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THE 2022 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

EXTENDED SUMMARY OF KEY FINDINGS AND POLICY IMPLICATIONS

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THE **2022** EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

Foreword

by Commissioner Mariya Gabriel

A few months after the adoption of the New European Innovation Agenda on 5 July, the 2022 EU Industrial R&D Investment Scoreboard brings encouraging news in the realm of innovation. I am pleased to see the rebound of EU companies' investment in research and development of 8.9% after a drop last year of 2.2% due to the COVID-19 pandemic.

Given that the focus of the Innovation Agenda is on Deep Tech Innovations, innovations to solve our deepest societal challenges, this rebound is timely. Innovations that do not have a solid industrial foundation can't create the innovations we need to address the most pressing challenges in our society.

The Scoreboard indicates a good EU base with broad sectoral diversification compared to its global competitors. EU Scoreboard companies retain the global lead for automotive R&D, contributing significantly to the EU's overall rebound, and it also features a number of R&D players in other sectors such as aerospace, defence and chemicals. A closer look at a wider sample of top 1000 EU R&D investors shows also a good number of smaller health and ICT companies investing in R&D.

This is promising and it is what we aim to achieve with the renewed European Research Area and the transition pathways for the different EU industrial ecosystems under the updated Industrial Strategy. EU Scoreboard companies are also among the leaders in terms of green technologies and perform the best concerning UN's Sustainable Development Goals, which mean that their R&D investment has positive environmental and social impacts.

While these are encouraging signs for industries in the European Union, we cannot rest easy. The New Innovation Agenda is the most cutting-edge policy framework in the world for supporting innovations with a hardware component, with 25 actions arranged into 5 flagships. To reach the Innovation Agenda's flagship of access to capital, which aims to mobilise EUR 45 billion for deep tech startups in their scale up phase, we must keep growing the base of limited partners in VC funds that attract institutional investors. Moreover, large companies featured on the EU Scoreboard, the results of whose R&D investments have a trickle-down effect on their ecosystems, must keep up their spending. This is crucial for economic growth and solving some of society's most pressing problems, such as the energy and food crises and speeding up the digital and green twin transition. In the end, it will be worth it.

The EU invests in industrial research and innovation (R&I) with Horizon Europe, including through the European Innovation Council and EU partnerships with the industry and InvestEU facilitates startups and SMEs' R&I financing on the market. National Recovery and Resilience Plans under the NextGenEU programme also allocate significant funding in industrial R&I.

R&I growth reflects strategic investment decisions by companies and must serve as a key indicator for policymakers to understand the dynamics. I hope it can be also useful for industry to compare against peers and encourage R&I investments

The effect of the war in Ukraine on R&D investment are not yet captured by the Scoreboard because it is based on 2021 data. However, the 2022 EU Survey on Industrial R&D Investment Trends, published together with the Scoreboard, reports that some existing R&I projects from top 1000 EU R&D investors are delayed in sectors like aerospace and defence, construction, health industries and automobiles. Other new R&D projects, however, were started as a consequence of the war.

I wish you an insightful reading.

EXTENDED SUMMARY

The EU Industrial R&D Investment Scoreboard (the *Scoreboard*) provides economic and financial information based on the most recent audited accounts of the world's top 2500 R&D investors and EU 1000 R&D investors. It is a tool to benchmark EU companies against their global competitors, understand industrial R&D dynamics and monitor trends going back up to ten years. Following the Open Innovation practice, the underlying database is publicly available to allow stakeholders such as companies, policy makers and scientists to undertake their own benchmarking and monitoring exercise.

The 2022 edition of the *Scoreboard* reports on the 2500 companies that invested the largest amounts in R&D worldwide in 2021. These companies, with headquarters in 41 countries and more than 900k subsidiaries all over the world, each invested over EUR 48.5 million in R&D in 2021. The total investment across all 2500 companies was EUR 1093.9 billion, an amount equivalent to 86.3% of the world's business-funded R&D.

The top 2500 includes 361 companies headquartered in the EU, accounting for 17.6% of the total R&D investment, 822 US companies (40.2%), 678 Chinese companies (17.9%), 233 Japanese companies (10.4%) and 406 from the Rest of the World (RoW, 13.9%). The RoW group comprises companies from the UK (91), Taiwan (80), South Korea (53), Switzerland (54) and companies based in other 21 countries.

The results of the 2022 *Scoreboard* reveal challenges and opportunities for the EU as it seeks to improve its technology capabilities and reinvigorate its industrial base in the context of increasing global competition pressure and ongoing green and digital transformations. This extended summary provides first the key highlights, followed by a section illustrating with more detail the key findings and a section discussing the policy implications.

Key highlights

- Global private R&D investment in 2021 recovered strongly (14.8% increase compared to 2020) beyond pre-pandemic crisis levels, surpassing the trillion mark for the first time (EUR 1.094 trillion, worldwide). After a 2.2% decrease in 2021 *Scoreboard*, companies headquartered in the EU increased their R&D investment by 8.9% in 2021. However, R&D growth for US and Chinese *Scoreboard* companies has been higher than that for EU *Scoreboard* companies (16.5% for the US; 24.9% for Chinese companies).

- Four key sectors account for 77.8% of total *Scoreboard* R&D: ICT producers (22.6%), health industries (21.5%), ICT services (19.8%) and automotive[1] (13.9%). EU *Scoreboard* companies retain the global lead for automotive R&D, contributing significantly to the EU's overall rebound. However, R&D growth in the four key sectors was higher for US and Chinese than for EU *Scoreboard* companies. In 2021, US *Scoreboard* companies lead in ICT (producers and services) and health R&D, while China is second in the ICT producers sector and services sectors.

- The number of Chinese companies more than tripled over the past decade (from 176 in 2011 to 678 in 2021), mainly driven by ICT companies entering the *Scoreboard*. In numbers of companies, China is second behind the US, whereas EU is third. The sustained growth of China's R&D observed in past editions of the *Scoreboard* continues this year and has produced a significant change: for the first time China has overcome EU not only in terms of number of companies but also in total R&D invested.

- Challenges for EU industry are illustrated with the examples of the automotive and semiconductors sectors. In the automotive sector, the EU's leadership is challenged by the shift to electric mobility and digitalisation trends with increasing competition from electric vehicles companies and big tech players from ICT industries. Semiconductors is a strategic sector, underpinning the technological development of key industries, involving a complex value chain that raises security of supply and technology dependencies issues. The *Scoreboard* data indicate a dominance of US companies in the chip design segment and a lead of Taiwanese and South Korean companies in chips manufacturing while EU companies appear underrepresented in both segments of the value chain.

- The top 50 corporate R&D investors represent around 40% of the total R&D in the *Scoreboard*. The composition of the top 50 remained relatively stable in the last decade. In this group of companies, the EU has a strong and stable presence in terms of number of companies.

- A more detailed analysis of top 1000 R&D investors in the EU showed a large number of smaller firms in health industries. SMEs with fewer than 250 employees account for 75% of companies in health industries; France, Sweden and the Netherlands have a strong lead in terms of R&D investment and number of firms. The extent to which these companies are able to achieve sustainably high growth rates will be an important determinant of the progress that the EU1000 can make over the next decade.

[1]Automotive is short name for the Automobiles & other transport sector that comprises the automobiles, auto parts, commercial vehicles & trucks and tires subsectors.

- As a new aspect of corporate innovation strategies, Corporate Venture Capital (CVC) has been analysed. It is used by two-thirds of *Scoreboard* companies and increased over the past 20 years, with positive correlation and complementarity between R&D and CVC especially in ICT and health. CVC by EU *Scoreboard* companies is just around half of that by US ones, and 80% of funds from EU-based companies go to US-based start-ups.

- A patent-based positioning of *Scoreboard* companies in green technologies and circular economy technologies shows that Japanese and EU *Scoreboard* companies lead in high-value patents, and the EU also leads in inventions relevant to circularity.

- The analysis of firm-level disclosure and reputation performance vis-a-vis the UN's Sustainable Development Goals (SDGs) shows above average SDG scores for EU (esp. energy and chemicals) and Japanese (automotive and ICT producers) *Scoreboard* companies. There is an emerging trend of high potential of breakthrough technologies to help achieve green and energy policy goals, thus contributing to fast-track SDGs progress.

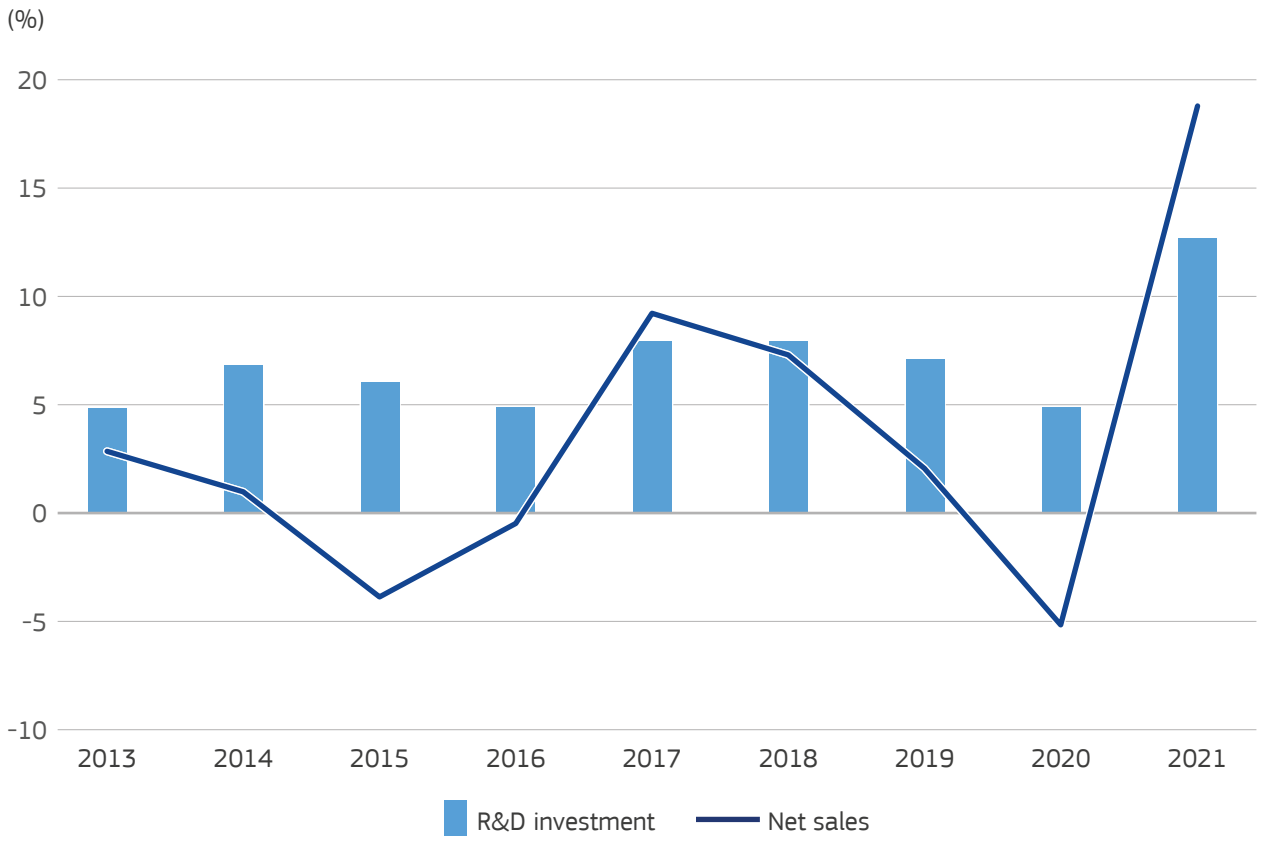
Key findings

1 Fast recovery from the COVID-19 crisis

Industrial R&D investment continued to grow significantly for the 12th consecutive year. Most corporate financial indicators that strongly suffered during the pandemic showed a significant recovery, particularly operating profits, net sales and capital expenditures.

The 2500 *Scoreboard* companies invested EUR 1 093.9 billion in R&D, 14.8% more than in 2020, and much higher than the increase in the 2021 *Scoreboard* (6.0%), which had lockdowns because of COVID-19. The net sales of the 2500 companies increased by almost 20%, reaching EUR 23.1 trillion, contrasting the drop of 4.6% in the 2021 *Scoreboard* (see Figure S1). Companies' operating profits showed the best performance, increasing substantially across most world regions and sectors, recovering a double-digit profitability level for the global top R&D investors.

Figure S1: Global top R&D investing firms: growth in R&D and net sales, 2013-2021

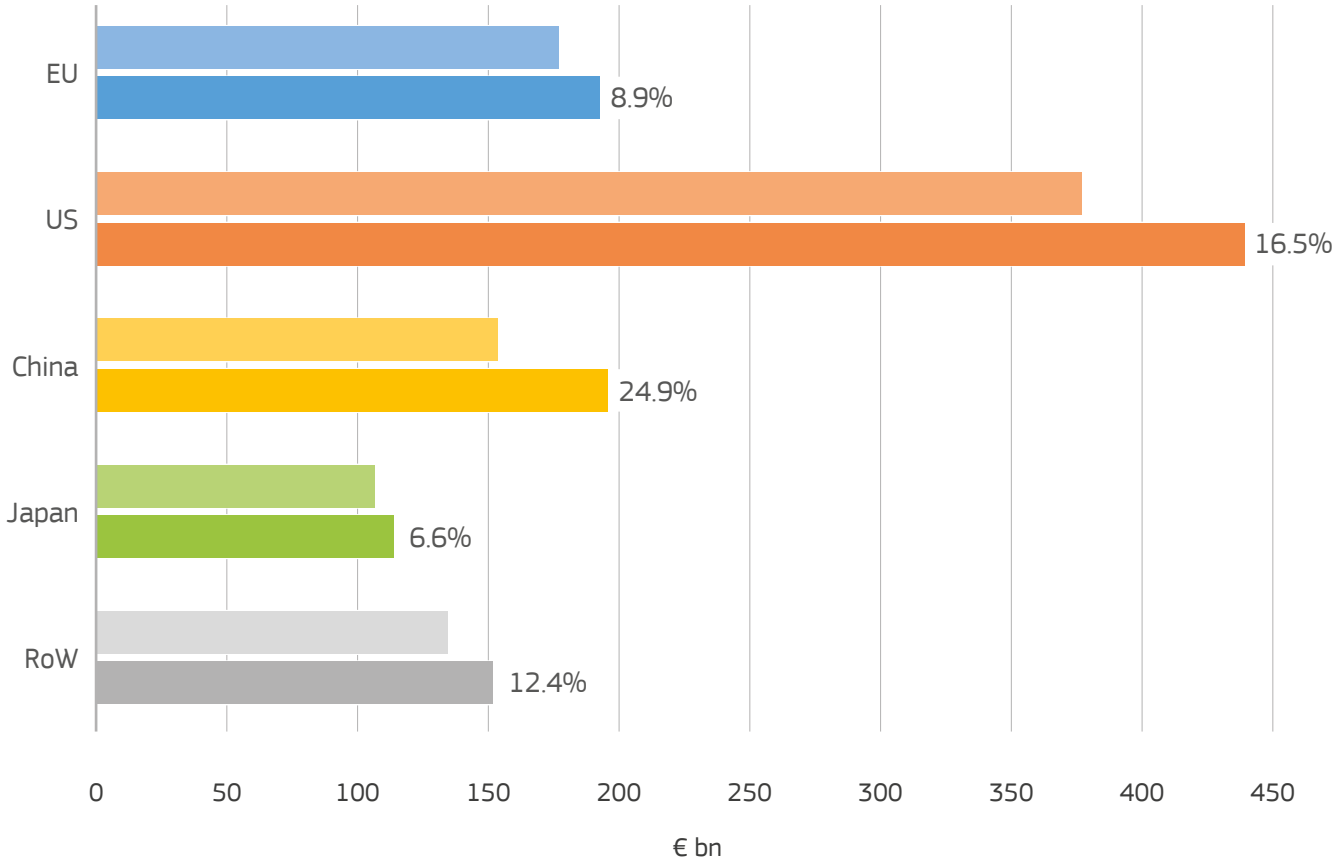


Note: Growth rates for R&D and net sales are computed for 1717 out of the 2500 companies for which data on R&D and net sales are available for the period 2012-2021. These companies represent 87% of R&D and 89% of net sales of the total sample in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

In 2021, the 361 companies based in the EU invested EUR 192.8 billion in R&D, which is an increase of 8.9% compared to 2020, in contrast to the reduction seen in the 2021 *Scoreboard* (-2.2%). The total R&D investment by these companies was thus 5.7% above the pre-COVID level of EUR 182.4 billion.

As in previous years, companies headquartered in the US and China showed the highest R&D growth (16.5% and 24.9%, respectively). Japanese companies also increased R&D but more modestly than their competitors (6.6%). Companies in the RoW group raised their R&D by 12.1%, driven by increased investments of companies based in the UK (12.6%), Taiwan (16.8%) and Switzerland (10.8%), see Figure S2.

Figure S2: R&D investment and growth rate by region/country, 2020-2021



Note: Growth rates have been computed for 360 EU, 819 US, 676 Chinese, 232 Japanese, and 401 RoW companies for which data are available for both years 2020 and 2021. Pale colour=2020; darker colour=2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

2 Global R&D trends driven by high-tech sectors

As in recent years, firms in the ICT services sector (19.5%), followed by the health and ICT producers sectors (16.8% and 11.9%, respectively), are the key drivers of global R&D growth. However, *Scoreboard* companies in other sectors also showed a double-digit R&D growth in 2021, except in the energy and aerospace & defence sectors (7.4% and 2.0%, respectively). The companies in the automotive sector (which was hit hard by the COVID-19 crisis in 2020) revealed a substantial recovery of R&D growth (12.3%). The chemicals sector broke the negative trend observed in the past few years increasing R&D growth strongly (13.1%).

In the EU, the main pillar of corporate R&D is the automotive sector, accounting for 32.5% of the total R&D and sustaining the average R&D growth (8.9% compared to -7.2% in the 2021 *Scoreboard*). Health companies also demonstrated a significant R&D growth above the EU's average (11.5%) as well as those in financials (14.7%). The chemicals and aerospace & defence sectors recovered from last year's drop with however modest R&D growth (4.8% and 0.6%, respectively); the growth rate for the chemicals sectors was sufficient to reach its pre-COVID R&D level (EUR 5.3 billion), but the aerospace & defence sector is still almost EUR 2 billion below its 2019 value of EUR 8.2 billion.

The R&D growth of the US companies was driven by double-digit figures in the top R&D investing sectors, namely ICT services (21.2%), health (18.5%), and ICT producers (10.0%). The high growth of *Scoreboard* firms in the US automotive (27.1%) should be noted as well.

Firms headquartered in China in the sectors ICT producers (18.0%), ICT services (21.6%), industrials (32.2%), construction (21.7%), and health (35.8%) contributed most to the overall R&D growth. As for the US, we register a high R&D growth by firms in the Chinese automotive (26.5%), see Figure S3.

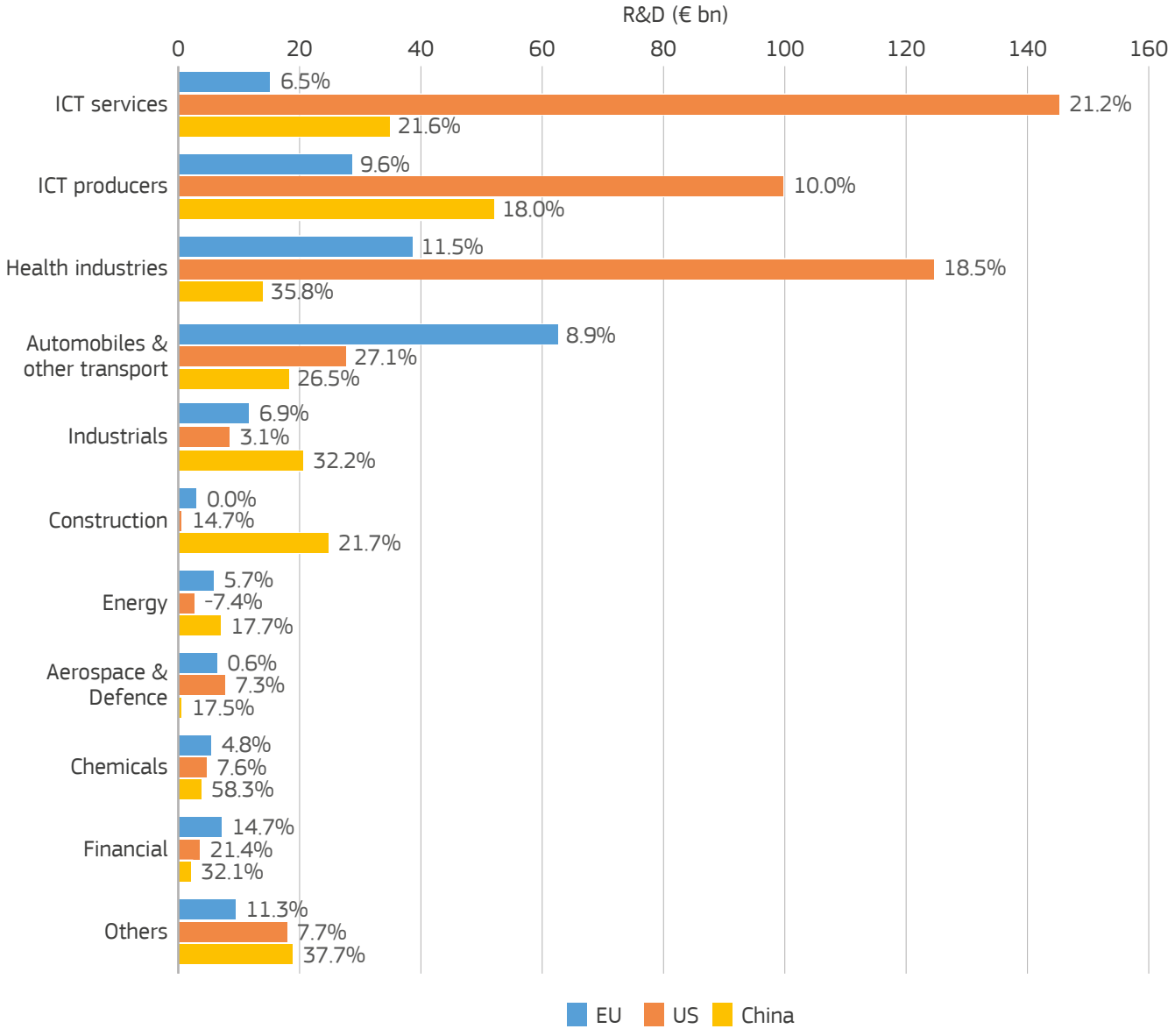
Within the EU, the R&D growth was sustained by companies based in Germany, the largest R&D investor country accounting for 47.2% of the total EU's R&D investment. The set of German companies increased R&D by 8.1% driven by companies from the automotive sector, e.g. Volkswagen (12.2%), BMW (9.4%) and Mercedes-Benz (6.3%) and from the health and ICT sectors, e.g. Boehringer Sohn (11.7%), BioNtech (86.6%), SAP (16.2%) and Infineon Technologies (30.2%).

Companies from France, the second R&D investing country accounting for 15.8% of the EU's R&D investment, showed a modest R&D increase (2.6%). Good performance from companies such as Alstom (66.2%) were offset by poor results of other companies, e.g. Renault (-14.1%).

Other EU countries whose companies reported significant R&D increases are the Netherlands[2] (21.4%), e.g. by companies such as Stellantis[3] (52.3%), CureVac (725.8%), CNH Industrial (27.9%), NXP Semiconductors (14.8%) and Denmark (15.7%), mainly by Novo Nordisk (18.8%) and Vestas (34.1%).

[2] Several top R&D investors, e.g., Airbus, Stellantis, STMicroelectronics and CureVac, are headquartered in the Netherlands but have most of their operations in different countries.
[3] The increase of Stellantis' R&D is entirely due to the merger of the group with the French PSA group in 2021.

Figure S3: R&D investment and 1-year growth rate by region/country and sector, 2021



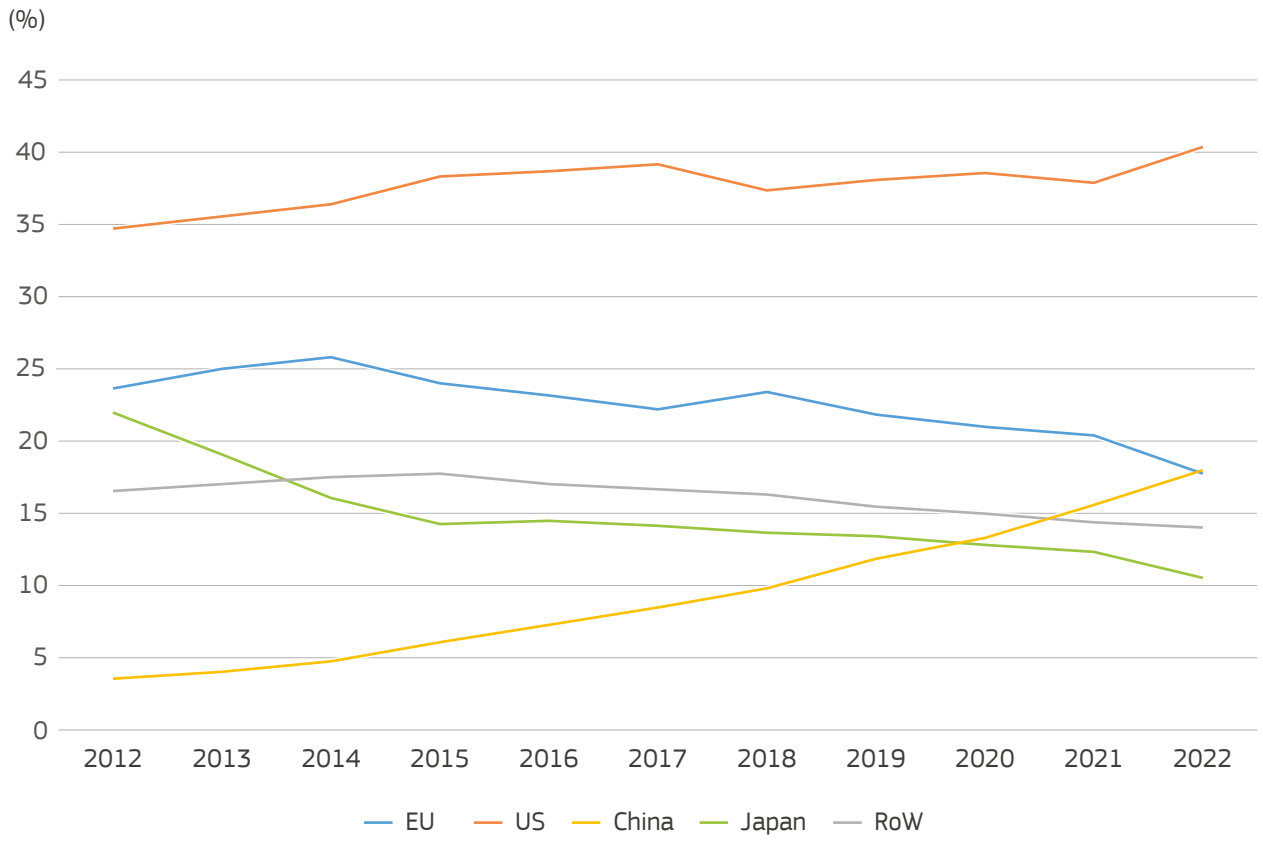
Note: R&D 2021 growth rates have been computed for 360 EU, 819 US and 676 Chinese companies for which data are available for both years 2020 and 2021. Sectors ordered from top to bottom in terms of overall R&D investment in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

3 The ongoing technology race reshaped the R&D landscape

The technology race intensified in 2021 with EU companies showing a recovery, US and Chinese companies continuing to increase sharply their R&D investments and Japanese companies following behind. As a result, the share in global R&D investment of EU companies decreased to 17.6% and that of US companies reached 40.2% in 2021. Chinese companies continued to increase their R&D share sharply, reaching 17.9%. In contrast, Japanese companies' share of global *Scoreboard* R&D continued to shrink (10.4%).

The outstanding R&D growth by companies headquartered in China has resulted in surpassing the Japanese companies in 2020 and those headquartered in the EU in 2021. Both, the number of Chinese firms and their R&D investment increased markedly in the top 2500 ranking. EU companies invested EUR 192.8 billion of R&D in 2021, compared with EUR 195.9 billion for Chinese companies. The US remains first, with EUR 439.7 billion, while Japan is behind both the EU and China with EUR 113.8 billion, see Figure S4.

Figure S4: Share of global R&D investment by region – 2012 to 2022 *Scoreboard* (SB) editions



Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

4 Continued R&D investment concentration in lead sectors

Consistent R&D growth trends for more than 10 years have changed the global R&D landscape. R&D investment is increasingly concentrated in four major sectors accounting for 77.8% of total R&D in 2021, compared to 73% in 2012. These sectors are ICT producers (22.6%), health industries (21.5%), ICT services (19.8%) and automotive (13.9%).

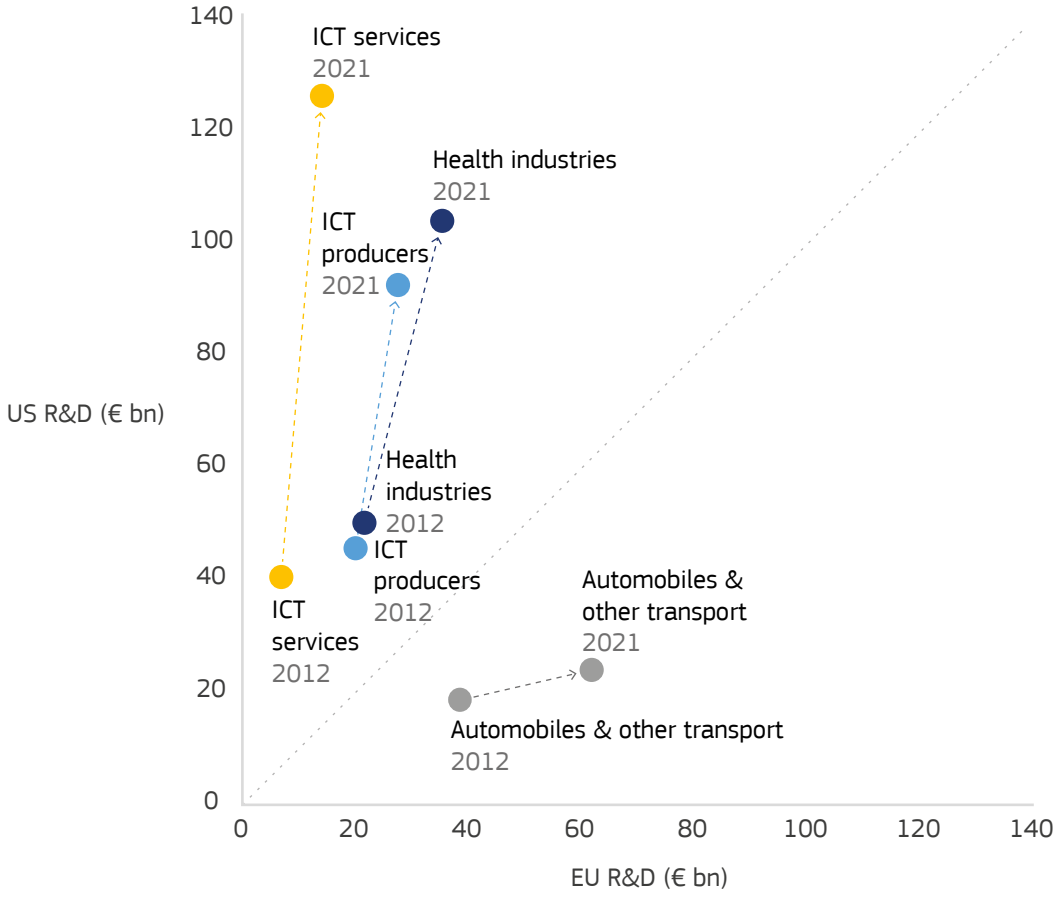
In this context, EU companies continued to show a balanced sector mix of R&D investment and a stable concentration in the automotive sector, accounting for one third of the total EU's R&D in 2021 compared to 26.7% in 2012. The R&D funded by US companies continued to concentrate in ICT and health industries accounting for 83.4% of the total US' R&D. The R&D by the Chinese companies is performed mainly in the two ICT sectors that account together for 44.4% of the total China's R&D.

In 2012, EU and US companies showed a distinct R&D specialisation: in the automotive sector EU companies invested in R&D more than twice as much as their US counterparts. In contrast, in the health and ICT producers sectors the EU companies invested only 40% of the amount invested by their US counterparts and in the ICT services sector only 20%.

In 2021, this specialisation pattern continued: the EU companies invested 2.6 times more than their US counterparts in the automotive sector but only 30% of the US companies' R&D investment in the health and ICT producers sectors, and 10% in the ICT services sectors, see Figure S5.

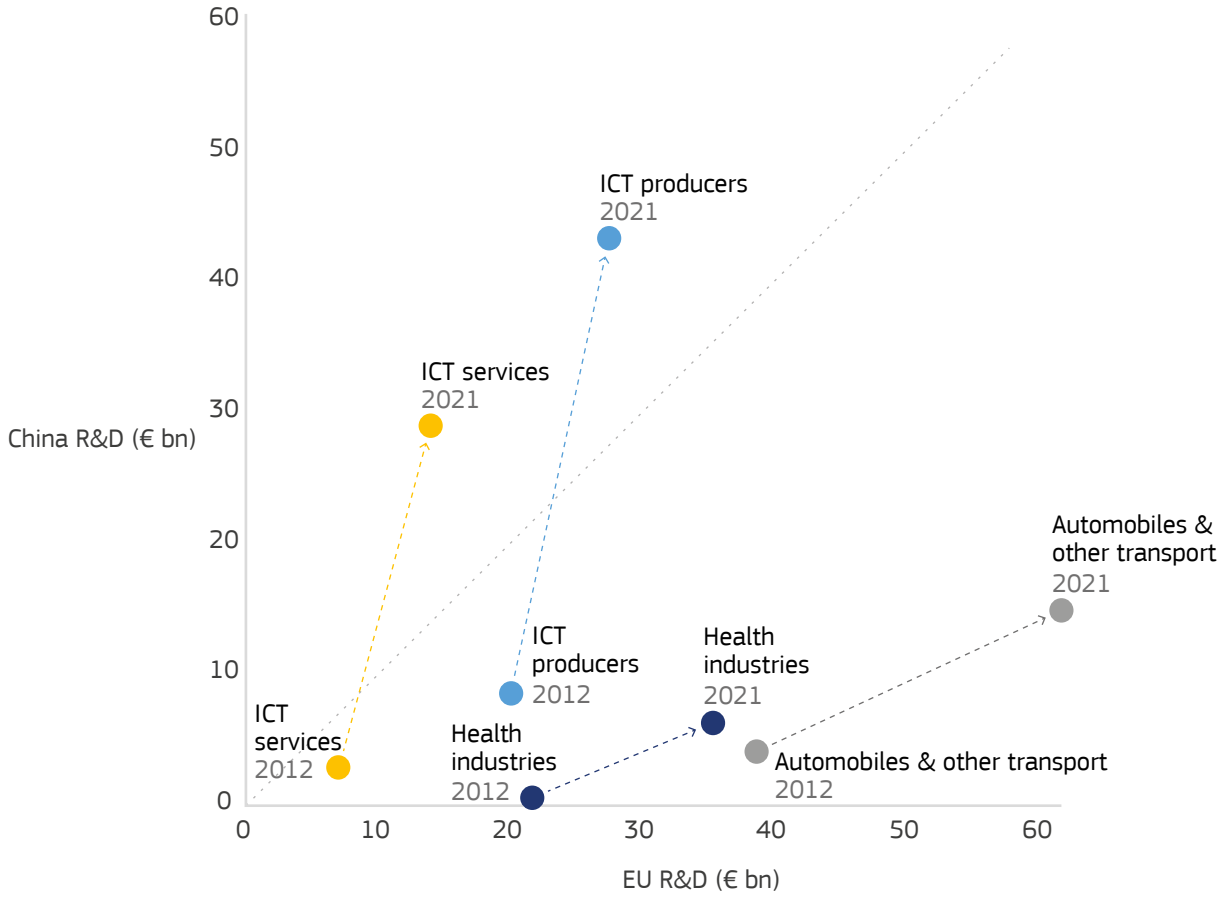
In 2012, the EU invested more than China in all four major sectors under consideration. In the past 10 years, however, the Chinese companies operating in the ICT sectors have increased substantially their R&D investment. The result is that in 2021, the Chinese companies invested in R&D twice as much as their EU counterparts in the ICT services sector and 1.6 times more in the ICT producers sector. By contrast, the EU retained its lead in the automotive and health sectors (4.2 and 5.6 times more R&D investment, respectively), see Figure S6.

Figure S5: Comparison of R&D investment in selected sectors in the EU and US, 2012-2021



Note: Data refers to 502 (EU: 149, US: 353) of the 835 companies (EU: 174, US: 661) in the four sector groups in the two regions considered for which R&D data are available for the period 2012-2021, accounting for 89.6% of the R&D in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure S6: Comparison of R&D investment in selected sectors in the EU and China, 2012-2021



Note: Data refers to 382 (EU: 149, CN: 233) of the 556 companies (EU: 174, CN: 382) in the four sector groups in the two regions considered for which R&D data are available for the period 2012-2021, accounting for 88.2% of the R&D in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

5 Composition of the top 50 global R&D investors remains stable over time

The top 50 companies in the *Scoreboard* account for around 40% of the total R&D investment. This group is characterised by a high persistence over time: 14 companies in the top 50 are new in 2022 compared to 2012. Out of the entrants, 11 companies were already in the *Scoreboard* in 2012, all of them in the top 500 with one exception. The remaining three companies, i.e. China State Construction (CN), Abbvie (CN) and Stellantis (EU), were not in the *Scoreboard* under these names. However, two of the predecessors of Stellantis (Fiat and Peugeot) as well as one of Abbvie (Abbot) were already included in 2012, in or close to the top 50. These dynamics do not appear high over such a long time span, highlighting the persistence in the top 50.

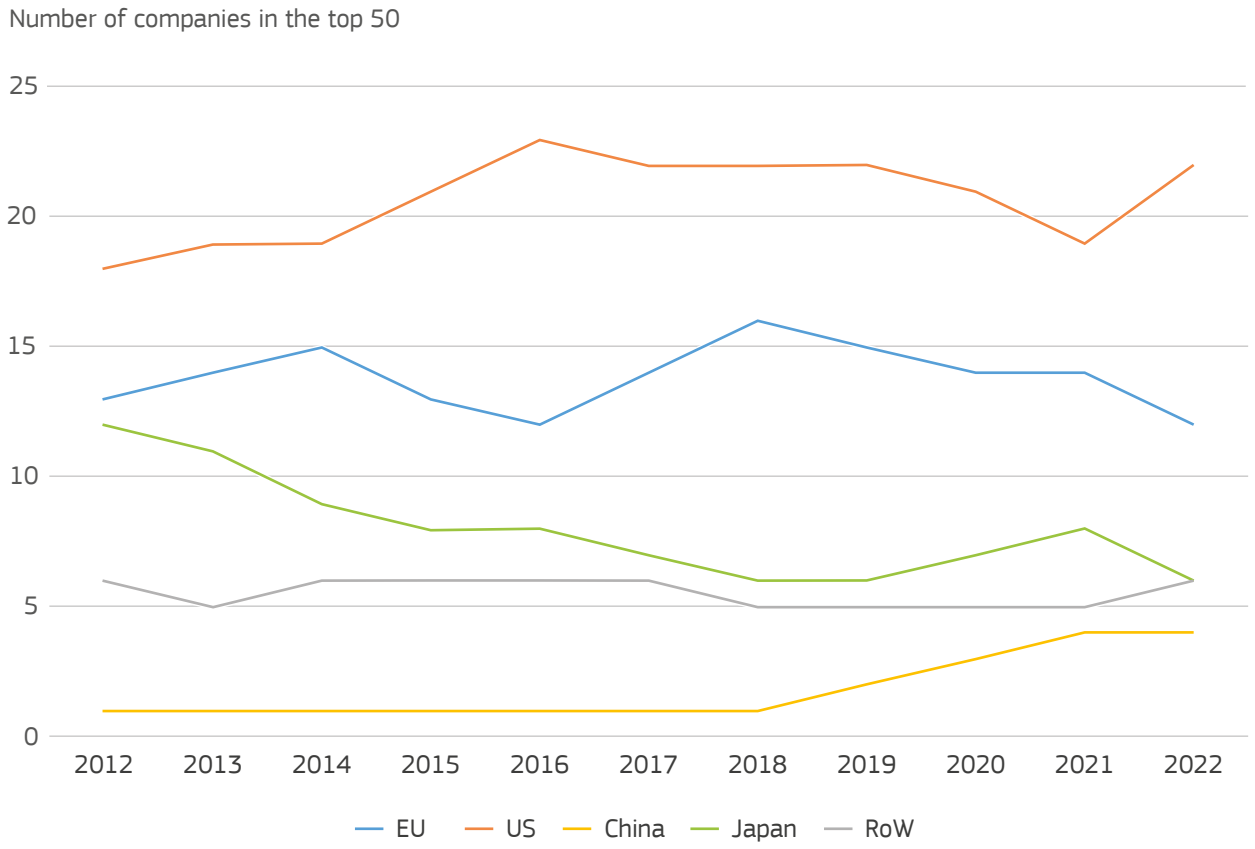
Among the 14 entrants, the ICT sectors dominate with 9 companies. It is followed by health (3) as well as construction and automotive with one each. The share of ICT companies' R&D in the top 50 increased from 36% in 2012 to 52% in 2022. Although increasing in terms of number, the R&D share of health companies decreased by 5 percentage points from 32% in 2012. Likewise, the automotive sector dropped by 5 percentage points from its level of 23% in 2012.

The top 50 is dominated by US companies, mainly in ICT services and producers, as well as from the health sector. Recently, the US presence has strengthened in the health sector: while its 6 companies in 2012 accounted for 47% of the health industry R&D, in 2022 the number of companies increased to 8 and they invested 54% of the total health sector R&D of the *Scoreboard*.

EU headquartered companies are strongly represented in the top 50. There are currently 12 EU companies in the top 50, which is only a single company (Airbus, ranked 60 in 2022) less than 10 years ago. Apart from Airbus and Peugeot (see Stellantis case) it was only Alcatel-Lucent that exited the *Scoreboard* in 2017, but only as a brand. It has de facto remained in the top 50 as a result of the takeover by Nokia. The remarkable stability of the EU presence can be observed also on the sectoral level: there is the same number of companies in each of the key sectors in 2022 as in the *Scoreboard* 2012. However, the ranks of the EU companies have worsened, mainly due to the strong US presence in the top half. The EU is still the second largest R&D investor of the top 50 behind the US.

The largest number of companies exiting are from Japan, their number in the top 50 has halved compared to 2012. They exited mainly from the ICT sector and the 'others' category, the latter due to the dropout of Panasonic (leisure goods), and Toshiba (general industrials). The Japanese R&D in the top 50 group fell by EUR 4 billion. Although China is now number two after the US in the *Scoreboard* with respect to companies and total R&D, its presence in the top 50 with only 4 companies is still modest. However, its investments have expanded rapidly, mainly in the two ICT sectors, see Figure S7.

Figure S7: Main changes in the number of companies in the top 50 by region/country, 2012-2021



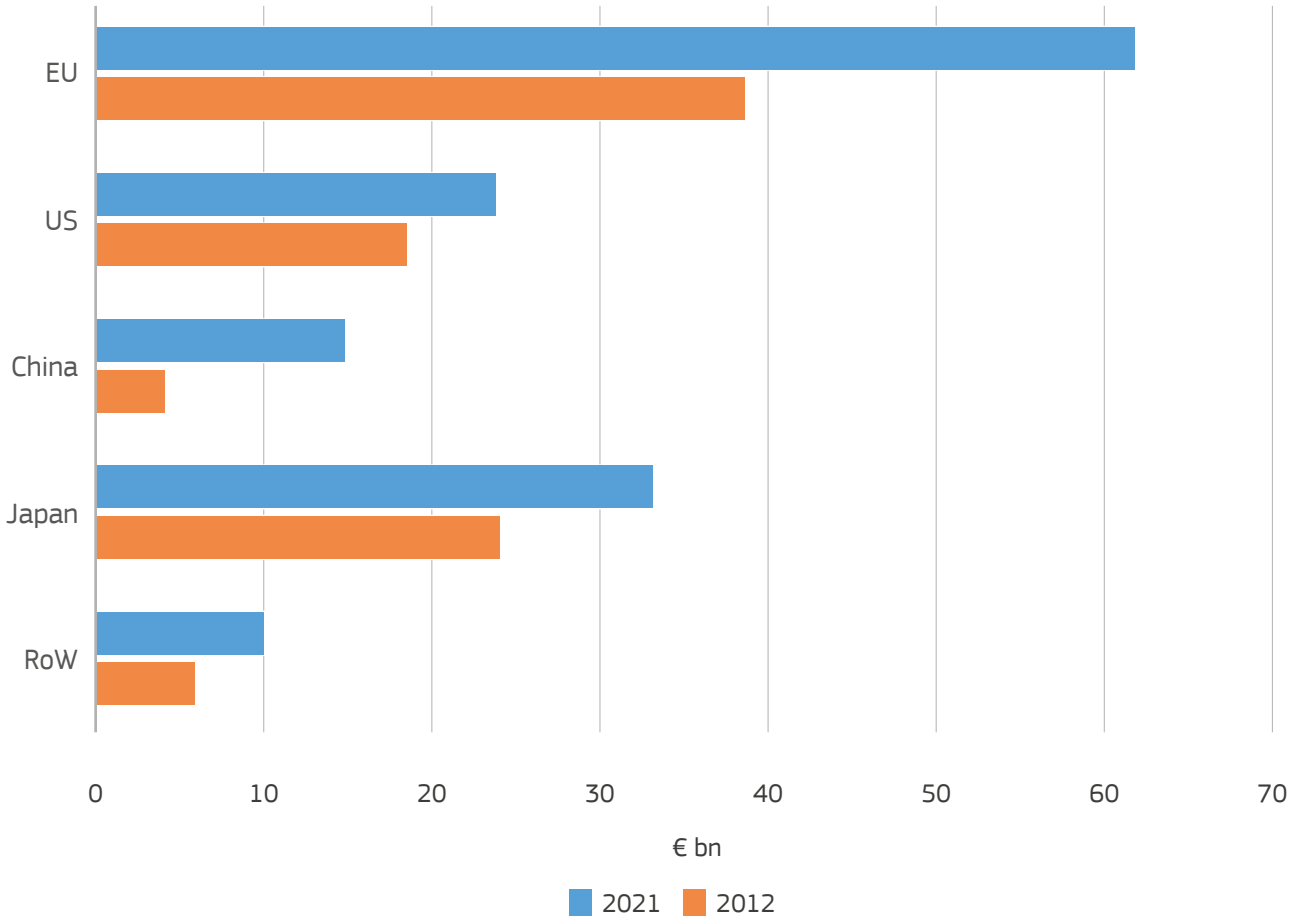
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

6 Challenges and opportunities for the EU: the automotive and semiconductor industries in the *Scoreboard*

The EU is facing major industrial challenges to cope with increasing global competitiveness pressure and to succeed with the forthcoming industrial green and digital transformations.

Automotive is the sector where the EU companies invest by far the most in R&D, accounting for one-third of the EU's total R&D investment. Globally, EU-based companies accounted for more than 40% of this sector's total R&D investment in 2021. The EU's leadership is reflected in much larger R&D investment, larger sales, larger profitability and more employees than their competitors. There are nine EU companies among the top 20 automotive companies by R&D investment. Over the past decade, the R&D investment increased significantly across all world regions but especially in China whose companies multiplied by four their R&D investment in this period. However, the R&D of Chinese automotive companies is still lower than their EU, US or Japanese counterparts, see Figure S8.

Figure S8: R&D investment in the automotive sector by country/region in 2012 and 2021

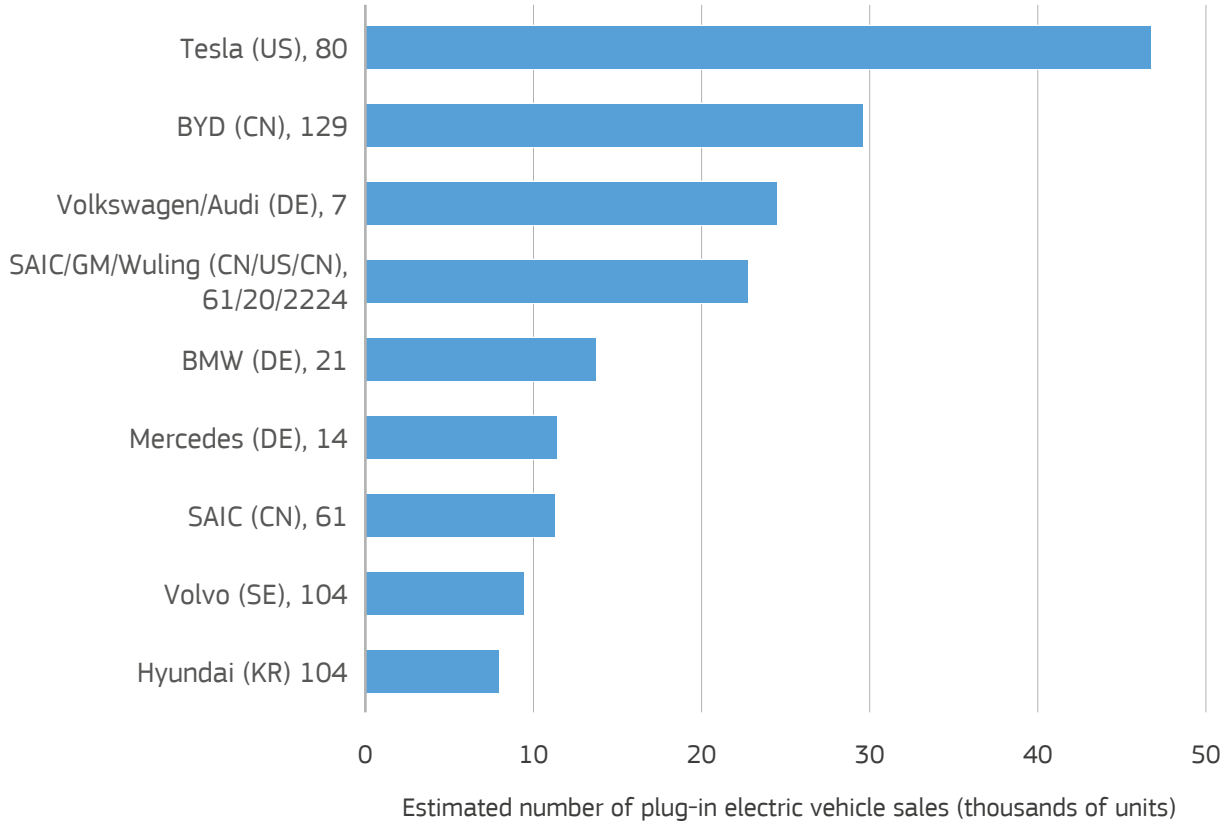


Note: Data refers to 149 automobiles & other transport companies (out of 180 in the sector) for which R&D data are available for the both years, accounting for 94.2% of R&D investment in 2021 in the sector.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The shift to electric mobility and digitalisation of the automotive industry is enhancing the competition with the arrival of new automotive companies and key players from ICT industries. Compared to the 2012 *Scoreboard,* there are now 10 EU companies less, same number of US companies and 35 more Chinese companies. Some of the new companies are fully operating in the electric vehicles (EVs) market. From 2012 to 2021, the number of EVs sold worldwide increased from 120 000 to 16.5 million, accounting for 10% of global car sales. The top 9 companies by sales included four EU companies in 2021, see Figure S9.

These trends pose a major challenge for the EU that has to react to keep its leadership, taking the new business opportunities and overcoming the barriers arising in the reshaped value chain of the automotive industry. In this context, the EU launched in 2017 the European Battery Alliance aimed at developing an innovative, competitive and sustainable battery value chain in Europe.

Figure S9: Top companies by global sales of electric vehicles, 2021



Note: The number after the country code indicates the position in the global *Scoreboard* ranking.
Source: Statista, https://www.statista.com/statistics/977407/global-sales-of-plugin-electric-vehicles-by-brand/, 2022.

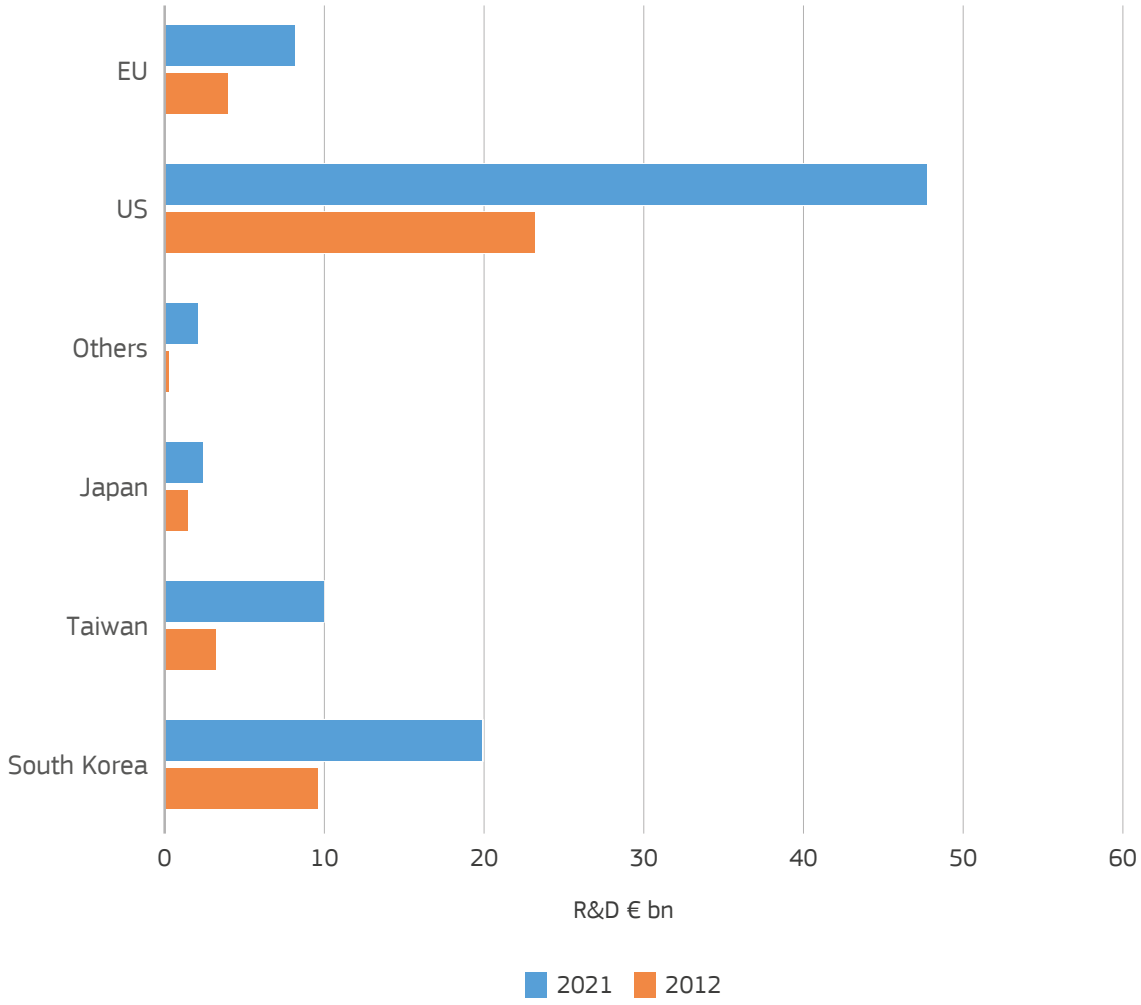
Semiconductors is a strategic sector having a role as enabler for the whole value chain of key sectors from ICT-related industries to automotive, biotechnology, food, energy and environmental sectors. Chips play a central role for technological leadership in science, artificial intelligence, electric mobility, aerospace & defence equipment.

The US *Scoreboard* companies dominate in the chip design segment of the semiconductors sector. In chip manufacturing the leading companies are based in Taiwan and South Korea. The EU hosts few players in the key segments of the semiconductors value chain, i.e. in both chip design and manufacturing.

Among the top R&D investors, US companies' R&D investment and net sales are larger than those of the other world regions together (6 times more R&D and 5 times more sales than their EU counterparts). There are 11 US companies among the top 20 companies by R&D investment and 4 EU companies. Over the past 10 years, the R&D investment in semiconductors increased significantly across all world regions but especially in China whose companies multiplied by seven their R&D in this period, see Figure S10.

In this context, the EU launched in 2022 the European Chips Act aimed at increasing resilience to supply chains disruptions and to increase its global share in manufacturing.

Figure S10: R&D investment in the semiconductors sector by country/region in 2012 and 2021



Note: Data refers to 87 semiconductors companies (out of 90 in the sector) for which R&D data are available for both years, accounting for 99.7% of R&D investment in 2021 in the sector.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

7 Potential for growth: high-tech companies and SMEs in the EU1000

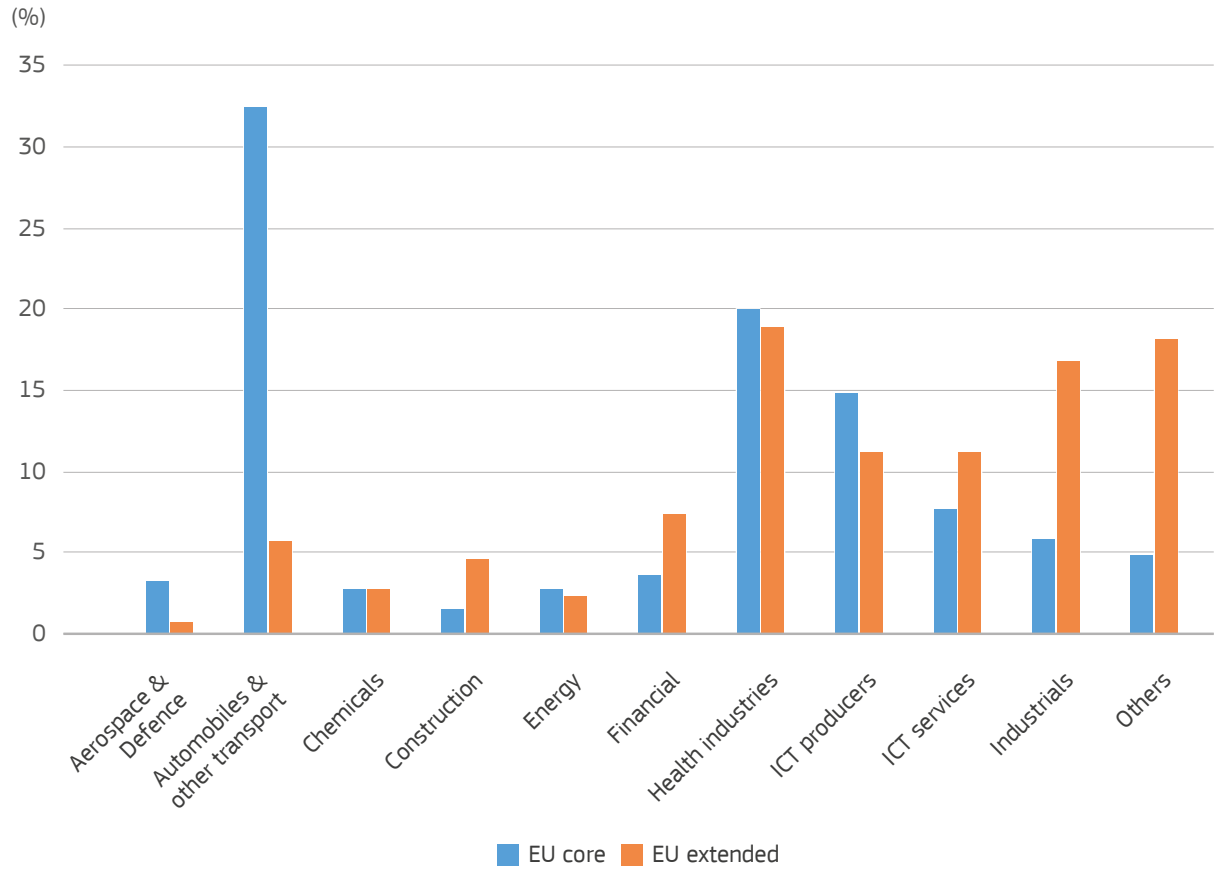
In order to give a more detailed description of industrial R&D investment across EU countries, the sample of 361 EU companies from the top 2500 (the 'core' group) was expanded by adding 639 companies that invest less than EUR 48.7 million (the threshold for the top 2500 ranking) but more than EUR 3.1 million (the 'extended' group). Together, these make up the sample of the EU1000 companies. The companies are located in 19 Member States and invested EUR 202.8 billion in R&D in 2021, of which 5% come from the extended group firms.

While in the core group, the automotive and other transport sectors dominate the distribution, the extended group distribution has more weight in the high-tech sectors health industries and ICT services. (see Figure S11).

SMEs with fewer than 250 employees account for 75% of companies in health industries – out of all 170 SMEs in the EU1000 – and 96 are in the extended group in the health sector; here, France, Sweden and the Netherlands have a strong lead in terms of R&D investment and number of SMEs.

The analysis of the sectoral distribution of R&D in the extended sample provides insights into the role of small R&D investors in important high-tech sectors where the EU lags behind its competitors. The extent to which these companies are able to achieve sustainably high growth rates will be an important determinant of the progress that the EU R&D large investors (including SMEs) can make over the next decade.

Figure S11: R&D share by sector – core vs extended group in the EU 1000 sample, 2021



Note: the percentages are the shares of R&D by sector of the core (blue bars) and extended (orange bars) groups.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

8 Positioning of the EU in green technologies and circularity

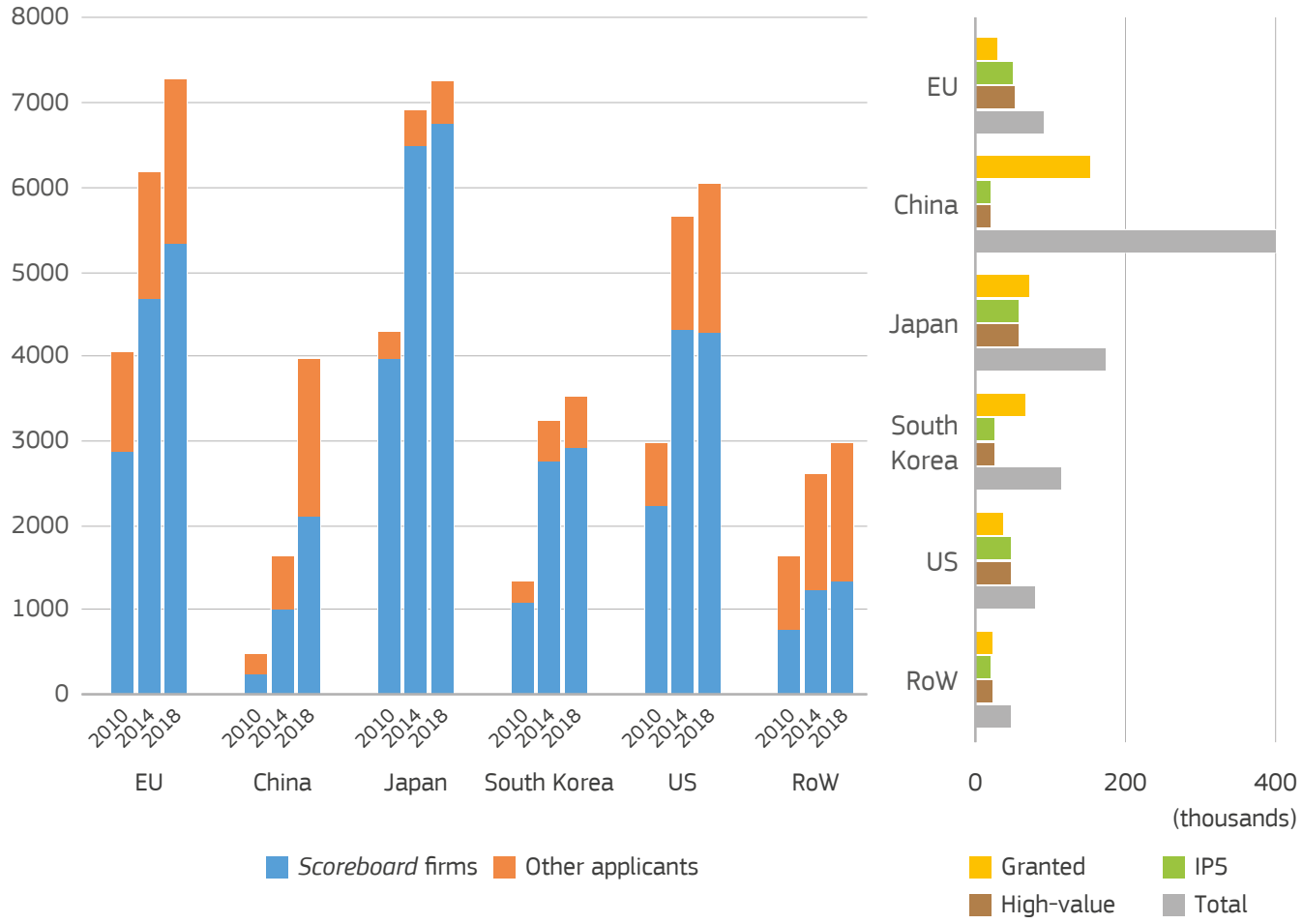
The report includes a patent analysis on green inventions[4], with additional focus on the production or processing of goods for circular economy technologies (CETs), in the subgroups construction, energy-intensive industries, food, fuel from waste, and others (including textiles). The latest statistics confirm that EU firms continue to contribute substantially to the Green Deal policy objectives (Figure S12), and that the EU leads in inventive efforts in CETs.

The analysis shows that the global share of green inventions has increased constantly to 9% of all patent filings in 2018, driven by very high numbers of Chinese inventions patented domestically only. Green high-value[5] inventions had a share of 10% of all high-value patent filings in 2018. As shown in Figure S12, the EU and Japan lead in green high-value patents, with the US in third place. At 58%, the US and the EU have the highest shares of high value patents (patents filed at several patent offices, indicating international protection) among their green patents. The EU and the US also have a more diverse contribution to green innovation from applicants beyond the *Scoreboard*. In contrast, in Japan and South Korea, most of the high-value green filings come from major *Scoreboard* investors. Energy and transport remain as the most prominent areas in the EU portfolio of green inventions (33% and 28%, respectively), and the EU had highest specialisation index on green patents. The EU also leads in inventions relevant to circularity both in absolute terms and as a share in overall green inventions.

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

[5] An invention is considered high-value invention, when it contains patent applications protected in more than one patent office around the world.

Figure S12: Trends in high-value green inventions: *Scoreboard* firms and other applicants, 2010-2018



Note: On the left: trend of annual filings of high-value green inventions for major economies for the years 2010, 2014 and 2018. On the right: Green inventions in the period 2010-2018: total number of inventions, high-value inventions, IP5 inventions and granted inventions for major economies.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

9 Top R&D investors continue to show progress in UN's sustainable development goals

The study also presents an analysis of *Scoreboard* companies' disclosure and reputation performance in the UN's Sustainable Development Goals (SDGs). The clear upward trend across SDG scores reported in the 2020 *Scoreboard* for the period between 2016 and 2020 is confirmed by the 2021 data. This signals an ongoing commitment of the top R&D investing companies to social and environmental responsibility. In line with past evidence, clean and affordable energy (SDG 7), decent work and economic growth (SDG 8) and life on land (SDG 15) achieve the highest absolute scores. Overall, the scores increased by 10% or more between 2016 and 2021, with some growing by almost 20% (e.g. climate action - SDG 13). From a sectoral viewpoint, companies operating in the automotive sector and the chemicals sector achieve on average high SDG progression scores in almost all of the environmental SDGs as well as in the socio-economic SDGs 8 (decent work and economic growth) and 9 (industry, innovation and infrastructure). Notably, SDG 9 increased by 9.1 points in 2021 with respect to the average for the period 2016-2020 for companies in the chemicals sector. It also increased by 6.5 points or more on average in every region, with companies from China (+7.6 points) and the Rest of the world (+7.2 points) performing significantly better than average along this dimension.

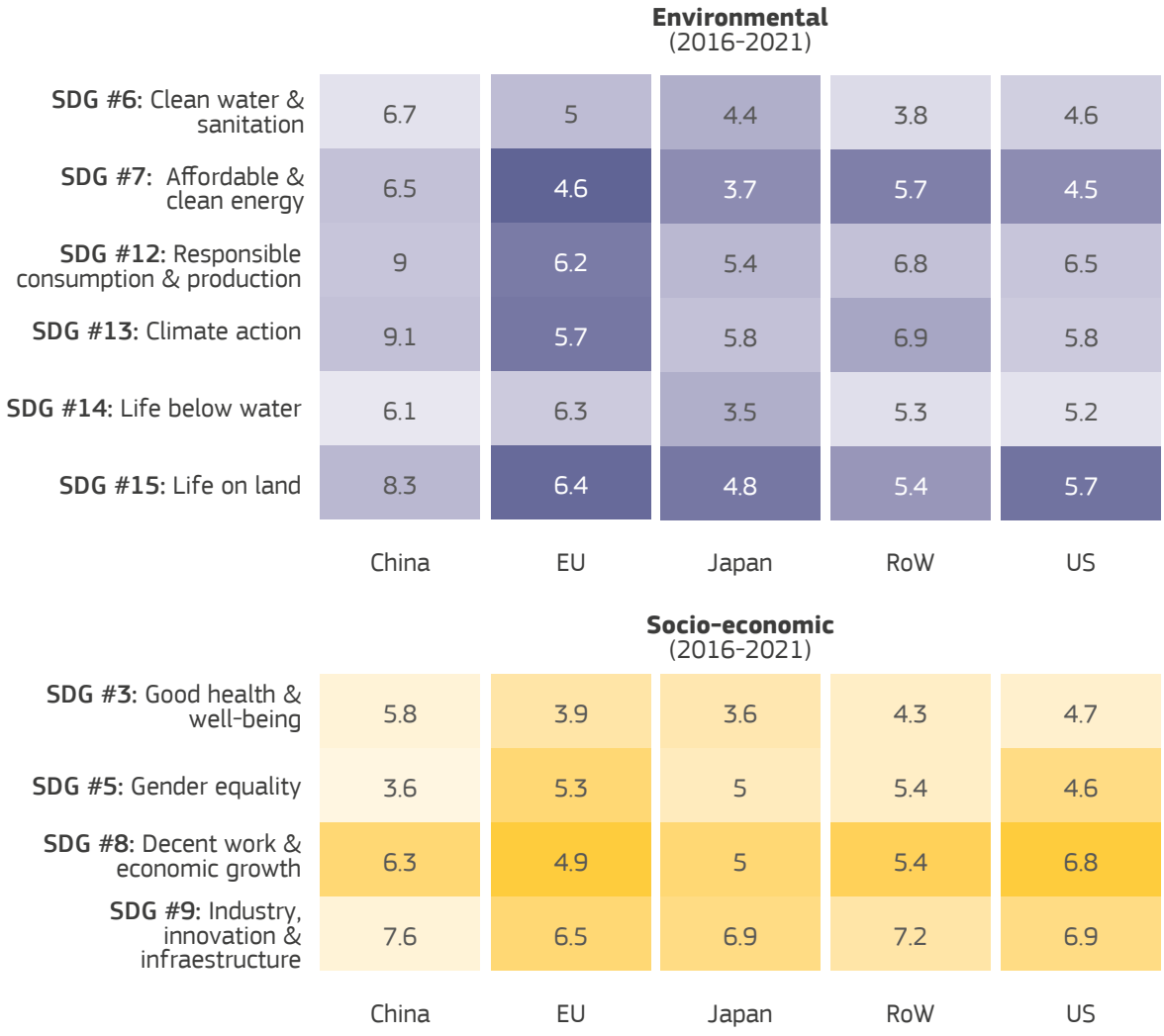
As shown in Figure S13, EU-based companies scored high in many environmental SDGs in 2021: affordable and clean energy (SDG 7), life on land (SDG 15), responsible consumption and production (SDG 12) and climate action (SDG 13). EU companies also achieved high scores across the board in the socio-economic SDGs.

Scoreboard companies reduced overall carbon intensity by 20% compared with 2013, which is rele-vant to both climate action (SDG 13) and clean and affordable energy (SDG 7). This decrease is mostly due to increased energy efficiency (energy intensity), while the adoption of clean energy production technologies still lags behind.

Figure S14 provides a breakdown of the trend in carbon intensity, distinguishing between EU-based and non EU-based *Scoreboard* companies. EU *Scoreboard* companies saw a reduction in carbon intensity of more than 30% compared to 2013 levels. This is thanks to both the adoption of energy-saving technologies, which contributed to a reduction of nearly 30% in energy intensity and the substitution of fossil fuels in energy consumption, with a reduction of 5% in carbon energy intensity. Non-EU *Scoreboard* companies expe-rienced a less pronounced decrease in their carbon footprint (-10%). For them, the important decrease in energy intensity (-20%) was contrasted by an increase in carbon energy intensity (+15%), mainly due to firms from China and the rest of the world.

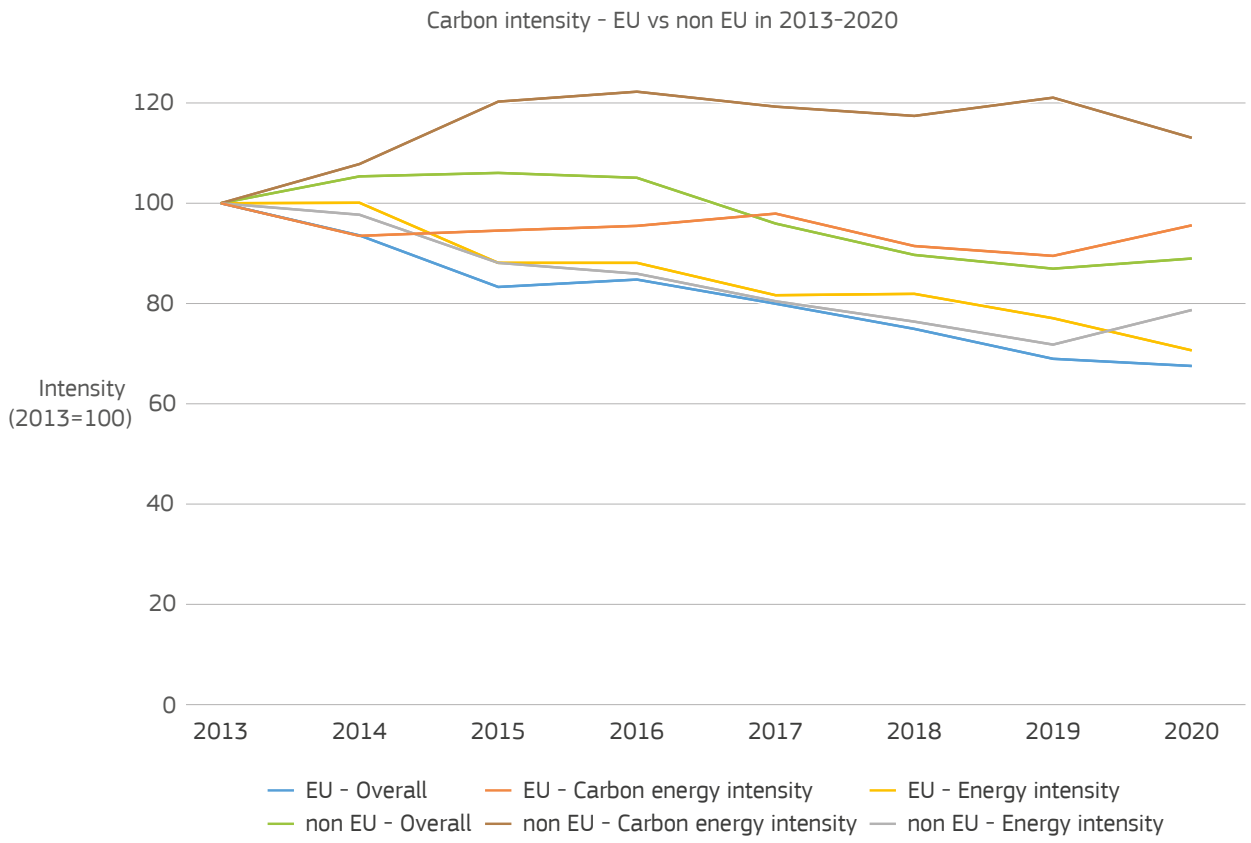
Scoreboard companies are also central in developing breakthrough technological and scientific solutions to tackle SDG-related challenges. Patenting linked to climate action (SDG 13) is concentrated in tech-nologies related to energy storage, decarbonisation, and materials for low-power electronics. These tech-nologies are also relevant to clean and affordable energy (SDG 7) as are technologies in the water-en-ergy nexus, green buildings, and sustainable elec-tronics. In contrast, scientific research relevant to SDG 7 is concentrated in relatively few technologies, while scientific research linked to SDG 13 is spread across a much wider range of fields. This indicates the potential for breakthrough technologies to help achieve green and energy policy goals as well as SDG targets.

Figure S13: SDG progression scores. Regional comparison: 2016-2020 vs. 2021



Note: each cell refers to a unique combination of industrial sector SDG. The number and the colour of each cell convey different information. The colour refers to the average score achieved in 2021 in a given SDG (see row) by companies from a given region (see column); darker colour shades correspond to a higher score in 2021. The number in the cell is the difference between the average score achieved in a given SDG by *Scoreboard* companies from a given region computed in 2021 and in 2016-2020; a positive number in the cell means that there was an improvement.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure S14: Carbon intensity by year – 2013-2020 (2013 base year = 100)



Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Policy implications

Since the establishment of the EU Industrial R&D Investment Scoreboard in 2003[6], private R&D investment has captured substantial attention by policy-makers. EU innovation and industrial policy initiatives highlight the importance of monitoring and analysing the state of overall innovation activity in Europe, including private R&D investment (ERA Policy agenda, Digital Compass, European Education Area, and New European Innovation Agenda)[7]. The *Scoreboard* is being developed to contribute to policy monitoring, in particular combining R&D investment data with other data and indicators.

The war in Ukraine has no impact on the 2022 *Scoreboard* data due to the earlier cut-off dates for financial accounts in 2021, but statements by EU firms are available in the 2022 Survey on EU Industrial R&D Investment Trends, which has been taken between June-September 2022 and is published together with this report[8]. The 100 EU-based *Scoreboard* firms participating therein indicated that, despite generally worsening economic prospects during the surveyed period due to the Russian war in the Ukraine, they expect their sales, profits and employment to increase in 2022 and 2023. This indicates the resilience of innovative EU companies, especially in high-tech segments, such as ICT and health. During the surveyed time until autumn 2022, the war in Ukraine did not cause any change in R&D investment for 86% of the respondents with little effect on the research portfolio of these rather large firms. Delay of existing R&D projects participants are expected most frequently by respondents in aerospace and defence, construction, health industries and automobiles and parts. But respondents also report that they started new R&D projects that were inspired by the war: this is the case for 80% of the companies in aerospace and defence – which are also the ones facing the most interruptions. Also several respondents in the energy sector and in ICT services report new R&D projects that were influenced by the war context. Overall, the impact of the war on R&D was still limited at the time of this *Survey* and mostly for the above sectors.

Despite COVID-19, the 2022 *Scoreboard* data show strong global growth of industrial R&D investments for the 12th consecutive year, revealing the strategic nature of such investments. However, the growing differences between the R&D investment levels and growth rates for EU companies and those from the US and China are a cause for concern and action to be taken in both the private sector and public policy domains. Here, also population size enters the equation raising the question why the EU and the US, which are comparable in population size, have taken such different paths in sector specialisation in the past decades and how the EU can create and grow more key players in the ICT and health sectors.

The following EU-level policy measures could be considered to accelerate growth in private R&D investment:

- **Support reindustrialisation of Europe.** Innovation policies need to be promoted to harness the broad industrial base in Europe including particularly the medium and low-tech sectors. The Industrial Strategy includes the establishment of transition pathways for the identified industrial ecosystems[9] and initiatives with industry and Member States

[6] Under the ERA 2003 with a direct mandate from the 3% Action Plan COM (2003) 226 final: Action 6.6: "Set up an industrial research monitoring activity, including a score-board, to analyse trends and facilitate benchmarking of research investment and research management practices between firms, building on experience in Member States (Implementation: Commission support; first report early 2005)".

[7] September 2020 ERA Communication COM (2020) 628 final, May 2021 updated Industrial Strategy for Europe COM (2020) 102 final, 2030 Digital Compass COM(2021) 118 final, and European Education Area COM (2020) 625 final, and the New European Innovation Agenda COM (2022)332 final. The data have been used in SRIP reports and lately in the McKinsey report "Securing Europe's competitiveness – Addressing its technology gap" of September 2022.

[8] The aim of the 2022 Survey on Industrial R&D Investment Trends is to gain further insight on the trends in R&D and innovation and to address factors and policies that influence these investment decisions from the EU-1000 subsample of *Scoreboard* firms. The 2022 questionnaire addresses R&D investment expectations, financing and collaboration, technology transfer & open innovation, as well as short assessments of the effects of the COVID-19 pandemic and the war in Ukraine. See: https://iri.jrc.ec.europa.eu/rd_monitoring.

[9] These 14 industrial ecosystems are: aerospace and defence, agri-food, construction, cultural and creative industries, digital, electronics, energy intensive industries, energy-renewables, health, mobility – transport – automotive, proximity, social economy and civil security, retail, textile and tourism (see https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en).

which will benefit from links with ERA policy instruments (common industrial technology roadmaps, industrial alliances, and Horizon Europe missions and partnerships). This can benefit from enhanced coordination and directionality of regional, national and EU innovation policies, which can mobilise and accelerate sustainability-oriented economic growth.

- **Promote Corporate Open Innovation to advance industrial transformation.** Although large players, such as top R&D investors, play a key role in R&D investment worldwide due to their size and centrality, radical and game-changing innovations often come from young and innovative companies which were able to grow and scale-up quickly. The EU has an existing base of smaller firms in key sectors, such as ICT and health, and excellent technology capacities across Member States. The EU policy objective in the medium-term could be to provide incentives to retain home-grown technologies and firms, and to facilitate their growth into emerging sectors, particularly green and/or digital.[10] This concerns policies to integrate digital talent and technologies better in traditional manufacturing sectors, support growth strategies of start-ups as well as midcap companies (e.g. to grow beyond SME status, go on international markets), and to increase industrial capacities where more/most of the added value in value chains is produced (e.g. "down" the value chain). Also the New European Innovation Agenda inter alia addresses firm creation and growth in emerging technologies to trigger spill overs between sectors. This would have the effect of reducing both EU R&D investment and R&D intensity gaps vis-à-vis its main global competitors.[11]

- **Explore start-up and scale-up measures in relation to Corporate Venture Capital (CVC) activities of existing European and global lead firms.** On a general level, CVC investments of EU-headquartered *Scoreboard* companies are 2.4% of own-funded internal R&D, compared to 4% of their US-headquartered peers. CVC by EU *Scoreboard* companies is just around half of that by US ones. However, 80% of funds from EU-based companies goes to US-based start-ups. A positive regard is that this already produces spillovers, which are also at the heart of the New European Innovation Agenda. Potential measures to close the gap to the higher developed US VC capital market[12] could include better exit opportunities (e.g. facilitating easier floating on the stock market), the promotion of VC networks, or to enhance the visibility of European start-ups, especially outside the country of the headquarters of the mother company to increase the deal flow across national borders and sectors of activity. On a sectoral level, ICT producers and ICT services and health sector have shown a particularly strong positive correlation and high complementarity between R&D and CVC investments. This indicates potential to explore further firms' CVC portfolios towards understanding where to focus the start- and scale-up funding of the New Innovation Agenda,[13] e.g. via the European Innovation Council (EIC) Fund.

- **Strike the right balance between the objectives of strategic autonomy/technological sovereignty, industrial transformation (green and digital) and industrial competitiveness/welfare, together with international key partners.**[14] In the currently challenging geopolitical and global competition context, the question arises on how to boost industrial innovation, while achieving a proper balance between these three objectives, and in particular the potential trade-offs between Open Strategic Autonomy and the transformative

[10] Diodato D., P. Moncada-Paternò-Castello, F. Rentocchini and A. Tübke (2022) 'Industrial innovation for sustainable competitiveness: Science-for-policy insights'. Science for Policy Brief – Industrial Innovation & Dynamics Series. JRC 128430. European Commission, Joint Research Centre – Directorate for Growth and Innovation, Seville (Spain), February 2022.

[11] Moncada-Paternò-Castello, P. Top R&D investors, structural change and the R&D growth performance of young and old firms. Eurasian Bus Rev 12, 1–33 (2022). https://doi.org/10.1007/s40821-022-00206-3.

[12] Available venture capital investment in the EU is about one sixth of the amount it is in the US with a particularly worrying situation for scale-ups in their growth or later stage phases. These figures are from JRC analysis based on Dealroom data that was presented at the expert webinar "Tackling the Scale-Up Gap" on 5 October 2021. This webinar was introduced by Commissioner Mariya Gabriel and was organised by the JRC together with DG-R&I and EISMEA to better quantify the scale-up financing gap, establish what is known about the causes of the gap and its negative economic consequences and to identify how best to address the gap, see: https://publications.jrc.ec.europa.eu/repository/handle/JRC127232).

[13] COM (2022) 332 final.

[14] Technology Sovereignty as an Emerging Frame for Innovation Policy - Fraunhofer ISI Discussion Papers, July 2021.

agenda, on one hand, and global industrial competitiveness, on the other.[15] From the point of view of industrial innovation, digital, trade and competition policies, this brings new requirements for key sectors and technologies.[16] The more than tripling number of Chinese *Scoreboard* firms over the past decade benefited from a favourable globalisation context and came mostly from organic growth and growth via acquisition of R&D investing companies. These Chinese M&A peaked until around 2018,[17] and are now at a 10-year low.[18] This contributed to a higher sensitivity for the possible impact of foreign takeovers and their innovation dimension, e.g. also reflected in the new referral possibility to the Commission of smaller take-overs under the Merger Regulation.

- **Build global partnerships.** In the current geopolitical and competition context, the Global Approach to R&D aims at building stronger partnerships with like-minded countries and at adopting a modulated approach with non-EU countries based on reciprocity, a level-playing field and respect of fundamental and shared values and principles. The application of Article 22 (5) of Horizon Europe is one of the tools that help the EU to safeguard its assets, interests, technological autonomy or security. The overall new geopolitical situation affects also EU strategies for stepping up science diplomacy, strategic partnerships with countries that share EU values, standard-setting or capitalising on leadership in technological circularity. Maintaining strong EU input at international level, such as standard-setting, circularity or Mission Innovation 2.0 as important channels to demonstrate Europe's "green tech" leadership.

- **Take into account the "glocal" nature of innovation ecosystems.** Innovation ecosystem have both a global and a local dimension. Global lead companies, such as those in the *Scoreboard*, play a key role in vitalising innovation ecosystems given their large (direct and indirect) market and innovation power, and an as entry point towards regional and local upgrading via collaboration and internationalisation.[19] Presence of such large companies or their subsidiaries in regional innovation ecosystems could leverage the New Innovation Agenda's connected regional innovation valleys[20] or other territorial policies.[21] The Partnerships for Regional Innovation (PRI)[22] enhance the coordination and directionality of regional, national and EU innovation policies, bringing the above aspects into policy implementation.

- **Pursue the policy strategies rooted in the renewed ERA strategy and the (updated) Industrial Strategy,** This includes *transition pathways* for some of the 14 identified *industrial ecosystems*, *ERA Common industrial technology roadmaps* (a key tool to help accelerating transfer of R&I results into the economy through R&I investment agendas developed with Member States and stakeholders), *industrial alliances* (to mobilise and build industrial capacities in key industrial and technological areas)

[15] 2022 Strategic Foresight Report: Twinning the green and digital transitions in the new geopolitical context COM (2022) 289 final, and Communication on the Global Approach to Research and Innovation COM (2021) 252 final.

[16] See Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52452-6, doi:10.2760/54, JRC129319

[17] Chinese Mergers and Acquisitions (M&As) in the EU grew strongly (21% between 2017-2019 vs. 2013-2016) and faster than inbound deals from any other strategic partner country (such as the US or Japan), in the EU targeting mostly manufacturing firms (45%). Technology-oriented Chinese companies prefer to acquire radically new technologies not already in their portfolios compared to their European peers that engage in a higher share of coherently diversified (i.e. technologically related) M&As deals. See: Alves Dias, P., Amoroso, S. et al. China: Challenges and Prospects from an Industrial and Innovation Powerhouse, Preziosi, N., Fako, P., Hristov, H., Jonkers, K. and Goenaga Beldarrain, X. editor(s), EUR 29737 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-02997-7, doi:10.2760/445820, JRC116516.

[18] See the Second Annual Report on the Screening of Foreign Direct Investments into the Union, COM(2022)433.

[19] Home-bases of *Scoreboard* firms drive the knowledge flows of their home regions on the international scene, see Dosso, M. and Lebert, D.: "A geography of corporate knowledge flows across world regions: evidence from patent citations of top R&D-investing firms", JRC Working Papers on Corporate R&D and Innovation No 03/2019, JRC 118006, https://iri.jrc.ec.europa.eu/sites/default/files/2019-10/TR%20Geografy% 20of% 20corporate_0.pdf

[20] These valleys will bring together less with more innovative regions by building on strategic areas of regional strength and specialisation in support of key EU priorities. For this purpose, 3-4 inter-regional innovation projects will be launched by the end of 2023 building on Smart Specialisation Strategies and, where applicable, on the participation in the Partnerships for Regional Innovation (PRIs), see: https://s3platform.jrc.ec.europa.eu/pri

[21] Such as I3 start-up villages under Cohesion Policy as part of the long-term vision for rural areas policy; Euroclusters under the Single Market Programme; and Horizon Europe, including European Innovation Ecosystems, Start-up Europe, Widening Participation and Strengthening the ERA, Missions, and the work of the European Institute of Innovation and Technology's Knowledge and Innovation Communities and the regional innovation scheme.

[22] See https://s3platform.jrc.ec.europa.eu/pri.

and *Horizon Europe partnerships* with industry (as a stepping-stone for such alliances to develop industrial investment plans, and to provide the starting basis for ERA technology roadmaps.) Focus should be on the effective implementation of the agreed actions, and careful selection and design of possible new ones, based on a co-creation approach with Member States and stakeholders. Some industrial eco-systems benefit from a combination of initiatives, e.g. Horizon partnerships with industry and industrial alliances, which is a good basis for effective public-private synergies building on complementarity, relevant R&I results and mutual input.

More information, including activities and publications surrounding the *Scoreboard,* is available at:
https://iri.jrc.ec.europa.eu/home/
https://research-and-innovation.ec.europa.eu/strategy/support-policy-making_en.

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