CHANGE MITIGATION TECHNOLOGIES: FOCUS ON ENERGY INTENSIVE INDUSTRIES

4.1 Introduction

The 2020 EU Industrial R&D Investment Scoreboard (hereafter the Scoreboard) provided an extensive analysis on patenting trends in Climate Change Mitigation Technologies (CCMTs, also referred to as 'green' patents) for the EU, a comparison with other major economies, and insights into the performance of EU Scoreboard companies and their subsidiaries in green innovation. In addition, it offered a short, broad look into the decarbonisation of key industries, such as metal processing, cement and chemicals. This year's chapter provides a short review and analysis of the evolution of general trends in Climate Change Mitigation Technologies with the extension of the dataset to 2018, as well as a deeper analysis of green inventions for Energy Intensive Industries (EIs). Focusing on the

Climate Change Mitigation Technologies addressing the production or processing of goods⁹⁷, we adjust the selection of patent classes to cover 8 energy intensive industries in more detail. Table 4.1 in Box 4.1 shows the industries that will be analysed (Cement, Ceramics, Chemicals, Fertiliser, Glass, Lime, Refining, Steel) and the corresponding Cooperative Patent Classification (CPC) codes used.

Both in the case of Climate Change Mitigation Technologies and the focus section in Energy Intensive Industries, we first present an analysis of all activity (companies and other actors) and then focus on the activity of the Scoreboard companies.

4.2 Update on overall trends in green patenting activity

The Compared to last year's edition, the average annual share of green inventions⁹⁸ in all patenting activity in the period 2000 to 2018 increased from 7% to 8%. Data from the last couple of years shows that the decline in the share of green inventions, observed

following the previous financial crisis, has stopped, and the share has remained stable since 2015. At the same time the decline in filings observed post 2012, especially for green technologies addressing energy production, has halted with numbers stabilising.

⁹⁷ Section Y02P of the CPC classification.

⁹⁸ We use patent families as a proxy for inventions (see also Box 4.1).



China has been the exception in this trend, showing no decline in the time following the last economic crisis. The global number of green inventions has been increasing constantly, driven by green inventive activity in China, which however, as discussed in last year's edition, focuses mostly on its domestic market, given that a very small share of its inventions are of high-value i.e. also filed for protection with other IP offices (Figure 4.1). Thus international filings, which were not boosted by the activity in China also slowed down in the last economic crisis and are now stable.

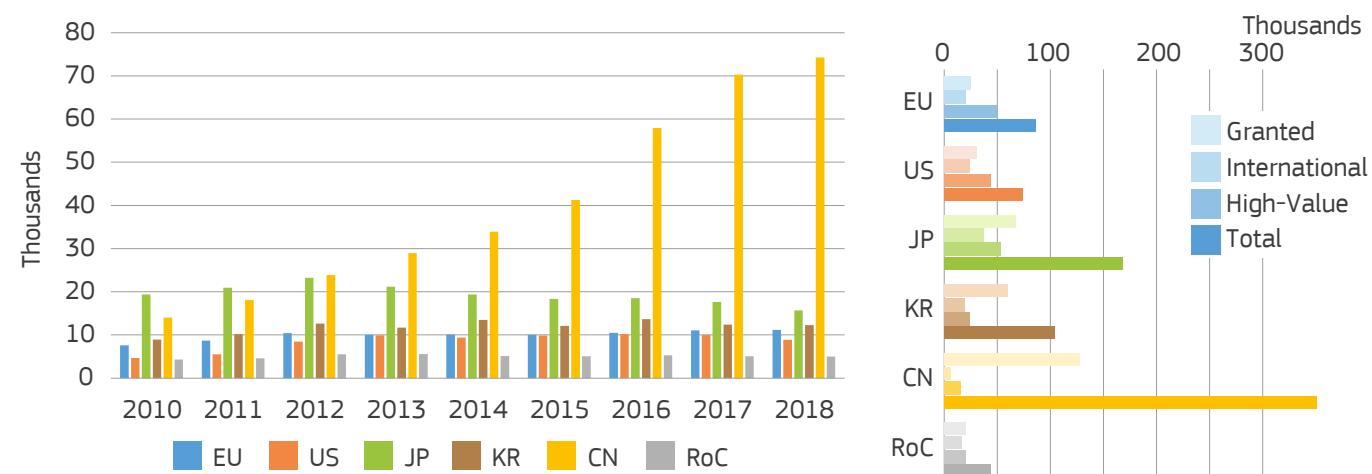
The overall findings of last year's Scoreboard in terms of the EU's positioning remain largely unchanged. In the period 2010-2018, the EU has the second highest share of high-value inventions⁹⁹ (57%) just below the USA (58%). Similarly, 23% of the EU green inventions are protected internationally, the second highest share following the USA with 33%. Among major economies, South Korea and the EU have the largest share of green technologies in all inventions (over 11%).

However, in 2018 the EU had the highest specialisation index based on the share of green technologies

within each country's patent portfolio, moving up from being second behind South Korea in 2016. Nonetheless, in the period 2010-2018, the EU was second to Japan and the USA in terms of cumulative high-value inventions and international inventions, respectively. China and the USA remained the two most targeted countries in terms of the international protection of green inventions.

In the period 2010-2018, energy and transport remain the most prominent areas in the EU portfolio of green inventions, with shares of 35% and 32% respectively. The share of inventions in the energy domain has increased across all major economies. Among the EU member states, Denmark remains the country with the highest share of green inventions in total inventions (21%, nearly 3 thousand patent families) in its national portfolio. Germany continues to rank first in terms of the total number of green inventions (over 47 thousand) followed by France (over 15 thousand). The share of green inventions is 12% for both Germany and France, which rank first and second respectively in all but one subcategory of green technologies (in ICT Sweden is first) and account for 50% or more of total inventions.

Figure 4.1: Trend of green inventions and share of international and high-value green inventions.



Note: On the left: annual trend in the period 2010-2018 of green inventions for major economies. On the right: Total green inventions for major economies in the period 2010-2018 (dark colours) and high-value inventions, international inventions and granted inventions (lighter colours) with label indicating the share over the total inventions.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

⁹⁹ An invention / patent family is considered of high-value when it contains patent applications to more than one office (see also Box 4.1)..



North-Central EU regions are the most active: Stuttgart and Upper Bavaria in Germany and the Parisian Region in France produced more than 17% of all filings of EU green inventions between 2010 and 2018. Europe remains the geographical area with the highest degree of collaboration among countries, even if the USA is the world leader both in terms of number of international partners, and number of international co-inventions in green technologies.

Regarding the Scoreboard companies, Toyota (JP) remained the top producer of green inventions globally (nearly 3 thousand), and Bosch (DE) was the top EU representative among the Top10 companies (just over a thousand inventions). Companies belonging to the alternative energy sector have the highest share of green inventions, about 79%, but record a lower number of total inventions compared to other sectors. Automobiles & Parts is the EU ICB sector that produces the highest number of inventions, and 17% of these are related to green technologies (Figure 4.2). Compared

to last year's findings, and relevant to the discussion on EUs, the Chemicals sector has become more prominent in terms of green inventions in the EU. Comparing the green patent share of the EU ICB sectors to the global performance per ICB sector, the EU Scoreboard companies are markedly more active in green innovation in the sectors of Mining, Industrial Transportation, Banks, General Retailers, Mobile Telecommunications and Travel and Leisure, while showing lower activity in General Industrials, Support Services, Automobiles and Parts, Construction Materials and Industrial Metals and Mining.

There is also a slight increase in the share of green inventions produced by non-EU subsidiaries of the EU Scoreboard companies, mainly in China and the USA. While these inventions are seeking protection in the EU market, the trend is also accompanied by an increased share of inventions of EU subsidiaries protected in the China and the USA.

Box 4.1: Methodology

Patenting trends are produced following the methodology developed by the JRC¹⁰⁰ to derive indicators on the global inventive activity in clean energy technologies¹⁰¹. Patent data are retrieved from PATSTAT 2020 Autumn Edition, and the analysis 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). Note that due to the time lag, datasets for 2018 are provisional and we are not able to capture the effects of the Covid-19 pandemic.

The JRC methodology uses patent families as a proxy for inventions, and the two terms are used interchangeably in the text. Patent families include all documents relevant to a distinct invention, including patent applications to multiple jurisdictions as well as those following regional, national and interna-

¹⁰⁰ JRC publications:

- Pasimeni, F., Fiorini, A., and Georgakaki, A. (2021). International landscape of the inventive activity on climate change mitigation technologies. A patent analysis. Energy Strategy Reviews, 36, 100677. <https://doi.org/10.1016/j.esr.2021.100677>
- Pasimeni, F. and Georgakaki, A. (2020). Patent-Based Indicators: Main Concepts and Data Availability. JRC121685, https://setis.ec.europa.eu/patent-based-indicators-main-concepts-and-data-availability_en
- 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. <https://doi.org/10.1016/j.wpi.2019.101927>
- Pasimeni, F. (2019). SQL query to increase data accuracy and completeness in PATSTAT. World Patent Information, 57, 1-7. <https://doi.org/10.1016/j.wpi.2019.02.001>
- Fiorini, A., Georgakaki, A., Pasimeni, F. and Tzimas, E. (2017). Monitoring R&D in Low-Carbon Energy Technologies. EUR 28446 EN, Publications Office of the European Union, Luxembourg. ISBN 978-92-79-65591-3, <https://doi.org/10.2760/434051>

¹⁰¹ SETIS Research & Innovation data: <https://setis.ec.europa.eu/publications/setis-research-innovation-data>

tional routes. These patent families are collections of documents/applications (sometimes filed in different authorities) protecting the same invention, so these can be in the application process or granted, filed locally, internationally or both, filed in more than one country/authority and/or be high value or not. Statistics are produced based on applicants only (as the owners of the patent and, thus, directly financing the R&D activities producing the patent) and considering different categories of applicants, namely companies, universities and government non-profit organisations. In cases of multiple documents per invention, and when more than one applicant or technology code is associated with an application, fractional counting is used to proportion effort between applicants or technological areas, thus preventing multiple counting. An invention is considered 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 for it prospects in international markets.^{102,103}. 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. In addition, international patents denote efforts to protect solely outside the country of residence of the applicant. A granted invention only sums 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.

The analysis of EU Scoreboard companies focuses on 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&I investments.

The selection of CCMTS relevant to Energy Intensive Industries (EII) is done through the codes shown in Table 4.1. In the case of the Fertiliser and Steel Industries, it is necessary to cross-reference the Y02P with codes from the technology classification to restrict the scope of the CCMT class. For example, the Steel EII includes those patent families that are tagged with Y02P 10 (metal processing) and also have at least one tag in C21B (Manufacture of iron or steel) or C21C (Processing of pig-iron) or C21D (Ferrous metals).

Table 4.1: Concordance of CPC classes and EII technologies.

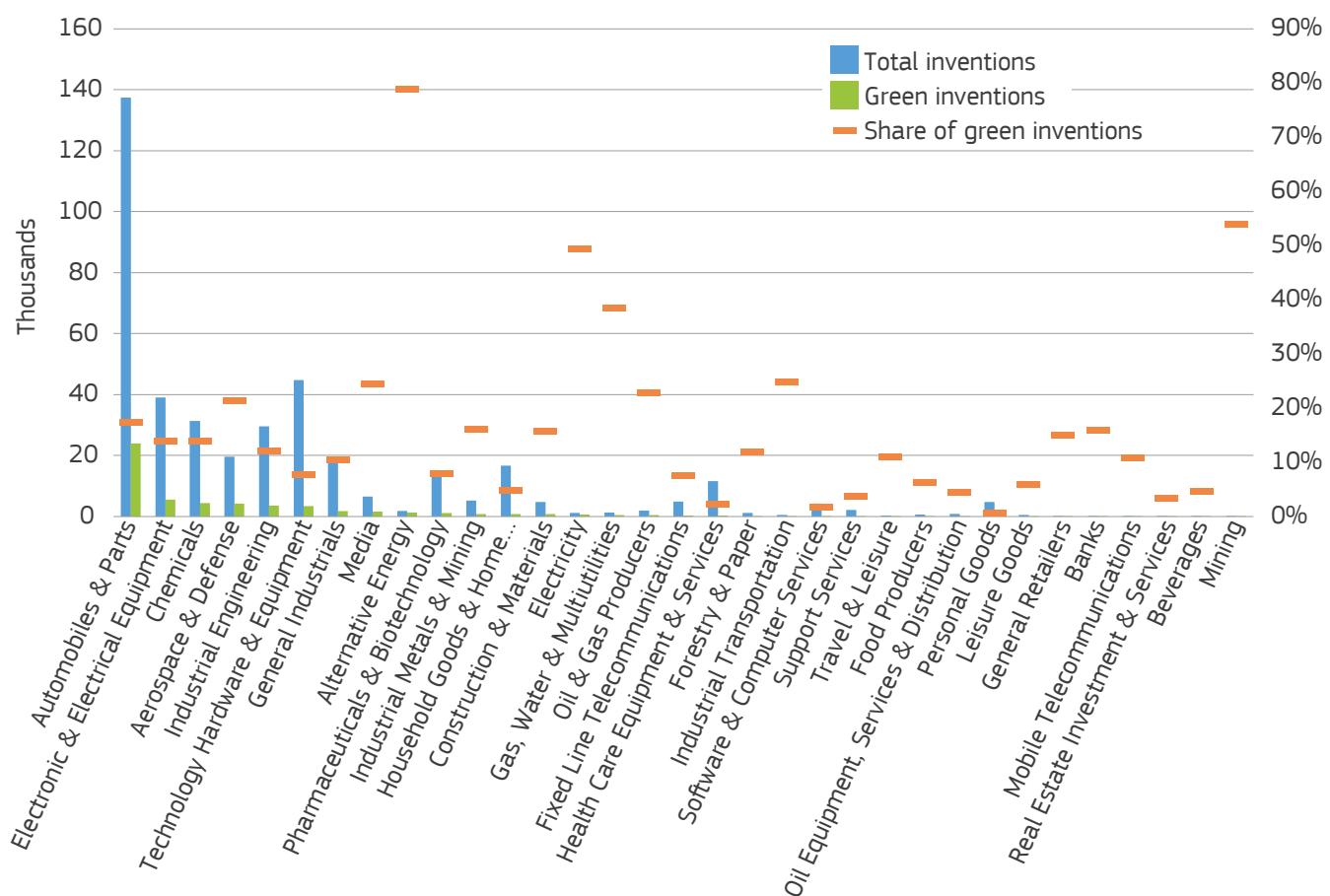
EII Industries	Y02P classes	Extra filter
Cement	Y02P 40/10, Y02P 40/12, Y02P 40/18	
Ceramics	Y02P 40/60, Y02P 40/69	
Chemicals	Y02P 20 and subclasses	

¹⁰² Dechezleprêtre, A., et al., (2011) Invention and transfer of climate change–mitigation technologies: a global analysis. Review of environmental economics and policy.

¹⁰³ Dechezleprêtre, A. et al., (2015) Invention and International Diffusion of Water Conservation and Availability Technologies. OECD Environment Working Papers, No. 82.

EII Industries	Y02P classes	Extra filter
Fertiliser	Y02P 60 and subclasses	C05
Glass	Y02P 40/50, Y02P 40/57	
Lime	Y02P 40/40, Y02P 40/45	
Refining	Y02P 30 and subclasses	
Steel	Y02P 10 and subclasses	C21B or C21C or C21D

Figure 4.2: EU Scoreboard companies' invention activity by ICB sector - 2010-2018.



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 2010-2018.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

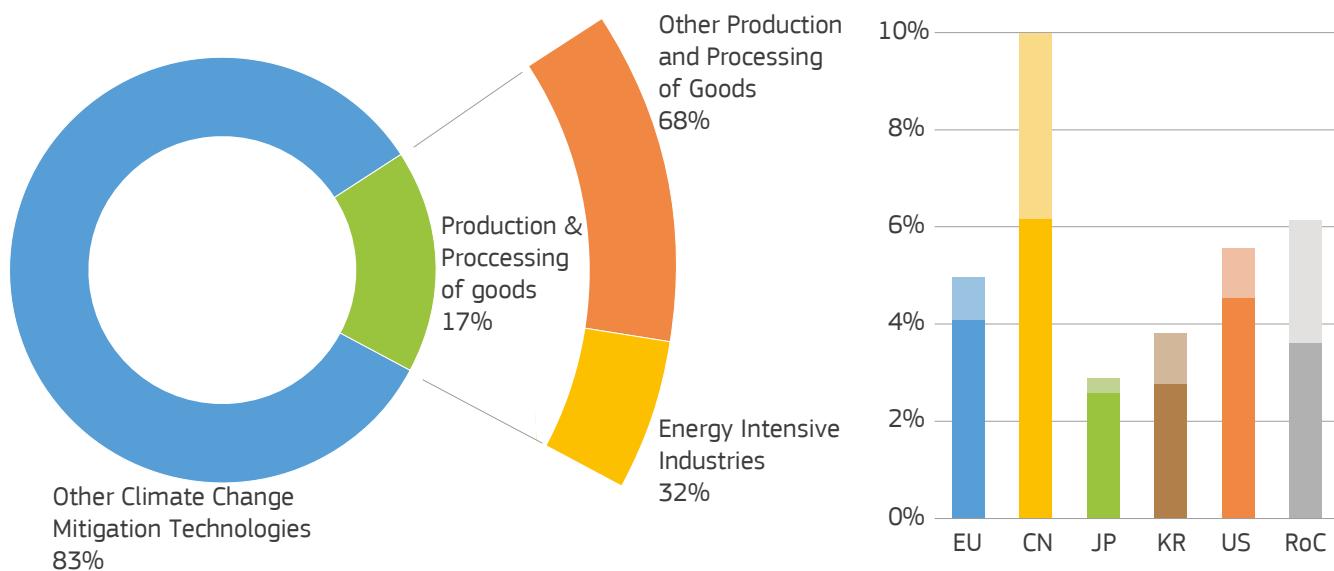
4.3 Patenting trends in green inventions relevant to energy intensive industries

The decarbonisation of energy intensive industries will be key for the EU to reach its climate goals. The innovative capacity of the EU's leading companies will be crucial for the industry to remain competitive while doing so. The innovation needed is capital and technology intensive, may require large-scale infrastructure for demonstrations, and is thus not easily undertaken by start-ups or small companies outside the field. The energy intensive industry sector is dominated by large multinational incumbents, which may be more likely to keep knowledge in-house and thus have varying propensity to patent across countries and industries.

In the period 2010-2018, inventions in energy intensive industries accounted for about a third of filings in the area of production or processing of goods, that in turn represented 17% of the total green inventions (Figure 4.3) Globally, the inventive activity addressing

EII accounts for about 5% of the total green inventions on average, and this share has been almost constant over the last 10 years. Nonetheless, the levels of activity are quite different among major economies. The share is highest for China, where there is also a much more significant contribution from non-business sectors. China, with its heavy reliance on coal-burning power stations and high level of air pollution, also has a very urgent need for green technology solutions. The EU has the second largest share of EII inventions within the Y02P technology area (35%) after the USA (37%). As in the case of all green inventions, filings relevant to EIIs have been increasing every year, mainly driven by applicants from China, with the exception of the glass and refining industries. Since 2010, the number of green inventions in EII that applicants seek to protect each year has doubled.

Figure 4.3: Share of green inventions in energy intensive industries (2010-2018).



Note: On the left: share over the inventions in production and processing of goods and green inventions. On the right: share by major economies. Dark colours represent the contribution of companies.

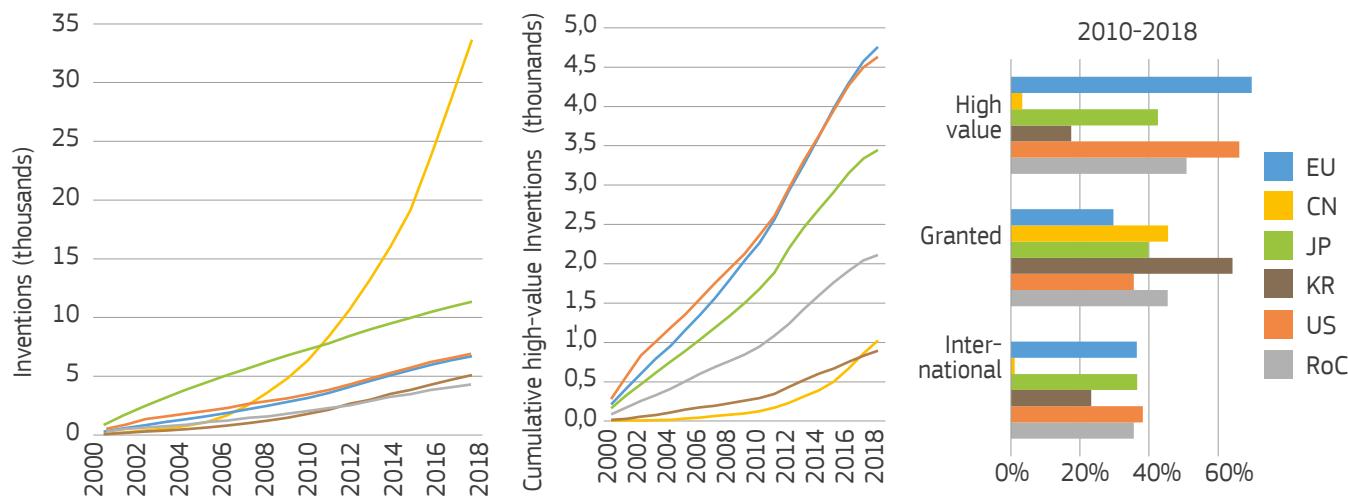
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



China ranks first in inventions in energy intensive industries and, with a cumulative number of inventions of the same order of magnitude as those produced by all other actors put together. When it comes to inventions protected in multiple jurisdictions (i.e., high-value inventions), however, the EU and USA are in the lead, followed by Japan. While South Korea and China have a higher share of granted inventions, stakeholders from the EU, Japan and USA tend to file internationally for a larger proportion of inventions in energy intensive industries. In summary, Figure 4.4 shows that – as in the case of

all climate change mitigation technologies – Chinese applicants mostly protect inventive activity related to energy intensive industries in the national jurisdiction, spurred by intellectual property laws that incentivise patenting activity via grants and a large, rapidly growing internal market. In contrast, applicants from the EU, the USA and Japan have a more international focus, indicating the readiness of innovative technologies in their portfolio to flow across borders and capture emerging markets.

Figure 4.4: Trends in green inventions in energy intensive industries.



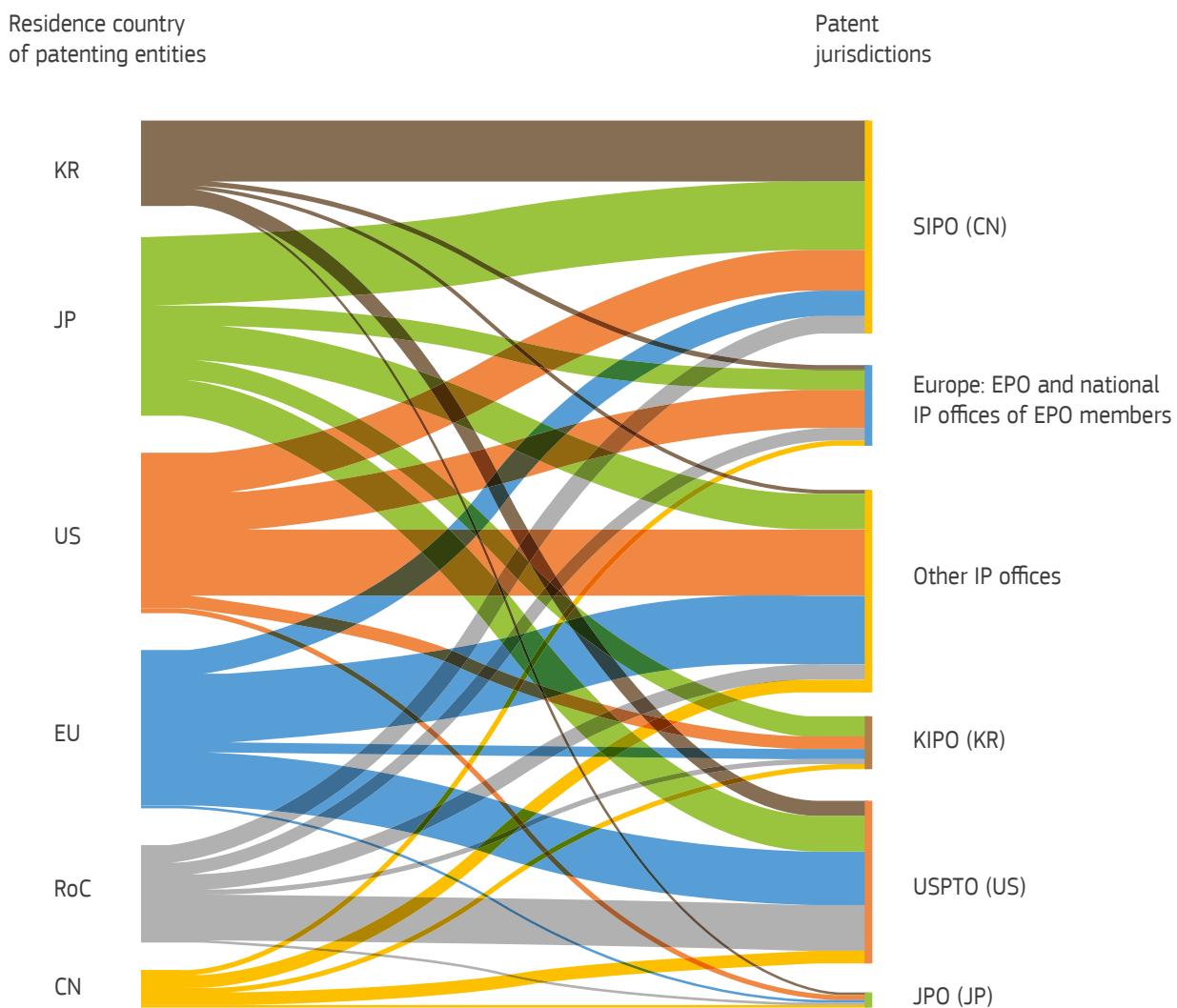
Note: Cumulative inventions (left), high-value inventions (centre), and share of high-value, granted and international inventions (right) for major economies in the period of 2010-2018.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Accordingly, Figure 4.5 shows China is the jurisdiction attracting the most foreign originating inventions in energy intensive industries (29%), followed by the USA (28%). Europe is the third most targeted geographical area where foreign applicants decide to protect inventions in energy intensive industries (11%). About 33% of the respective EU inventions are protected in the USA, while about 43% have as destination geographical areas outside the major economies. Note that Japan features very little as a destination for the protection of inventions by foreign applicants. Its strong industry and technology base, coupled with the specificity of regulations that apply, tend to make this a rather difficult and insular market for foreign technology providers.

Among major economies, over recent years, China shows the highest specialisation in inventive activity in energy intensive industries. The USA and the EU that were leading in this area since 2007 have gradually lost this advantage and been overtaken by China in the period 2015 - 2016 (Figure 4.6). Japan and South Korea maintain their level of specialisation, which is however lower than the world average. Between 2010 and 2018 the EU has more or less maintained the same level of specialisation in the energy intensive industries in focus with the exception of the fertiliser and steel industries where there has been a marked drop, and the refining and petrochemical industries where the already prominent advantage has increased. The results are not surprising given

Figure 4.5: Flow of green inventions in energy intensive industries.



Note: Country of applicant (left) and foreign authorities targeted for protection (right) in the period 2010 onwards.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

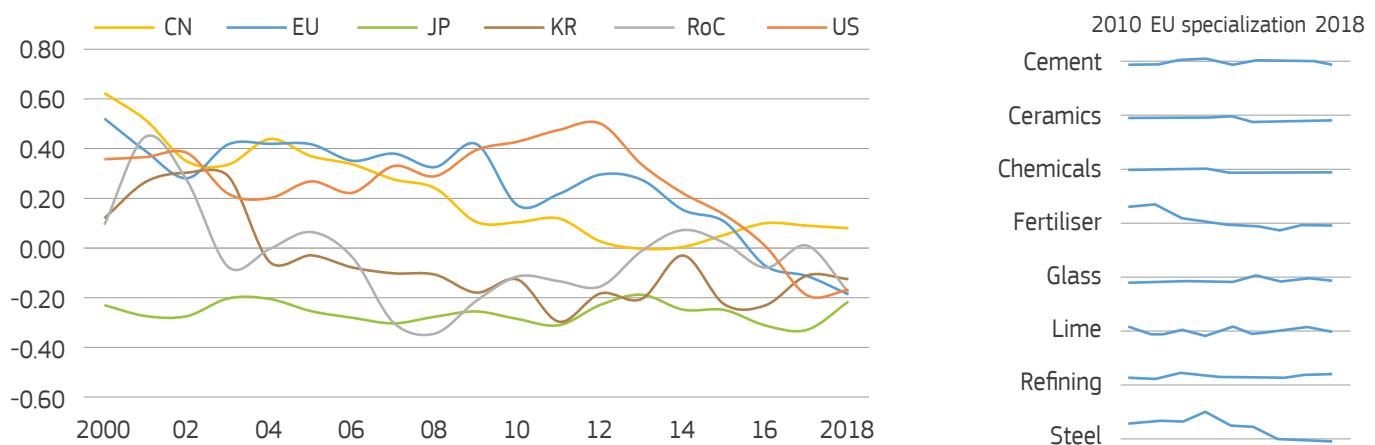
the policy support in China and exponential increase in filings, and have to be put into perspective, taking into consideration the focus and strength of each economy, and how many of these innovation outputs aim for international protection (see also Figure 4.4). They do however provide an idea on the change of relative importance of the subject areas of innovative activity within each economy – irrespective of whether or not this aims to serve the national or international market.

Figure 4.7 provides a breakdown of the portfolio of inventions in energy intensive industries based on the filings of entities headquartered in each major economy. The numbers and shares reflect both the R&D effort carried out and the propensity to patent that may vary significantly between industry sectors and technologies.

On average, inventions related to the chemical industry account for about 60% of the portfolio of inventions



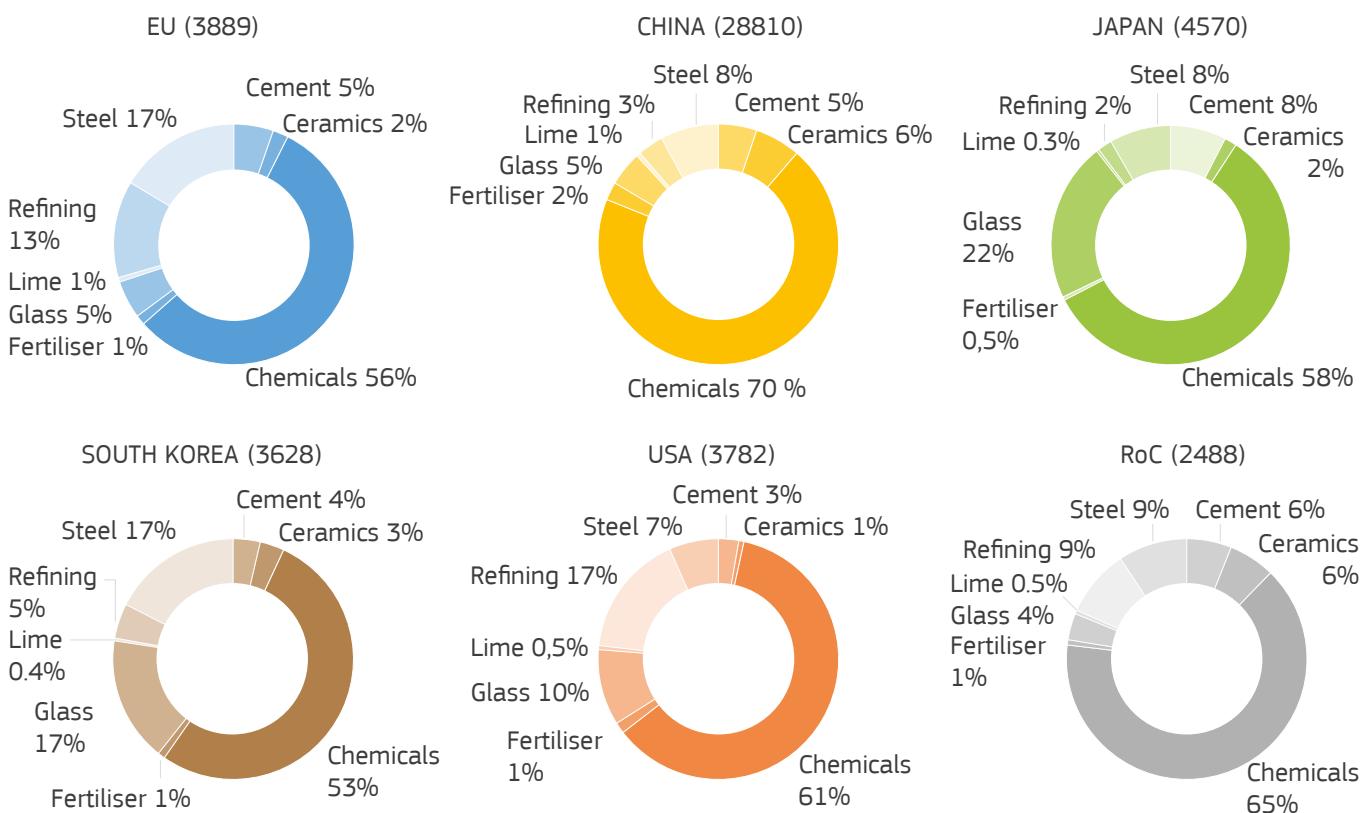
Figure 4.6: Specialisation index in green inventions for energy intensive industries.



Note: On the left, the share of inventions relevant to energy intensive industries within CCMTs for the production and processing of goods for major economies. On the right, the trend in EU specialization by energy intensive industry between 2010 -2018. The horizontal axis denotes the world average.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 4.7: Share of inventions per energy intensive industry for major economies, 2010-2018.



Note: The number in brackets shows the number of inventions.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

across all major economies. In China the share is as high as 70% while in the EU it is 56%. In the period 2010-2018, and consistent with maintained specialisation in this area, the EU has one of the highest share of inventions related to refining (13%), second only to the USA (17%). Similarly, the EU has the second highest share of inventions related to steel (16%), second to

that of South Korea (18%). Nonetheless, the relatively high share of steel in inventions from China, may account for the drop in relative specialisation in economies that did not follow the same rate of increase of filings. 23% of Japanese inventions in energy intensive industries relate to the production of glass, the highest among all portfolios.

4.3.1 National and regional performance in the EU

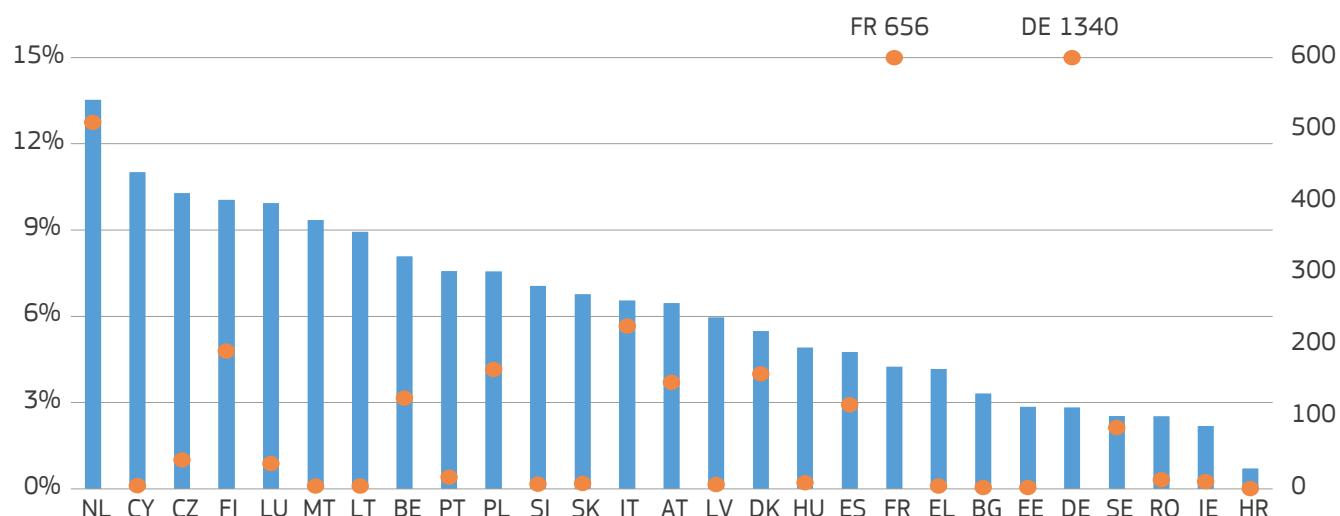
Over the period 2010-2018, among the EU member states, the Netherlands had the highest share of green inventions addressing the energy intensive industries in focus (14%). Germany had by far the highest number of inventions, which however only correspond to 3% of the green inventions produced by German applicants Figure 4.8.

Given the difference the magnitude of patenting output between Germany and the rest of the member states, it is not surprising that the country ranks among the top five in each of the energy intensive industries examined in terms of share of inventions in the EU (Figure 4.9). While it leads in six out of nine industries, it just loses out to Italy on Ceramics and ranks second and fourth in green inventions related to the lime and

refining industries, led by Finland and the Netherlands respectively. France is second highest in the number of inventions and the only other EU country that ranks in the top five in all the industries in focus. Italy and Poland are second and third in the number of inventions related to ceramics, accounting respectively for 24% and 20% of the total EU inventive activity in this area.

Different companies lead the number of inventions in each of the eight energy intensive industries, apart from the German BASF that ranks first in both Chemicals and Fertilisers. Cement technology is led by Heidelberg Cement (DE), Ceramics by Keller HCW (DE), Glass by Heraeus Quarzglas (DE), Lime by Upm Kymmene (FI), Refining by Shell Research (NL) and Steel by Daimler (DE).

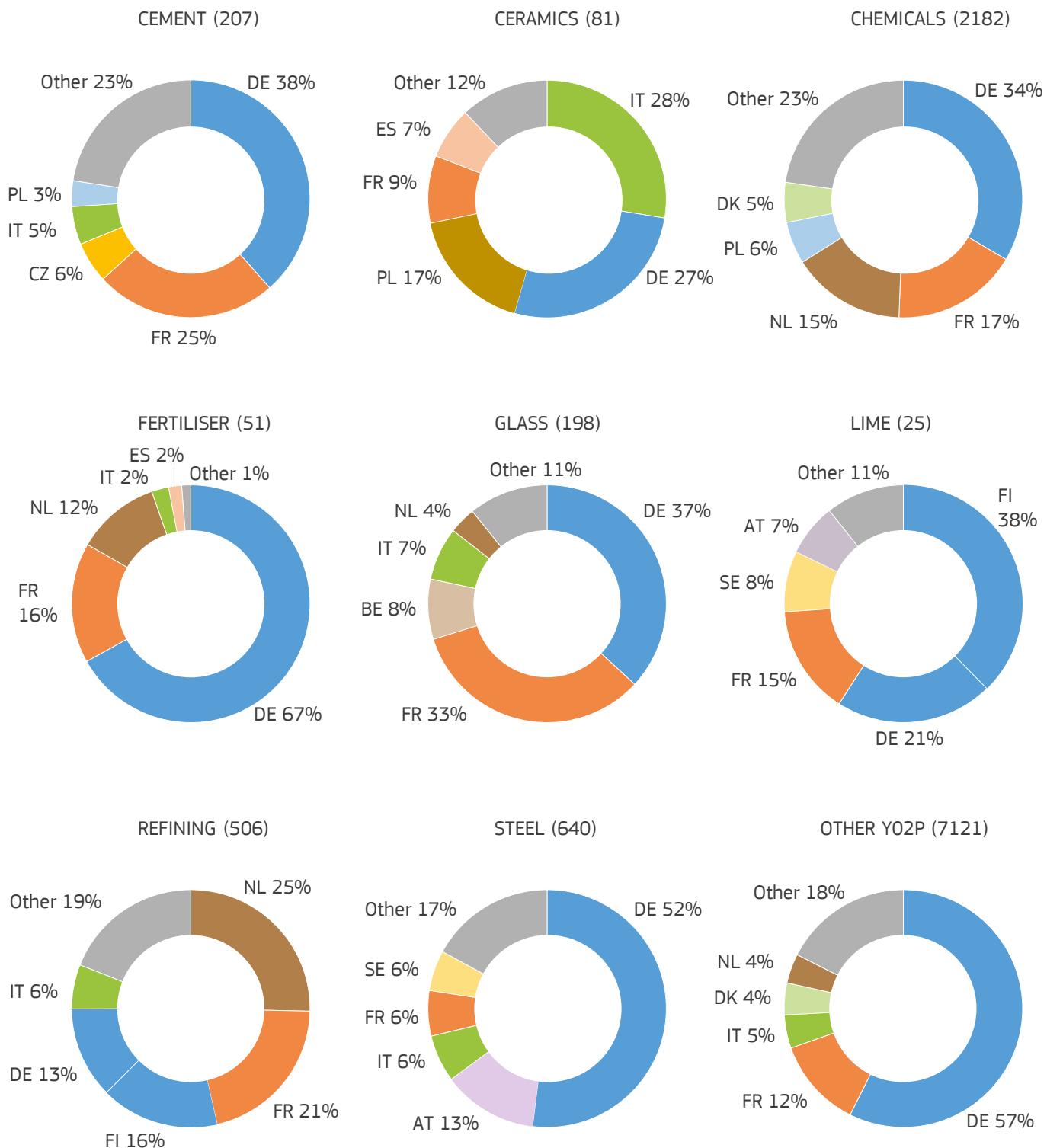
Figure 4.8: Green inventions in energy intensive industries per EU member state.



Note: Share of energy intensive industry in green inventions (bars coloured in blue, left axis) and number of inventions in energy intensive industries (dots in orange, right axis) per EU member state in the period 2010-2018.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 4.9: Share of green inventions and champions per industry and EU member state, 2010-2018e.



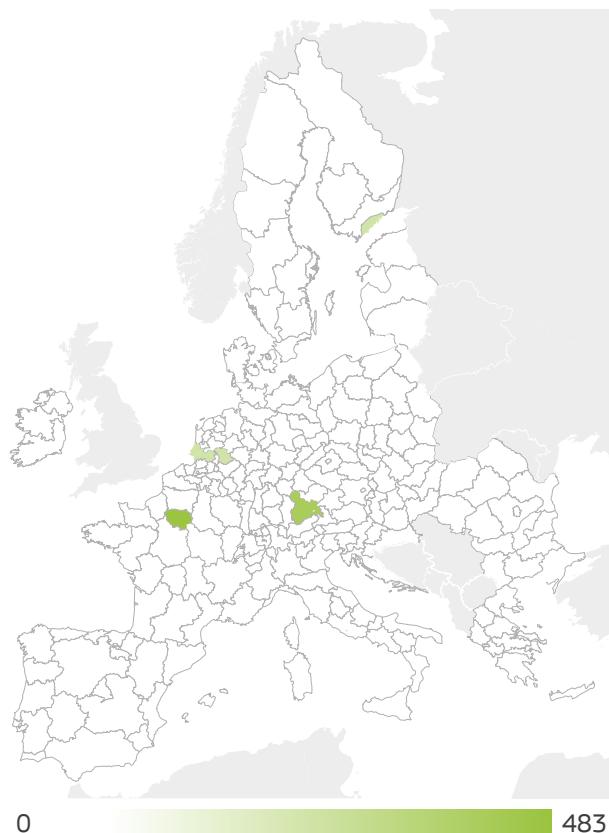
Note: The number in brackets shows the number of inventions.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

In cement, the top 10 is made up of 7 German and 3 French companies, with Heidelberg Cement the clear leader. In ceramics the field is more diverse with companies from all 5 leading countries represented in the top 10. The top 10 in Chemicals features companies from the Netherlands, Germany and France, the Danish Haldor Topsoe just missing out on a top 3 position. Half of the top 10 companies in fertilisers are also headquartered in Germany, while German and French companies dominate the top 10 EU innovators in the glass industry. Two Finish companies lead in the lime industry, where Scandinavian companies make up half of the top 10. Finish companies also have a strong presence in refining. However Shell Research is well ahead at the top of the field. Germany has a strong presence in the top 10 of the steel industry, with Austria the only other country with two representatives.

These leading companies are concentrated in specific regions, making them stand out as innovation hotspots for the energy intensive industries. Île de France is the EU region with the highest number of inventions (Figure 4.10). The Oberbayern region in Germany follows, while four more German regions are in the EU top 10. The Netherlands has two, Zuid-Holland and Noord-Brabant, in the top 10 regional list, and Finland and Denmark one region (Helsinki-Uusimaa and Hovedstaden, respectively). Three of these regions, namely Île de France, Oberbayern and Noord-Brabant also feature in the top 10 as the hosts of innovators in all climate change mitigation technologies.

Figure 4.10: Regional distribution of green inventions in energy intensive industries and key industrial players resident in the top 5 Nuts regions (2010 onwards).



Nuts region	Inventions	Major industrial players
Île de France (FR10)	333	IFP Énergies nouvelles, Air Liquide, Arkema, Commissariat à l'Énergie Atomique et aux Énergies Alternatives, Saint-Gobain Glass, Centre national de la recherche scientifique
Oberbayern (DE21)	200	Linde AG, Siemens AG, Fraunhofer Society
South Holland (NL33)	184	SHELL Internationale Research Maatschappij B.V.
Rheinhessen-Pfalz (DEB3)	173	BASF SE
Düsseldorf (DEA1)	70	Evonik Industries, ThyssenKrupp AG

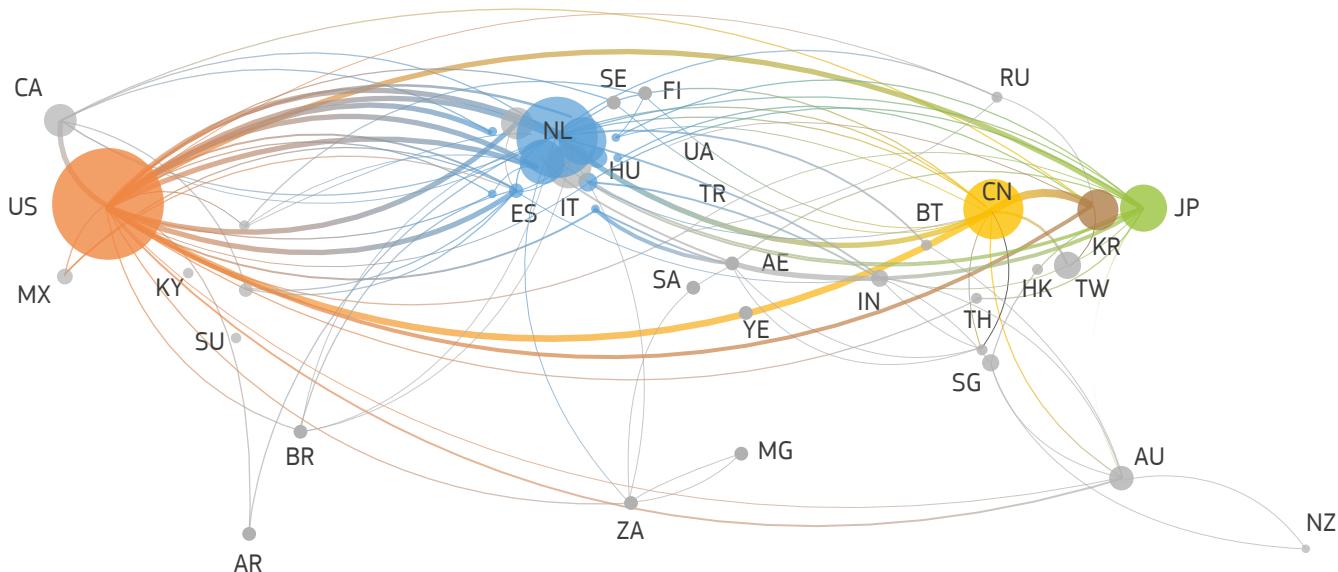
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

4.3.2 International alliances in green inventions in energy intensive industries

In the period since 2010, the USA and the Netherlands are the two countries with the highest number of co-inventions in energy intensive industries (Figure 4.11). In a similar way to the trend observed for the overall green inventive activity, the USA also ranks first in terms of links with other countries in green inventions for energy intensive industries, having collaborations with 39 countries around the world (Figure 4.12). Overall, the EU shows a very dense network among Member States

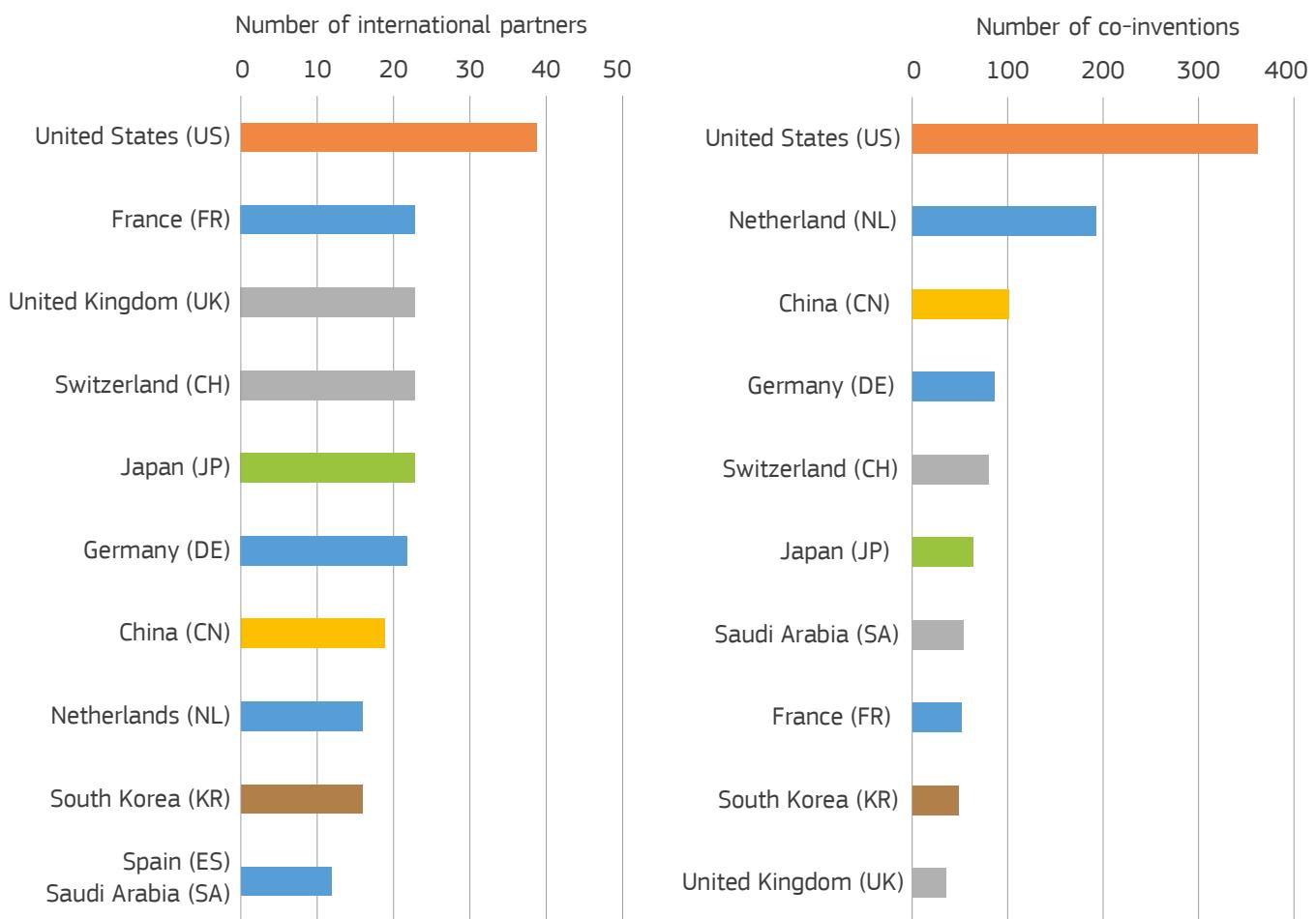
that collaborate with the USA more than with any other country. France, Germany and the Netherlands are the EU countries collaborating with the most international partners. The Dutch and USA subsidiaries of Shell have produced the highest number of co-inventions in collaboration with other entities. They are followed by the Saudi Arabian Oil Company, the German BASF SE, and the American Aramco Services Company.

Figure 4.11: Alliances network in green inventions in energy intensive industries-2010 onwards.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 4.12: Countries with the most international partners and highest number of green co-inventions in energy intensive industries -2000 onwards.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

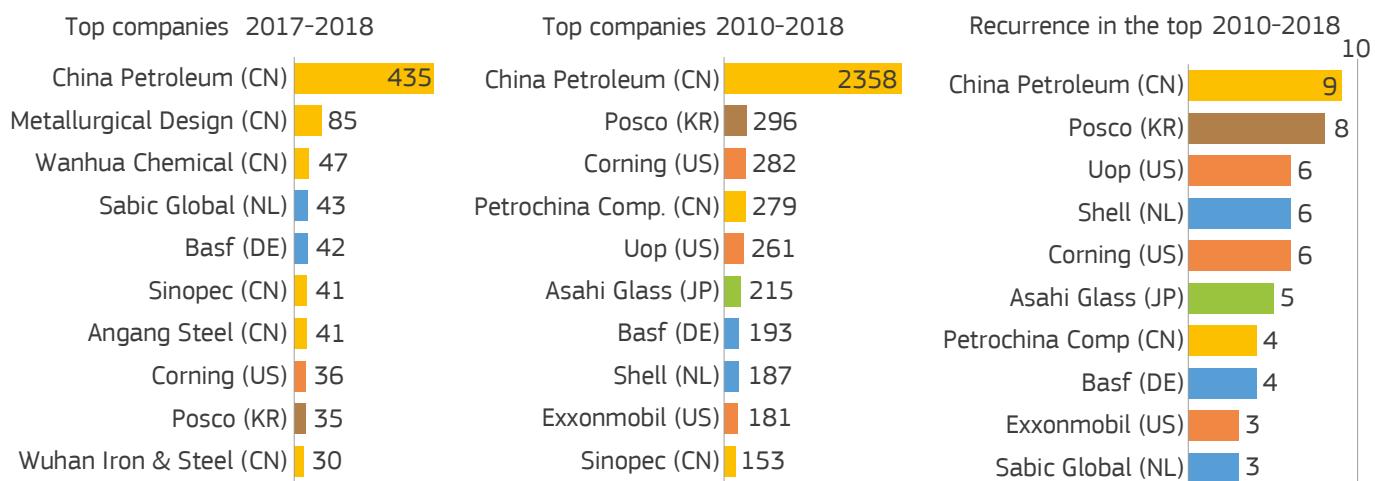
4.3.3 Leading international companies

In the period 2010 -2018, companies from China have increased their presence among the top patenting entities, claiming six spots in the top 10 in 2017-2018. Two EU resident companies (Sabic Global in the Netherlands and BASF in Germany) also feature, while US-based companies have also been prominent within the extended time frame 2010-2018. Within this period, China Petroleum always features in the top 10 applicants of green inventions in energy intensive industries. It is followed by Posco (KR), Uop (US) and Shell Internationale Research Maatschappij B.V. (NL) in terms of

constant inventive activity and recurrence in the top 10 (Figure 4.13). The increasing prominence of companies from China is consistent with the trends relayed in the previous sections and the incentives driving patent filings in the domestic IP office. As discussed previously, and also shown in the following sections that look into the performance of the EU Scoreboard companies, most of this activity remains internal. Nonetheless, this is not to say that it does not generate knowledge or that it does not interfere with the advance of foreign companies in IP protection and commercialisation in China.



Figure 4.13: Top companies in green inventions in energy intensive industries.



Note: Top 10 in 2017-2018 (left), Top10 in 2010-2018 (centre) and recurrence in the Top 10 in 2010-2018 (right).

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

4.3.4 Positioning of the EU Scoreboard Companies in green inventions for energy intensive industries

In the following, the activity of subsidiary companies has been aggregated and attributed to the EU Scoreboard parent company. This introduces differences in the resulting performance and location (headquarters) of some companies as this now refers to the group and not the subsidiary that may have been referenced in the above.

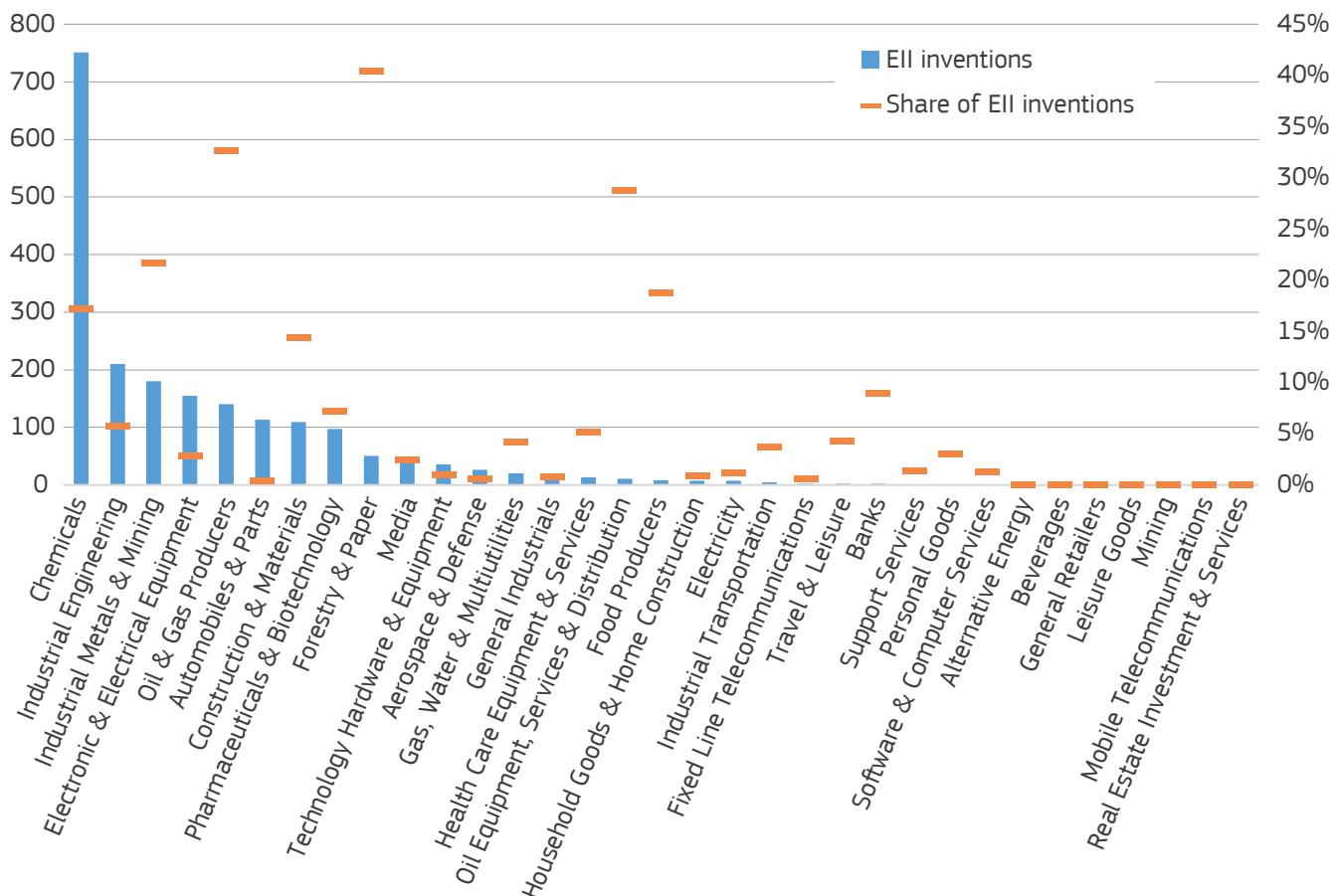
The EU Scoreboard companies, including the inventive activity of subsidiaries located outside the EU, account for about a third of the global green inventive activity in energy intensive industries from 2010 onwards. Not surprisingly, and consistent with the figures in the previous sections, the EU Scoreboard companies in the ICB chemicals sector are those with the highest number of inventions in EIIs (Figure 4.14). This value accounts for the 17% of the green inventions produced by EU Scoreboard companies in the Chemicals sector (ticked in red in Figure 4.14). The ICB sectors of Forestry & Paper, Oil & Gas Producers, Oil Equipment, Services & Distribution, Industrial Metals & Mining, and Food Producers all have a share of 17% or higher in terms of inventions for energy intensive industries in their green inventive activity. All

five of these sectors are predominantly active in green inventions related to the chemicals industry, except for Forestry & Paper that focuses half of its activity towards solutions for the refining industry and Industrial Metals & Mining that addresses over a third of inventions to the steel sector. Notably, the Forestry & Paper sector mostly comprises Scandinavian companies, most prominent among them UPM Kymmene.

The ICB Chemicals sector accounts for 37% of all green inventions in energy intensive industries produced by the EU's Scoreboard companies (Figure 4.15), followed by Industrial Engineering (10%). Scoreboard companies headquartered in Germany account for about half of the inventions in energy intensive industries from EU Scoreboard companies and for 60% of those by the ICB chemicals sector. France is second, hosting EU Scoreboard companies that account for 23% of green inventions in energy intensive industries, 41% of which come from the ICB chemicals sector.

About 85% of the EU's Scoreboard companies' green inventions addressing energy intensive industries are

Figure 4.14: EU Scoreboard companies' green activity in energy intensive industries by ICB sector.



Note: Number of inventions in energy intensive industries (blue, left axis), and share of inventions in energy intensive industries in green inventive activity by ICB sector (red, right axis) for EU Scoreboard companies in the period 2010-2018.

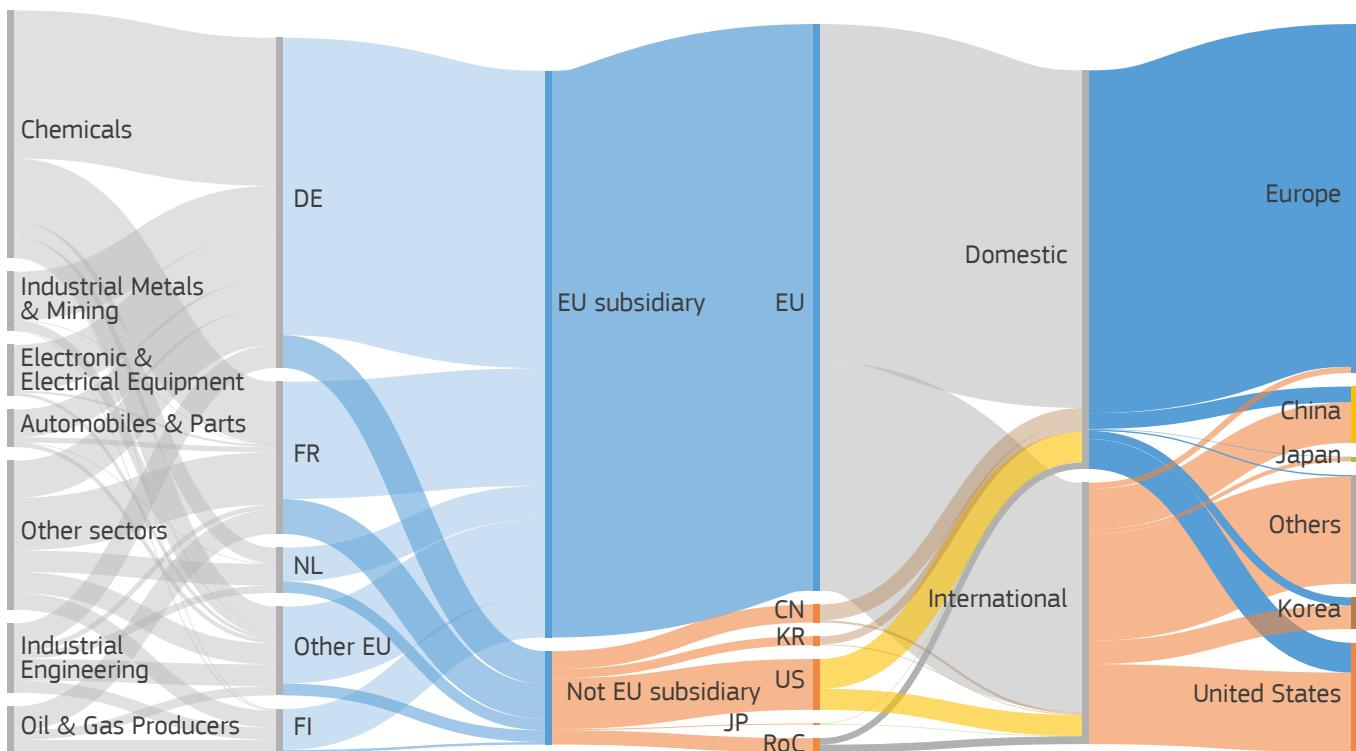
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

produced by subsidiaries also resident in the EU, 40% of which are then protected internationally, with about a third protected in the USA. Just over half of all inventions produced by non-EU residents of EU Scoreboard companies are from companies in the USA, followed by about a fifth from companies resident in China. In total, about a half the effort to protect green inventions in energy intensive industries by EU Scoreboard companies targets Europe, while the rest addresses other jurisdictions, and especially the USPTO (the USA attracts about 17% of green inventions in energy intensive industries).

Consistent with Figure 4.15, the top 10 Scoreboard companies shown in Figure 4.16 are dominated by

Germany and France (BASF leads the ranking, followed by Air Liquide) with Neste from Finland completing the list. BASF and Siemens are also in the top 10 performers in all climate change mitigation technologies. The same figure shows that the top 10 companies in terms of share of inventions for energy intensive industries in their green patenting activity are more diversified in terms of host countries. Two companies resident in the Netherlands top the list. Italy and Finland appear twice, while France and Germany only appear once. SMS Holdings and Neste are the only companies appearing in both rankings, both having a substantial number of filings addressing energy intensive industries and a high degree of focus on the topic within their portfolio of green patents.

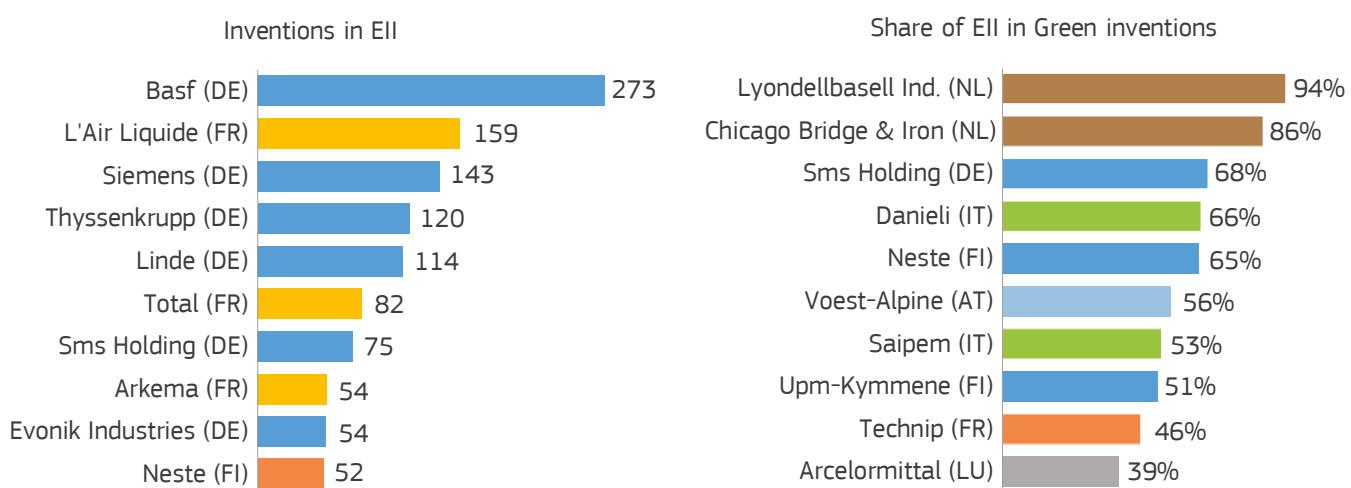
Figure 4.15: EU Scoreboard companies' green activity in energy intensive industries by ICB sector, country of applicant and targeted jurisdiction.



Note: Inventions by ICB sectors (1st column), country of headquarters (2nd column), country where subsidiaries are domiciled (3rd and 4th columns) and IPO jurisdictions (5th and 6th columns) targeted, 2010 onwards..

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 4.16: Top EU Scoreboard companies in green inventions for energy intensive industries.



Note: Top EU Scoreboard companies by number of green inventions in energy intensive industries (left), and by share of energy intensive industries over the green inventions (right), 2010-2018

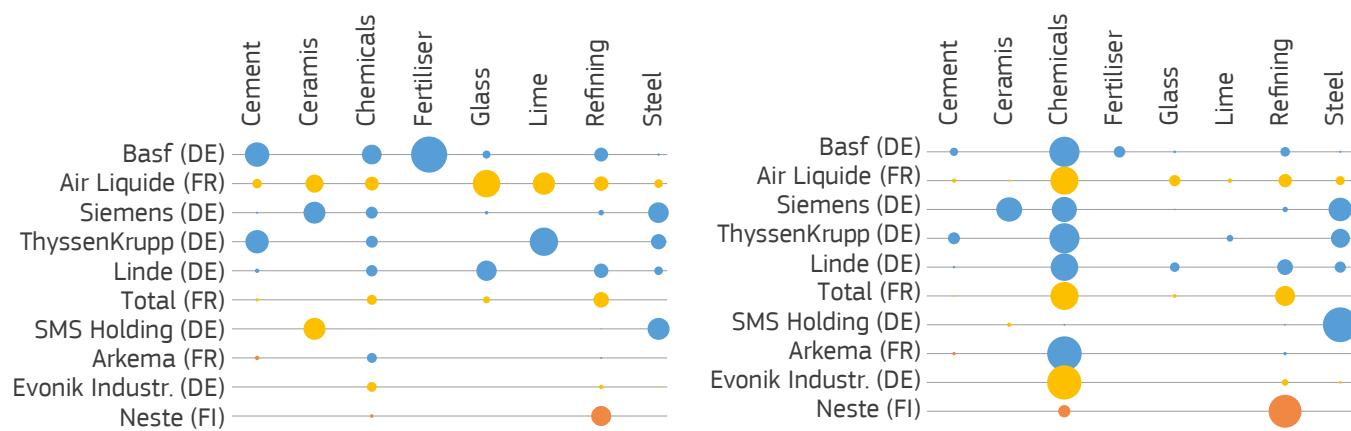
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



Figure 4.17 shows the split of activity per industry for the top 10 Scoreboard companies with the highest number of inventions (Figure 4.19 left). Apart from Neste (refining) and SMS Holdings (steel) all companies have a strong focus on chemicals (over half of their EII portfolio) and share inventions equally among them in the top 10. BASF

also has a presence in cement, fertilisers and refining; Air Liquide in Glass and Refining, and Siemens in Steel. Fertilisers, ceramics and lime are the industries less addressed by the top 10 – but also those with the lowest numbers of inventions (see Figure 4.9) often produced by smaller, regional entities.

Figure 4.17: Split of the activity of the top EU Scoreboard companies by energy intensive industry.



Note: The bubble size represents the share of inventions for each industry, within the top 10 (left), within the company's activity in energy intensive industries (right).

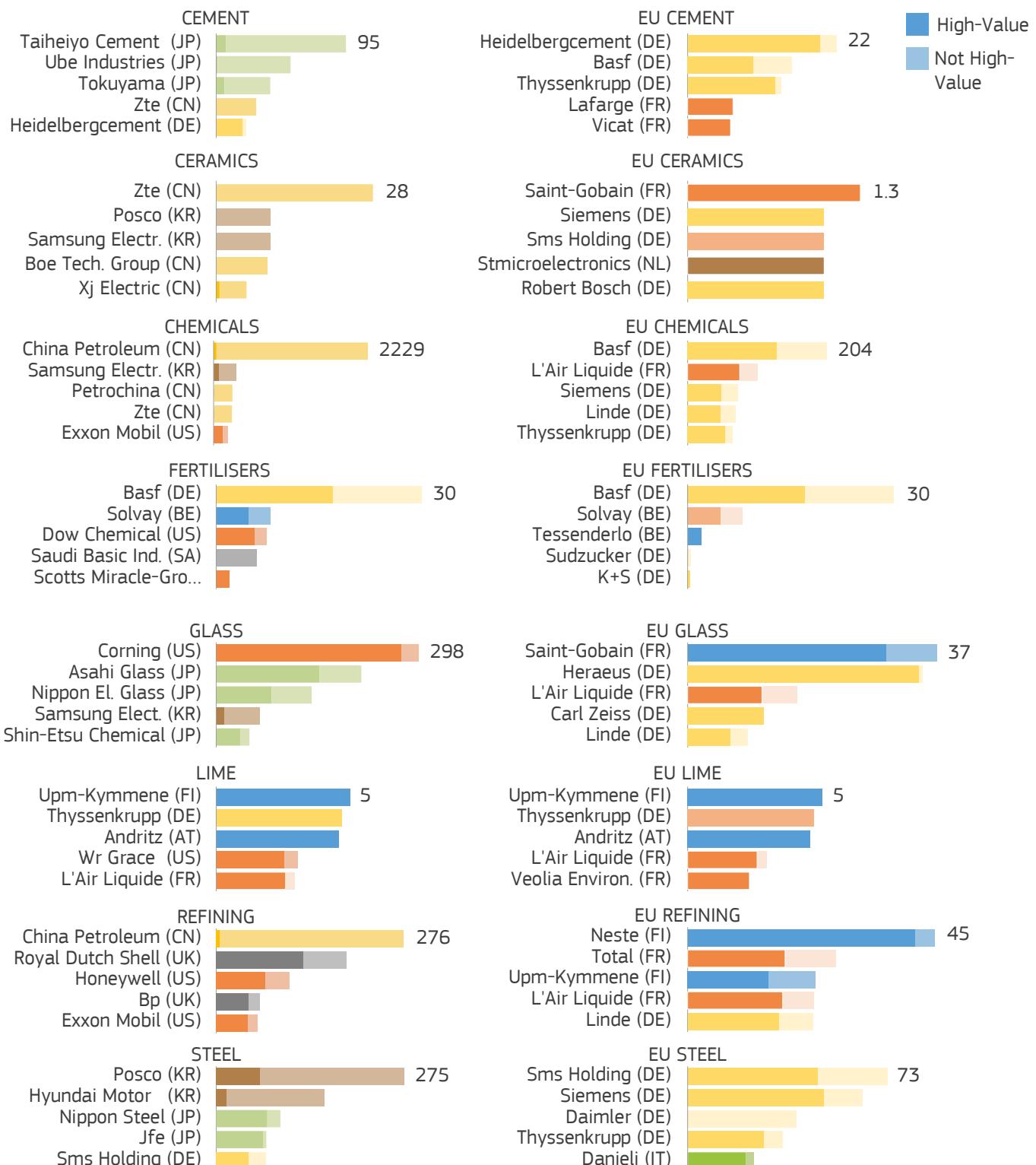
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

4.3.5 Top Scoreboard innovators per energy intensive industry

Japanese Scoreboard companies lead the inventive activity in green inventions for the cement industry. This is consistent with Japan having the highest share of inventions for cement, within the selection of energy intensive industries in focus, among the major economies. However, much of this inventive activity seems to only be protected within the Japanese market, as is the activity of leading Chinese companies. In contrast, the EU top innovators, as a rule, protect their inventions in more than one jurisdiction. The three top EU companies also make the global top 10. Chinese and Korean Scoreboard companies top the list in Ceramics (where global activity is low) and Chemicals although as previously discussed, the share of high-value inventions among their filings is very low (Figure 4.18). BASF makes it into the top 10 in green inventions for the chemical industry, while Neste and Total feature in the respective top 10 for the refining industry, which also included

two UK groups. Note that, as shown previously, the innovative green activity of Shell is located with its Dutch subsidiary. Corning tops green patenting in the glass industry, joined by three Japanese companies and Samsung Electronics; Saint Gobain and Heraeus make it into the global top 10 for the EU. Note that, unlike the cement industry, green inventions in the glass industry are more likely to seek protection internationally. EU Scoreboard companies lead the global ranking in the fertilisers and lime industries; however, activity in these two sectors remains low. Four EU Scoreboard companies (all headquartered in Germany) also make the global top 10 in green inventions for the steel industry. The following charts provide some insight into the specific climate change mitigation technologies within each energy intensive industry that are the focus of the Scoreboard companies in major economies, as revealed by their patent filings.

Figure 4.18: Top 5 Scoreboard companies in green inventions per energy intensive industry.



Note: Positioning of the top Scoreboard companies (left) against those based in the EU (right) in green inventions for energy intensive industries in the period 2010-2018. The dark shading signifies the share of high-value inventions, in the total (light colour.).

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Green inventions related to the Cement industry

Over 80% of green patenting activity in the cement industry is classified under generally improving or optimising production methods. 15% addresses energy efficiency measures and the use of renewable energy sources, and 5% involves innovations introducing CCS in the production process. While Japan leads in all areas, except for CCS where the EU has an advantage, the EU has a higher share of the inventions protected internationally. With the exception of Vicat, all the EU top 5 along with Vinci and L'Air Liquide have a strong presence in CCS, which is one of the main solutions for the decarbonisation of the industry. Prominent non-EU innovators in this field are the Swiss Holcim, along with Schlumberger and Calix from the US.

Green inventions related to the Ceramics industry

The selection of codes describing green inventions in the ceramics industry is not broken down further by technological aspects – not surprising given the limited activity in the field. Chinese Scoreboard companies (mainly ZTE) account for more than half of the activity in filings; however EU Scoreboard companies still account for over one third of high-value patents, with the main contributor being Saint-Gobain, followed by Siemens, SMS HOLDING, STMicroelectronics, and Bosch.

Green inventions related to the Chemicals industry

About 38% of the green inventions in the chemical industries are dedicated to improvements in the production of bulk chemicals using selective catalysts, with an additional 18% looking into innovations in recycling unreacted materials or catalysts. A further 10% is dedicated to improving process efficiency. In all these three areas, China Petroleum & Chemicals shows by far the most activity in selective catalysts, followed by PetroChina, Exxon Mobil, Samsung Electronics and Saudi Basic Industries. Nevertheless, China Petroleum is joined by a different selection of companies when it comes to recycling; Dow Chemical, BASF, Honeywell, and Arkema make up the top 10, indicating a higher

focus on recycling for EU and US companies. Chinese companies also top the activity in process efficiency inventions. Siemens and ThyssenKrupp are among the top 5 in energy recovery (e.g. by cogeneration, H₂ recovery or pressure recovery turbines), with Siemens also third in inventions incorporating renewable energy sources, two fields not dominated by Chinese companies to the same degree. EU companies lead inventions on the reduction of greenhouse gases from the chemical industry (an area with markedly less activity by China), with L'Air Liquide and Linde, the latter also in the top 5 for feedstock innovations. EU companies are prominent in innovation related to chlorine production.

Green inventions related to the Fertiliser industry

In the Fertiliser EII, about 92% of the all inventions relates to the reduction of greenhouse gas emissions in agriculture, mostly dinitrogen oxide (N₂O) using aquaponics, hydroponics or efficiency measures. The EU leads with about 54% of the total inventive activity, followed by the USA (about 22%). BASF, Solvay, Dow Chemical and Saudi Basic Industries are the key Scoreboard innovators in this technology area.

Green inventions related to the Glass industry

In glass production, the focus is on improving the yield, e.g. by reduction of reject rates. Even if Japanese Scoreboard companies collectively account for about half of all the inventive activity, Corning (US) is the company with the highest number of inventions ahead of the Japanese firms Asahi Glass and Nippon Electric Glass.

Green inventions related to the Lime industry

In the production or processing of lime, most patents are filed under the generic code, addressing, for example, limestone regeneration of lime, with less than 2% of inventive activity dedicated to using fuels from renewable energy sources. EU Scoreboard companies take the lead in this area with nearly half of the (limited) inventive activity, with UPM-Kymmene (FI), ThyssenKrupp (DE), and Andritz (AT) sharing the top spot.



Green inventions related to the Refining and Petrochemical Industry

Over 70% of the green inventive activity in the refining and petrochemical industries relates to technologies using bio-feedstock, with another 25% addressing ethylene production. The USA (25% of the total) is the most active country followed by the United Kingdom (22%) and China (22%). NESTE and UPM-Kymmene (both from Finland) together make up a third of the EU inventions related to bio-feedstock.

Green inventions related to the Steel Industry

Recycling and process efficiency are the two most prominent areas in green innovation for the steel industry accounting for 52% and 40% of the activity respectively. The EU Scoreboard companies lead in process efficiency with about 38% of the total inventive activity, while Korean companies lead in recycling (40% of the total). Daimler, ThyssenKrupp, Siemens and SMS Holding (all from Germany) are the most prominent EU companies in producing inventions related to process efficiency but the lead in this area goes to Nippon Steel and POSCO. Siemens and SMS Holding are also very active in recycling. Very little activity is recorded in other areas, such as using renewable energy sources or reducing greenhouse gas emissions.

Key Points

The share of green inventions in overall patenting activity, over the period 2000-2018 is 8%. The EU and South Korea have the highest respective shares among major economies (9.3%). In more recent years (2010-2018) the share is above 11% for both countries.

Filings in green inventions continue to increase, driven by the activity in China, which is still focused mostly on its domestic market, given that a very small share of inventions are filed for protection with other IP offices.

Since 2015 the decline in the share of green inventions, observed following the previous financial crisis, has stopped, and the share has remained stable. The same applies for international filings in green energy technologies, which were not boosted by the activity in China.

In 2018, the EU had the highest specialisation index based on the share of green technologies within each country's patent portfolio, and was second in terms of high-value inventions.

In the period 2010-2018, energy and transport remained the most prominent areas in the EU portfolio of green inventions, with shares of 35% and 32%

respectively. The share of inventions in the energy domain has increased across all major economies.

Among the EU member states, Denmark remains the country with the highest share of green inventions (21%, 3 thousand patent families) in its national portfolio. Germany continues to rank first in terms of the total number of green inventions (over 47 thousand) followed by France (over 15 thousand).

The EU Scoreboard companies in the ICB sector of Automobiles & Parts ICB produce the highest number of inventions; 17% of these address green technologies.

In the period 2010-2018, inventions in energy intensive industries accounted for a third of filings in the areas of production or processing of goods, accounting for 5% of the total green inventions; and this share has been approximately constant over the last 10 years.

The EU has the second largest share of EII inventions within the technology area of production or processing of goods (35%) after the USA (37%). The EU and USA also lead in inventions high-value inventions in EII.



After China (29%) and the USA (28%). Europe is the third most targeted geographical area for foreign applicants deciding to protect inventions in energy intensive industries (11%). About 33% of the respective EU inventions are protected in the USA, while about 43% have as their destination geographical areas outside the major economies.

Between 2010 and 2018 the EU has maintained the same level of specialisation in the energy intensive industries in focus with the exception of the fertiliser and steel industries where there has been a marked drop, and the refining and petrochemical industries where its already prominent advantage has increased. The EU has one of the highest shares of inventions related to refining (13%) and the second highest share of inventions related to steel (16%).

Among the EU member states, the Netherlands had the highest share of green inventions addressing the energy intensive industries in focus (14%). Germany had by far the highest number of inventions, which however only correspond to 3% of the green inventions produced by German applicants.

In the period since 2010, the USA and the Netherlands are the two countries with the highest number of co-inventions in energy intensive industries. Overall, EU Member States collaborate with the USA more than with any other country.

BASF, Shell and Sabic Global are the companies headquartered in the EU with a consistent presence in the global top 10 for green patenting activity in energy intensive industries. Chinese companies have a very strong presence in the top10, but their activity mostly focuses on the Chinese market and patent office.

The EU's Scoreboard companies, including the inventive activity of subsidiaries located outside the EU, account for about one third of the global green inventive activity in energy intensive industries from 2010 onwards. The ICB Chemicals sector is the most active; 17% of all the green inventions produced by EU Scoreboard companies in this ICB sector are in the area of EII and account for 38% of all EII inventions by EU Scoreboard companies.

Japanese Scoreboard companies lead the inventive activity in green inventions for the cement industry and are also very prominent in the glass sector. Chinese and Korean Scoreboard companies top the list in Ceramics and Chemicals. EU Scoreboard companies lead the global ranking in the fertilisers and lime industries. Korea also has a strong presence in the steel industry along with Japan, while the USA and UK are very prominent in refining.



CHAPTER 5

TOP R&D INVESTORS AND THE UN SUSTAINABLE DEVELOPMENT GOALS

Following the coronavirus pandemic and the support made available from the European Union (EU) for reforms and investments via the Recovery and Resilience Facility (RRF), the topics at the core of the 17 Sustainable and Development Goals (SDGs) contained in the 2030 Agenda of the United Nations (UN) have become central to achieve a sustainable and resilient EU economy.¹⁰⁴ The European Commission remains committed to the 2030 Agenda through transformative policies, including the Industrial Strategy for Europe,¹⁰⁵ and has confirmed its target of making its economy sustainable and climate-neutral by 2050 with the European Green Deal.¹⁰⁶

Research, development and innovation (RD&I) are key drivers and critical success factors for achieving a rapid transition to sustainability¹⁰⁷. The Agenda for Sustainable Development and the EU growth strategy explicitly acknowledge the transformative role that RD&I will play in the pursuit of sustainable competitiveness and of a just and inclusive transition for all. The UN SDGs should be seen as both challenges and opportunities for developing business-led solutions and technologies with the potential to contribute to green and social transformations as well as to assure a sustainable recovery for the EU countries in the next decades.

EU policies, as well as legislative and regulatory initiatives with the ability and intent to address SDGs in Europe, are already well developed, particularly concerning good health and well-being (SDG #3) and decent work and economic growth (SDG #8) with, respectively, 933 and 835 initiatives at present.¹⁰⁸ Clearly, the implementation of new and existing EU policies and legislative initiatives interacts with the needs and strategies of the private sector to meet global targets for social and environmental protection and development, the integration of public and private efforts is essential.

Industry has a key role to play in tackling SDG-related challenges. Although the private sector is partly responsible for creating the existing sustainability issues (e.g., climate change, inequality, gender bias in the workplace), it is also a key actor that can deliver solutions to the above problems in the form of technological and organisational innovations. For example, half of the contribution to the reduction in CO₂ emissions by 2050 should come from technologies that are currently in the early stages of development (e.g., demonstration or prototype).¹⁰⁹ Consequently, a high rate of RD&I will be necessary to reduce the cost of further developing early-stage inventions and, given

¹⁰⁴ Transforming our world: the 2030 Agenda for Sustainable Development: <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication>

¹⁰⁵ Delivering on the UN's Sustainable Development Goals – A comprehensive approach, Staff Working document SWD(2020) 400 final of 18.11.2020

¹⁰⁶ 'A European Green Deal': https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

¹⁰⁷ 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

¹⁰⁸ For a more complete picture, please refer to the EU SDG policy mapping: <https://knowsdgs.jrc.ec.europa.eu/intro-policy-mapping>



the high-risk that is inherently associated with them, to also produce more novel approaches to tackle the same problems. RD&I are thus crucial elements in the transition of our economy, society, and planet to a sustainable future that can credibly aim for widespread wellbeing. This is reflected in the notion of sustainable development, where the concept of growth is coupled to sustainability for future generations.

In recent years, there has been an increased effort by the private sector towards greater corporate transparency, which represents an opportunity to challenge existing industry standards by reporting publicly on performance in sustainability-related matters, including for example climate change initiatives and social practices.¹¹⁰ Further to last year's edition of the Scoreboard, this chapter aims at improving our understanding of top R&D investors' commitment to sustainability. This chapter extends the pilot exercise from the 2020 Scoreboard which characterised, through a data analytics approach, the scores achieved by Scoreboard companies in relation to a selected number of SDGs. These scores, which address the behaviour of each company, bring together disclosed data concerning environmental, social and governance (ESG) strategies as well as reputational aspects that have to do with the companies' societal and environmental impacts. The computation of the scores is described in Box 5.1 below. The disclo-

sure and reputation scores are then condensed in an overall score, which balances both dimensions. In the assessment of the global performance of each company in meeting the SDG goals, the scores presented refer exclusively to the overall SDG score.¹¹¹

The 2021 edition of the Scoreboard expands on the approach employed for last year's report by providing new insights on three main dimensions. Section 5.1 adds a temporal perspective to the analysis. It provides insights on how the adherence of top R&D investors to sustainability and social issues has changed in the past five years (2016-2020). Section 5.2 looks at SDG disclosure and reputation scoring across the world's major regions for selected industries. It does so by looking at a larger number of SDGs compared to the 2020 edition of the Scoreboard. SDGs are aggregated into two major groups to provide clearer science-to-policy implications: i) environmental SDGs and ii) social and economic SDGs. Finally, Section 5.3 shows the association between R&D and innovation with the SDG scores of Scoreboard companies, with a focus on energy intensive industries. This chapter brings a new angle to the analysis of top R&D investors with respect to progress made in targeting green, just and inclusive transitions by leveraging RD&I. The results of this analysis are aimed to inform policy makers about the strengths and weaknesses of EU companies for sustainable competitiveness.

Box 5.1 - Methodology for computing the SDG scores

SDG scores are based on data collected by Covalence SA¹¹² and refer to the ESG dimensions related to workplace, sustainability, corporate social responsibility, and business ethics within companies. ESG data at the corporate level have been increasingly used in empirical research on corporate sustainability issues.¹¹³

¹⁰⁹ IEA (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector, October 2021 revised version. Available here

¹¹⁰ Ioannou, I. and Serafeim, G., The Consequences of Mandatory Corporate Sustainability Reporting (May 1, 2017). Harvard Business School Research Working Paper No. 11-100.

¹¹¹ The SDGs 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. See Box 5.1 for further details about the methodology behind the computation of the SDG scores.

¹¹² 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/>.

¹¹³ See for example Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, 60(11), 2835-2857. For an application using Covalence EthicalQuote dataset please refer see: Capelle-Blancard, G., & Petit, A. (2019). Every little helps? ESG news and stock market reaction. *Journal of Business Ethics*, 157(2), 543-565.

Contrary to the OECD approach¹¹⁴, which uses a database of sustainability reports in English as the sole source of information to derive SDG scores by firm, the Covalence scores are articulated in two dimensions: disclosure and reputation. Disclosure scores cover ESG data published by companies. They are characterised by a quantitative component (ESG indicators from Refinitiv (formerly Thomson Reuters) such as CO2 emissions, waste disposal, etc.) as well as a qualitative component (sustainability-related corporate communications).

The reputation dimension includes qualitative data published by the relevant stakeholders of the company, 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), which is analysed via natural language processing and text analysis to retrieve positive and negative nuances relating to compliments or criticisms.

The table below provides examples of ESG reputation:

Company	Date	ESG	Source	Description
Bayer	January 2002	Environmental, negative	Media	"Bayer was one of several multinationals to export highly toxic obsolete pesticides to Nepal, and abandon them there after they reached their expiry date or were banned. (...) The obsolete pesticides had been inadequately stored in rusting and rotting original packaging (...). The toxic waste threatens the health of residents, workers and livestock in the area as well as local water supplies, irrigation systems and soil. Despite requests to Bayer from the Royal Nepalese Government, the company has refused to help"
Coca-Cola	December 2002	Environmental, negative	Media	"A Coca-Cola bottling plant in Kerala (India) gets its water from 60 wells the plant has drilled in the area. Local villagers claim this is draining their water supply and leaving what is left contaminated. (...) Protesting villagers want the plant closed but Coke says (...) they 'have not found any change in the water situation'"
Procter and Gamble	December 2004	Social, positive	NGO	"A new water purification product developed by Procter and Gamble is being launched in Haiti, where diarrhoea is a major killer of children under 5, by an initiative funded by the Global Development Alliance of the US Agency for International Development (USAID)"

¹¹⁴ OECD, 2021, « Industrial Policy for the Sustainable Development Goals – Increasing the Private Sector's Contribution », <https://doi.org/10.1787/2cad899f-en>

Wal-Mart	November 2003	Social, negative	Media	"Wal-Mart, the world's biggest company and the largest employer in the US, is being taken to court by a group of former immigrant employees. The workers have accused the US supermarket chain of conspiring with cleaning contractors to employ them in conditions that were "one step away from slavery" (...) foreign workers have told of working seven-night, 56-h weeks at the budget stores for as little as \$325, well below the national minimum hourly wage"
Riggs Bank	January 2005	Governance, negative	NGO	"Riggs Bank pleaded guilty to helping former Chilean dictator Augusto Pinochet and the leaders of oil-rich Equatorial Guinea hide hundreds of millions of dollars. The federal judge questioned whether a \$16 million fine agreed to by prosecutors was enough. US District Judge Ricardo Urbina in Washington today asked whether the penalty is "just a business expense" that wouldn't even cover the profits Riggs made on the suspect accounts. (...)"

Source: Covalence database.

The data is first classified according to 50 criteria inspired by the Global Reporting Initiative (GRI).¹¹⁵ It is then recoded into hundreds of disclosure or reputation indicators. For example, the news item below has been linked to SDG 4 (Quality Education). "Microsoft Corp. is doubling-down on its workforce development investment in El Paso, adding 15 public schools to its computer skills program and investing \$1.5 million in a binational business accelerator. Microsoft President Brad Smith made the announcement on Monday during a meeting with regional business and political leaders at the Epic Railyard building near Downtown El Paso."

Finally, the 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 score, which is normalised to a range between 0 and 100. A score of 50 represents a neutral value: if, for a given SDG, a company scores above 50, it means that it positively contributes to that SDG. Conversely, a score below 50 means that the company is not doing enough and/or has performed poorly with respect to that SDG.

¹¹⁵ <https://www.globalreporting.org/>

The SDG reputation score

Let $P(g,t,c)$ and $N(g,t,c)$ be the sets of positive and negative news for SDG g at time t for company c , whose elements are the number of months of each news item. Applying a 2% obsolescence factor ($\alpha=0.98$), the current volumes of positive and negative news for goal g at time t are computed as:

$$P(g,t,c) = \sum_{p \in \mathcal{P}(g,t,c)} \alpha^p$$

and

$$N(g,t,c) = \sum_{n \in \mathcal{N}(g,t,c)} \alpha^n$$

The total volume of news for company c , SDG g at time t is:

$$V(g,t,c) = P(g,t,c) + N(g,t,c)$$

A final SDG reputation score ranging from 0 to 100 is given by the ratio between positive news and total news

$$SDG(g,t,c) = \frac{P(g,t,c)}{V(g,t,c)} \times 100$$

The score is treated as missing or not available when the volume of information is lower than a threshold δ .

5.1 Top R&D investors and SDGs

This section examines the performance of top R&D investors in targeting 10 sustainable development goals across time and industry: SDG 3 (Good health and well-being); SDG 5 (Gender equality); SDG 6 (Clean water and sanitation); SDG 7 (Affordable and clean energy); SDG 8 (Decent work and economic growth), SDG 9 (Industry, innovation and infrastructure); SDG 12 (Responsible consumption and production); SDG 13 (Climate Action); SDG 14 (Life below water); and SDG 15 (Life on land).¹¹⁶ We further group the ten SDGs above

into two more general thematic groups, which we present separately: environmental SDGs (6, 7, 12, 13, 14 and 15) and socio-economic SDGs (3, 5, 8 and 9).

Figure 5.1 presents the development of SDG scores over 5 years for Scoreboard companies for which SDG scores are reported for all years from 2016 to 2020 (713 distinct firms).¹¹⁷ The figure shows an upward trend in time for all the scores, indicating an increasing interest and commitment by top R&D investors to

¹¹⁶ We leave out of the analysis the following SDGs: SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 4 (Quality education), SDG 10 (Reduced inequalities), SDG 11 (Sustainable cities and communities), SDG 16 (Peace, justice and strong institutions) and SDG 17 (Partnerships for the goals). We do so because of their lack of relevance to the corporate sector, which is often reflected in the lack of reliable data reported by SB companies for these SDGs. Note that zero hunger is addressed, for example, by SB companies using biotechnology to improve crop and farm animal yields.

¹¹⁷ Similar results are obtained when shorter time periods are taken into consideration with the purpose of retaining a higher number of companies, e.g. 2017-2020 (774 firms), 2018-2020 (967 firms), 2019-2020 (1218 firms).

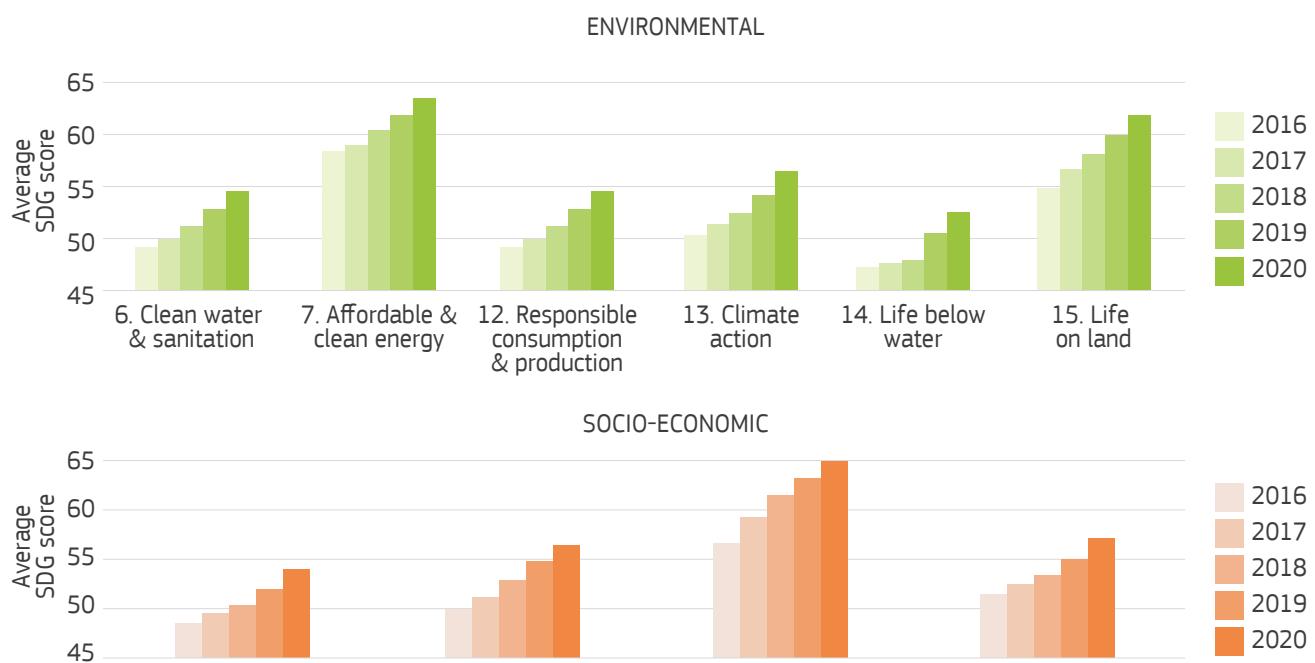


sustainability themes. SDG 7 (clean and affordable energy), 8 (decent work and economic growth) and 15 (life on land) have been the topics subject to most effort by top R&D investors, in terms of absolute score values achieved; the latter two have also performed exceptionally well in terms of the overall growth of the associated SDG scores over the period 2016–2020, which have increased respectively by 13% and 15%. In general, SDG scores have grown considerably across the board, since almost all have increased by more than 10%. The only exception is SDG 7 which, however, has the best historical track record of all other goals and remains sensibly ahead of all other environmental SDGs in 2020.

In the rest of this chapter, where the focus is on a shorter timescale, we retain the set of Scoreboard companies reporting SDG scores over the period 2018–2020 (1426 distinct firms record a score in at least one year of the period, 967 an SDG score in all

years).¹¹⁸ Figure 5.2 shows the performance of the top industrial R&D investors for the ten SDG scores across represented sectors. The results show that the SDG scores differ across industries. Overall, companies from the Energy, Chemicals and Transport sectors show the highest scores on many SDGs. Conversely, top investors in R&D that operate in ICT services and in Health have lower SDGs scores compared to the whole sample. Interestingly, the financial sector seems to be the one devoting most effort towards gender balance with the highest score in SDG 5 (Gender equality). The R&D investment in the Energy, Chemicals and Transport sectors is likely to be a response to the high level of regulation characterising these industries. Increasing stringency in environmental and socio-economic regulations has been shown to drive investments by the private sector. In strictly regulated sectors, innovative companies set a high industrial benchmark for competitors by providing innovative solutions in a range of relevant sustainability goals.

Figure 5.1: Average SDG scores by year – 2016–2020.



Note: data refers to 713 unique companies for which yearly data is available for the period 2016–2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

¹¹⁸ Scores for 2016 and 2017 are likely to be affected by selection bias, as they were calculated by Covalence in year 2018 retrieving only the past information still available in 2018.

Figure 5.2: Average SDG scores by sector and SDG – 2018-2020.

ENVIRONMENTAL												
	Aerospace & Defence	Automobiles & other transport	Chemicals	Construction	Energy	Financial	Health industries	ICT producers	ICT services	Industrials	Others	
6. Clean water & sanitation	47	51	58	54	54	40	39	48	37	50	50	
7. Affordable & clean energy	57	61	65	60	69	63	40	57	43	60	55	
12. Responsible consumption & production	49	56	59	53	55	45	38	50	40	51	53	
13. Climate action	51	56	56	52	60	50	39	47	40	51	51	
14. Life below water	46	52	54	49	49	38	37	47	36	46	49	
15. Life on land	54	59	59	57	56	52	44	57	44	54	59	
SOCIO-ECONOMIC												
	Aerospace & Defence	Automobiles & other transport	Chemicals	Construction	Energy	Financial	Health industries	ICT producers	ICT services	Industrials	Others	
3. Good health & well-being	46	52	53	50	52	48	40	48	40	49	50	
5. Gender equality	51	50	51	51	54	59	51	51	51	50	54	
8. Decent work & economic growth	58	61	63	61	62	60	51	61	51	60	52	
9. Industry, innovation & infrastructure	52	55	58	55	54	47	39	50	39	52	50	

Note: data refers to 967 companies for which the overall SDG score is available in the reference period 2018-2020, representing 82% of the R&D invested in the whole sample (the percentages of representation of R&D by region are: 25% for EU, 40% for US, 15% for Japan, 8% for China, 12% for RoW).
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

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

This section presents a more detailed picture by accounting for region-specific factors in the comparison of the SDG scores of Scoreboard companies in different sectors. This is relevant because, apart from voluntary reporting by firms, governments usually set up legislative frameworks for companies to report on their SDGs or indirectly influence them to do so by implementing stricter regulations. Second, a geographical breakdown comparing different areas could inspire a debate on the reasons for the differences and the design and implementation of new policy measures.

Figure 5.3 reports the average SDG scores by the world region where the Scoreboard companies are headquartered. Scoreboard companies based in the EU and Japan present higher SDG scores for all sectors compared to other areas. The EU seems to co-lead or lead on four relevant sustainability goals: SDG 7

(Affordable and clean energy), SDG 13 (Climate action), SDG 5 (Gender equality) and SDG 8 (Decent work and economic growth). These are all SDGs which align to a greater extent with the objectives set out in the past years by the EU to move towards a more just and climate-neutral society.

Figure 5.4, below, presents a further breakdown of the SDG scores by world region and industry and illustrates the high heterogeneity of R&D investors' response to sustainable development goals. There is overall a high performance of the EU and Japanese firms in relation to SDGs, which seems to be driven by the strength of industrial innovation that each region displays in different sectors: Energy and Chemicals for the EU, Transport and ICT producers for Japan. While overall they appear to be under-performing, geographical areas such as the US and the rest of the world (RoW) have

Figure 5.3: SDG scores by geographical area.

	ENVIRONMENTAL					SOCIO-ECONOMIC					
	CN	EU	JP	RoW	US	CN	EU	JP	RoW	US	
6. Clean water & sanitation	43	51	57	49	45	3. Good health & well-being	45	52	53	50	45
7. Affordable & clean energy	50	63	61	57	51	5. Gender equality	43	57	52	50	53
12. Responsible consumption & prod.	46	54	57	51	46	8. Decent work & economic growth	56	63	62	62	56
13. Climate action	47	55	53	52	45	9. Industry, innovation & infrastructure	43	54	55	50	48
14. Life below water	41	48	57	46	42		CN	EU	JP	RoW	US
15. Life on land	48	59	61	56	52						

Note: data refers to 967 companies for which the overall SDG score is available in the reference period 2018-2020, representing 82% of the R&D invested in the whole sample; the above can be assigned to regions as follows: 25% for EU, 40% for US, 15% for Japan, 8% for China, 12% for RoW.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

sectors with high SDG scores (compared to other sectors in the same area), such as Construction for the US and Financials for RoW. Conversely, China still lags in several industries and SDGs, although some notable improvements have been made especially in the Energy and ICT producers sectors. The evidence for China is very much in line with evidence provided by recent work showing lower ESG scores compared to Europe, the US and Japan.¹¹⁹

Notwithstanding the geographical heterogeneity between regions, there are also some general patterns in the overall SDG scores. For instance, SDG #7 "Affordable and clean energy" and #15 "Life on land" often display above-average scores for all sectors. Similarly, in the

cases of SDG #8 "Decent work and economic growth" and, to some extent, of SDG #5 "Gender equality", the performance of the EU and the US stands out from the rest. Finally, from a sectoral perspective, the Transport and Chemical industries achieve high marks across SDGs. This tendency is mirrored by the quite opposite behaviour of the Health and Financial industries, which score lower across the board, though with notable exceptions such as SDG #3 "Good health and well-being" and SDG #8 "Decent work and economic growth" in the Japanese Health industry or the socio-economic SDGs #5 "Gender equality" and #8 "Decent work and economic growth" in the EU financial sector.

Figure 5.4: SDG scores by geographical area and industry.

EU-ENVIRONMENTAL												
	Aerospace & Defence	Automobiles & other transport	Chemicals	Construction	Energy	Financial	Health industries	ICT producers	ICT services	Industrials	Others	
6. Clean water & sanitation	51	52	59	58	55	40	43	49	42	49	53	
7. Affordable & clean energy	60	64	72	65	76	68	46	62	52	62	59	
12. Responsible consumption & production	52	58	61	57	58	45	42	52	47	53	57	
13. Climate action	53	61	61	57	63	53	43	50	48	53	55	
14. Life below water	51	55	53	50	50	38	40	47	40	45	52	
15. Life on land	60	61	62	63	59	53	49	57	51	56	64	
EU-SOCIO-ECONOMIC												
6. Clean water & sanitation	49	55	54	51	54	49	46	50	46	50	52	
7. Affordable & clean energy	55	58	57	57	58	60	53	56	56	54	58	
12. Responsible consumption & production	62	63	66	62	65	60	58	64	59	63	65	
13. Climate action	55	57	61	59	58	48	44	53	44	53	52	

¹¹⁹ Singhania, M., & Saini, N. (2021). Institutional framework of ESG disclosures: comparative analysis of developed and developing countries. Journal of Sustainable Finance & Investment, 1-44.



JAPAN-ENVIRONMENTAL

6. Clean water & sanitation	64	60	54	50	25	54	59	45	57	55
7. Affordable & clean energy	67	62	57	62	50	51	63	53	62	58
12. Responsible consumption & production	66	59	52	50	29	52	60	51	53	55
13. Climate action	64	55	46	54	33	50	51	45	50	52
14. Life below water	68	59	53	48	25	53	61	44	55	56
15. Life on land	71	58	57	52	29	58	64	52	57	61

Automobiles &
other transport Chemicals Construction Energy Financial Health
industries ICT producers ICT services Industrials Others

6. Clean water & sanitation	57	55	51	49	30	55	54	46	51	53
7. Affordable & clean energy	51	52	49	51	50	55	52	54	50	51
12. Responsible consumption & production	64	61	62	57	43	64	65	63	59	61
13. Climate action	61	56	52	49	37	49	58	53	55	52

JAPAN-SOCIO-ECONOMIC

US-ENVIRONMENTAL

6. Clean water & sanitation	50	49	56	52	57	36	35	45	34	48	48
7. Affordable & clean energy	59	58	64	68	64	46	36	53	38	57	50
12. Responsible consumption & production	48	52	56	56	52	42	33	46	35	48	49
13. Climate action	51	49	52	59	51	41	35	43	36	49	47
14. Life below water	46	47	54	54	46	34	33	43	33	43	44
15. Life on land	54	57	59	62	54	46	39	53	39	53	57

Aerospace
& Defence Automobiles &
other transport Chemicals Construction Energy Financial Health
industries ICT producers ICT services Industrials Others

6. Clean water & sanitation	44	48	50	56	49	42	38	44	36	45	46
7. Affordable & clean energy	55	49	50	59	55	54	48	51	50	49	56
12. Responsible consumption & production	58	59	61	65	62	56	47	57	47	57	59
13. Climate action	52	55	57	63	59	39	35	47	36	53	50

US-SOCIO-ECONOMIC



RoW-ENVIRONMENTAL

6. Clean water & sanitation	40	49	57	61	52	45	40	46	44	50	50
7. Affordable & clean energy	54	59	64	69	66	73	44	54	52	60	56
12. Responsible consumption & production	46	54	61	62	56	48	40	49	49	51	53
13. Climate action	48	55	56	66	66	57	43	48	48	51	51
14. Life below water	38	49	55	56	48	42	37	46	40	47	48
15. Life on land	47	55	60	65	55	57	44	57	54	53	58

Aerospace & Defence Automobiles & other transport Chemicals Construction Energy Financial Health industries ICT producers ICT services Industrials Others

6. Clean water & sanitation	44	52	55	59	54	55	44	48	48	49	51
7. Affordable & clean energy	42	47	47	55	50	67	49	47	56	47	53
12. Responsible consumption & production	55	60	64	66	62	69	56	61	60	60	64
13. Climate action	46	54	58	62	50	55	39	47	46	52	50

RoW-SOCIO-ECONOMIC

China

6. Clean water & sanitation	29	38	43	43	50	50	41	45	35	43	40
7. Affordable & clean energy	30	53	46	47	58	48	39	57	38	50	42
12. Responsible consumption & production	32	45	44	41	52	49	44	51	36	46	43
13. Climate action	38	48	43	41	58	47	46	46	36	48	42
14. Life below water	25	37	40	37	50	50	37	44	34	38	39
15. Life on land	28	44	46	42	51	59	47	55	39	47	44

Aerospace & Defence Automobiles & other transport Chemicals Construction Energy Financial Health industries ICT producers ICT services Industrials Others

6. Clean water & sanitation	30	44	46	40	48	48	45	47	38	45	42
7. Affordable & clean energy	30	41	39	37	44	52	42	46	40	40	39
12. Responsible consumption & production	31	53	60	52	62	61	58	61	48	56	53
13. Climate action	30	46	43	43	45	42	35	49	36	43	36

China

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

5.3 R&D and sustainability goals

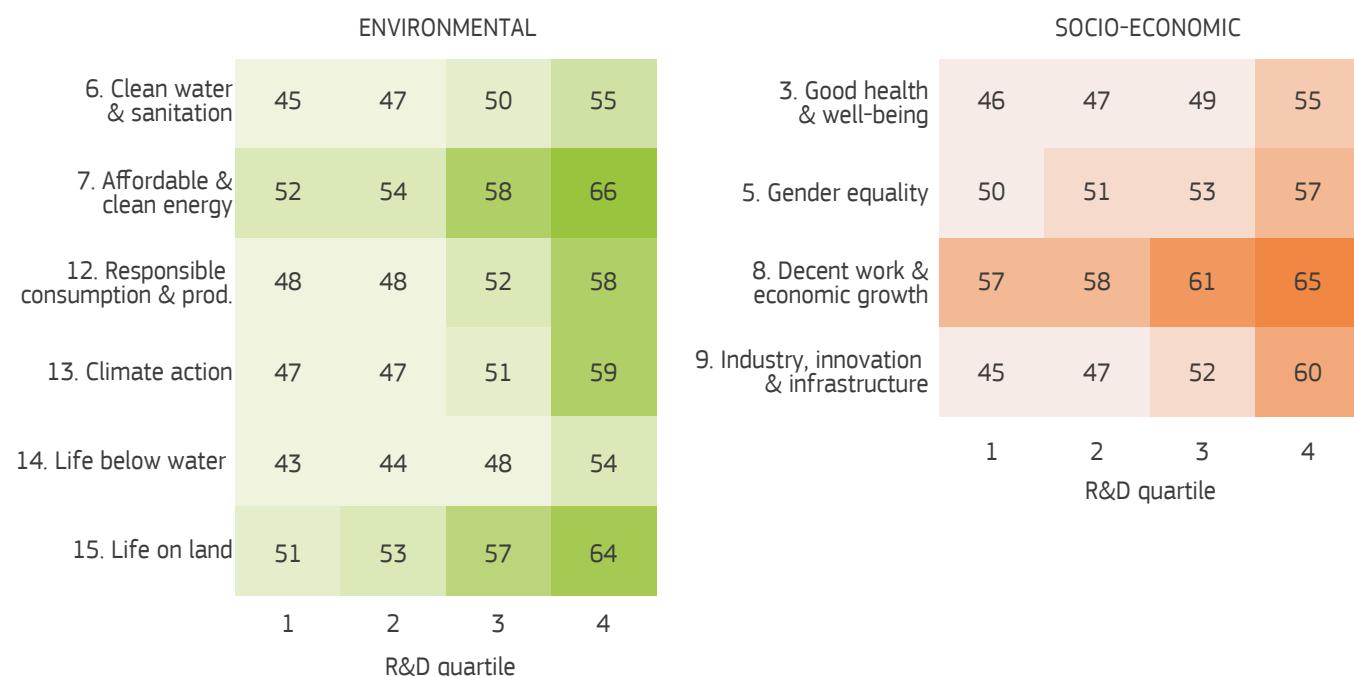
Over the past several years, the private sector has developed a growing interest in aligning corporate- and business-level strategies with the targets set out in the SDGs, particularly via sustainability reporting and impact measurement. This endeavour underlines the relevance of SDGs. From a policy perspective, there is a need to better understand how the SDGs guide the development of new business models, new products and services and technological development, while enabling more sustainable growth and shareholder value. For this purpose, we report evidence on the role that R&D plays in the path to sustainable development by top R&D investors.

Figure 5.5 reports the average SDG score by group (environmental or socio-economic) for each quartile

of R&D investment by the top R&D investors.¹²⁰ For all quartiles of R&D, the average SDG score for every SDG tends to increase, which means that the higher the investment in R&D by companies, the higher the effort made in targeting the SDGs. This result points to a relevant overall association between investment in R&D by Scoreboard companies and their attention to sustainability issues in any form.

Based on the evidence above, the achievement of most of the United Nations's sustainability goals seems to be positively associated with the introduction of new and improved technologies resulting from R&D. To better refine the evidence above, we provide some examples of recent technological advances that have an impact on relevant SDGs. For this purpose, we take a series

Figure 5.5: The association between R&D investment and SDGs.



Note: The data refers to 967 companies for which the overall SDG score is available in the reference period 2018–2020. The figure reports on the horizontal axis the quartiles of R&D spending and on the vertical axis the different SDGs (left panel, environmental SDGs; and right panel, socio-economic SDGs). The values in the cells report the average score for the SDG in the corresponding quartile of R&D spending. Darker colour indicates higher values.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

¹²⁰ This analysis refers to the sample of 1426 scoreboard companies observed over the period 2018–2020. These companies are then allocated to quartiles based on their R&D investment.



of major technological advances and, for each, indicate the SDG or SDGs whose realisation they will help to achieve. In most cases there will be several SDGs enabled by each technological advance. This approach attempts to link recent technological developments based on R&D investment with their ability to contribute to sustainable development goals. In this analysis, we focus on the nine main UN SDGs that can be influenced by technological innovation.¹²¹ These are: SDG

#3 Good health, SDG #6 Clean water & sanitation, SDG #7 Affordable & clean energy, SDG #8 Decent employment, economic growth & no poverty, SDG #9 Industry, innovation & infrastructure, SDG #12 Responsible consumption & production, SDG #13 Climate action, SDG #14 Life below water and SDG #15 Life on land. The contribution of technologies to the realisation of SDGs is reported in Box 5.2.

Box 5.2 - Contribution of technologies to the realisation of SDGs

Advanced computational modelling (SDGs #9, #13). For SDG #13 the science of 'weather attribution'¹²² carried out, for example, by the Environmental Change Institute of the University of Oxford which feeds results into the UN's Intergovernmental Panel on Climate Change (IPCC) informs relevant stakeholders on the occurrence of extreme weather events in specific locations. The same methodology can be used to calculate the effects of further global warming. Such estimates of the frequency of extreme events enable preventive measures such as flood prevention works to be justified economically and then implemented in good time. Quantum computing should enhance the abilities and applications of computational modelling.

Biotechnology (SDGs #3, #6, #8, #9, #12, #14). Biotech, the growth sector of the 21st century, has multiple applications. These include SDG #3 (new vaccines, immunotherapies for cancer), SDG #6 (wastewater treatment), SDG #8 (interesting jobs based on biotech in new and existing industries), SDG #9 (innovation and the creating of new industries and expansion of existing ones), SDG #12 (eco-friendly production) and SDG #14 (biotech for improved fish farming). One very recent example of the power of biotech is the new malaria vaccine developed by GlaxoSmithKline and approved in 2021 which should dramatically reduce the rates of a disease that kills more than a quarter of a million African children under the age of five each year. Trials showed that the vaccine resulted in a 70% reduction in hospital admissions and deaths.

ICT technologies (AI, databases, smart mobile communications, quantum computing) (SDGs #3, #8, #9). ICT is the other main growth area of the 21st century and again has multiple applications such as in health (diagnostics, hospital management, patient records, epidemiology, telehealth), education (learning technologies), economic growth (fast growing software & hardware sectors), industry (process control, CRM, mobile comms, databases).¹²³

Robotics & human augmentation (SDGs #3, #8, #9). Applications include health (such as Intuitive Surgical's da Vinci robotic surgery systems), efficient production and economic growth (robotic factories, farming and deliveries) and a new industrial sector making robots.

Improved batteries/electric vehicles (SDGs #3, #7, #9, #13). Advantages include healthier, sustainable cities with lower pollution levels; cleaner vehicles with zero greenhouse gas emissions.

¹²² Weather attribution (WA) is the science of determining what causes extreme weather events such as the heatwaves, wildfires and floods seen in 2021. WA uses large ensembles of simulations of regional climate models to run two different analyses – representing the current climate as observed and representing the same events in the world minus the effects of human-induced climate change.

¹²³ Despite the importance that ICT technologies play in addressing several SDGs, we should not forget the need for energy efficiency, lower energy consumption and green energy in order to mitigate climate emissions from increased ICT and data centre use (SDG #13).



Space technology (SDGs #6, #8, #9, #13). Low-cost multi-satellite systems such as that being put up under SpaceX's Starlink project are aimed to provide broadband internet to rural communities in all continents and for the many areas where conventional broadband is uneconomic to install. This will help to bring quality education, mobile communications and innovation to sustain more isolated communities and help isolated farmers. Satellite technology is also very important for monitoring pollution of water and the atmosphere and detecting illegal logging in rain forests.

Technology start-ups (SDGs #8, #9). Minimising the regulatory barriers to starting and running new technology-based businesses and ensuring they have access to finance is crucial for decent work, economic growth, industrial innovation and sustainable communities nourished with many small tech businesses.

Below we outline the relationship between R&D investment and SDG scores for a selected number of sectors which are particularly energy intensive because of the relevance of Energy Intensive Industries (EII) for policy decisions to be taken by the EU in the coming years to comply with Europe's 2050 climate-neutrality targets.¹²⁴ The transition to climate-neutrality will require transformational efforts in EII, which make up more than half of the energy consumption of the EU industry.^{125, 126}

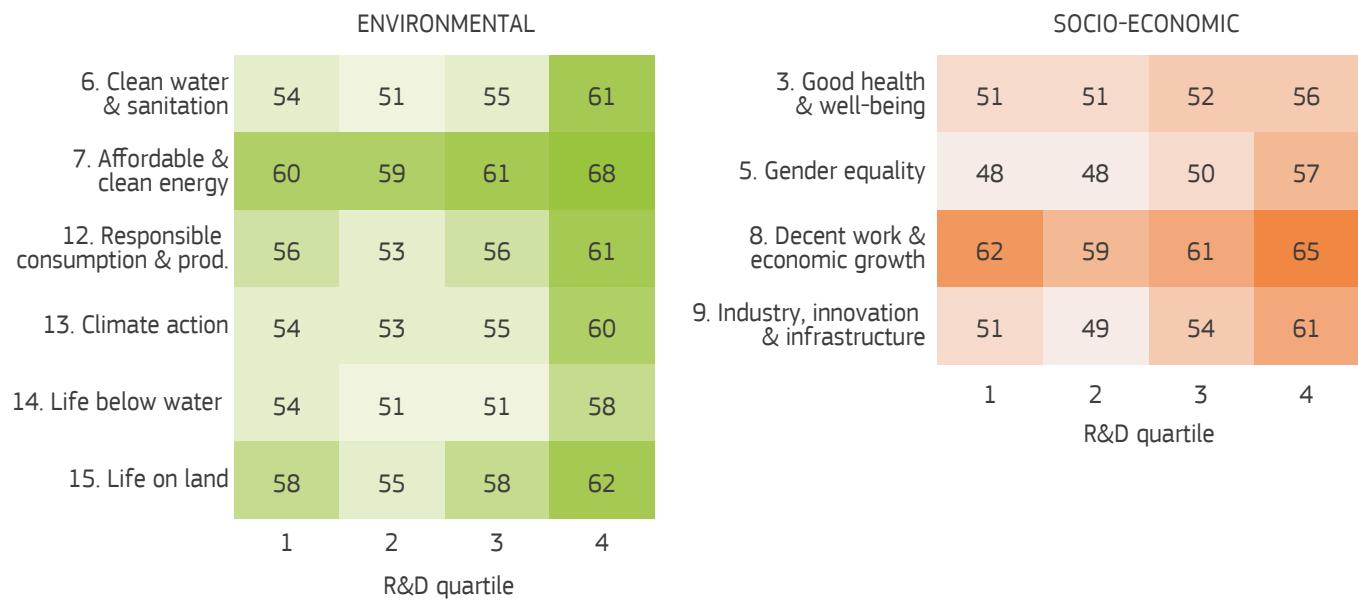
The results displayed in Figure 5.6 show that increasing investment in R&D by Scoreboard companies in EII (higher R&D quartiles) is associated with higher commitment to SDGs (higher SDG scores). As expected, the SDG dealing with "affordable and clean energy" is where most dedicated effort is put in by top R&D investors operating in EII, followed by "decent work and economic growth" and "life on land". Looking at the quartiles, SDG scores increase in proportion to the level of R&D investment, which points to an important relationship between R&D and attention to sustainable development goals by EII companies.

¹²⁴ HLG-EII. (2019). Masterplan for a competitive transformation of EU energy-intensive industries enabling a climate-neutral, circular economy by 2050. Available at <https://op.europa.eu/en/publication-detail/-/publication/be308ba7-14da-11ea-8c1f-01aa75ed71a1/language-en>

¹²⁵ We select the following industries (3 digit NACE rev. 2 classification) which are included in the industry classification of scoreboard companies (share of observations is in parentheses): 171 Manufacture of pulp, paper and paperboard (2.92), 172 Manufacture of articles of paper and paperboard (5.84), 192 Manufacture of refined petroleum products (4.74), 201 Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms (21.17), 202 Manufacture of pesticides and other agrochemical products(2.19), 203 Manufacture of paints, varnishes and similar coatings, printing ink and mastics (4.74), 204 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations (7.66), 205 Manufacture of other chemical products (22.26), 206 Manufacture of man-made fibres (2.92), 231 Manufacture of glass and glass products (4.38), 232 Manufacture of refractory products (0.36), 234 Manufacture of other porcelain and ceramic products (1.82), 235 Manufacture of cement, lime and plaster (3.28), 241 Manufacture of basic iron and steel and of ferro-alloys (6.2), 244 Manufacture of basic precious and other non-ferrous metals (9.49).

¹²⁶ It would be useful to read the following section in conjunction with chapter 4 technological development by Scoreboard companies for EII.

Figure 5.6: The association between R&D investment and SDGs in Energy Intensive Industries.



Note: The data refers to 246 companies for which the overall SDG score is available in at least one year during the reference period 2018-2020. The figure reports on the horizontal axis the quartiles of R&D spending and on the vertical axis the different SDGs (left panel environmental SDGs and right panel socio-economic SDGs). The values in the cells report the average score for the SDG in the corresponding quartile of R&D spending. Darker colour indicates higher values. This is a focus on Scoreboard companies included in EIIs. EIIs classification follows HLG-EII. (2019).

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



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 initiative¹²⁷ with a 3 % headline target for intensity of research and development (R&D)¹²⁸. R&D investment from the private sector plays also a key role for other relevant European initiatives such as the Industrial Policy¹²⁹, Digital Agenda and New Skills for New Jobs flagship initiatives.

The project "Global Industrial Research & Innovation Analyses" (GLORIA)¹³⁰ 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 office¹³¹. 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 unit¹³². Therefore, the Scoreboard R&D figures are comparable to BES-R&D data only at the global level.

¹²⁷ 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.

¹²⁸ 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).

¹²⁹ 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.

¹³⁰ 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>).

¹³¹ 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.

¹³² The Scoreboard refers to all R&D financed by a company from its own funds, regardless of where the R&D is performed. BES-R&D refers to all R&D activities funded by businesses and performed by all sectors within a particular territory, regardless of the location of the business's headquarters. The sources of data also differ: the Scoreboard collects data from audited financial accounts and reports whereas BES-R&D typically takes a stratified sample, covering all large companies and a representative sample of smaller companies. Additional differences concern the definition of R&D intensity (BES-R&D uses the percentage of R&D in value added, while the Scoreboard considers the R&D/Sales ratio).



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%¹³³ 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.

¹³³ According to latest Eurostat statistics.



ANNEX 2

METHODOLOGICAL NOTES

The data for the 2021 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 2020 fiscal year accounts, although due to different accounting practices throughout the world, they also include accounts ending on a range of dates between late 2019 and mid-2021. Furthermore, the accounts of some companies are publicly available more promptly than others. Therefore, the current set represents a heterogeneous set of timed data. However, around 70% of companies closed their accounts in December 2020.

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. 2¹³⁴ 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, paragraph 1.2.3 describes typical levels of the industrial classification applied in the Scoreboard.

Limitations

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

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.

¹³⁴ NACE is the acronym for "Nomenclature statistique des activités économiques dans la Communauté européenne".

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 IFRS¹³⁵, 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 2020 as shown in Table A2.1¹³⁶. The exchange rate conversion also applies to the historical data. The result is that over time the Scoreboard reflects the domestic currency results of the companies rather than economic estimates of current purchasing parity results. The original domestic currency data can be derived simply by reversing the translations at the rates above. Users can then apply their own preferred current purchasing parity transformation models.

¹³⁵ 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/>).

¹³⁶ 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.

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 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: $1 \text{ yr growth} = 100*((C/B)-1)$; 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 (31.12.2020). The variation in the exchange rates from the previous year directly affects the ranking of companies, favouring those based in countries whose currency has appreciated with respect to the other currencies. In this reporting period, the exchange rate of the Euro appreciated by 9.8%, 3.8% and 5.8% 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 not affected by currency changes.

The growth rate of the different indicators for companies operating in markets with different currencies is affected in a different manner. In fact, companies' consolidated accounts have to include the benefits and/or losses due to the appreciation and/or depreciation of their investments abroad. The result is an 'apparent' rate of growth of the given indicator that understates or overstates the actual rate of change. For example, this year the R&D growth rate of companies based in the Euro area with R&D investments in the US is partly understated because the 'losses' of their overseas investments due to the depreciation of the US dollar against the Euro (from \$1.12 to \$1.23). Conversely, the R&D growth rate of US companies is partly overstated due to the 'benefits' of their investments in the Euro area. Similar effects of understating or overstating figures would happen for the growth rates of other indicators, such as net sales.

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

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

In most cases, companies' accounts do not include information on the place where R&D is actually performed; consequently the approach taken in the Scoreboard is to attribute each company's total R&D investment to the country in which the company has its registered office or shows its main economic activity. This should be borne in mind when interpreting the Scoreboard's country classification and analyses. 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)¹³⁷

Table A2.1: Euro exchange rates applied to Scoreboard data for companies reporting in different currencies (as of 31 Dec 2020).

Country	As of 31 Dec 2019	As of 31 Dec 2020
Australia	\$ 1.60	\$ 1.59
Brazil	4.52 Brazilian real	6.38 Brazilian real
Canada	\$ 1.47	\$ 1.58
China	7.85 Renminbi	8.02 Renminbi
Czech Republic	25.41 Koruna	26.24 Koruna
Denmark	7.50 Danish Kroner	7.43 Danish Kroner
Hungary	331.13 Forint	364.83 Forint
Hong Kong	8.75 HKD	9.51 HKD
India	80.06 Indian Rupee	89.65 Indian Rupee
Israel	3.88 Shekel	3.95 Shekel
Japan	122.55 Yen	127.16 Yen
New Zealand	1.67 NZD	1.70 NZD
Norway	9.86 Norwegian Kronor	10.47 Norwegian Kronor
Poland	4.27 Zloty	4.61 Zloty
Russia	69.54 Rouble	90.65 Rouble
Singapore	1.51 SGD	1.62 SGD
South Africa	15.76 ZAR	18.02 ZAR
South Korea	1298.70 Won	1335.11 Won
Sweden	10.45 Swedish Kronor	10.03 Swedish Kronor
Switzerland	1.09 Swiss Franc	1.08 Swiss Franc
Taiwan	\$ 33.82 New dollar	\$ 34.98 New dollar
Turkey	6.68 Turkish lira	9.02 Turkish lira
UK	£0.86	£0.91
US	\$ 1.12	\$ 1.23
United Arab Emirates	4.13 Dirham	4.51 Dirham

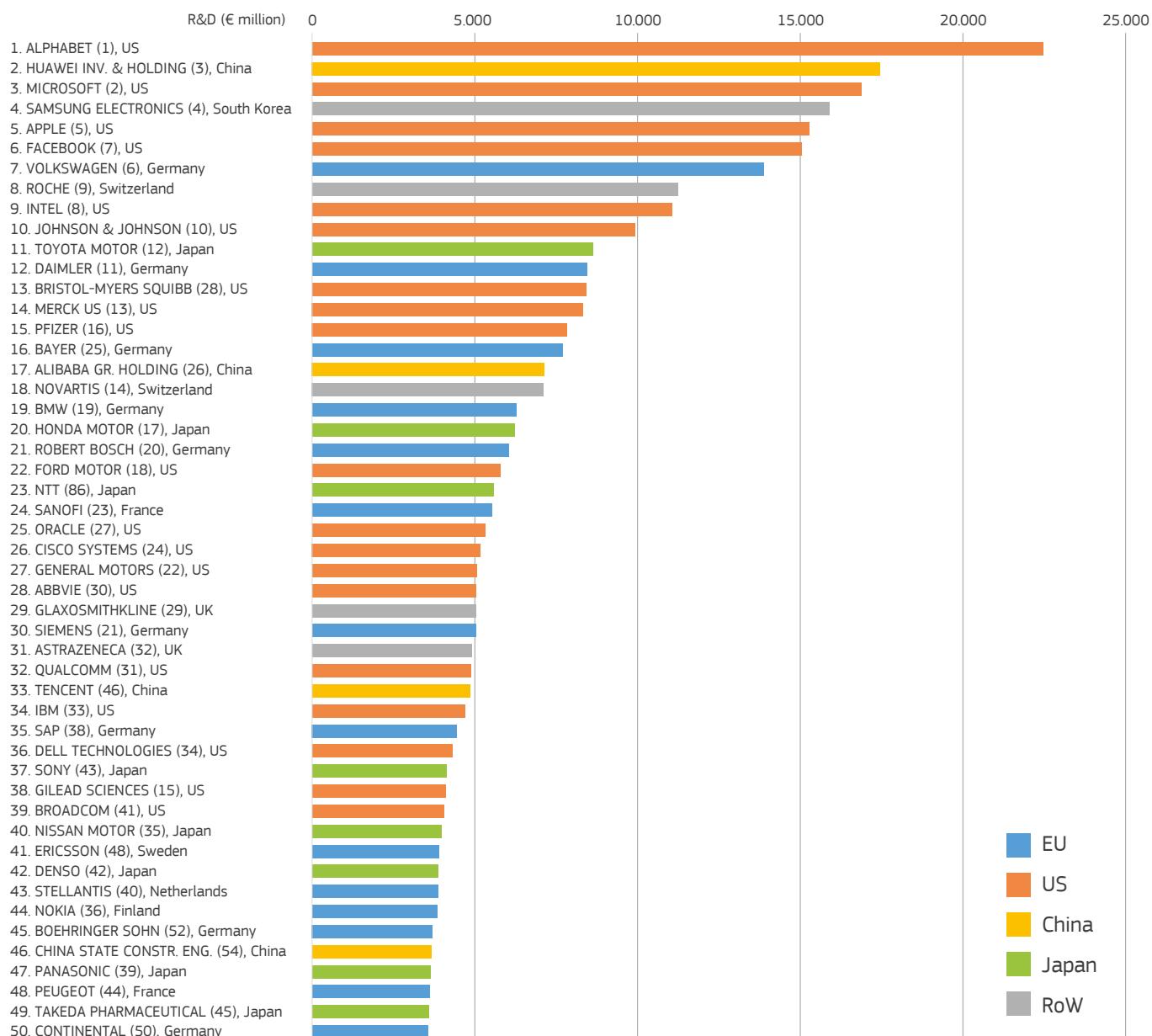
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

¹³⁷ Since 2005, the European Union requires all listed companies in the EU to prepare their consolidated financial statements according to IFRS (see: EC Regulation No 1606/2002 of the European Parliament and of the Council of 19 July 2002 on the application of international accounting standards at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002R1606:EN:HTML>)

ANNEX 3

ADDITIONAL TABLES

Figure A3.1: Top 50 R&D investing companies.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.1: Top 10 R&D investors in 2021 and 2020 Scoreboards, € million.

Rank SB2021	Rank SB2020	Company	Country	Sector	R&D-2020 € million (SB2021)	R&D-2019 € million (SB2020)	y-o-y, %
1	1	ALPHABET	US	ICT services	22,470	21,203	6
2	3	HUAWEI INV.&HOLD	CN	ICT producers	17,460	16,359	6.7
3	2	MICROSOFT	US	ICT services	16,882	15,703	7.5
4	4	SAMSUNG	KR	ICT producers	15,895	15,125	5.1
5	5	APPLE	US	ICT producers	15,282	13,216	15.6
6	7	FACEBOOK	US	ICT services	15,033	11,083	35.6
7	6	VOLKSWAGEN AG	DE	Automobiles	13,885	14,306	-2.9
8	9	ROCHE HOLDING CH AG		Health	11,247	10,824	3.9
9	8	INTEL CORP	US	ICT producers	11,047	10,889	1.5
10	10	JOHNSON & JOHNSON	US	Health	9,909	9,254	7.1
Total Top 10					149,109	137,961	8.1
Total top 2500					908,875	861,004	5.6
Share of Top 10 in Total Top 2500, %					16.4	16	

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.2: Changes in the ranking positions.

Ranking group	Average	Maximum
Top 1-500	49.9	2,139
501-1000	114.7	889
1001-1500	163.1	997
1501-2000	195.2	934
2001-2500	228.0	1,201

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.3: Outliers in rank changes.

Company name	Rank in SB21	Rank in SB20	Change in positions	Sector	Country
CHINA EVERGRANDE	242	2382	+2140	Automobiles & o.t.	China
KONAMI	1024	2520	+1496	ICT services	Japan
LOTUS GROUP	1356	2706	+1350	Others	UK
KODIAK SCIENCES	1313	2575	+1262	Health industries	US
PARADOX INTERACTIVE	1732	2949	+1217	ICT services	Sweden
FANGDD NETWORK GROUP	2445	1245	-1200	Financial	China
WUSTENROT & WURTTEMBERGISCHE	1496	2621	+1125	Financial	Germany
BGI GENOMICS	1546	2596	+1050	Health industries	China
ELO	2262	1257	-1005	Others	France

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.4: Exits from the top 500.

Company name	Rank in SB21	Rank in SB20	Change in positions	Sector	Country
ALLERGAN	n.a.	100	n.a.	Health industries	Ireland
MYLAN N.V	n.a.	275	n.a.	Health industries	Netherlands
INFOR INC	n.a.	321	n.a.	ICT services	US
OSRAM LICHT AG	n.a.	337	n.a.	Others	Germany
SHANGHAI FOSUN PHARMA	n.a.	338	n.a.	Health industries	China
SNCF	517	371	-146	Industrials	France
BOMBARDIER INC	750	376	-374	Aerospace & Defence	Canada
SAUDI BASIC INDUSTRIES	n.a.	381	n.a.	Chemicals	Saudi Arabia
SOHU.COM INCORPORATED	666	391	-275	ICT services	China
MELLANOX TECHNOLOGIES	n.a.	396	n.a.	ICT producers	Israel
TORONTO DOMINION BANK	640	397	-243	Financial	Canada
IDORSIA LTD	510	403	-107	Health industries	Switzerland
DELPHI TECHNOLOGIES PLC	n.a.	406	n.a.	Automobiles & o.t.	UK
HALLIBURTON CO	545	408	-137	Energy	US
AGIOS PHARMACEUTICALS, INC.	564	428	-136	Health industries	US
SAGE THERAPEUTICS, INC.	570	430	-140	Health industries	US
ALLSCRIPTS HEALTHCARE	555	431	-124	ICT services	US
BP PLC	513	436	-77	Energy	UK
JOYY INCORPORATED	529	437	-92	ICT services	China

Company name	Rank in SB21	Rank in SB20	Change in positions	Sector	Country
CYPRESS SEMICONDUCTOR	n.a.	439	n.a.	ICT producers	US
SOLVAY SA	518	446	-72	Chemicals	Belgium
MONDELEZ INTERNATIONAL	514	450	-64	Others	US
IHI CORPORATION	670	451	-219	Industrials	Japan
MALLINCKRODT PLC	575	452	-123	Health industries	Ireland
DYSON JAMES GROUP LIMITED	n.a.	454	n.a.	Others	UK
MATCH GROUP INCORPORATED	610	459	-151	ICT services	US
ALPS ALPINE CO.,LTD.	559	461	-98	ICT producers	Japan
BIOHAVEN PHARMACEUTICAL	706	462	-244	Health industries	US
EXPERIAN PLC	509	464	-45	Others	UK
OFILM GROUP COMPANY	547	465	-82	ICT producers	China
SEKISUI CHEMICAL CO LTD	505	466	-39	Construction	Japan
MONTAGE RESOURCES CORP	n.a.	468	n.a.	Energy	US
MITSUI CHEMICALS INC	521	472	-49	Chemicals	Japan
TERADATA CORPORATION	511	474	-37	ICT services	US
KOITO MANUFACTURING	534	477	-57	Automobiles & o.t.	Japan
KOBE STEEL LIMITED	563	480	-83	Industrials	Japan
DEUTSCHE BAHN AG	537	481	-56	Others	Germany
NORTONLIFELOCK INC.	611	482	-129	ICT services	US
PACCAR INC	600	483	-117	Automobiles & o.t.	US
EAST JAPAN RAILWAY	714	484	-230	Others	Japan
ING GROEP NV	621	487	-134	Financial	Netherlands
JOHNSON CONTROLS INTERNAT.	599	488	-111	Industrials	Ireland
NAVISTAR INTERNATIONAL	528	489	-39	Automobiles & o.t.	US
BAE SYSTEMS PLC	546	491	-55	Aerospace & Defence	UK
INVENTEC CORPORATION	501	492	-9	ICT producers	Taiwan
TEIJIN LIMITED	533	493	-40	Chemicals	Japan
VISTEON CORP	792	494	-298	Automobiles & o.t.	US
FUJI ELECTRIC CO., LTD.	524	495	-29	ICT producers	Japan
AB SKF	544	498	-46	Industrials	Sweden
SHANXI TAIGANG STAINLESS STEEL	540	499	-41	Industrials	China
XEROX HOLDINGS CORPORATION	631	500	-131	Others	US

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.5: Entries into the top 500.

Company name	Rank in SB21	Rank in SB20	Change in positions	Sector	Country
AIRBNB	69	entry	n.a.	ICT services	US
GEELY SWEDEN HOLDING	110	entry	n.a.	Others	Sweden
ANT GROUP	119	entry	n.a.	Financial	China
FAURECIA	131	entry	n.a.	Automobiles & o.t.	France
SIEMENS ENERGY	133	entry	n.a.	Energy	Germany
KUAISHOU TECHNOLOGY	203	entry	n.a.	Others	China
DIDI	212	entry	n.a.	ICT services	China
CHINA EVERGRANDE	242	2382	2140	Automobiles & o.t.	China
CHINA MOBILE	264	entry	n.a.	ICT services	China
HUNAN VALIN STEEL	292	823	531	Industrials	China
PALANTIR TECHNOLOGIES	326	entry	n.a.	ICT services	US
VIATRIS	328	entry	n.a.	Health industries	US
BIONTECH	336	654	318	Health industries	Germany
GOERTEK	343	584	241	ICT producers	China
ZOOLION HEAVY INDUSTRY S&T	348	646	298	Industrials	China
NOVAVAX	361	1254	893	Health industries	US
MCAFEE	369	entry	n.a.	ICT services	US
EXELIXIS	375	538	163	Health industries	US
CHINA CSSC	392	1019	627	Industrials	China
CSPC PHARMACEUTICAL	397	537	140	Health industries	China
COMMONWEALTH BANK OF AUSTRALIA	411	617	206	Financial	Australia
MERCADOLIBRE	415	613	198	ICT services	US
FAW JIEFANG	416	1006	590	Automobiles & o.t.	China
CNOOC	421	631	210	Energy	China
COUNTRY GARDEN HOLDINGS	426	547	121	Financial	China
UNITY SOFTWARE	427	entry	n.a.	ICT services	US
SINOTRUK	432	entry	n.a.	Automobiles & o.t.	China
LONGI GREEN ENERGY TECHNOLOGY	439	624	185	ICT producers	China
PTC THERAPEUTICS	446	614	168	Health industries	US
SICHUAN CHANGHONG ELECTRIC	447	516	69	Others	China
SUNNY OPTICAL TECHNOLOGY	448	508	60	ICT producers	China
KE HOLDINGS	449	entry	n.a.	Financial	China
SIGNIFY	451	507	56	Others	Netherlands



Company name	Rank in SB21	Rank in SB20	Change in positions	Sector	Country
NOVATEK MICROELECTRONICS	452	539	87	ICT producers	Taiwan
ARGENX	454	860	406	Health industries	Netherlands
CGN POWER	457	506	49	Energy	China
AHOLD	461	610	149	Others	Netherlands
NARI TECHNOLOGY	462	518	56	ICT services	China
MASTERCARD	464	503	39	Financial	US
WINBOND ELECTRONICS	465	562	97	ICT producers	Taiwan
WINGTECH TECHNOLOGY	473	593	120	ICT services	China
DEXCOM	474	559	85	Health industries	US
ROKU	479	573	94	Others	US
ANSYS	483	520	37	ICT services	US
ZYNGA	485	509	24	ICT services	US
KOREA AEROSPACE INDUSTRIES	488	1058	570	Aerospace & Defence	South Korea
NCSOFT	489	568	79	ICT services	South Korea
SEA	490	882	392	ICT services	China
DRAGERWERK	492	530	38	Health industries	Germany
IFLYTEK	495	541	46	ICT services	China
FORTINET	499	552	53	ICT services	US

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.6: Changes in the ranking of companies per quintile groups and regions in SB2020-SB2021.

Rankings	1-500					501-1000					1001-1500				
Country/ Region	fall	-	rise	new entry*	total # of comps	fall	-	rise	new entry*	total # of comps	fall	-	rise	new entry*	total # of comps
China	16	1	64	6	87	32	1	69	6	108	40	0	64	12	116
Japan	52	2	16	0	70	56	1	7	0	64	43	1	14	2	60
US	95	4	59	5	163	85	0	56	16	157	80	0	67	13	160
EU	51	4	47	3	105	53	0	39	3	95	39	0	29	3	71
Rankings	1501-2000					2001-2500					Total				
Country/ Region	fall	-	rise	new entry*	total # of comps	fall	-	rise	new entry*	total # of comps	fall	-	rise	new entry*	total # of comps
China	40	0	67	22	129	48	0	43	66	157	176	2	307	112	597
Japan	34	0	4	0	38	52	0	6	3	61	237	4	47	5	293
US	77	0	52	32	161	74	0	22	42	138	411	4	256	108	779
EU	37	1	36	4	78	28	1	11	12	52	208	6	162	25	401

Note: *new entry to the top 2500

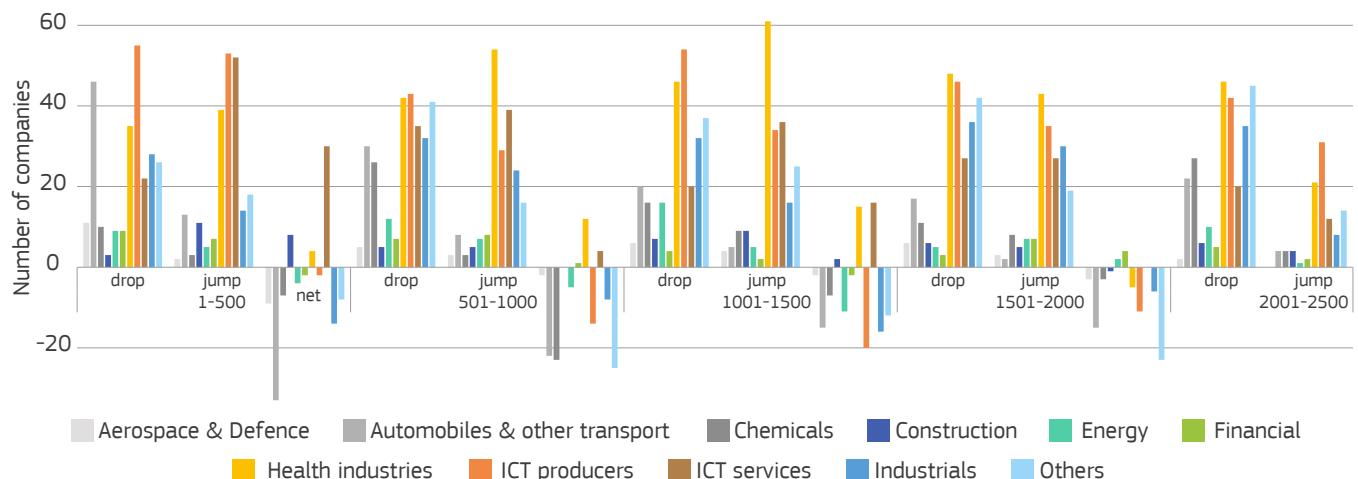
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.7: Changes in the average volume of R&D investments per regions in SB2020-SB2021.

Region	# companies without new entrants	R&D investment without new entrants, € million	Average R&D without new entrants, € million
China	485	18,248	38
Japan	288	888	3
US	671	24,007	36
EU	376	-4,303	-11

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure A3.2: Net changes in the number of companies per quintile groups and sectors of activity in SB2020-SB2021.



Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

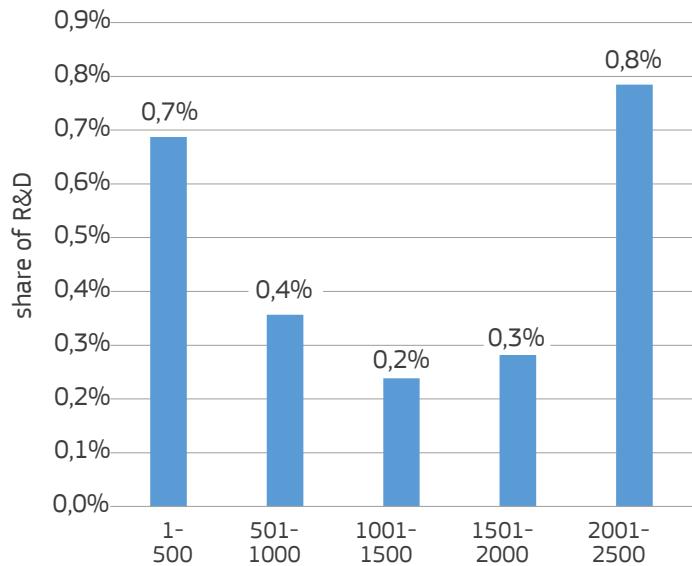
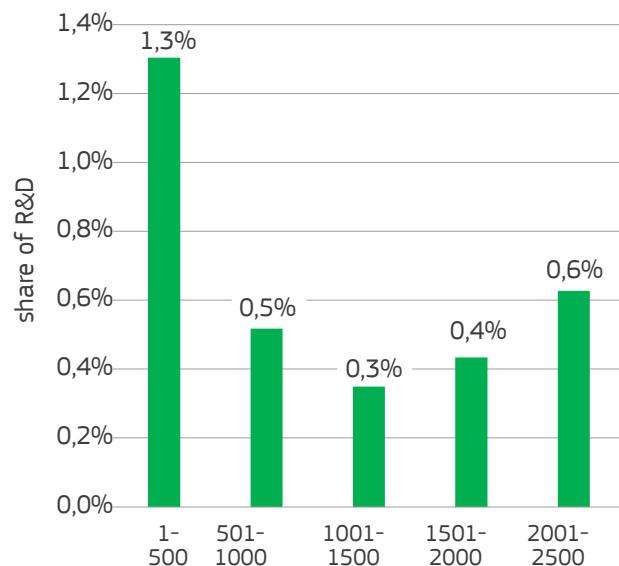
Table A3.8: Number of companies in 2016 and 2021 by sectors of activity and by the main geographic regions.

number of companies	SB2016				SB2021			
	EU	Japan	China	US	EU	Japan	China	US
Aerospace & Defence	12	1	5	19	10	0	5	13
Automobiles & other transport	91	78	64	62	38	36	45	35
Chemicals	19	38	11	35	16	34	28	25
Construction	18	16	16	8	8	13	35	4
Energy	30	15	13	13	28	12	18	8
Financial	26	0	3	11	26	1	13	9
Health industries	78	38	32	252	72	33	72	278
ICT producers	55	69	81	171	48	53	129	120
ICT services	36	10	37	166	32	10	81	190
Industrials	31	25	27	23	66	49	89	34
Others	61	66	38	77	57	52	82	63
Total Region	457	356	327	837	401	293	597	779

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



Figure A3.3: Entry/exits dynamics of the Scoreboard: shares of R&D investments of entrants and exiting companies by quintiles of ranking.



Note: for entries, shares refers to the total of R&D2020 from SB2021. For exits, shares refers to the total of R&D2019 from SB2020.

Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.9: R&D “acquired” and “lost” via entries and exits between SB2020 and SB2021, € million.

	exits (adjusted for the exchange rates)					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT		13.8		17.6	130.8	162.3
BE		29.7			21.9	51.6
DK		149.5			111.1	260.7
FI		10.7				10.7
FR		10.9	197.9	64.2	17.4	290.4
DE	15.9	12.9	31.3	31.9	613.6	705.6
EL			12.7		83.0	95.7
IE		1481.0			136.7	1617.7
IT					10.6	10.6
LU						
NL	114.2	562.9			75.0	752.1
PT					36.3	36.3
SI					18.3	18.3
ES					9.9	9.9
SE		30.6	11.7	76.8	66.1	185.3
Total exits	130.1	2301.9	253.6	190.6	1330.8	4207.0



entries					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors
AT				20.3	20.3
BE		32.7		15.3	10.4
DK					64.2
FI	16.2		13.7	10.4	27.2
FR	1187.3		11.3	63.8	219.9
DE		14.4	1176.0	27.6	163.6
EL					
IE					46.2
IT	17.4	11.6			29.0
LU				16.8	16.8
NL		168.3		11.1	182.3
PT					
SI					
ES					
SE	35.6	17.8	10.8	17.9	1498.2
Total	1256.5	244.7	1211.8	163.0	2232.3
					5108.3
net					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors
AT		-13.8		-17.6	-110.5
BE		3.0		15.3	-11.5
DK		-149.5			-46.9
FI	16.2	-10.7	13.7	10.4	27.2
FR	1187.3	-10.9	-186.6		202.5
DE	-15.9	1.5	1144.7	-4.4	-450.0
EL			-12.7		-83.0
IE		-1481.0			-90.5
IT	17.4	11.6			-10.6
LU				16.8	0.0
NL	-114.2	-394.6		11.1	107.3
PT					-36.3
SI					-18.3
ES					-9.9
SE	35.6	-12.8	-0.9	-58.9	1432.1
Total	1126.4	-2057.2	958.2	-27.6	901.5
					901.3

Note: Other sectors for exits include: chemicals, industrials, others. Other sectors for entries include: construction, financial, industrials, others
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table A3.10: R&D “acquired” and “lost” via entries and exits between SB2016 and SB2021, € million.

	exits (adjusted for the exchange rates)					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	8.2	20.8		76.1	125.1	230.2
BE		22.8			66.3	89.1
CZ					23.9	23.9
DK		71.7		23.4	94.8	189.9
FI			34.3	31.8	119.0	185.1
FR	38.7	97.8	2643.8	249.1	881.9	3911.3
DE	235.4	161.2	119.3	161.5	656.2	1333.7
EL		44.3	17.8		43.3	105.4
IE		2215.7		21.3	10.0	2247.1
IT	52.5				2038.3	2090.8
LU			8.4		71.3	79.6
NL	102.4	612.9	446.4	104.7	1086.4	2352.7
PL						
PT				100.0	27.8	127.8
RO					10.0	10.0
SI					28.2	28.2
ES	68.2				310.7	378.9
SE	6.7	256.1	13.5	43.3	315.9	635.5
Total exits	512.1	3503.3	3283.6	811.2	5909.0	14019.2
<hr/>						
	entries					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	17.6	69.0	57.8		239.4	383.8
BE		113.3	20.7	15.3	145.9	295.3
CZ						
DK		680.3	19.5	73.3	189.4	962.4
FI	16.2	12.9	13.7	13.4		56.1
FR	1252.7	248.4	29.9	263.3	532.9	2327.2
DE	231.2	164.9	1421.2	218.3	1163.2	3198.8
EL						
IE	119.8	185.5	35.4		301.2	641.9
IT		26.4			78.2	104.5



LU			16.8	83.5	100.2
NL	159.0	233.8	366.4	693.5	1452.7
PL				104.8	104.8
PT				12.2	12.2
RO					
SI					
ES	58.8				58.8
SE	275.1	205.0	24.0	130.0	1632.8
Total entries	2130.5	1939.5	1622.2	1096.7	5177.0
					11965.9

	net					
	Automobiles & other transport	Health	ICT producers	ICT services	Other sectors	Total
AT	9.3	48.2	57.8	-76.1	114.3	153.6
BE		90.5	20.7	15.3	79.7	206.2
CZ					-23.9	-23.9
DK		608.6	19.5	49.8	94.7	772.5
FI	16.2	12.9	-20.7	-18.4	-119.0	-129.0
FR	1214.0	150.6	-2613.9	14.2	-349.0	-1584.1
DE	-4.2	3.7	1301.9	56.8	507.0	1865.2
EL		-44.3	-17.8		-43.3	-105.4
IE	119.8	-2030.2	35.4	-21.3	291.2	-1605.1
IT	-52.5	26.4			-1960.1	-1986.2
LU			-8.4	16.8	12.2	20.6
NL	56.6	-379.0	-446.4	261.7	-392.9	-900.0
PL					104.8	104.8
PT				-100.0	-15.6	-115.6
RO					-10.0	-10.0
SI					-28.2	-28.2
ES	-9.4				-310.7	-320.1
SE	268.5	-51.1	10.5	86.7	1316.8	1631.3
Total	1618.4	-1563.8	-1661.3	285.5	-732.0	-2053.3

Note: Other sectors for exits include: chemicals, industrials, others. Other sectors for entries include: construction, financial, industrials, others.
Source: The 2021 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.



ANNEX 4

ACCESS TO THE FULL DATASET

The 2021 Scoreboard comprises two data samples:

The world's top 2500 companies that invested more than €36.5 million in R&D in 2020.

The top 1000 R&D investing companies based in the EU with R&D investment exceeding €2.0 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
<https://iri.jrc.ec.europa.eu/scoreboard/2021-eu-industrial-rd-investment-scoreboard>

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