ISSN 1831-9424

European Commission

THE 2022 EU INDUSTRIAL R&D INVESTMENT SCOREBOARD

EUR 31337 EN

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)
Email: JRC-B7-SECRETARIAT@ec.europa.eu
Tel.: +34 954488318

EU Science Hub
https://joint-research-centre.ec.europa.eu

JRC132035

EUR 31337 EN

PDF	ISBN 978-92-76-60180-7	ISSN 1831-9424	doi:10.2760/485648	KJ-NA-31-337-EN-N
Print	ISBN 978-92-76-60181-4	ISSN 1018-5593	doi:10.2760/712583	KJ-NA-31-337-EN-C

Luxembourg: Publications Office of the European Union, 2022

How to cite this report: Grassano, N., Hernandez Guevara, H., Fako, P., Nindl, E., Georgakaki, A., Ince, E., Napolitano, L., Rentocchini, F., Tübke, A. *The 2022 EU Industrial R&D Investment Scoreboard*, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/485748, JRC132035.

Table of Contents

1 Introduction 4

1.1 The economic and technological context 4

1.1.1 The economic context 4

1.1.2 The technological context 5

1.2 The industrial R&D landscape 7

1.2.1 Company location and R&D investment by world region 8

1.2.2 Breakdown of companies and R&D investment by sector 11

1.2.3 The subsidiary structure of the *Scoreboard* companies 14

1.3 Key points 16

2 Where the EU stands compared to other world regions 17

2.1 Main changes in companies' *Scoreboard* indicators in 2020-2021 17

2.1.1 EU companies 17

2.1.2 The global picture 20

2.1.3 Non-EU companies 21

2.1.4 Large R&D changes in big companies 25

2.2 Positioning of the EU in relation to main competitors 26

2.2.1 The EU vs the US 26

2.2.2 The EU vs China 27

2.2.3 The EU vs Japan 28

2.3 Financing companies' innovation activities: Corporate Venture Capital 29

2.4 Focus on selected sub-sectors: Automotive and semiconductors 32

2.4.1 Automotive sector 32

2.4.2 Semiconductors 35

2.5 Key points 37

3 Scoreboard dynamics between 2012 and 2022 39

3.1 General R&D trends over 10 years in the main geographical regions and industrial sectors 39

3.2 Now and then: Top rankings in the 2012 and 2022 *Scoreboards* 42

3.3 Now and then: ranking changes, entry and exit 46

3.4 Now and then: World regions and sectors - comparison between the 2012 and 2022 *Scoreboards* 48

3.5 Keys points 51

4 A closer look at the EU 52

4.1 Top 1000 EU R&D investors – country overview 52

4.2 Top 1000 EU R&D investors – sectoral overview 53

4.3 Top 3 Sectors in the Extended Group 55

4.4 Country Focus – Top 5 EU Countries 57

4.5 Key points 59

5 Patenting trends in Green and Circular Economy Technologies 60

5.1 Update on overall trends in CCMTS 60
5.2 Patenting trends in Circular Economy Technologies 64
5.3 Global Scoreboard and the EU Scoreboard 71
5.4 Key Points 74
6 Top R&D investors and the UN sustainable development goals 76
6.1 Environmental and socio-economic practices of top R&D investors – 2021 update 78
6.2 Environmental impact of the top R&D investors – analysis of climate action (SDG 13) and affordable and clean energy (SDG 7) 81
6.3 SDG-related innovative output by top R&D investors 89
6.4 Key points 95
7 Policy implications 97
List of boxes 100
List of figures 101
List of tables 103
Annexes 104
Annex 1 Background information 104
Annex 2 Methodological notes 105
Annex 3 Chapter 3 - additional tables 110
Annex 4 Access to the dataset 113

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.

Acknowledgements

The 2022 EU Industrial R&D Investment Scoreboard has been published within the context of the Global Industrial Research & Innovation Analyses (GLORIA) project that is jointly carried out by the European Commission's Joint Research Centre —Directorate B, Innovation and Growth— and the Directorate General for Research and Innovation (R&I) —Directorate E, Prosperity.

GLORIA has received funding from the European Union's Horizon Europe research and innovation programme under a specific action for scientific and technical services by the Joint Research Centre. The main expected impact of GLORIA is the better understanding of corporate Research & Development (R&D) efforts in relation to the green deal and sustainability objectives, starting from the top R&D investors in their global competitiveness perspective.

The project was coordinated under the leadership of Xabier Goenaga and Fernando Hervás (respectively, Head and Deputy Head of JRC.B7 Knowledge for Finance, Innovation and Growth) and Doris Schröcker (Head of DG R&I E1 Industrial Research, Innovation & Investment Agendas). This document was produced by Nicola Grassano, Héctor Hernández Guevara, Péter Fako, Elisabeth Nindl, Aliki Georgakaki, Ela Ince, Lorenzo Napolitano, Francesco Rentocchini and Alexander Tübke (JRC B7 Knowledge for Finance, Innovation and Growth, JRC C7 Knowledge for the Energy Union) as the main authors.

The report benefitted from substantial contributions by Doris Schröcker (Head of DG R&I E1), Evgeni Evgeniev (Policy Officer DG R&I E1), and Florence Roger (Policy Assistant DG R&I E1). Comments on Chapter 6 were provided by Athina Karvounaraki (Statistical Officer DG R&I G1) and Laura Roman (Policy Officer DG R&I E4). Michael Tubbs from Innovomantex Ltd. greatly contributed to this work, reviewing the analytical work and providing industrial insights. Alberto Cáceres Guillén from Alepro Data Analysis & Consulting supported the quality control of the company dataset. Data have been collected by Bureau van Dijk – A Moody's Analytics Company under supervision by Petra Steiner, Vivien Schulz, Yu-Wen Kang, Jacquet Damien, and David Pérez Vicente.

We are grateful to Xenia García and Emiliano Bruno (JRC Directorate B, Innovation and Growth) for the editorial and communication support; to Florence Roger, Martina Daly and Sandra Milev (Directorate General for Research and Innovation) also for their support in the communication activities, as well as Rafa Hohr and Claudia Orlando (Prodigioso Volcán) for the layout and visuals assets.

Authors

Nicola Grassano

Héctor Hernández Guevara

Péter Fako

Elisabeth Nindl

Aliki Georgakaki

Ela Ince

Lorenzo Napolitano

Francesco Rentocchini

Alexander Tübke

Executive summary

The EU Industrial R&D Investment Scoreboard has been published annually since 2004 – this is its 19th edition. It provides the most recent economic and financial information based on the latest published audited accounts of the world's top 2500 R&D investors, including the top 1000 EU-based ones. The world's top 2500 Scoreboard companies, with headquarters in 41 countries and more than one million subsidiaries all over the world, each invested over EUR 48.5 million in R&D in 2021.

The Scoreboard 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 report shows that Europe's industry is back on track in research and development investments with an increase of 8.9% in 2021 compared to the -2.2 % pandemic-related dip in 2020. The EU remains the global leader in R&D investments by the automotive sector, where the transformation towards electric vehicles and digitalization is fully underway in both established companies and younger firms. The Scoreboard also shows a broad sectoral diversification for the EU, especially compared to the US, where R&D investment is highly concentrated in Information and Communication Technologies (ICT).

Globally the private sector R&D investment grew strongly beyond pre-pandemic levels (by 14.8% in 2021 vs. 2020). For the first time since the 2004 Scoreboard, total R&D investment by the world's top 2500 firms passed above one trillion euros (€1094 billion). An important change is that all Chinese Scoreboard firms together now have a slightly bigger share of the global total than the EU companies (17.9% Chinese and 17.6% EU, respectively). The leading share of US firms increased to 40.2% of the global total.

The Scoreboard highlights the intensification of the global tech race in the four key sectors which account for more than three-quarters of the total company R&D reported: ICT producers (22.6%), health industries (21.5%), ICT services (19.8%) and automotive (13.9%).

The R&D growth rates of US and Chinese companies - 16.5% and 24.9%, respectively - continued to outpace that of EU counterparts, due to the fact that US Scoreboard companies are leading R&D investors in ICT (both as producers and service providers) and health sectors, while Chinese Scoreboard firms are ahead of the EU not only as ICT producers, but also in ICT services. The number of Chinese Scoreboard companies more than tripled over the past decade (from 176 in 2011 to 678 in 2021), displacing EU and Japanese firms from more traditional manufacturing sectors.

It is encouraging that many EU Member States have significant R&D players in sectors such as aerospace, defence and chemicals industries, in addition to the automotive, ICT and health industries. The top 1000 EU companies include a substantial number of small- and medium-sized enterprises (SMEs) in health and ICT sectors with encouraging R&D growth in 2021. This is a welcome signal for important target groups of the New European Innovation Agenda, which among others addresses scale-up and growth in emerging deep tech and breakthrough technologies and triggers spillovers between sectors with the support of the European Innovation Council. The updated Industrial Strategy also promotes innovation policies in the broad industrial base in Europe including the high-technology sectors.

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

The 2022 report also analyses performance in relevant UN's Sustainable Development Goals (SDGs). EU companies achieved the highest scores in most SDGs and showed progress across the Scoreboard. From a sectoral perspective, companies in the automotive and chemical sectors achieved on average high progress in SDGs. The review also reveals the high potential of deep technological solutions to tackle global challenges.

As a new aspect of corporate innovation strategies, Corporate Venture Capital (CVC) has also been analysed. CVC has been increasing over the past 20 years and is now used by two-thirds of Scoreboard companies. R&D and CVC complement and support each other, especially in ICT and health. CVC by EU companies amounts to around half of that by US companies. Moreover, 80% of funds from EU-based companies go to US-based start-ups, which triggers important spillovers.

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.

1 Introduction

This chapter first describes the economic and technological environment in which the EU Industrial R&D Investment Scoreboard firms (from here on the *Scoreboard*) operated in 2021 and 2022, before it presents the main characteristics of the sample. The top 2500 companies that invested the largest sums of R&D worldwide are analysed by geographical location and by sector, including an overview on their subsidiaries.

1.1 The economic and technological context

1.1.1 The economic context

The main macroeconomic factors affecting companies in the *Scoreboard* are interest rates, inflation, energy prices (mainly oil and gas) and expectations of changes in these factors. The COVID pandemic was still a major problem at the end of 2020 when both interest rates and inflation were still low. But inflation was rising by the end of 2021. For example, EU-27 inflation was 0.7% for 2020 but 2.9% for 2021 (with Germany 3.1%, UK 2.5%, France 1.6%), the US 1.2%/4.7% and Japan 0.1%/-0.2% for 2020/2021. But by April 2022 these figures had increased to EU-27 8.1%, US 8.3% and Japan 2.5%.[1] US inflation seemed to moderate in mid-2022 since it fell from 9.1% in June to 8.5% in July. Central bank interest rates had been kept very low for several years after the financial crisis of 2008/09 but were raised as inflation began to rise.[2] Oil and gas prices contribute to inflation and are rising. For example, West Texas Intermediate (WTI[3]) was USD 61.7 in early January 2020, down to USD 49.8 in early January 2021 (because of reduced demand during the pandemic), up to USD 77.9 in early January 2022. Rising oil and gas prices have been a major contributor to increased transport and heating costs and rising food prices because they increase fertiliser costs, greenhouse heating costs and fuel costs for farm machinery. The World Bank gives real GDP growth for the world as 2.6% in 2019 falling to -3.3% in 2020 because of the pandemic but recovering to 5.7% in 2021.[4]

The pandemic, extensive lockdowns in China, and Russia's invasion of Ukraine have all contributed to big changes in the economic environment and have disrupted global value chains. They have radically modified the way many companies organise their operations and finances. In addition, the recent steep rises in energy prices are leading companies to urgently evaluate ways of reducing costs by minimising their energy use, such as by replacing some manufacturing processes with more energy-efficient alternatives. Five major examples of the way company operations and financing are changing are supply chains and reshoring, just-in-time manufacture changing to resilient manufacturing, working from home, the need to reduce reliance on China and the importance of reducing debt. We will briefly discuss each of these.

The pandemic highlighted the dangers of long supply chains which, coupled with pandemic-related reductions in airline services and restrictions on key staff travelling to many countries, left many manufacturers with inadequate supplies of essential components. This has led to a substantial move for reshoring with key components being made in a manufacturer's home country or a nearby stable economy. This means that in many sectors globalisation is giving way to regional distributed manufacturing.

Just-in-time manufacturing (JITM) is very cost-efficient but relies on component suppliers delivering with 100% reliability just before the components are needed. Experience during the pandemic shows that resilience is more important and that points to reshoring and holding stocks of key components. Recent examples that emphasise this include the shortage of chips for cars and the effects on customer companies of the 2022 lockdowns in Shanghai and other major Chinese cities.

Controlling the spread of the COVID pandemic in 2020 required as many people as possible to work from home (WFH) and a substantial proportion of employees in many companies proved to be keen to continue WFH in 2021 and 2022 or at least to embrace hybrid working. It has proved to be difficult for many employers to enforce a substantial return to the office because of labour shortages. Studies of WFH vs. office productivity give mixed results but one detailed Japanese study found that WFH productivity was only 61% of office working in 2020 rising with experience to 78% in 2021.[5] Associated with WFH was an increase in the

1 https://www.oecd-ilibrary.org/economics/data/prices/consumer-prices-complete-database_0f2e8000-en
2 https://commonslibrary.parliament.uk/research-briefings/sn02802/
3 https://tradingeconomics.com/commodity/crude-oil
4 https://www.worldbank.org/en/news/press-release/2022/06/07/stagflation-risk-rises-amid-sharp-slowdown-in-growth-energy-markets
5 https://www.weforum.org/agenda/2022/03/productivity-dynamics-of-working-from-home/

proportion of retail sales taking place online which peaked in early 2021 but in mid-2022 remained well above its pre-pandemic level. This has benefited Amazon and other mainly online companies.

Many companies started to rely on China for cheap goods and components in the early years of this century. However, the risks of this practice have been emphasised by rising costs, experiences of delivery delays during the pandemic and the effects of recent strict lockdowns in Shanghai and other cities over the Omicron variant. Adding to this is the Chinese government's increasing tendency to control private sector companies and pressure them to follow the communist party's agenda. Other Asian countries now offer more business-friendly environments and labour costs which are substantially lower than China's.

During the decade after the financial crisis, interest rates were very low and companies could expand at low cost by taking on substantial debt. However, now that interest rates are rising and are likely to rise further, high debt/equity ratios have become a problem since a company can reduce dividends but not debt interest. Indebted companies therefore need to reduce debt particularly if there is a potential danger of breaching their banking covenants. If cash flow is high this is possible but rising energy prices, inflation of labour and materials costs and rising interest rates on debt are shrinking profit margins for some companies and therefore reducing cash flow to dangerously low levels. Companies are therefore likely to face cost pressures with particular problems looming for heavily indebted companies as interest rates rise and profit margins are squeezed. These pressures may lead some CEOs to propose reductions in their R&D budgets which would lead to project cancellations and a reduced new product pipeline. R&D managers can point to experience in previous recessions which shows that those companies that increase (or at least maintain) their R&D emerge from a recession with improved ranges of products and services that give them a competitive edge in the upturn.

1.1.2 The technological context

Technological change is most rapid in the high R&D intensity sectors of biotechnology, pharmaceuticals, health, software, and technology hardware. But there are also major changes taking place in sectors where renewable energy is starting to replace fossil fuels – notably in transport (automotive and aerospace) and energy generation.

The potential of 21st century biotechnology was demonstrated in 2020 by the rapid development and approval of COVID-19 vaccines by AstraZeneca/Oxford University, BioNTech/Pfizer and Moderna in just less than a year from the publication of the virus' genome in January 2020. This compares with the 5-10 years previously required to develop a new vaccine. The mRNA technology underlying two of these vaccines is now being used to develop cancer vaccines and there are mRNA treatments in clinical trials for advanced melanoma and prostate, head and neck, ovarian and pancreatic cancer (BioNTech) and a personalised cancer vaccine and treatments for solid tumours and lymphomas (Moderna). Recently, a small clinical trial at Memorial Sloan Kettering Cancer Centre of a BioNTech/Genentech vaccine for pancreatic cancer – a very difficult to treat cancer – showed promising results that indicate the vaccine can train the immune system to kill pancreatic cancer cells. And the team behind the AstraZeneca vaccine has just completed a Phase IIb trial of their new malaria vaccine which offers an unprecedented 77% rate of protection.[6] It is hoped the vaccine can be licensed in 2023. Progress is also being made with new antibiotics to treat superbugs resistant to the usual antibiotics. For example, Fetroja (Shionogi & Co) can treat complex urinary tract infections and some forms of antibiotic resistant pneumonia. There have been many recent advances in the health sector such as in medical electronics (e.g. pacemakers unaffected by MRI and cardiac resynchronisation therapy) and in areas such as 3D printing. For example, a first ever transplant on a patient of a 3D-printed ear was successful in a clinical trial. The new ear was formed from cells grown from a one-half gram of ear cartilage from the remnant ear.[7] And para-olympian Jessica Smith has now been fitted with a bionic hand having 29 grips that she even uses to apply her makeup.[8]

Substantial progress is being made in Artificial Intelligence (AI) often in seemingly routine areas such as the reduction of returns for online fashion goods or the detection of fraudsters posing as telephone banking customers. And a machine-learning algorithm, the UrbanDenoiser, has been developed to detect weak earthquake signals close to tectonic plate boundaries such as in Los Angeles by filtering out city noise. The UrbanDenoiser improves signal to background by 15db and already detects 10% more events but can be

6 https://www.ox.ac.uk/news/2021-04-23-malaria-vaccine-becomes-first-achieve-who-specified-75-efficacy-goal
7 https://www.thetimes.co.uk/article/surgeons-attach-3d-printed-ear-built-with-cells-from-patients-own-cartilage-20grg3kp9
8 https://news.sky.com/story/amazing-bionic-hand-can-be-updated-with-new-movements-from-anywhere-in-the-world-12674248

improved further. AI is increasingly used in robotics with applications such as AI-enabled manipulation and grasping (with no need for a human controller) and AI-enhanced navigation and motion control.[9] Dyson is investing GBP 2.75 bn by 2025 into creating AI-enhanced robots that will perform a range of domestic tasks beyond cleaning.[10] AI is also moving into the professions with AI already being quicker and cheaper than junior lawyers for reviewing documents.[11] And AI/robotics is being used in surgery (e.g. Intuitive Surgical's da Vinci robotic surgery systems), diagnosis and the interpretation of diagnostic scans. For example, a recent trial showed that AI analysis of a single MRI brain scan could spot early Alzheimer's in 98% of people who had it. Early detection is vital since it is then easier to slow or halt its spread with the latest drugs.[12] And Faculty, the AI company, has developed an AI tool in partnership with Genomics England that can predict how quickly tumours will progress and hopefully this will bring in a new era of personalised cancer treatments. The large tech companies are moving into healthcare with Oracle paying USD 28 bn for Cerner, a clinical software company, Amazon buying One Medical (a chain of healthcare practices) and Pillpack (an online pharmacy) and Bytedance buying Amcare (one of China's largest hospital chains). The rapid progress being made in AI, software and cybersecurity mean that there is a shortage of tech talent for companies in these fields. The Korn Ferry Institute has estimated that, by 2030, there will be a world shortage of 4.3 million skilled tech people which will cost lost output of USD 450 bn.[13]

The new frontier in AI and tech hardware is in quantum technologies – large quantum computers together with their control systems and associated engineering infrastructure. The US is currently leading in quantum computing with Google, Microsoft, IBM and 12 other listed companies working in the field and 78 start-ups.[14] IBM has made a 127-qubit computer and plans to have a 4158+qubit processor in 2025.[15] ExxonMobil and IBM are working on quantum algorithms that will enable Exxon to use IBM quantum computers to solve complex maritime routing problems to optimise the management of large shipping fleets.[16] Goldman Sachs is developing quantum optimisation algorithms to price assets based on the inherent risk associated with different options or stocks and Daimler is investigating how quantum computers can simulate new materials for high performance car batteries.[17] One of the major advances needed to enable quantum computers to reach their full potential is an effective error correction system and Riverlane & Rigetti, for example, are working together to achieve this.[18] Microsoft has a topological qubit which incorporates some error correction.[19] The US government is well aware of the potential of quantum computers in cryptography and has started a multi-year programme to shift vulnerable computer networks to quantum-resistant cryptography.

Major changes are occurring in manufacturing through the combination of digitisation, the use of AI and robotics/automation, additive manufacturing and regional distributed manufacturing. These and other technological trends are coming together as smart manufacturing which will extend from high value products into mass produced products. Robotics is transforming farming with a 3-year project demonstrating a complete hands-free cropping cycle by a group of businesses working with Harper Adams University on a 35-hectare area.[20] And John Deere, the world's largest agricultural equipment manufacturer, plans to build a world of fully autonomous farming by 2030.[21]

Materials developments include interesting work at Berlin's BAM Institute on the use of muon detectors to image large concrete structures to identify internal faults that could lead to the collapse of buildings or

---

9 https://www.techtarget.com/searchenterpriseai/feature/Application-of-AI-in-robotics-boosts-enterprise-potential#:~:text=With%20the%20help%20of%20AI,navigation%20paths%20and%20process%

10 https://www.business-live.co.uk/manufacturing/dyson-reveals-275bn-investment-robotics-19354180

11 https://futurism.com/ai-contracts-lawyers-lawgeex

12 https://www.imperial.ac.uk/news/237494/single-brain-scan-diagnose-alzheimers-disease/

13 https://thefintechtimes.com/tech-industry-talent-shortage-could-reach-an-unrealised-output-of-449-70billion-globally-by-2030/#:~:text=According%20to%20the%20Korn%20Ferry,a%20hub%20

14 https://www.businessofbusiness.com/articles/whos-winning-the-quantum-computing-race

15 https://www.forbes.com/sites/moorinsights/2022/05/18/ibms-newest-quantum-computing-roadmap-unveils-four-new-quantum-processors-and-future-plans-for-a-quantum-supercomputer/

16 https://www.zdnet.com/article/ibm-and-exxonmobil-are-building-quantum-algorithms-to-solve-this-giant-optimization-problem/

17 Physics World Vol. 35, #9, 2022

18 https://www.riverlane.com/news/2022/06/riverlane-and-rigetti-partnership-to-tackle-quantum-error-correction/#:~:text=Riverlane%20and%20Rigetti%20will%20work,by%20using%20a%20quantum%

19 Physics World Vol. 35, #9, 2022

20 https://www.fwi.co.uk/arable/crop-management/video-hands-free-farm-turns-to-drilling-after-good-harvest

21 https://www.cnbc.com/2022/10/02/how-deere-plans-to-build-a-world-of-fully-autonomous-farming-by-2030.html

bridges[22] such as the 2021 Florida apartment block collapse which killed 100 people. Graphene materials development is proceeding at a rapid pace and applications in batteries and supercapacitors are likely to be amongst the first to reach the market.

Battery electric vehicles (BEVs) doubled their global market share from 2020 to 2021 reaching 8.4%. China accounts for around half of all BEV sales.[23] Recent work at the Idaho National Laboratory has used AI to optimise the charging protocol for electric car batteries and this enables charging from zero up to 90% of capacity in 10 minutes while protecting the battery's long-term health.[24] Hydrogen fuel cells are likely to be a better long-term solution for long haul trucks than heavy batteries.

The aerospace and shipping industries are also developing zero emission technology. For example, Heart Aerospace of Sweden has orders from Air Canada, United and Mesa Airlines for its 30-passenger electric planes.[25] These planes have a range of 124 miles on one charge but this can be extended to 500 miles with a fuel-powered generator. The company says its planes could be ready by 2028 subject to regulatory approvals. Hurtigruten of Norway has said it is launching its first zero-emission passenger ship by 2030 and the German state of Saxony has commissioned its first fleet of passenger trains running solely on hydrogen.

CO_2-free energy generation methods that do not use fossil fuels have become increasingly important, especially in the context of the Green Deal and twin transitions. This means increased investment in wind, solar and nuclear. Nuclear reactor technology is advancing with small modular fission reactors (SMRs) that can be constructed as modules in factories and then transported and commissioned on site relatively quickly. The Rolls-Royce SMR consortium plans to produce 470MW reactors (which each have output equivalent to 150 wind turbines and can power 1 million homes) costing around GBP 2.3 bn each with 90% of the manufacturing and assembly carried out in controlled factory conditions. Regulatory approval is expected in mid-2024 and, with an order placed in late 2022, Rolls says the first SMR can be online in 2029. The US is also developing SMR designs. A longer-term solution will use nuclear fusion in which major advances have recently been made. For example, in February 2022, JET (Joint European Torus) at Culham, UK demonstrated a world record sustained fusion output of 59MJ.[26] Laser induced fusion is also a promising approach and is being developed at Lawrence Livermore Laboratory which achieved the threshold of fusion ignition in August 2021.[27] Several start-up companies are exploring alternative and lower cost approaches to fusion such as First Light Fusion which has demonstrated the feasibility of its technique of firing high velocity slugs at fuel pellets to release energy.[28] And an Australian start-up, HB11, has demonstrated hydrogen/boron fusion using high power lasers.[29]

In summary, rapid technological progress is being made in high R&D intensity sectors such as biotech, pharmaceuticals, software, technology hardware, health and also in transport and energy generation where the move away from fossil fuels is accelerating because of the advent of new technologies. Progress is being made in Europe but more needs to be done to close the gap with the US and, increasingly, with China.

1.2 The industrial R&D landscape[30]

The top 2500 global companies invested a total of EUR 1093.9 billion in 2021 in R&D[31], which is 14.8%[32] more than what they invested in the previous year.[33] The threshold to enter the sample this year - in other

---

22 https://link.springer.com/article/10.1007/s10921-021-00797-3

23 https://www.autocar.co.uk/car-news/business-dealership%2C-sales-and-marketing/battery-electric-vehicles-doubled-global-market#:~:text=Battery-electric%20vehicles%20(BEVs),3.1%25%20just%20

24 https://www.newscientist.com/article/2334799-supercharging-tweak-could-fill-electric-car-batteries-90-in-10-mins/

25 https://www.smithsonianmag.com/smart-news/electric-planes-are-taking-flight-180980821/

26 https://ccfe.ukaea.uk/fusion-energy-record-demonstrates-powerplant-future/

27 https://www.llnl.gov/news/national-ignition-facility-experiment-puts-researchers-threshold-fusion-ignition

28 https://firstlightfusion.com/media/fusion#:~:text=First%20Light%20has%20achieved%20fusion,other%20fusion%20scheme%20in%20history

29 https://www.powerengineeringint.com/nuclear/australias-hb11-energy-demonstrates-laser-powered-nuclear-fusion/

30 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 could be larger than Alphabet's so Amazon should probably have been #1 in the 2022 *Scoreboard* R&D ranking.

31 The *Scoreboard* is based on information taken from the companies' latest published accounts. For most companies, these correspond to the calendar year 2021. However a significant number of companies' financial years ended on 31 March 2022. This is the case for many Japanese companies and many UK firms. Few companies included in the sample have financial years that end as late as the end

words, the amount invested in R&D by the company ranked 2500th in the Scoreboard - is EUR 48.5 million, about one third higher than the one of last year (EUR 36.5 million).

After the relative slowdown of the 2021 Scoreboard– R&D investments at global level grew at 6.0% compared to 8.9% in the 2020 Scoreboard – the pace of R&D growth increased again and even surpassed pre-pandemic levels.

1.2.1 Company location and R&D investment by world region

The top 2500 *Scoreboard* includes companies from 41 countries. 16 of these 41 countries are EU Member States, down from 17 last year. The total R&D investment made by these 2500 companies accounts for 86.3% of global business-funded R&D (see Box 1.2).

Table 1.1 shows the breakdown of the companies in the *Scoreboard* by country/region. The figure in parentheses shows the number of companies present in the same country in the previous edition of the *Scoreboard*.

Table 1.1 Distribution of companies and R&D by country/region

EU countries	No. of companies in	R&D (EUR bn)	Non-EU countries	No. of companies in 2022 (2021)	R&D (EUR bn)
Germany	114 (124)	91.03	US	822 (779)	439.7
France	57 (66)	28.78	China	678 (597)	195.9
Netherlands	38 (34)	24.08	Japan	233 (293)	113.8
Sweden	26 (34)	11.50	Switzerland	55 (57)	34.9
Ireland	24 (27)	8.28	South Korea	53 (60)	34.3
Denmark	25 (29)	7.14	UK	95 (105)	32.8
Finland	12 (15)	5.30	Taiwan	84 (86)	24.8
Italy	20 (21)	5.21	India	24 (25)	5.6
Spain	12 (14)	4.48	Canada	28 (26)	5.2
Belgium	12 (13)	3.11	Israel	22 (21)	4.1
Austria	13 (14)	2.04	Australia	10 (11)	3.1
Luxembourg	3 (4)	1.25	Singapore	7 (6)	1.6
Portugal	2 (2)	0.18	Norway	9 (11)	1.4
Hungary	1 (1)	0.17	Saudi Arabia	1 (1)	0.9
Slovenia	1 (1)	0.15	Brazil	4 (5)	0.5
Malta	1 (1)	0.06	Other 10 countries	14 (9)	2.5
Total EU	361 (401)	192.8	Total	2139 (2099)	901.1

Note: Figures in parentheses show the number of companies from the 2021 edition of the *Scoreboard.*

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

The US has again the highest number of top R&D investing companies in the *Scoreboard* (822 companies), followed by China (679), the EU (361), Japan (233), UK (95), Taiwan (84), Switzerland (55), South Korea (53), Canada (28) and India (24). The top 10 countries/regions is the same as last year, except for Switzerland which overtook South Korea. The difference between the results from the 2021 and the 2022 Scoreboard is the relative weight of each country or region. For example, there was a notable increase of 82 Chinese and 41 US companies on the *Scoreboard* compared to last year. Japan saw a considerable decrease by 60 companies,

---

of June 2022. A small number had accounts available only up to the end of 2020. Therefore, we should refer to the data of the last available year as 2021/22 and those of the previous years as 2020/21, and so on. However, for most companies the last available year corresponds to the calendar years 2021, 2020, and so on. For reasons of clarity and consistency, we refer to the last available year as 2021, the previous year as 2020, and so on.

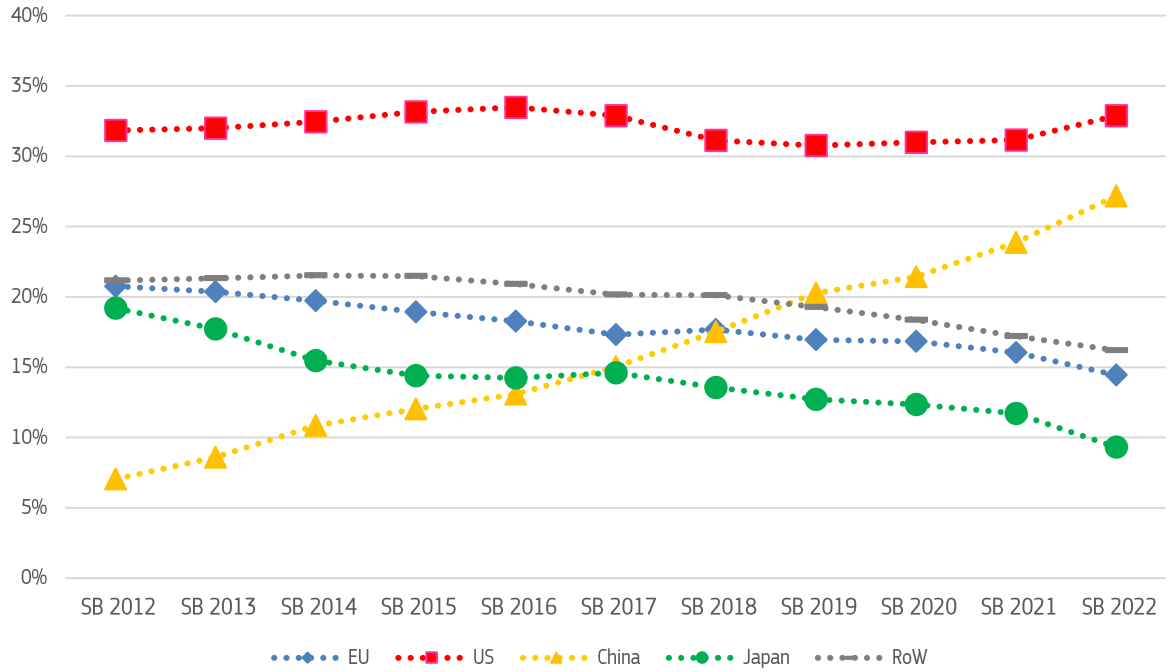
32 This growth rate is very similar in terms of order of magnitude to the rate predicted using an early sample dataset in June 2022, which forecast a 12.7% R&D growth rate. See Grassano, N. and Hernandez Guevara, H., Top R&D investors recovering fast from the Covid-19 crisis: Preliminary insight to the 2022 EU Industrial R&D Investment Scoreboard, European Commission, 2022, JRC130014.

33 The 2021 *Scoreboard* reported R&D for the top 2500 companies as €908.9 billion in 2020, which is an increase of 20.3% – not 14.7%. Exchange rates are the main reason for this apparent discrepancy. The US dollar depreciated from €1=$1.23 at end 2020 to €1=$1.13 at end 2021. If the 2022 Scoreboard R&D is expressed at 2021 Scoreboard exchange rates, the total R&D for the 2 500 companies is EUR 1033.8 bn. This represents a 13.7% increase. The remaining 1% difference is explained by the entry-exit of companies. See details on exchange rates in Annex 2 Box 1 and Table 1). Overall, the significant appreciation of the USD against the Euro favoured the increase of US companies and decrease of EU companies in the R&D ranking.

as did the EU with 40 companies less than last year[34]. With this reduction, twice as many EU companies left the top 2500 than last year, whereas the number of Chinese companies increased by one third.

The gap in terms of number of companies among the top R&D investors between the US and China on one side and the EU, Japan and the rest of the world from the other side is widening, as shown in Figure 1.1. Even if we take the total number of companies located in Europe (adding to the EU[35] also UK, Swiss, Norwegian and other European based companies), China would still be second in the ranking by a wide margin (678 Chinese companies against 522 European companies).

Figure 1.1 Share of companies by region – SB 2012 to 2022



Note: Data from *Scoreboard* (SB) editions 2012 to 2022.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The EUR 1093.9 bn invested in R&D by the companies in the sample is distributed across world regions as shown in Figure 1.2. Since the *Scoreboard* was first published in 2004, the US accounts for the majority of companies and of R&D invested – in this *Scoreboard* it is 822 companies and 40.2% of all R&D.

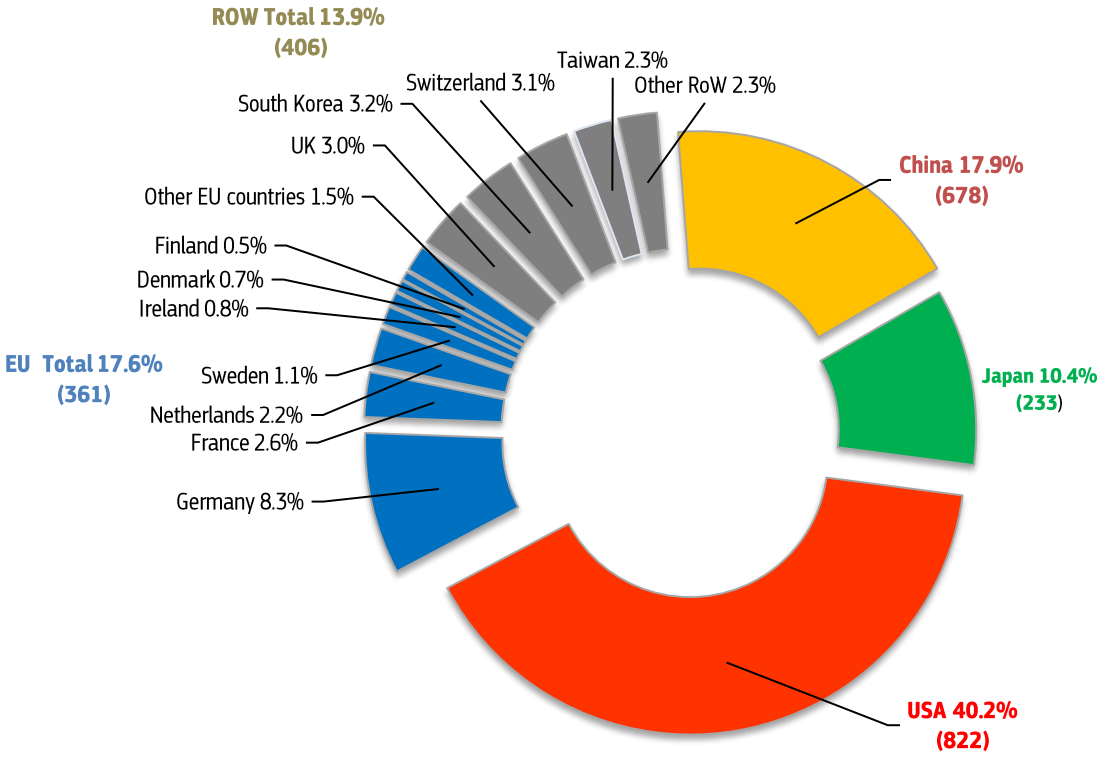
The constant and fast growth of China's number of companies in the *Scoreboard* and their R&D, in contrast to investment in the EU and Japan, as reported in past editions of the *Scoreboard* continues this year and has produced a significant change. For the first time, China overtook the EU, both in the number of companies and also in the total volume of R&D invested.

EU companies invested EUR 192.8 bn of R&D in 2021, against EUR 195.9 bn from Chinese companies. The US remains the largest investor, investing EUR 439.7 bn. Japan is behind both the EU and China with EUR 113.8 bn. The previous edition of the *Scoreboard* predicted that China would overtake the EU. However, the growth rate of R&D investment in China combined with the considerable increase in Chinese companies in the top 2500 ranking resulted in this change happening in 2021 rather than in 2022 or 2023 as forecast.

[34] The location of companies is where they have their headquarters. This can cause some over (or under) statement for some countries such as the Netherlands or Ireland, where companies are registered but whose principal activities are carried out elsewhere.

[35] 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 re-codified to include in the EU group only companies headquartered in one of the EU-27 Member States.

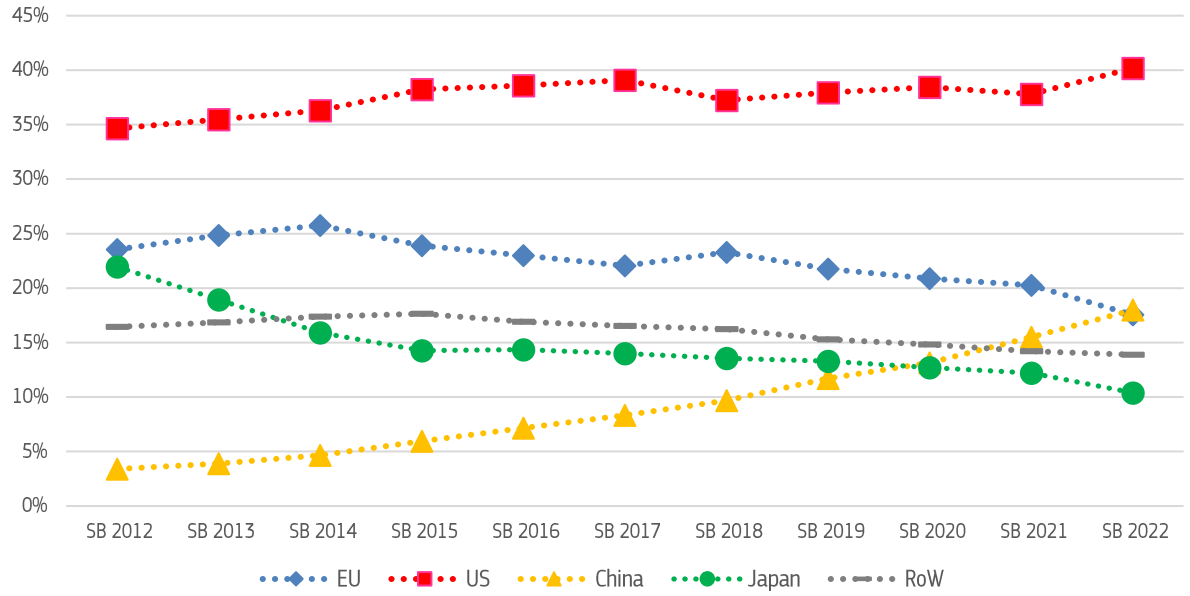
Figure 1.2 R&D investment by region and country



Note: the figure in parentheses shows the number of companies per country/region.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 1.3 reports the trends of R&D shares by region in the *Scoreboard* since 2012. This shows the steady rise of the US and China and the progressive decline of R&D investment shares of the EU and Japan.

Figure 1.3 Share of global R&D investment by region – SB 2012 to 2022



Note: Data from *Scoreboard* (SB) editions 2012 to 2022.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

1.2.2 Breakdown of companies and R&D investment by sector

Large and multinational companies often operate in multiple sectors. This makes it difficult to categorise a company in a specific sector. Since the *Scoreboard*'s first edition in 2004, we have categorised a company by the main sector in which they carry out their business using taxonomies, such as the International Classification Benchmark (ICB). This is usually the sector indicated by the companies themselves in their annual reports. Table 1.2 shows the breakdown of companies by sector according to this indicator and grouped in broad macro sectors. It is also interesting to aggregate companies according to the role they play in industrial ecosystems (comprising all industrial players operating in a value chain). See in Box 1.1 the distribution of the *Scoreboard* companies following the ecosystem definition applied by the European Commission in its new industrial strategy.

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

Industrial Sector	Sector classification ICB4 digits	No. of firms	R&D 2021 (EUR bn)	R&D intensity (%)	Total R&D (%)	R&D per firm (EUR million)
Aerospace & Defence	Aerospace; Defence	44 (43)	17.7	3.9	1.6	402.3
Automobiles & other transport	Auto Parts; Automobiles; Commercial Vehicles & Trucks; Tires	179 (184)	152.4	4.9	13.9	846.7
Chemicals	Commodity Chemicals; Specialty Chemicals	115 (125)	25.1	2.4	2.3	218.6
Construction	Building Materials & Fixtures; Construction and Materials; Heavy Construction	65 (67)	30.9	2.3	2.8	474.7
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	80 (82)	19.5	0.5	1.8	243.7
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	61 (67)	19.1	2.7	1.7	313.9
Health industries	Biotechnology; Health Providers; Medical Equipment; Medical Supplies; Pharmaceuticals	567 (525)	235.3	12.4	21.5	415.0
ICT producers	Computer Hardware; Electrical Components & Equipment; Electronic Equipment; Electronic Office Equipment; Semiconductors; Telecommunications Equipment	456 (458)	246.8	7.0	22.6	541.2
ICT services	Computer Services; Internet; Software; Mobile Telecommunications	365 (355)	216.3	9.3	19.8	592.5
Industrials	Aluminium; Containers & Packaging; Diversified Industrials; Delivery Services; Industrial Machinery; Iron & Steel; Nonferrous Metals; Transportation Services	260 (274)	54.8	2.5	5.0	210.7
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	308 (320)	75.9	2.6	6.9	247.3
Total		2500	1093.8	4.7	100.0	437.7

Note: * Sectors listed under 'Others' are presented at ICB-3 digits level. Figures in parentheses are the number of companies in these sectors in the 2021 *Scoreboard*. R&D intensity is defined as R&D investment over net sales, R&D per firm constitutes the average per sector.
Source: The 2022 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG R&I.

With 567 companies, which represent a share of 22.7%, the health sector has the highest share of companies in the sample. There are 42 more companies in this sector compared to the 2021 *Scoreboard*, which is the largest increase in numbers recorded for any sector since last edition. This is followed by ICT producers who, despite the slight drop in number of firms, have a share of 18.2% of companies in the sample. ICT services has the third highest share with 14.6% and 10 more companies than last year. The industrials and chemical sectors saw the largest decrease in companies since last year, with 14 and 10 less companies, respectively. This is in line with the trend that companies from sectors frequently investing less in R&D than in high-tech

sectors such as health and ICT, drop out of the *Scoreboard* as ICT companies (notably from China) and health companies enter (see Chapter 3 for more details).

Table 1.3 gives a breakdown of the number of companies by sector and region, illustrating a trend towards specialisation observed in several past editions of the *Scoreboard*.

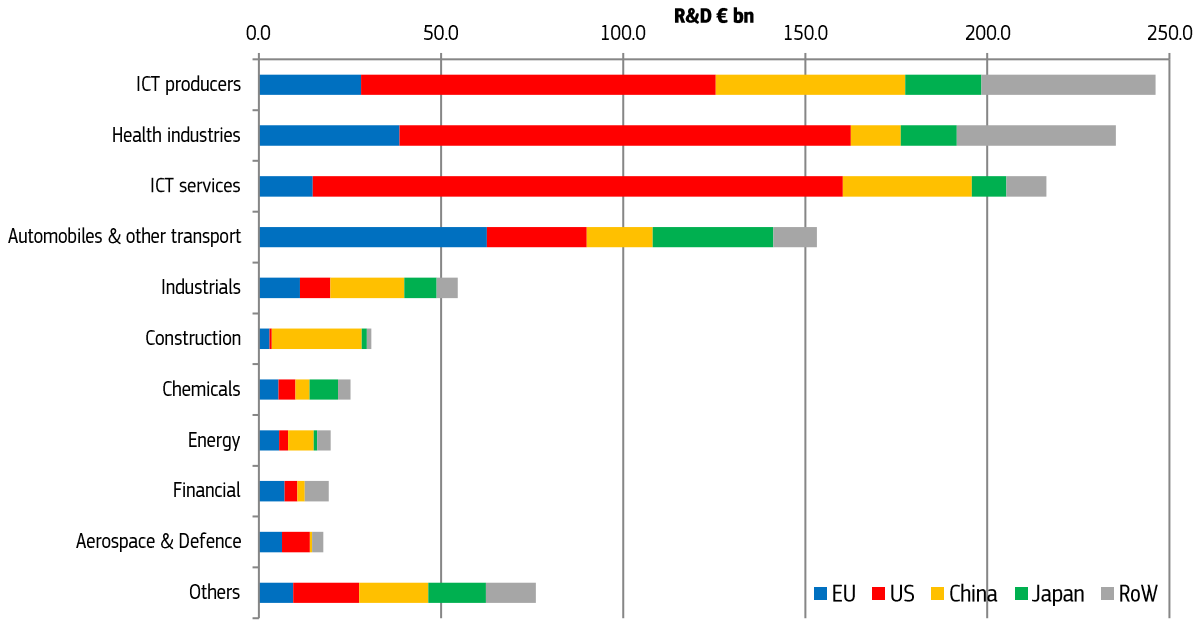
Table 1.3 Distribution of global 2500 by sector and country/region – number of companies

Industry	EU	US	China	Japan	RoW	Total
Aerospace & Defence	10 (22.7%)	15 (34.1%)	5 (11.4%)	0	14 (31.8%)	44 (1.8%)
Automobiles & other transport	34 (18.9%)	37 (20.6%)	54 (30%)	28 (15.6%)	27 (15%)	180 (7.2%)
Chemicals	16 (13.9%)	21 (18.3%)	33 (28.7%)	28 (24.3%)	17 (14.8%)	115 (4.6%)
Construction	9 (13.8%)	4 (6.2%)	35 (53.8%)	10 (15.4%)	7 (10.8%)	65 (2.6%)
Energy	26 (32.5%)	10 (12.5%)	20 (25%)	10 (12.5%)	14 (17.5%)	80 (3.2%)
Financial	22 (36.1%)	9 (14.8%)	12 (19.7%)	0	18 (29.5%)	61 (2.4%)
Health industries	68 (12%)	309 (54.5%)	92 (16.2%)	31 (5.5%)	67 (11.8%)	567 (22.7%)
ICT producers	42 (9.2%)	112 (24.6%)	153 (33.6%)	45 (9.9%)	104 (22.8%)	456 (18.2%)
ICT services	30 (8.2%)	203 (55.6%)	83 (22.7%)	6 (1.6%)	43 (11.8%)	365 (14.6%)
Industrials	57 (21.9%)	35 (13.5%)	99 (38.1%)	36 (13.8%)	33 (12.7%)	260 (10.4%)
Others	47 (15.3%)	67 (21.8%)	92 (30%)	39 (12.7%)	62 (20.2%)	307 (12.3%)
Total	361 (14.4%)	822 (32.9%)	678 (27.1%)	233 (9.3%)	406 (16.2%)	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 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

US firms lead in ICT services and health and China maintains its digital leadership in ICT proders, construction and the industrial sector. EU firms have a relative majority in the energy and financial sectors. However, this changes slightly if we look at the volume of R&D investment instead of the number of companies. Just as last year, ICT producers and health industries are still the top two sectors in terms of R&D invested. Together they account for almost 44.1% of R&D investment globally in 2021 (43.7% in the 2021 *Scoreboard*). Figure 1.4 presents the share of R&D by sector and region.

Figure 1.4 R&D investment by sector and country/region in EUR bn



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

Although the ICT producers sector has the second highest number of companies behind the health sector (see Table 1.2), it invests slightly more. The ICT services sector remains the third largest sector in terms of share of R&D. It overtook the automotive sector and is edging closer to the health sector. This year's data also

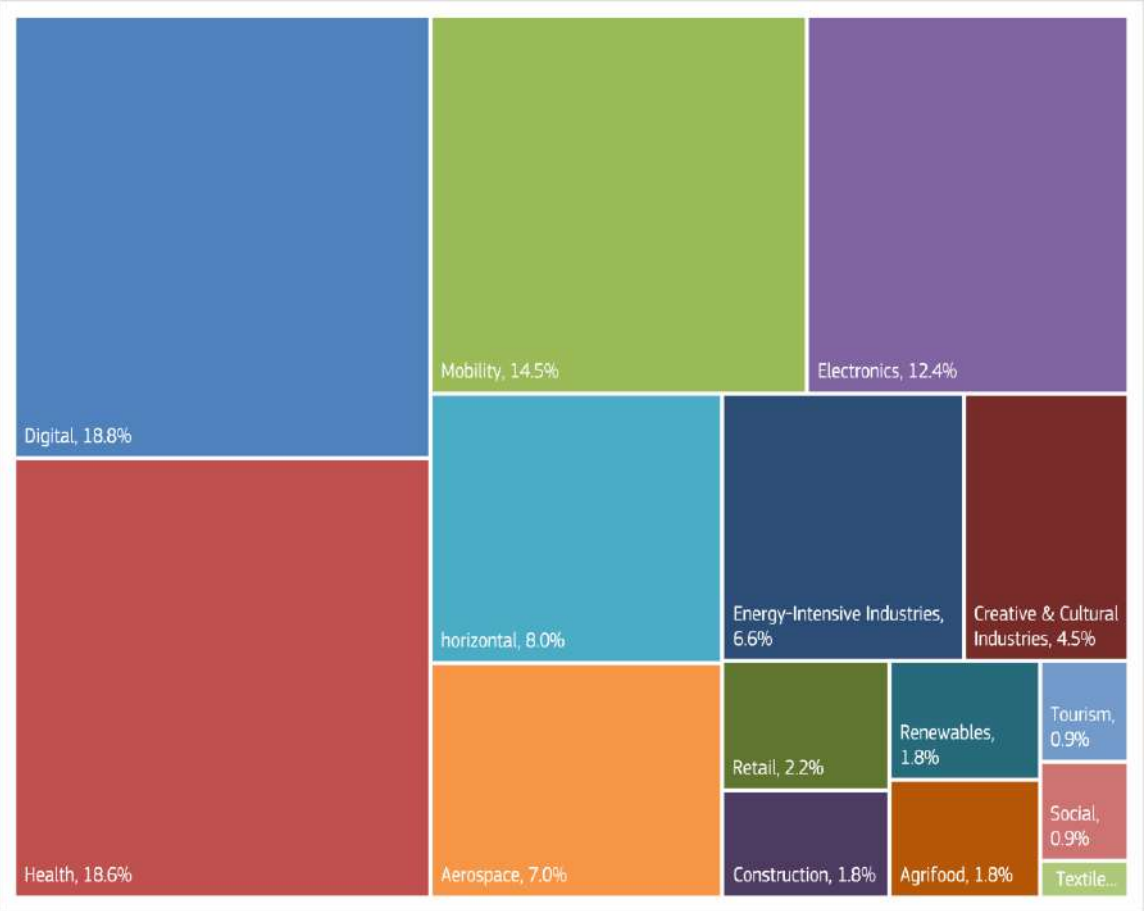
confirms the sector shift reported in last year's edition of the *Scoreboard*: high-tech sectors are progressively widening the gap with mid- and low-tech sectors. Lastly, the EU specialisation in the automobile industry is still strong. In spite of having fewer companies in this sector than China and the US, EU companies are responsible for 41.1% of the total R&D investment in this sector.

Box 1.1 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 Communication "A new Industrial Strategy for a green and digital Europe"[36], put forward 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 see what the *Scoreboard* would look like from an ecosystem perceptive (Figure B.1).

Figure B.1 R&D investment 2021 by ecosystem



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

The majority of R&D is concentrated in the digital, health, mobility and electronics ecosystems, which account for 64.3% of R&D. This is in line with both the analysis carried out using ICB sectors and the ecosystem approach in the previous edition of the *Scoreboard*.

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

[36] See https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

1.2.3 The subsidiary structure of the *Scoreboard* companies.

The top 2500 companies investing in R&D control about 935 000 subsidiaries. Almost 300 000 of these are corporate subsidiaries[37]. While companies' headquarters are located in only 41 different countries, there is at least one subsidiary[38] of a *Scoreboard* company in 201 countries/territories.

The distribution of corporate subsidiaries, as the distribution of headquarters, is quite concentrated. As shown in Figure 1.5, 72% of subsidiaries are located in 20 countries. In line with the distribution of headquarters, the country where the majority of subsidiaries are located is the US, which accounts for 30.7% of the total. This is followed by China with 15.2%. The countries with the highest number of subsidiaries (US, China, UK, Germany and Canada) are the same top four as last edition (2021 *Scoreboard*), plus Canada which has overtaken France.

Figure 1.5 Subsidiaries of the top 2500 companies for R&D investment by location – top 20 host countries

Note: corporate subsidiaries are labelled as 'national' if they are located in the same country as their parent company. Otherwise, they are 'international'.

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

International corporate subsidiaries are those located in a different country from the headquarter of their parent company. By focusing on these, we can gain an insight into how attractive a country is as a subsidiary location for a top R&D investor. The green bars in Figure 1.5 indicate international corporate subsidiaries. The top 20 locations for international corporate subsidiaries are the same 20 countries that account for the majority of all subsidiaries. However, a significant exception is Japan, which dropped outside the top 20 locations (it ranks 21). The top 3 locations are the same, while the rankings of some other countries change. Apart from Japan exiting the top 20, the most interesting differences are that Canada is ahead of Germany at the fourth rank, and Brazil ranks 6th ahead of France.

Figure 1.6 shows how corporate subsidiaries of *Scoreboard* companies are distributed across five of the world's countries and regions. As in the previous edition of the *Scoreboard*, companies headquartered in the EU own the relative majority of subsidiaries – 30.6% located in 191 different countries. US companies follow closely, owning 29.2% of subsidiaries in 175 countries. Chinese and Japanese companies own a similar share of subsidiaries – 12.9% and 11% respectively; China's subsidiaries are located in 147 countries, and similarly Japan has subsidiaries located in 151 countries.

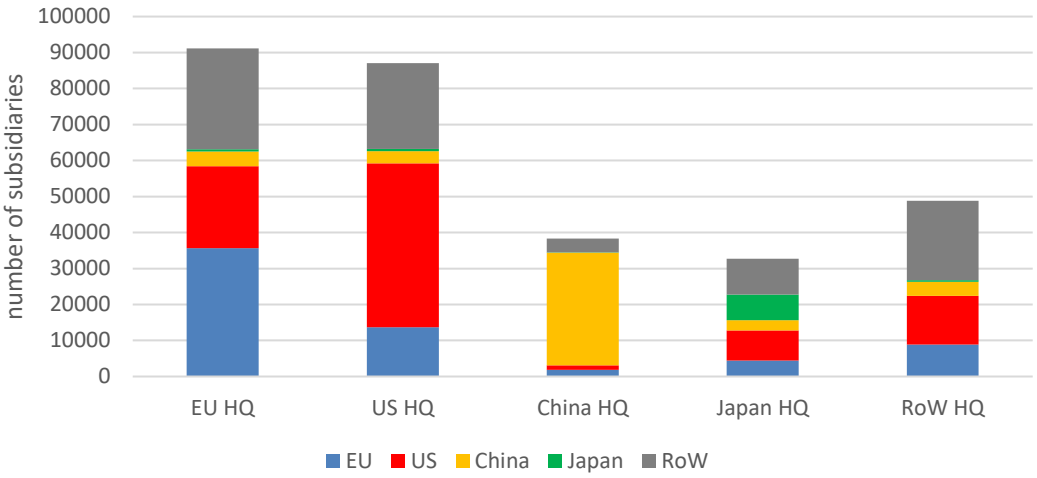
Companies headquartered in the EU have most of their subsidiaries located in the EU (39.1%), followed by the US (25.0%). Companies headquartered in the US have just over half of their subsidiaries located in the US

[37] 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.

[38] It should be noted that not all subsidiaries necessarily carry out R&D.

(52.3%) and about a sixth located in the EU (15.7%). Four out of every five subsidiaries owned by Chinese companies are located in China (81.6%). Opposite to this, Japanese companies confirm also in this year's *Scoreboard* that they are the most internationalised ones, as only 21.8% of their subsidiaries are located in Japan.

Figure 1.6 Distribution of the number of subsidiaries by country/region

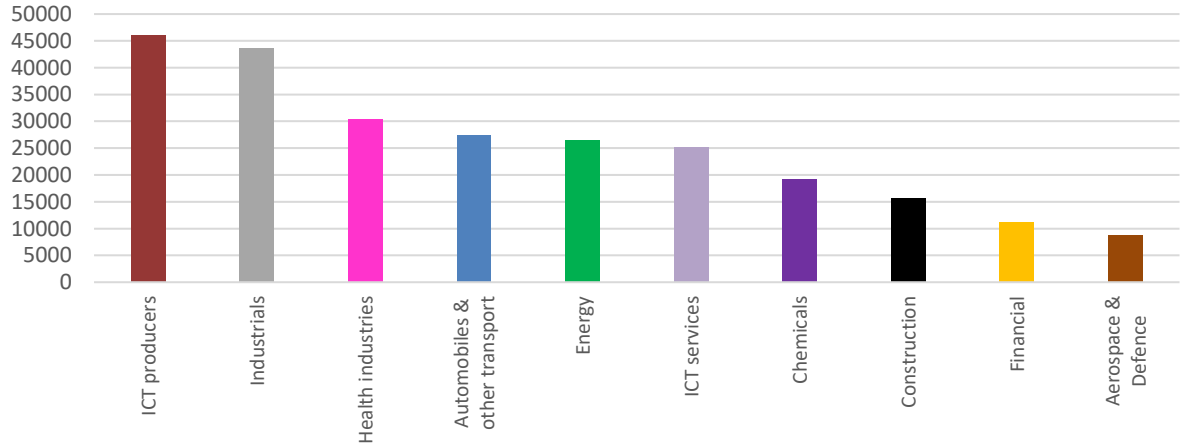


Note: Data refers to 2310 companies (accounting for 97.2% of R&D invested in 2021 by the 2022 *Scoreboard* companies) for which data on subsidiaries are available.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The overall number of corporate subsidiaries is a bit lower than last year. However, their location across different economies is similar to last year. This means that the industrial structure of the top R&D investors has remained stable through the COVID-19 crisis.

As reported in Figure 1.7, companies in the ICT producers and industrial sectors have the highest number of subsidiaries. Energy and automobile companies have a number of corporate subsidiaries not much lower than the health companies and slightly higher than the ICT services companies, which are both sectors where there are considerably more mother companies. This means the energy and automobile sectors typically have relatively larger company networks.

Figure 1.7 Number of subsidiaries of the top 2500 companies by sector of the mother company



Note: Data refers to 2310 companies. These account for 97.2% of R&D invested in 2021 by the 2022 *Scoreboard* companies) for which data on subsidiaries are available.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

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 Manual[39], the *Scoreboard* refers to all R&D financed by companies from their own funds, regardless of where the R&D activities are performed. Conversely, 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 (2020) with the R&D data from the 2021 *Scoreboard* (company data for 2020). This comparison shows that the amount of R&D investment by the top 2500 companies (EUR 908.9 bn) is equivalent to 58.2% of the total expenditure on R&D worldwide (GERD, EUR 1479.8 bn) and to 86.3% of the R&D expenditure financed by the business sector worldwide (BES-R&D, EUR 1093.7 bn).

Source: Latest figures reported by Eurostat including most countries reporting R&D, extracted on 24/10/2021. GERD, from all funding sources and performed in all sectors. BES-R&D performed in all sectors and funded by the business enterprise sector. *The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.*

1.3 Key points

— The top 2500 global companies invested a total of EUR 1093.9 billion in R&D in 2021, which is 14.8% more than in the previous year.

— After the relative slowdown of the 2021 *Scoreboard* – R&D investments at global level grew at 6.0% compared to 8.9% R&D growth in the 2020 *Scoreboard* – the pace of R&D growth increased again and even surpassed pre-pandemic levels.

— For the first time, China overtook the EU, both in the number of companies on the *Scoreboard* and also in terms of the total volume of R&D invested.

— This year's data also confirms the sector shift reported in last year's edition of the *Scoreboard*: high-tech sectors are progressively widening the gap with mid- and low-tech sectors.

— EU specialisation in the automobile industry is still strong.

— Despite having fewer companies in this sector than China and the USA, EU automotive companies invest 41.1% – by far the biggest share of the total R&D investment in the sector.

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

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, focusing on the comparison of EU companies' performance against that of their global counterparts.

The first part describes companies' performance over the previous year, whereas the second part analyses EU performance relative to its main competitors, over the past 10 years with particular attention to 4 selected industries (ICT producers, ICT services, health and automobiles) with higher R&D intensity that account for the majority of global R&D investment.

The sample of 2500 is divided into 5 sets, based on the location of companies' headquarters: the EU (361), the US (822), China (678), Japan (233) and the rest of the world (RoW) (406). The RoW group comprises companies from the UK (91), Taiwan (80), South Korea (53), Switzerland (54), Canada (28), India (24), Israel (22) and a further 18 countries. The EU group includes companies from 16 EU countries[40].

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 with the reduction seen in the year before (-2.2%). The global R&D share of EU companies (17.6%) decreased compared to the previous year (20.3%). The number of EU companies in the global ranking (361) fell by 40 compared to the 2020 *Scoreboard*.

2.1 Main changes in companies' *Scoreboard* indicators in 2020-2021

The main indicators, ratios and 1-year changes for the 2500 companies by country/region are presented in table 2.1**Error! Reference source not found.**.

Table 2.1 Main R&D and economic indicators by country/region in the 2022 *Scoreboard*.

	EU	US	China	Japan	RoW	Total
Number of firms	361	822	678	233	406	2500
R&D in 2021, EUR bn	192.8	439.7	195.9	113.8	151.8	1093.9
One-year change, %	8.9	16.5	24.9	6.6	12.4	14.8
Net Sales, EUR bn	4865.7	5540.2	5414.8	2886.3	4382.8	23089.8
One-year change, %	18.0	20.8	24.0	13.0	20.3	19.8
R&D intensity, %	3.9	7.8	3.6	3.9	3.4	4.7
Operating profits, EUR bn	538.4	921.9	442.4	215.8	748.6	2867.2
One-year change , %	125.7	72.7	33.6	11.1	102.3	71.9
Profitability, %	11.2	16.8	8.2	7.6	17.2	12.5
Capex, EUR bn	270.9	301.3	380.5	185.3	305.5	1443.4
One-year change, %	5.2	15.1	11.7	3.9	15.2	10.8
Capex / net sales, %	6.0	5.4	7.0	6.5	7.5	6.4
Employees, million	14.8	10.7	15.1	7.4	5.6	53.5
One-year change, %	0.7	5.1	5.9	0.44	1.5	3.1
R&D per employee, EUR	12917.5	40759.2	12888.4	14161.6	15834.7	18947.0
Market Cap[41], EUR bn	5950.5	22766.4	5654.8	2979.4	8240.3	45591.4
One-year change, %	33.0	30.5	13.2	22.6	22.9	26.5

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

2.1.1 EU companies

The 361 EU companies are headquartered in 16 of the 27 EU countries (17 countries in 2020). Of these, 3 countries (Germany, France and the Netherlands) account for the majority of companies and of R&D investment. Companies headquartered in Germany, France and the Netherlands are responsible for 47.2%, 14.9% and 12.5% of R&D investment by the EU companies, respectively. The figure for the Netherlands overstates R&D investment in the country as the list of Dutch companies includes some whose main

[40] Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, Spain and Sweden.

[41] Market prices at close on 31.08.2022 for all listed companies

operations are in other countries[42]. The top 20 EU companies by R&D range from Volkswagen at #7 in the global rankings to Novo Nordisk at #90.

There are 12 EU companies in the global top 50 group (see further details in Chapter 3):

- 8 German companies (Volkswagen (ranking 7th in the world), Mercedes-Benz (14th), BMW (21st), Robert Bosch (26th), Bayer (33rd), Siemens (37th), SAP (38th) and Boehringer Sohn (45th);
- 1 French company (Sanofi (32nd);
- 1 Finish company (Nokia (44th));
- 1 Swedish company (Ericsson (47th)); and
- 1 Dutch-headquartered company (Stellantis[43] (29th)).

Of these companies, 5 belong to the automotive sector, 3 to the health sector, 3 to the ICT producers sector and one to the ICT services sector. Table 2.2 shows the main performance indicators for the top 20 companies in the EU group.

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

Company	Country	Sector	RD 2021		Net sales 2021		Employment 2021	
			(€ million.)	1 year growth rate (%)	(€ million.)	1 year growth rate (%)	N of employees	1 year growth rate (%)
VOLKSWAGEN	DE	Automobiles & other transport	15583.0	12.2	250200.0	12.3	643297	-2.9
MERCEDES-BENZ	DE	Automobiles & other transport	8973.0	6.3	167971.0	8.9	172425	-40.2
BMW	DE	Automobiles & other transport	6870.0	9.4	111239.0	12.4	118909	-1.5
ROBERT BOSCH	DE	Automobiles & other transport	6328.0	4.7	78748.0	10.1	402614	1.9
STELLANTIS	NL	Automobiles & other transport	5889.0	52.3	149419.0	72.4	292434	52.5
SANOFI	FR	Health industries	5689.0	2.9	37761.0	4.8	95442	-4.0
BAYER	DE	Health industries	5515.0	1.0	44081.0	3.6	99637	0.1
SAP	DE	ICT services	5168.0	16.2	27842.0	1.8	107415	4.9
SIEMENS	DE	ICT producers	5136.0	2.3	62265.0	9.0	303000	3.4
NOKIA	FI	ICT producers	4141.0	7.8	22202.0	1.6	87927	-4.5
BOEHRINGER SOHN	DE	Health industries	4127.0	11.7	20618.0	5.4	n.a.	n.a.
ERICSSON	SE	ICT producers	4046.2	6.0	22694.5	0.0	101322	0.5
AIRBUS	NL	Aerospace & Defence	2898.0	-2.1	52149.0	4.5	126495	-3.7
CONTINENTAL	DE	Automobiles & other transport	2636.6	-25.8	38197.9	1.3	190875	-19.3
ZF	DE	Automobiles & other transport	2466.0	21.8	38313.0	17.5	157549	2.6
ASML HOLDING	NL	ICT producers	2431.1	17.5	18611.0	33.1	32016	14.0
MEDTRONIC PUBLIC LIMITED	IE	Health industries	2424.5	10.1	27976.3	5.2	95000	5.6
MERCK DE	DE	Health industries	2400.0	6.1	19687.0	12.3	60334	3.9
RENAULT	FR	Automobiles & other transport	2361.0	-14.1	46213.0	6.3	156466	-8.0
BASF	DE	Chemicals	2248.0	4.6	78598.0	28.9	111047	0.7

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

In 2021, the 361 EU-based companies invested EUR 192.8 billion in R&D, which is an increase of 8.9% compared to 2020, in contrast with the reduction seen in the year before (-2.2%). The global R&D share of EU companies (17.6%) decreased compared to the previous year (20.3%). The number of EU companies in the global ranking (361) fell by 40 compared to the 2020 *Scoreboard*.

Considering sectoral variations, the financial and health sectors showed the largest R&D investment increase (14.7% and 11.5% respectively). The automotive is the EU's largest R&D sector, accounting for 33% of total R&D investment. It sustained the overall R&D growth of the EU group, increasing R&D investment by 8.9%, bouncing back from the drop of 7.2% reported in 2020. The chemicals and aerospace & defence sectors recovered from last year drop but showing only modest R&D growth figures (4.8% and 0.6%, respectively).

In terms of countries, R&D growth was sustained by companies based in Germany, which is the country that invests the most in R&D, accounting for 47.2% of the EU's total R&D investment. The set of German

[42] Several top R&D investors, e.g. Airbus, Stellantis, STMicroelectronics and CureVac, are headquartered in the Netherlands but have most of their operations in other countries.

[43] 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 operations are distributed across many countries in particular France, Italy, the US and Brazil.

companies increased R&D investment 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%).

Other countries whose companies reported significant R&D increases are

- the Netherlands (21.4%), e.g. by companies such as Stellantis (52.3%), Curevac (725.8%), CNH Industrials (27.9%), NXP Semiconductors (14.8%), and
- Denmark (15.7%), mainly by Novo Nordisk (18.8%) and Vestas (34.1%).

France is the second-largest R&D investor, accounting for 14.9% of the EU's R&D investment. Its companies showed a modest R&D investment increase (2.6%). The high R&D growth from companies such as Alstom (66.2%) were offset by poor results of other companies, e.g. Renault (-14.1%).

Table 2.3 lists the 10 companies that contributed most to the R&D growth of the EU sample (top) and those that significantly held back the EU's R&D growth (bottom). The top 10 EU companies that contributed most to R&D growth are from the sectors that invest the most in R&D: 5 from the automotive sector, which bounced back from the poor results of the previous year due to the pandemic; 3 from the health sector and 2 from ICT sectors. However, R&D growth varied significantly within these sectors, which also comprise companies that showed the poorest performance in terms of R&D investment growth (i.e. Renault, Continental, Amadeus and Telefonica).

Large changes in companies' R&D investment are not necessarily due to organic growth, but may be explained by mergers, acquisitions, divestment or accounting practices (see Section 2.1.4). For example, the remarkable 52.3% increase of Stellantis' R&D investment is entirely due to the merger of FiatChrysler with the French PSA Group.

Table 2.3 Companies most affecting the R&D growth of the EU sample in 2021.

Companies that contributed most to the R&D growth of the EU sample			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
STELLANTIS	Netherlands	Automobiles & other transport	52.3
VOLKSWAGEN	Germany	Automobiles & other transport	12.2
SAP	Germany	ICT services	16.2
CUREVAC	Netherlands	Health industries	725.8
BMW	Germany	Automobiles & other transport	9.4
MERCEDES-BENZ	Germany	Automobiles & other transport	6.3
ZF	Germany	Automobiles & other transport	21.8
BOEHRINGER SOHN	Germany	Health industries	11.7
INFINEON TECHNOLOGIES	Germany	ICT producers	30.2
BIONTECH	Germany	Health industries	86.6
Companies that affected the R&D growth of the EU sample most negatively			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
CONTINENTAL	Germany	Automobiles & other transport	-25.8
RENAULT	France	Automobiles & other transport	-14.1
PHILIPS	Netherlands	Industrials	-7.5
TELEFONICA	Spain	ICT services	-12.9
AMADEUS	Spain	ICT services	-10.6
ING GROEP	Netherlands	Financial	-36.6
MALLINCKRODT	Ireland	Health industries	-29.4
DSM	Netherlands	Chemicals	-15.7
TOTALENERGIES	France	Energy	-7.9
AIRBUS	Netherlands	Aerospace & defence	-2.1

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

Trends in sales, capex, profits and employees for the 361 EU companies

The main financial indicators of the EU sample of companies were hit hard by the pandemic in 2020 but showed a solid recovery in 2021.

The 361 EU companies' net sales increased substantially by 20.8%, reaching EUR 4.9 trillion. The sectors showing the largest increases in net sales were energy (41.2%), chemicals (29.2%) and automotive (16.3%). The sectors that reported the lowest growth of net sales were ICT services (3.3%), aerospace & defence (4.9%) and financial (9.3%).

The overall operating profits of the EU sample showed an outstanding recovery, jumping 126%, with many sectors showing a double-digit or triple-digit increase of profits. The ICT services sector only showed a modest increase in profits (3.4%)

The 361 EU companies' capital expenditures (CAPEX) increased by 5.2% (an increase of EUR 13.2 billion, somewhat lower than the R&D investment increase of EUR 15.7 billion). The sectors showing the largest increase in CAPEX were financials (23.5%), construction (20.1%) and ICT producers (14.9%). The only sector that reduced its CAPEX was automotive (-11.0%), in contrast to the CAPEX increase of the sector worldwide (8%) and the good performance of the sector within the EU in terms of R&D (8.9%).

The 361 companies based in the EU employed 14.8 million people, a slight increase of 0.7% compared to the previous year. Employment decreased in construction, aerospace & defence and automotive sectors and increased in health, ICT producers and chemicals.

The market capitalisation of the listed companies based in the EU increased considerably by 33% (between 31 August 2021 and 30 August 2022) as stock markets recovered in 2021.

2.1.2 The global picture

R&D trends

The top R&D investors showed a fast recovery from the COVID-19 crisis in 2021. Industrial R&D investment continued to grow significantly for the 12th consecutive year. The 2500 *Scoreboard* companies invested EUR 1093.9 billion in R&D, a 14.8% increase compared to 2020, which is much higher increase than the year before (6.0%).

R&D investment increased across the board with most sectors showing a double-digit R&D growth. Global R&D growth was driven by the ICT services sector (19.5%), followed by the health and ICT producers sectors (16.8% and 11.9% respectively). Most other sectors showed double-digit R&D growth, except energy and aerospace & defence sectors (7.4% and 2.0%, respectively). The automotive sector that was hit hard by the crisis in 2020 showed a substantial recovery (12.3%). The chemicals sector broke the negative trend observed in the past few years by increasing its R&D significantly (13.1%).

EU companies' share in global R&D investment decreased to 17.6% (20.3% in last year's *Scoreboard*), US companies increased their share to 40.2% (37.8% in 2020) and Chinese companies continued to increase their share sharply, reaching 17.9% (from 15.6% in the last *Scoreboard*). In contrast, Japanese companies' share of R&D continued to shrink (10.4%, from 12.2% in the last *Scoreboard*).

Trends in company financial indicators

Across the 2500 companies, most financial indicators that had been negatively affected by the pandemic showed a significant recovery in 2021, particularly operating profits, net sales and CAPEX.

Companies' operating profit increased substantially across most world regions and sectors. Several sectors (aerospace & defence, automotive, energy and financial) showed a triple-digit profit increase. Most other sectors had a double-digit increase in profits, except for the ICT services sector, which showed a modest increase of 2.0%.

The overall net sales of the 2500 companies increased by almost 20%, reaching EUR 23.1 trillion, in contrast with the 4.6% drop in the year before. Most sectors showed a double-digit growth of net sales, except the aerospace & defence sector (4.0%). The largest increases in net sales were reported by sectors such as energy (40.1%), chemicals (29.9%), industrials (21.8%) and ICT producers (19.1%).

CAPEX increased by 10.8% worldwide recovering from the significant drop in the previous year (-4.6%). The increase in CAPEX (EUR 139.8 billion) is of the same order of magnitude as the increase in R&D investment

(EUR 140.8 billion). Companies in the ICT producers (26.7%), financials (20.4%), health (12.4%) and chemicals (12.0%) sectors showed the largest increases in CAPEX. Aerospace & defence had a slight CAPEX increase (0.6%) and construction reduced it by 1.3%.

The overall number of employees of the 2500 companies increased modestly by 3.1% to 53.5 million (compared to 0.9% increase from 2019 to 2020). Three industries reported a drop in the number of employees: energy (-2.8%), construction (-2.4%) and aerospace & defence (-0.6%). The main sectors that increased employment were ICT producers (5.8%), health (5.7%) and ICT services (5.3%).

2.1.3 Non-EU companies

Companies based in the US

The top 2500 R&D investors worldwide include 822 US companies. Among the top 10 companies in the US sample, the top five are from the ICT sectors: Alphabet (ranking first in the world), Meta (2nd), Microsoft (3rd), Apple (5th); and Intel (8th). The next 4 companies are from the health sector: Johnson & Johnson (ranking 10th in the world), Pfizer (11th), Bristol-Myers Squibb (12th) and Merck US (13th). The 10th company is from the automotive sector, General Motors (ranking 20th in the world). Table 2.4 shows the main indicators of the top 20 companies in the US group which range from #1 (Alphabet) to #42 (Broadcom) in the global ranking.

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

Company	Sector	RD 2021		Net sales 2021		Employment 2021	
		(€ million.)	1 year growth rate (%)	(€ million.)	1 year growth rate (%)	N of employees	1 year growth rate (%)
ALPHABET	ICT services	27866.8	14.5	227473.9	41.2	156500	15.7
META	ICT services	21768.5	33.7	104122.3	37.2	71970	22.8
MICROSOFT	ICT services	21642.2	18.3	175057.3	18.0	221000	22.1
APPLE	ICT producers	19348.4	16.9	322988.6	33.3	154000	4.8
INTEL	ICT producers	13411.6	12.1	69772.2	1.5	121100	9.5
JOHNSON & JOHNSON	Health industries	12991.3	21.0	82796.2	13.6	141700	5.4
PFIZER	Health industries	10239.3	20.6	71771.1	95.2	79000	0.6
BRISTOL-MYERS SQUIBB	Health industries	9283.1	1.9	40954.4	9.1	32200	6.4
MERCK US	Health industries	9133.8	1.2	43001.9	17.3	68000	-8.1
GENERAL MOTORS	Automobiles & other transport	6975.1	27.4	112134.9	3.7	157000	1.3
FORD MOTOR	Automobiles & other transport	6710.2	7.0	120378.7	7.2	183000	-1.6
ORACLE	ICT services	6373.8	10.6	37471.3	4.8	143000	8.3
QUALCOMM	ICT producers	6335.9	20.1	29636.2	54.5	45000	9.8
ELI LILLY	Health industries	6203.3	15.4	25003.0	15.4	35000	0.0
ABBVIE	Health industries	6164.6	13.0	49617.7	22.7	50000	6.4
CISCO SYSTEMS	ICT producers	5782.3	3.2	43985.5	1.0	79500	2.6
IBM	ICT services	5248.1	3.1	50635.7	3.9	307600	-18.0
GILEAD SCIENCES	Health industries	4735.1	6.4	24108.2	10.6	14400	5.9
NVIDIA	ICT producers	4651.2	34.3	23763.0	61.4	22473	18.4
BROADCOM	ICT producers	4285.7	-2.3	24236.3	14.9	20000	-4.8

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

The US companies' R&D investment continued to be concentrated in three high R&D-intensive sectors accounting for 83.4% of total R&D investment (comprising 624 companies, 76% of the total number of companies in the US sample). These sectors are ICT services (33.1%), health industries (28.2%) and ICT producers (22.2%).

The 822 companies based in the US invested EUR 439.7 billion in R&D, reflecting a significant increase of 16.5% over the previous period. The US companies' share in global R&D investment reached 40.2%, somewhat higher than in the previous year.

The R&D growth of the 822 US companies was driven by double-digit increases in the sectors that invest the most in R&D, namely ICT services (21.2%), health (18.5%), ICT producers (10.0%) and automotive (27.1%). The US companies reduced R&D investment only in the energy sector (-7.4%).

Companies based in the US increased net sales substantially (20.8%), with most sectors reporting double-digit growth except for the industrials and aerospace & defence sectors (8.5% and 6.5% respectively). Operating profits of the US companies were hit hard by the crisis in 2020 but recovered significantly in 2021. Profits

increased by double or triple digits and in most sectors, except the energy sector, which reported significant losses.

The US companies' capital expenditures also increased significantly by 15.1%, (an increase of EUR 39.6 billion, much lower than the R&D investment increase of EUR 62.4 billion). Many sectors showed a double-digit CAPEX increase and two sectors reported a CAPEX decrease: energy (-15.5%) and aerospace & defence (-2.4%). The number of employees of US companies (10.7 million) increased by 5.1%. The market capitalisation of listed companies based in the US increased substantially (30.5%) in the reference period (from 31 August 2021 to 30 August 2022).

Companies based in China

The top 2500 investors in R&D worldwide comprise 678 Chinese companies, 81 companies more than in the 2021 *Scoreboard*. Of the top 10 Chinese companies, 5 are from ICT industries: Huawei (ranking 4th in the world), Alibaba (17th), Tencent (18th), Baidu (53rd) and ZTE (70th). Another 4 companies operate in the construction sector: China State Construction Engineering (34th in the world), China Railway (54th), China Communications Construction (56th) and China Railway Construction (62nd). Moreover, one company is from the automotive sector (Saic Motor (61st in the world)). Huawei is by far the biggest R&D investor in China, accounting for 10% of total R&D investment in the Chinese sample. Table 2.5 shows the main indicators of the top 20 companies in the Chinese group. The top 20 by R&D range from Huawei at #4 in the global ranking to Lenovo at #116.

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

Company	Sector	RD 2021		Net sales 2021		Employment 2021	
		(€ million.)	1 year growth rate (%)	(€ million.)	1 year growth rate (%)	N of employees	1 year growth rate (%)
HUAWEI INVESTMENT & HOLDING	ICT producers	19533.8	0.7	121786.3	-1.4	195000.0	-1.0
ALIBABA GROUP HOLDING	ICT services	7687.3	-3.1	118232.6	18.9	254941.0	1.4
TENCENT	ICT services	7190.5	33.1	77631.2	16.2	112771.0	31.3
CHINA STATE CONSTRUCTION ENGINEERING	Construction	5509.5	35.2	259594.3	17.3	368327.0	3.3
BAIDU	ICT services	3456.4	27.8	17254.5	16.3	45500.0	11.0
CHINA RAILWAY	Construction	3431.1	13.4	148753.2	10.1	294013.0	1.8
CHINA COMMUNICATIONS CONSTRUCTION	Construction	3112.2	13.7	94606.8	9.3	136772.0	2.6
SAIC MOTOR	Automobiles & other transport	2854.5	37.6	102623.0	5.1	207246.0	1.2
CHINA RAILWAY CONSTRUCTION	Construction	2807.2	8.9	139565.5	12.0	267760.0	-6.5
ZTE	ICT producers	2498.4	20.7	15317.9	8.9	72584.0	-1.5
MEITUAN	Others	2250.7	53.4	24826.8	56.0	100033.0	44.5
POWER CONSTRUCTION CORPORATION OF CHINA	Construction	2231.0	5.4	61611.8	11.9	133207.0	0.8
METALLURGICAL CORPORATION OF CHINA	Industrials	2188.9	29.0	68834.4	25.1	97972.0	-3.0
PETROCHINA	Energy	2113.8	6.8	362343.3	35.2	417173.0	-3.4
KUAISHOU TECHNOLOGY	Others	2055.8	128.6	11237.7	37.9	28098.0	30.7
NETEASE	ICT services	1950.9	35.7	12142.0	18.9	32064.0	13.5
CRRC CHINA	Automobiles & other transport	1706.6	-3.6	30410.6	-1.2	160656.0	-2.1
MIDEA GROUP	Others	1665.2	18.7	42506.3	18.0	165799.0	11.1
XIAOMI	ICT producers	1635.6	40.0	45503.0	33.5	33427.0	51.4
LENOVO	ICT producers	1632.1	42.7	63233.4	17.9	75000.0	4.9

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

The Chinese companies' R&D investment mainly takes place in the ICT producers sector (26.4% of total R&D investment), followed by the ICT services sector (18%) and the construction sector (12.6%).

The 678 companies based in China invested EUR 195.9 billion in R&D in 2021, a substantial increase of 24.9% over the previous year. The Chinese companies showed double-digit R&D growth in all sectors. The sectors that contributed most to the R&D growth of China are ICT producers (18.0%), ICT services (22.8%), industrials (32.2%), construction (21.7%), health (35.8%) and automotive (26.5%). The Chinese companies' share in global R&D investment continued to increase in 2021, reaching 17.9%.

Also in terms of net sales, the 678 Chinese companies continued to show outstanding growth (24.9%). All sectors grew by double digits driven by strong sales in sectors such as chemicals, industrials and energy. The Chinese companies' CAPEX continued to grow in 2021 but at slower pace than the other indicators (11.5%). This represents a CAPEX increase of EUR 39.7 billion (similar to the increase of R&D of EUR 39.0 billion), driven by the sectors that invest the most in R&D (automotive, health and ICT). In contrast, the highly capital-intensive construction sector decreased its CAPEX by 7.3%. The operating profits of the Chinese companies showed a mixed performance, increasing much less than those of their US and EU competitors (33.6%), showing triple-digit growth in health and chemicals but reporting losses in the automotive sector. In 2021 the number of employees in the Chinese companies increased by 5.9%, almost twice the global average (3.1%).

The market capitalisation of the listed Chinese companies rose by 13.2% between 31 August 2021 and 30 August 2022.

Companies based in Japan

The top 2500 investors in R&D worldwide include 233 Japanese companies. Among the top 10 Japanese companies, 4 are from the automotive sector: Toyota (ranking 15th in the world), Honda (24th), Denso (50th) and Nissan (51st). Another two are leisure goods companies, Sony (ranking 39th in the world) and Panasonic (52nd), one is a health company (Takeda Pharmaceutical (46th)) and 3 are ICT companies: NTT (31st), Hitachi (66th) and Canon (86th). All of these 10 companies lost places in the global R&D ranking except Takeda, which rose 3 positions. Table 2.6 shows the main indicators of the top 20 companies in the Japanese group. The top 20 Japanese companies by R&D range from Toyota at #15 in the global rankings to Tokyo Electron at #165.

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

Company	Sector	RD 2021		Net sales 2021		Employment 2021	
		(€ million.)	1 year growth rate (%)	(€ million.)	1 year growth rate (%)	N of employees	1 year growth rate (%)
TOYOTA MOTOR	Automobiles & other transport	8691.3	3.1	242585.8	15.3	372817	1.8
HONDA MOTOR	Automobiles & other transport	6372.7	4.1	112502.6	10.5	204035	-3.5
NTT	ICT services	5732.1	4.7	93977.9	1.8	333840	2.8
SONY	Others	4901.6	20.7	76700.3	10.2	108900	-0.7
TAKEDA PHARMACEUTICAL	Health industries	4064.8	15.4	27590.9	11.6	47347	0.5
DENSO	Automobiles & other transport	3846.5	1.1	42638.8	11.7	154493	-8.3
NISSAN MOTOR	Automobiles & other transport	3742.2	-3.9	65128.0	7.1	n.a.	n.a.
PANASONIC	Others	3513.3	-1.5	57120.6	10.3	240198	-1.4
HITACHI	ICT producers	2658.1	12.7	79352.6	17.6	368247	5.9
CANON	ICT producers	2221.3	5.5	27160.7	11.2	184034	1.2
DAIICHI SANKYO	Health industries	2011.7	14.5	8077.8	8.6	16458	2.7
ASTELLAS PHARMA	Health industries	1901.8	9.6	10020.3	3.7	14522	-6.0
OTSUKA	Health industries	1795.8	7.1	11582.7	5.3	33226	0.2
SOFTBANK	ICT services	1551.4	12.7	48096.9	10.5	59721	1.6
MITSUBISHI ELECTRIC	ICT producers	1508.6	2.4	34608.5	6.8	145696	0.0
AISIN	Automobiles & other transport	1501.0	2.3	30284.5	11.1	117177	-1.0
SUMITOMO CHEMICAL	Chemicals	1329.1	-1.6	21377.9	20.9	34703	-0.1
TDK	ICT producers	1277.5	30.1	14704.8	28.6	116808	-9.7
SUZUKI MOTOR	Automobiles & other transport	1242.7	9.9	27586.1	12.3	69193	0.7
TOKYO ELECTRON	ICT producers	1223.4	15.8	15490.8	43.2	15634	8.0

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

The Japanese companies' R&D investment mostly takes place in the automotive sector (30.4%) and the ICT producers sector (18.3%) sectors. The sector specialisation pattern is similar to that in the EU sample, which is also led by the automotive sector.

The 233 companies based in Japan invested EUR 113.8 billion in R&D, 6.6% more than in the previous year. The Japanese companies' share in global R&D investment continued to decline (10.4% in 2021 compared to 22% in 2009), as it has done for 12 years. The sectors that contributed most to the R&D growth of the Japanese group are health (13.2%), leisure goods (9.6%), and chemicals (8.8%). In contrast, the Japanese sector that invests the most in R&D, automotive, increased R&D only by a modest 2.4%.

The other financial indicators of the Japanese companies showed a mixed performance. Net sales increased significantly (13.0%), with companies showing sales increases in all sectors. In comparison to other world regions, operating profits showed a moderate increase (11%) due mainly to construction, energy and ICT services sectors (the decline in the ICT services sector was mostly to considerable losses reported by Softbank).

CAPEX increased by a modest 3.9% (an increase of EUR 7 billion, similar to the R&D investment increase of EUR 7.1 billion). This CAPEX increase was mostly due to companies from the health, automotive and ICT producers sectors, while the construction and energy sectors showed a decrease. The number of people employed by the Japanese companies remained almost unchanged (7.4 million) and the market capitalisation of the listed companies increased by 22.6% (between 31 August 2021 and 30 August 2022).

Companies based in the rest of the world (RoW)

This group comprises 406 companies from 25 countries. Most R&D investment is concentrated in 4 countries, which account for 83.2% of the total R&D investment of the group: Switzerland (22.7%), South Korea (22.6%), the UK (21.4%), and Taiwan (15.9%). See Table 2.7.

Table 2.7 Performance of companies based in the largest countries of the RoW group

	No. of companies	R&D (EUR million)	World R&D share (%)	R&D 1-year growth (%)	Net sales (EUR million)	Sales 1-year growth (%)	R&D intensity. (%)
Switzerland	55	34866.9	3.2	11.4	427773.5	9.5	8.1
South Korea	53	34274.4	3.1	6.4	970315.3	18.5	3.5
UK	95	32819.1	3.0	12.8	1031974.1	9.8	3.1
Taiwan	84	24782.3	2.3	16.8	690962.3	13.3	3.6

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

In 2021, the 406 companies in the RoW sample invested EUR 151.8 billion in R&D, 12.4% more than the year before. As in other world regions, companies in health, ICT and automotive sectors drove R&D growth. The companies that contributed most to R&D growth were AstraZeneca (34.0%), Roche (12.8%), Samsung (6.5%), Tata Motors (46.5%), SK Hynix (25.0%), Novartis (7.8%), TSMC (13.9%), and Mediatek (24.3%).

Most other financial indicators of the 406 companies of the RoW showed a solid recovery from the pandemic, in particular operating profits (102.3%), net sales (20.3%) and CAPEX (15.2%). The number of employees increased slightly by 1.5%, reaching 5.6 million. The market capitalisation of the RoW listed companies increased by 22.9% between 31 August 2021 and 30 August 2022.

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

Table 2.8 lists the companies that contributed most 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 the sectors that invest the most in R&D: 5 in ICT services, 4 in health industries and one in the automotive sector. The 10 worst-performing companies are also from ICT (5) and health (2) and one each from aerospace & defence, chemicals and travel & leisure sectors ("others").

Table 2.8 Companies most affecting R&D growth in the non-EU sample in 2021

Companies that contributed most to R&D growth in the non-EU sample			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
META	US	ICT services	33.7
ALPHABET	US	ICT services	14.5
MICROSOFT	US	ICT services	18.3
APPLE	US	ICT producers	16.9
JOHNSON & JOHNSON	US	Health industries	21.0
ASTRAZENECA	UK	Health industries	34.0
TENCENT	China	ICT services	33.1
PFIZER	US	Health industries	20.6
ROCHE	Switzerland	Health industries	12.8
GENERAL MOTORS	US	Automobiles & other transport	27.4
Companies that most negatively affected R&D growth in the non-EU sample			
Company	**Country**	**Sector**	**1-year R&D growth (%)**
DELL TECHNOLOGIES	US	ICT producers	-51.1
BIOGEN	US	Health industries	-37.3
AIRBNB	US	Others	-48.2
INCYTE	US	Health industries	-33.4
HARRIS	US	ICT producers	-31.7
MCAFEE	US	ICT services	-61.3
ALIBABA GROUP HOLDING	China	ICT services	-3.1
DUPONT	US	Chemicals	-25.7
BOEING	US	Aerospace & Defence	-9.6
CORNING	US	ICT producers	-20.0

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

2.1.4 Large R&D changes in big companies

Large changes in sales and/or R&D from the prior year are sometimes the result of organic growth but can be the result of large acquisitions. This section lists the larger acquisitions made in 2020 and 2021 by *Scoreboard* companies. The list has been compiled both from lists of recent large acquisitions in high R&D intensity sectors and by looking at large companies whose sales have increased by 30% or more over the previous year. Some of the acquisitions listed were agreed in 2021 but will not now be completed until 2022, therefore they will affect the data in the 2023 *Scoreboard*. These are still included for completeness. Acquisitions where the cost was less than approximately USD 1 billion have been excluded to limit the size of Table 2.9. The increase in an acquirer's R&D due to the acquisition can be estimated by looking at the target's R&D in its last independent year's accounts.

Table 2.9 Major company mergers, acquisitions & divestments

Company name	R&D EUR m	Acquisition's Name	Date of close	Cost (USD bn)	Comment
AstraZeneca	7110	Alexion	7/21	39	
Bristol-Myers Squibb	9283	MyoKardia	11/20	13.1	
Johnson & Johnson	12991	Momenta Pharma	10/20	6.5	
Gilead Sciences	4735	Forty Seven	4/20	4.9	
		Immunomedics	10/20	21	
Sanofi	5689	Principia Biopharma	9/20	3.9	
		Translate Bio	9/21	3.2	
		Kadmon	11/21	1.9	
		Kymab	6/21	1.1 to 1.45	
Merck	9134	Velos Bio	11/20	2.75	
		Acceleron Pharma	11/21	11.5	
		Pandion	3/21	1.85	
Eli Lilly	6203	Protomer	7/21	1	
Pfizer	10239	Arena Pharma	3/22	6.7	
		Trillium Therapeutics	11/21	2.2	
Amgen	4255	Five Prime Therapeutics	4/21	1.9	
Novo Nordisk	2192	Dicerna Pharma	11/21	3.3	
Bayer	5515	Asklepios Biopharma	12/20	4	
CSL	1020	Vifor	8/22	16.4	Affects 2023 SB
Teladoc	312	Livongo	10/20	18.5	
Thermo Fisher Scientific	1241	PPD	12/21	17.4	
Nestle	1840	AImmune	10/20	2.1b	
Jazz Pharma	446	GW Pharma	5/21	7.6	
Horizon Pharma	321	Viela Bio	3/21	3	
Perrigo	107	HRA	5/22	2.1	
Servier	802	Agios Oncology	4/21	2	
Meta	21769	Kustomer	2/22	1	Affects 2023 SB
Stellantis	5889	Fiat/PSA merger	1/21	52	
Oracle	6374	Cerner	6/22	28.3	Affects 2023 SB
Bytedance	$14.6bn	Amcare	8/22	1.5	Affects 2023 SB
Salesforce	3942	Slack	7/21	27.7	
		Vlocity	2/20	1.3	
SK Hynix	3087	Intel's NAND business	12/21	9	
UBER	1813	Postmates	12/20	2.65	
		Drizly	10/21	1.1	
AMD	2512	Xilinx	2/22	49	Affects 2023 SB
Analog Devices	1144	Maxim	4/21	20	
Adobe	2243	Workfront	12/20	1.5	
Nvidia	4651	Mellanox	4/20	6.9	
Intuit	1545	Credit Karma	12/20	8.1	
Atlassian	1234	Halp	5/20	n/a	Total deals of over USD 1 bn
HPE	1747	Silver Peak	9/20	0.93	
Cisco	5782	Thousand Eyes	5/20	1	
		Fluidmesh Networks	7/20	n/a	

Twilio	751	Segment	11/20	3.2	
Microsoft	21642	Affirmed Networks	3/20	1.35	
		Activision Blizzard	1/22	68.7	Not yet completed
		Bethesda	3/21	7.5	
		Nuance	3/22	19.7	
Marvell technology	1258	Inphi	4/21	10	
Teledyne Technologies	264	FLIR	5/21	8.2	
Sinochem Holdings Corporation		Now owns both Sinochem & ChemChina	5/21	-	Result of merger

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

2.2 Positioning of the EU in relation to main competitors

This section compares the R&D investment performance of the EU set of companies in the *Scoreboard* over the past 10 years with that of the US, Chinese and Japanese companies for the top 4 sectors in terms of R&D investment. These sectors accounting for 77.8% of total R&D investment in the *Scoreboard* are ICT producers (22.6%), health industries (21.5%), ICT services (19.8%) and automotive (13.9%).

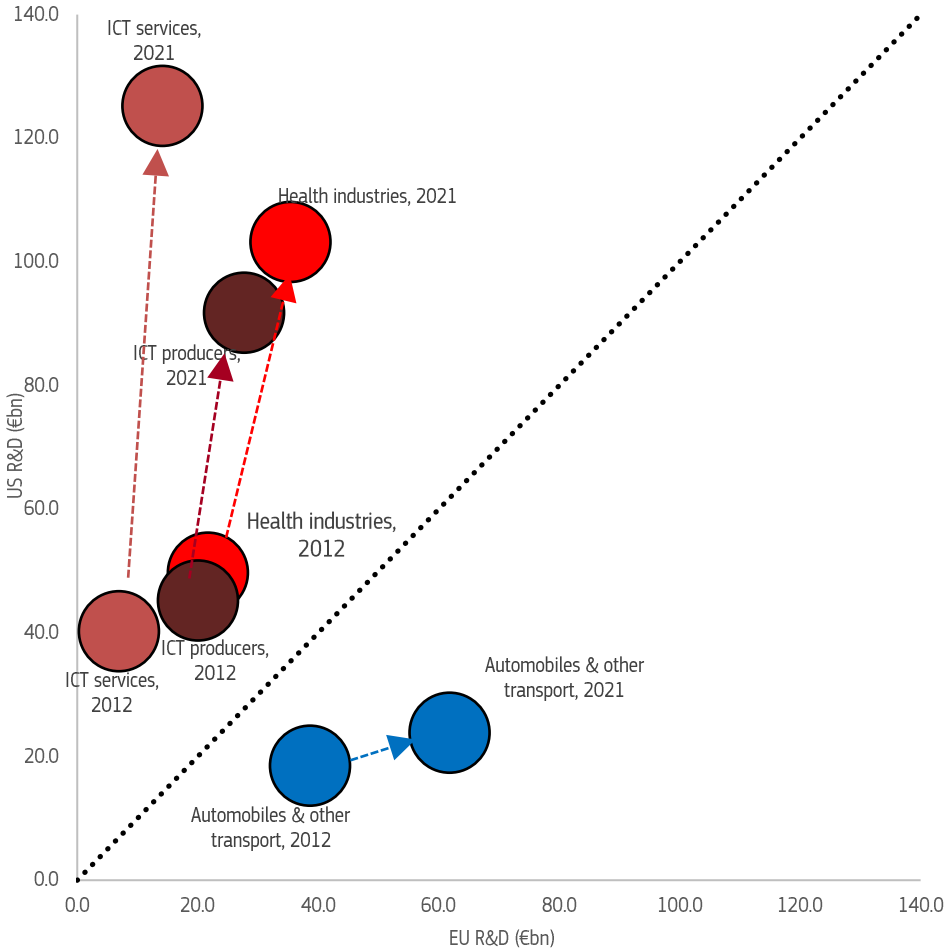
Figure 2.1, 2.2 and 2.3 compare the sector specialisation of the EU companies with that of the US, Chinese and Japanese companies respectively. The figures present R&D investment for the 4 main sectors in 2012 and 2021. Each dot represents a sector. If the dot is placed below (above) the diagonal, this means that EU firms are investing more (less) than their counterparts in that sector. The distance from the diagonal represents how much more (less) the firms are investing compared to their counterparts in each sector.

2.2.1 The EU vs the US

In 2012, the EU and the US companies showed a distinctive R&D specialisation: in the automotive sector, the EU companies invested in R&D more than twice as much as their US counterparts. In contrast, in the health industries and ICT producers sectors the EU companies invested only 40% of the amount invested by their US counterparts, whereas in the ICT services sector they invested 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 industries and ICT producers sectors, and 10% in the ICT services sectors.

Figure 2.1 EU-US comparison of R&D investment in 2012 and 2021, by sector



Note: data refers to 502 (EU:149, US:353) of the 834 companies (EU:174, US:660) in the 4 sector groups in the 2 regions considered for which R&D data are available for the entire 2012-2021 period, accounting for 89.6% of the R&D investment in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

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 EU-US R&D intensity gap increased in all high R&D-intensive sectors, especially in ICT services.

The average R&D investment per company for the four sectors has grown substantially in the two regions over the past 10 years. In the EU, it was EUR 466 million in 2012, and grew to EUR 933.5 million in 2021. In the US, it grew from EUR 290 million to EUR 974.4 million.

The trend in the number of companies also reflects 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 dynamics of companies entering and leaving the *Scoreboard* by sector and world region is analysed in Chapter 3. As mentioned 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 industries, where the US dominates.

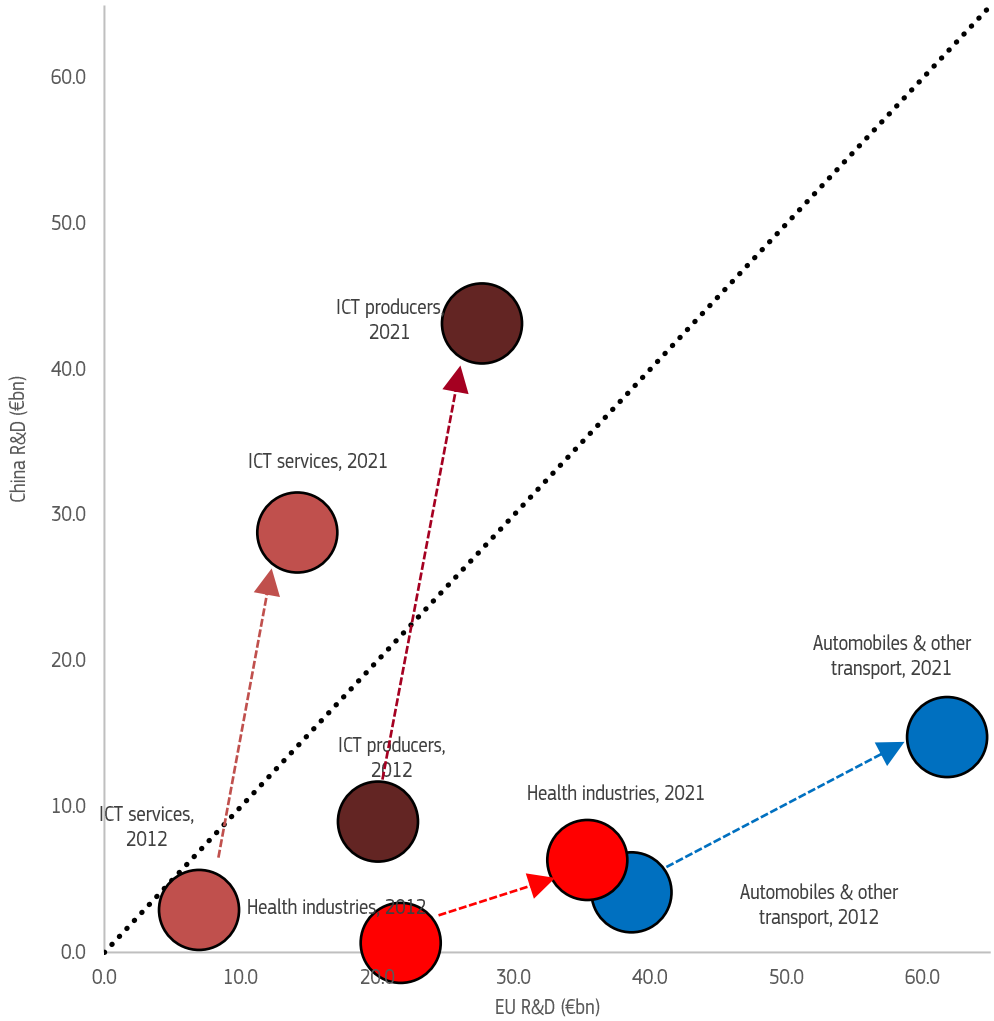
2.2.2 The EU vs China

In 2012, the EU invested more than China in all 4 major sectors under consideration. In the past 10 years, however, the Chinese companies operating in the ICT sectors have increased their R&D investment considerably. 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).

R&D intensity (R&D/net sales) was much higher for the EU companies in 2012 (6.0% vs 3.8%). It has grown in the past decade for the two samples, but at much higher pace for the Chinese companies, which are closing

the gap with the EU (7.0% vs 6.3%). In the ICT services sector, the Chinese companies have overtaken the EU (5.1% vs 6.9%).

Figure 2.2 EU-China comparison of R&D investment in 2012 and 2021 by sector



Note: data refers to 382 (EU:149, CN:233) of the 557 companies (EU:174, CN:383) in the 4 sector groups in the 2 regions considered for which R&D data are available for the entire 2012-2021 period, accounting for 88.0% of the R&D investment in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The average R&D investment per company in the *Scoreboard* grew significantly for both the EU sample and the Chinese sample, however, in 2021 it was still much higher in the EU (EUR 933.5 million vs EUR 399.6 million). This difference can be explained by the fact that more Chinese companies entered into these sectors than EU companies and the new companies inevitably start off in the lower reaches of the *Scoreboard*. See *Scoreboard* companies' dynamics in Chapter 3.

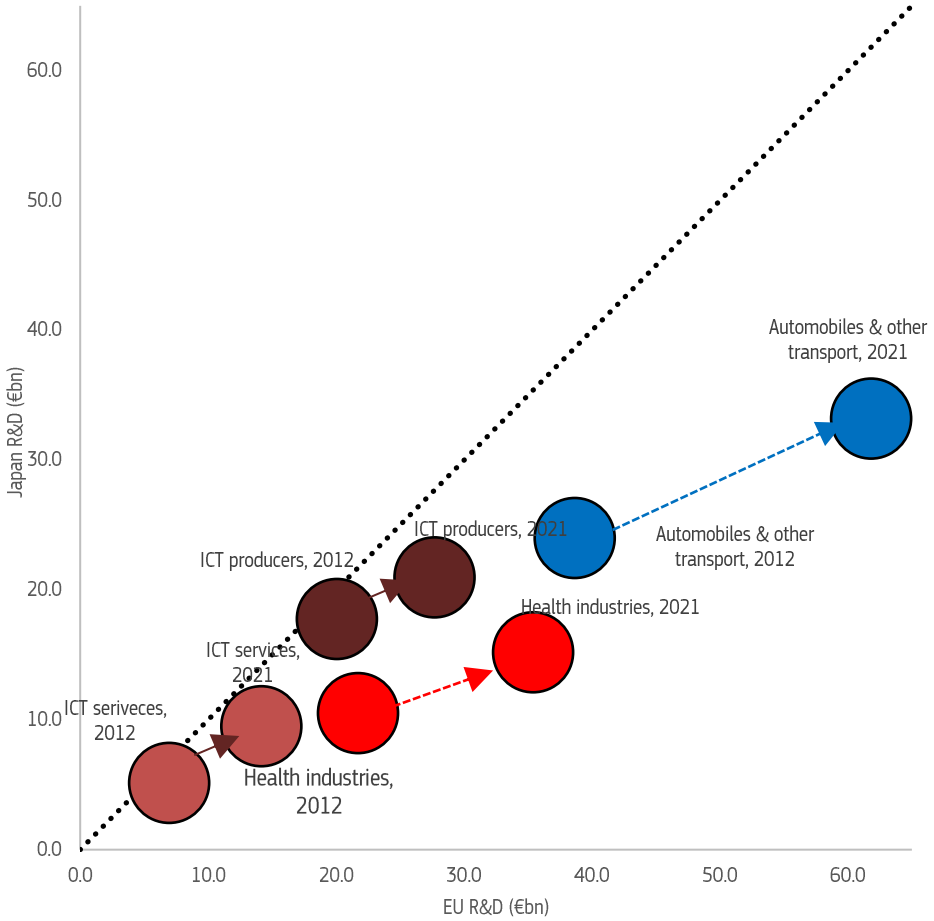
2.2.3 The EU vs Japan

In 2012, the EU companies in the *Scoreboard* invested 1.5 times more than their Japanese counterparts in all 4 major sectors under consideration. In 2021, this difference increased to 1.8 because the number of Japanese companies declined significantly over the past 10 years (see Chapter 3).

In the automotive sector, which is the most important sector for both regions in terms of R&D investment, the ratio of R&D investment between the EU and Japan has increased from 1.6 to 1.9 in the past 10 years.

In the past decade, R&D intensity has grown in the EU, while it remained practically the same for the Japanese companies. This has resulted in the EU having a much higher R&D intensity than Japan in 2021 (7.0% vs 5.3%).

Figure 2.3 EU-Japan comparison of R&D investment in 2012 and 2021 by sector



Note: data refers to 258 (EU:149, JP:109) of the 284 companies (EU:174, JP:110) in the 4 sector groups in the 2 regions considered for which R&D data are available for the entire 2012-2021 period, accounting for 97.5% of R&D investment in 2021.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

The average R&D investment per company has grown more rapidly in the EU than in Japan. In 2021, it was EUR 933.5 million for the EU companies and EUR 718.1 million for their Japanese counterparts.

2.3 Financing companies' innovation activities: Corporate Venture Capital

Corporate Venture Capital (CVC) investment is an innovation investment tool available to large companies to pursue their strategic interests. Its relevance has been steadily increasing during the past 20 years, thus making CVC activities in relation to start-ups and scale-ups an important policy focus. This section uses a matched dataset linking the top R&D investors from the 2020 *Scoreboard* and their subsidiaries with the companies listed as investors in Dealroom.co (DR). The analysis, which was included in the 2021 edition of the *Scoreboard*, comprised 1557 *Scoreboard* companies[44] investing in start-ups and scale-ups in the period 1999-2020.[45] It showed that almost two thirds of the 2500 *Scoreboard* companies invested in CVC, via dedicated

[44] The matching exercise from the 2021 edition of the *Scoreboard* 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 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. 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. 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 (3 745) is higher than the *Scoreboard* companies we can match (1 557).

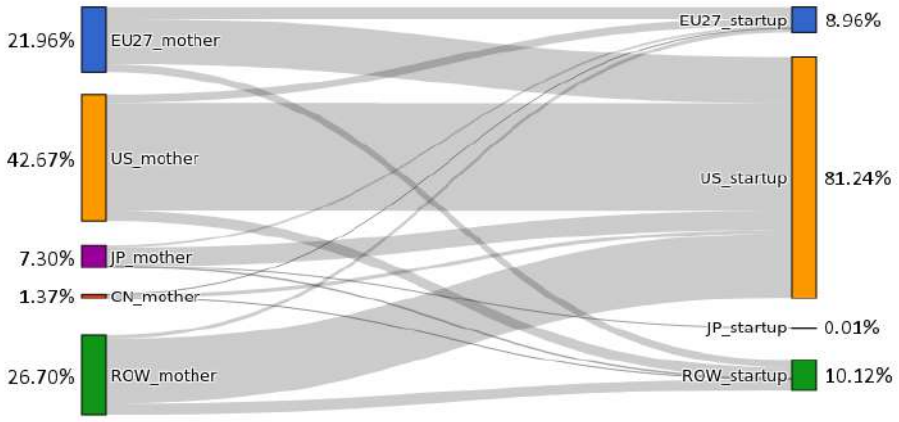
[45] At the time when the *Scoreboard*-Dealroom matching was established, Dealroom reported data about deals and investors from as early as 1999. However, Dealroom was first established only in 2013, suggesting that data referring to previous years might not be

subsidiaries and (less often) directly through the headquarters. Furthermore, an overall upward trend during the whole period was observed, with some slowdowns coinciding with periods of crisis. Total CVC investment grew constantly from USD 3.6 billion[46] in 2013 to USD 14.5 billion in 2019, followed by a small decline in 2020 coinciding with the outbreak of the COVID-19 pandemic. This subsection dives deeper into the geographical and sectoral patterns contained in the data.

CVC investments of EU-headquartered *Scoreboard* companies are 2.4% of own-funded internal R&D, compared to 4% of their US-headquartered peers (see Table 2.9 below); this suggests that, despite its growing importance, CVC still accounts for a relatively small amount of resources compared to R&D investments. The increasing relevance of CVC we observed for *Scoreboard* companies goes hand in hand with the steadily growing importance of venture capital overall. This is testified by the numerous policy schemes deployed over the last two decades to support innovative high-growth start-ups, especially in the early stages of their life[47], which have made access to seed funding considerably easier for innovative growth-oriented start-ups, and have systematically reduced the historical gap in seed funding compared to the US. However, there is still a sizeable gap between the EU and the US in growth funding, particularly for financing large later stage VC rounds, partly due to the smaller size of EU-based VC investors with respect to their non-EU counterparts.[48]

Figure 2.4[49] depicts the shares of early round CVC investment flowing from the world regions hosting the *Scoreboard* companies and their subsidiaries (left side) and the world regions hosting the DR start-ups (right side). The height of each node is proportional, respectively, to the share of total investment made by companies located in the corresponding region or received by start-ups located therein. The plot shows that US-based corporations were responsible for the majority of CVC investment and that US-based start-ups attracted most of it. EU *Scoreboard* companies invested 80% of their VC funds in US-based start-ups. Overall, they invested just around half of their US counterparts in CVC between 2013 and 2020.

Figure 2.4 Corporate Venture Capital investment by headquarter region of *Scoreboard* parent company



Source: JRC own compilation using R&D Scoreboard and Dealroom data.

---

fully consistent with the rest. For this reason, we restrict our attention to the period 2013-2020 throughout the section. The interested reader is referred to the previous edition of the report for further details on the composition of the data sample.

46 Dealroom reports investment in several currencies. Values are converted to 2014 PPP US Dollars for greater comparability.

47 Audretsch, D., Colombelli, A., Grilli, L., Minola, T., & Rasmussen, E. (2020). Innovative start-ups and policy initiatives. Research Policy, 49(10), 104027.

48 Colombo, M., Compaño, R., Napolitano, L., Rentocchini, F. and Tuebke A. "Policy challenges in supporting entrepreneurial ventures" Industrial R&I – JRC Policy Insights, forthcoming.

49 This and the following figures are from JRC analysis based on Dealroom data that was presented at the expert webinar "Tackling the Scale-Up Gap" on October 5th 2021. This webinar was introduced by Commissioner 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.

Despite its increasing relevance, CVC remains small compared to other open innovation strategies available to large corporations (e.g. M&A and R&D alliances)[50] and to internal R&D investment in terms of the amount of resources it mobilises. Nevertheless, it exhibits some interesting patterns.

Table 2.10 reports a regional breakdown of the expenditure in R&D and in CVC by the DR-matched *Scoreboard* companies between 2013 and 2018.[51] Even though in every region the CVC budget is only a small fraction of total R&D spending, it is relatively much more important in the USA than in any other region. The right column of Table 2.10 reports the elasticity of CVC expenditure to R&D spending (how much R&D increases in percentage terms in response to a 1% increase in CVC spending) and shows an overall complementarity between the two variables driven mostly by Japanese and US-based *Scoreboard* companies.

Table 2.10 *Scoreboard* R&D and CVC investment by region (2013-2018)

Sector	CVC/R&D Ratio [%]	R&D-CVC elasticity
EU 27	2.4	0.36
USA	4.0	0.54 *
China	2.6	0.56
Japan	1.2	0.61 *
RoW	1.0	0.001
Total	**2.6**	**0.39 ***

Notes: coefficients in the third column are the coefficients of the R&D variables in the log-log regressions where VC investments is regressed on R&D expenditure at the company level; estimates control for capital expenditure, number of employees and sector and year fixed effects; * asterisks signal a statistically significant effect at the 10% confidence level.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Table 2.11 reports regression coefficients from a sectoral breakdown of the CVC-R&D relation for *Scoreboard* companies and shows an overall positive correlation and complementarity between CVC and R&D in *Scoreboard* companies operating in the health and ICT sectors. The financials and automotive sectors display significantly negative elasticities, suggesting that CVC can be also used to tap into new business sectors.[52] This reveals the strategic interests of top R&D investors, which are looking to complement internal innovation capabilities, enlarge their product portfolio[53], explore new lines of business and/or counteract weaknesses in internal innovation capabilities[54] via CVC.

50 For evidence on the scale of M&A acquisitions by *Scoreboard* companies please refer to section 2.1.4.

51 The analysis is carried out on a restricted time window (2013-2018) due to the inclusion of several relevant balance sheet variables from *Scoreboard* companies (employment, capital expenditure, R&D), which leads to the loss of many observations if extended beyond the window on when the matching (with VC data) was performed.

52 R. Compaño, L. Napolitano, F. Rentocchini, C. Domnick, P. Santoleri, A. Tübke, & P. McCutcheon, Corporate Venturing for R&I: Practitioner's views and policy questions, European Commission, Seville, 2022, JRC130034.

53 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.

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

Table 2.11 *Scoreboard* R&D and CVC investment by sector (2013-2018)

Sector	CVC/R&D Ratio [%]	R&D-CVC elasticity
Aerospace & defence	0.003	
Automobiles & other transport	0.2	-1.10 *
Chemicals	0.1	
Energy	0.3	
Financials	17.7	-1.40 *
Health industries	2.2	0.25 *
ICT producers	3.3	0.02
ICT services	5.6	0.57 *
Industrials	0.5	-0.12
Others	2.5	-0.10
Total	**2.6**	**0.39 ***

Notes: coefficients in the third column are the coefficients of the R&D variables in the log-log regressions where VC investments is regressed on R&D expenditure at the company level; estimates control for capital expenditure, number of employees and sector and year fixed effects; * asterisks signal a statistically significant effect at the 10% confidence level.

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

2.4 Focus on selected sub-sectors: Automotive and semiconductors

This section analyses in further detail the R&D and economic trends of companies operating in two industries for which R&D is a critical competitive factor. The EU is facing major challenges in these industrial sectors, to cope with increasing global competitiveness pressure and the forthcoming industrial green and digital transformations.

2.4.1 Automotive sector

In 2021, the automotive sector was the industry that by far invested 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. However, the EU's lead in this sector is being challenged by two main factors: first, the shift in power source from fossil fuels to electricity, and second, the ongoing digital transformation of the automotive industry.

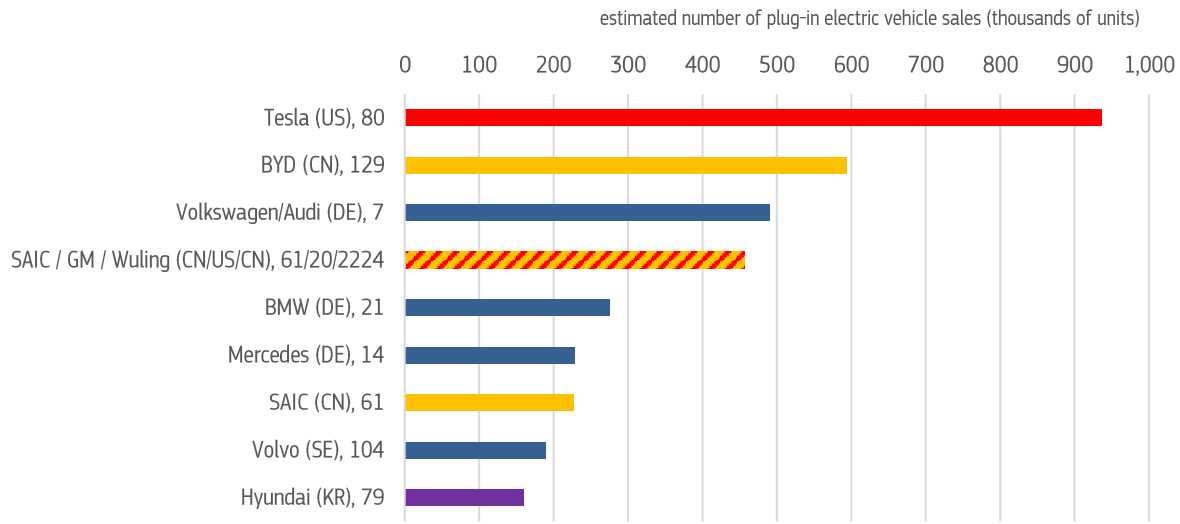
Shift to electric mobility

Worldwide, policy targets to phase out fossil fuels in transport are driving the fast growing sales of electric vehicles (EVs)[55]. From 2012 to 2021, the number of electric cars sold worldwide increased from 120 000 to 16.5 million, accounting for almost 10% of global car sales in 2021.

By world region, China's market is leading the EVs uptake with 3.3 million cars sold, followed by the EU (2.3 million), and the US far behind (0.76 million). By manufacturing company, the market is led by the US company Tesla (which has a factory in China), followed by the Chinese companies BYD and SAIC. There are 4 EU companies in the list of top companies by EV sales in 2021: The German companies Volkswagen, BMW and Mercedes, and the Swedish company Volvo, which is owned by the Chinese Geely Group (see Figure 2.5).

[55] EV market figures taken from "*Global EV Outlook 2022, Securing supplies for an electric future*", International Energy Agency, 2022.

Figure 2.5 Top companies by global sales of EVs in 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.

Plug-in battery electric vehicles (BEVs) now have two key components – the battery and chips/software – with other parts of the vehicle being fairly low technology which is widely available. This creates a difficult situation for the existing large car companies that have to continue to develop and improve their ranges of internal combustion engine cars while simultaneously developing a range of new battery electric vehicles. By contrast, the pure EV companies such as Tesla (and also smaller ones such as Rivian) have a laser focus solely on improving their BEVs and working on future ranges of partly and then fully autonomous vehicles.

These trends are raising new issues related to the supply of critical raw materials (e.g. cobalt, lithium and nickel for batteries), charging infrastructure and recycling. In particular, the supply chain of batteries is currently concentrated in China (producing three quarters of all lithium batteries and accounting for more than half of the processing and refining of the key battery raw materials), whereas Europe produces over one-quarter of the EVs but holds a very small share of the supply chain.

In this context, the EU launched in 2017 the European Battery Alliance aiming to develop an innovative, competitive and sustainable battery value chain in Europe.

Digital transformation

The incorporation of new ICT-based technology is making up a larger proportion of the value added in the whole automotive value chain. For many years, car companies have been using increasing numbers of semiconductor chips and more complex software to improve their vehicles and subsystems, to increase manufacturing productivity and efficiency, reach new markets and optimise supply chains. Nowadays, ICT is enabling new opportunities such as connected vehicles, autonomous driving and mobility services. Following this trend, big tech companies from the ICT industries such as Google, Amazon, Apple, Microsoft and Baidu are investing heavily in the personal mobility market.

R&D and economic trends of top R&D investors in the automotive sector

The main indicators of the automotive sector for the main world regions are summarised in Table 2.12.

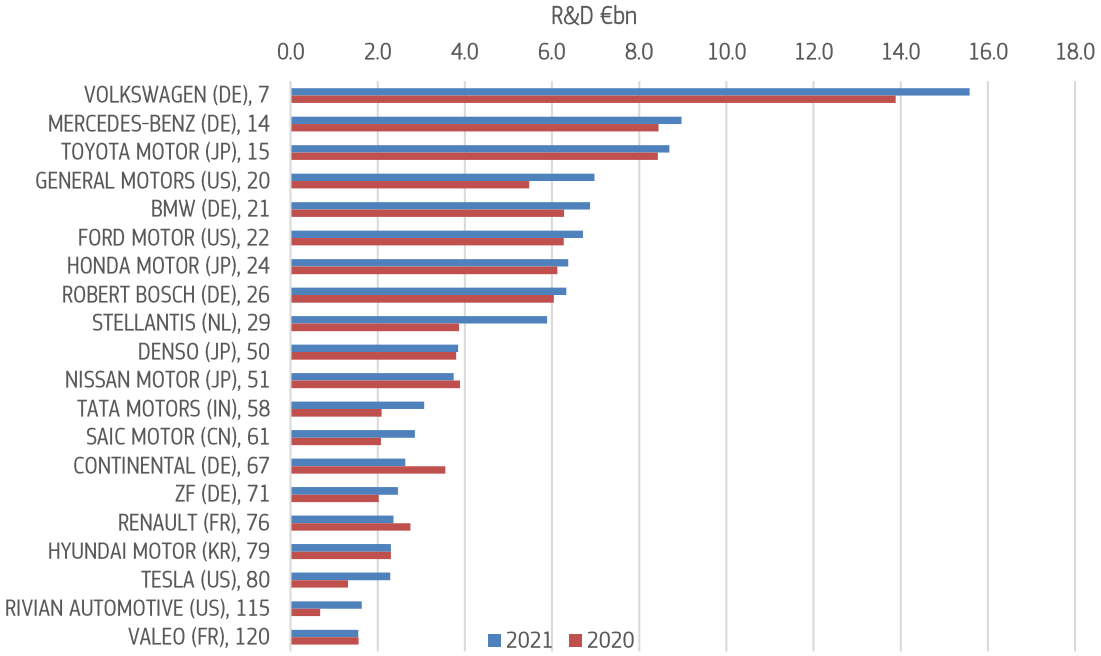
Table 2.12 Automotive R&D and financial indicators for main world regions

	EU	US	China	Japan	RoW	Total
Number of firms	34	37	54	28	27	180
R&D in 2021, EUR bn	62.6	27.6	18	33.2	11	152.4
Net Sales, EUR bn	1118.2	507.8	403.2	749.6	330.7	3109.6
R&D intensity, %	5.7	6.1	4.6	4.5	3.3	5
Capex, EUR bn	38.7	38.3	15	52.3	11.4	155.7
Capex / net sales, %	4.1	10.6	4.8	7.4	3.9	5.9
Profitability, %	9	6.1	1.8	7.3	5.6	7
Employees, million	2.9	0.8	1.1	1.7	0.5	7
Sales/employee, EUR k	352.3	445.2	291.1	413.1	205.7	357.8

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

Figure 2.6 shows the top 20 automotive companies ranked by amount of R&D investment. As in other sectors, R&D investment by company is highly concentrated: these 20 companies account for 73% of total R&D investment of the automotive sector. Unfortunately, companies do not give enough information about their R&D strategies to enable their R&D on electric vehicles and autonomous driving to be separated from conventional automotive R&D on internal combustion engine vehicles.

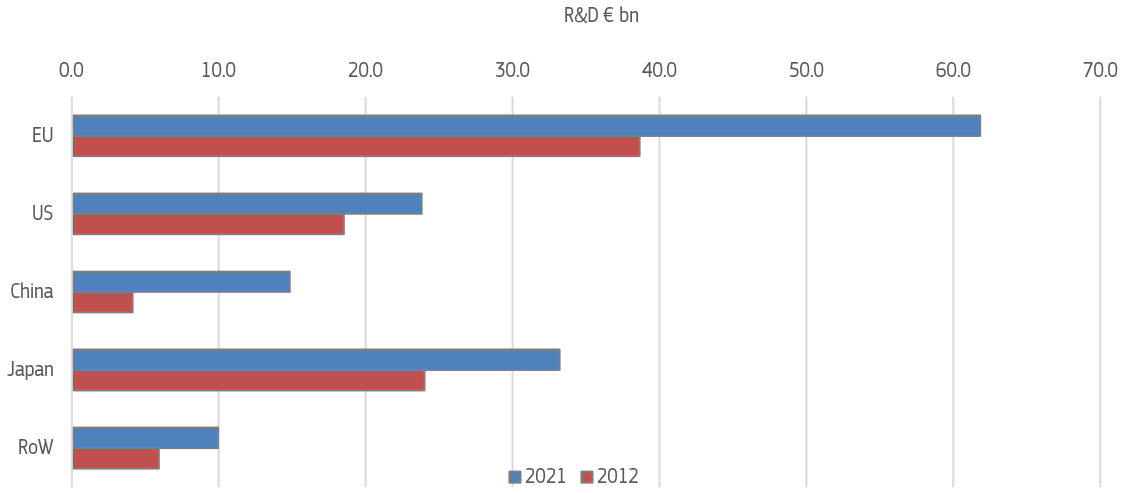
Figure 2.6 Top 20 automotive companies ranked by level of R&D investment in 2021



Note: the number after the country code indicates the position in the global Scoreboard ranking.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 2.7 compares the R&D investment of the automotive sector for the main regions over the past 10 years, including only those companies that have been present in the *Scoreboard* since 2012, i.e. 121 (out of 147) companies, accounting for 94% of total R&D investment of the sector in 2021.

Figure 2.7 R&D investment in the automotive sector for main world regions in 2012 and 2021



Note: data refers to 121 companies (out of 147 in the sector) for which R&D data are available for the both years, accounting for 94.0% of R&D investment in 2021.

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

2.4.2 Semiconductors[56]

Semiconductor chips[57] are indispensable components of electronic devices. They are enablers for the whole value chain of key industries, such as ICT, automotive, health, food, energy, and environment sectors. Moreover, chips are expected to play a central role for technological leadership[58] in space, science, artificial intelligence, electric mobility, aerospace and defence equipment.

In 1990 the chip manufacturing market was fully controlled by three regions[59]: Europe (44% market share), the US (37%) and Japan (19%). Over the past three decades, Europe and the US radically reduced their market share to 9% and 12% respectively and chip manufacturing shifted to Asia, namely to Taiwan, South Korea and China. In 2020 their market share was as follows: Taiwan 22%, South Korea 21% and China 15%.

Over the past couple of years, the semiconductor industry attracted much policy attention worldwide due to an exceptional chip shortage, mostly because of the pandemic, that severely hurt a wide range of industries including automotive. To address this issue, a number of policy measures have been launched to improve the chip supply chain's resilience and to reduce dependence on foreign countries. In fact, no country nor any world region is able to control the entire chip-making supply chain, which involves complex design, equipment, processing technology, materials and chemicals.

At present, in the semiconductor industry, chip design is led by US companies, and manufacturing is led by companies based in Taiwan and South Korea. The EU hosts few players in two key segments of the semiconductor value chain, i.e. chip design and manufacturing.

R&D and economic trends of top R&D investors in the semiconductor industry

The main indicators of the semiconductor sector for the main world regions are summarised in Table 2.13. This table includes companies classified in the *Scoreboard* in the semiconductor sector and 3 companies classified in other sectors but showing strong activity in the semiconductor sector (Apple, Samsung and Qualcomm).

---

56 Some leading companies in the semiconductor industry operate in several sectors. For example, in the *Scoreboard*, Apple, Samsung and Qualcomm are classified in a different industrial sector.

57 A chip is a set of electronic circuits on one small flat piece or "chip" of semiconductor material, usually silicon.

58 The scramble for semiconductors is our era's industrial Great Game, *Financial Times*, 27/01/2022.

59 SMC: the Taiwanese chipmaker caught up in the tech cold war; *Financial Times*, 24/10/2022.

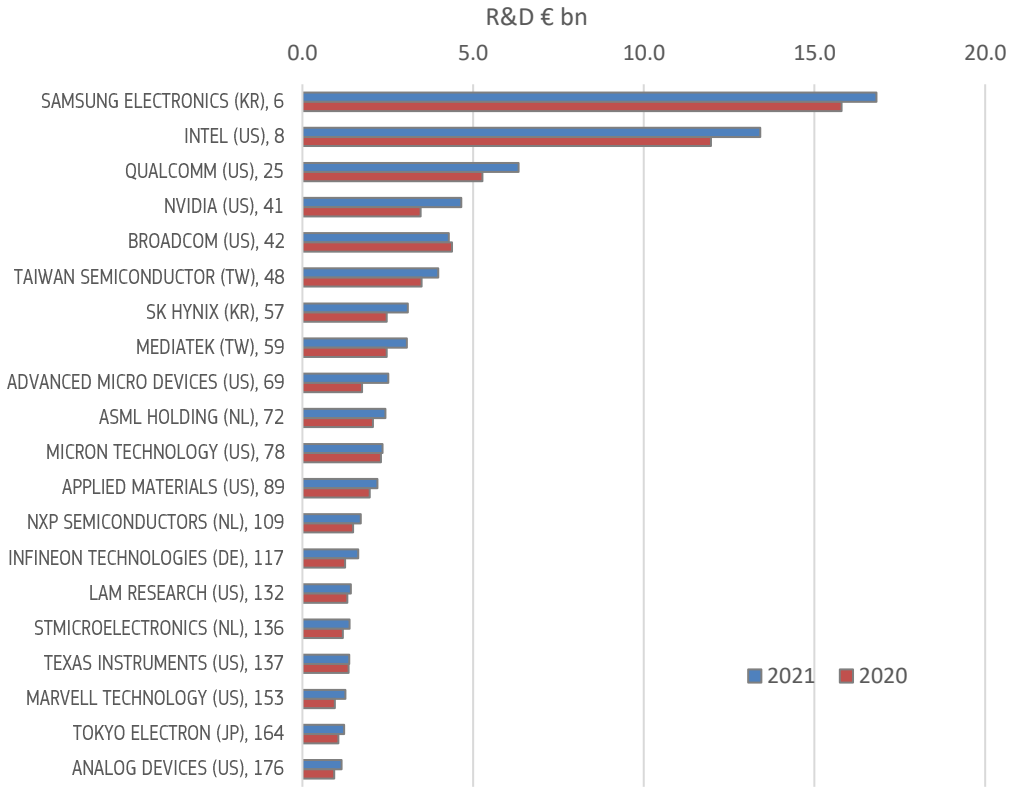
Table 2.13 Semiconductors' R&D and financial indicators for regions/countries

	EU	US	China	Japan	Taiwan	South Korea	Total
Number of firms	9	39	11	8	18	4	89
R&D in 2021, EUR bn	8.2	47.9	2.2	2.5	10.0	20.1	90.9
Net Sales, EUR bn	59.2	304.0	46.3	31.0	93.8	241.9	776.1
R&D intensity, %	13.9	15.8	4.7	8.1	10.7	8.3	11.7
Capex, EUR bn	4.9	37.5	7.8	1.8	30.6	47.3	129.9
Capex / net sales, %	8.4	12.3	16.8	5.8	32.6	19.5	16.7
Profitability, %	24.6	28.8	9.0	25.4	32.3	19.8	24.8

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

Figure 2.8 shows the top 20 semiconductor companies ranked by volume of R&D investment. As in other sectors, R&D investment is highly concentrated, these 20 companies account for 85% of total R&D of the semiconductor sector.

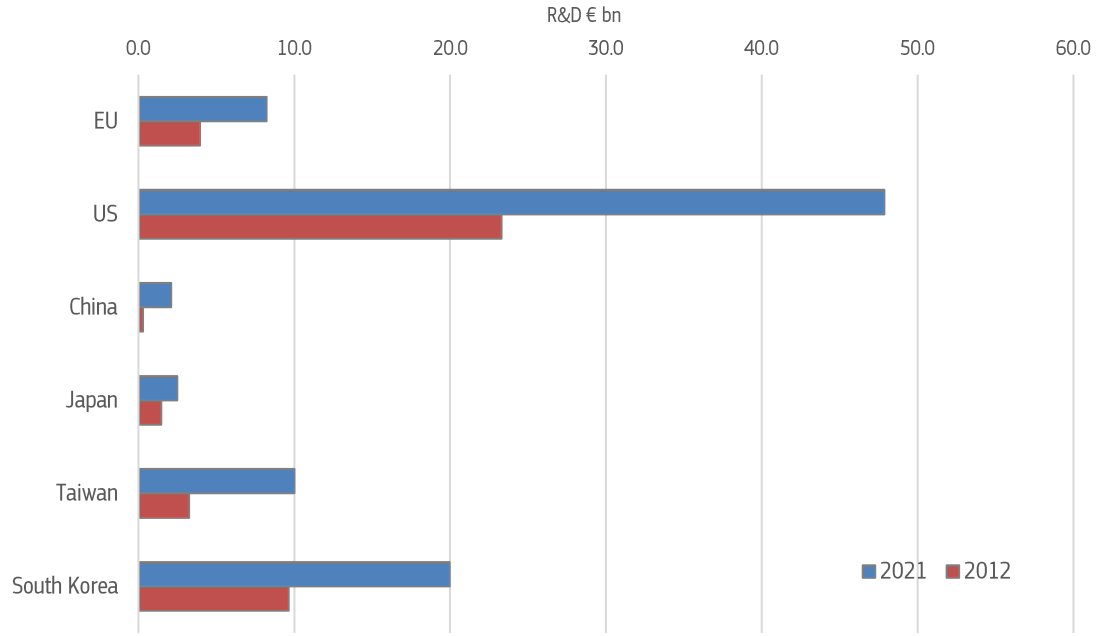
Figure 2.8 Top 20 Semiconductors companies ranked by volume of R&D investment in 2021



Note: The number after the country code indicates the position in the global Scoreboard ranking.
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG R&I.

Figure 2.9 compares the R&D investment of the semiconductor sector for the main regions over the past 10 years, including only those companies that have been present in the *Scoreboard* since 2012, i.e. 88 (out of 90) companies, accounting for 99.8% of total R&D investment in 2021.

Figure 2.9 R&D investment in the semiconductors sector in 2012 and 2021 for regions/countries



Note: data refers to 87 companies (out of 89 in the sector) for which R&D data are available for the both years, accounting for 99.8% of the R&D in 2021.

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

2.5 Key points

- The ICT services sector is led by the US whose R&D in this sector has more than tripled over the last 10 years. China is in second place but with less than one quarter of the US's R&D, even though its R&D in this sector has increased by almost ten times over the decade. The EU has just over half of the R&D of China with Japan in fourth place with around two-thirds of EU R&D.
- The biotech sector is also led by the US with over two-and-a-half times the R&D of the EU in second place. Japan is in third place with less than half of the EU's R&D and China follows with around half the R&D of Japan. The US is particularly strong in biotechnology and several US pharmaceutical companies have enhanced their pipelines of new drugs by acquiring biotech companies.
- The ICT producers' sector is again led by the US with more than twice the R&D of China. The EU has around two-thirds of China's R&D in this sector with Japan around two-thirds of the EU's.
- The automotive sector is led by the EU with nearly twice the R&D of Japan. The US has around two-thirds the R&D of Japan with China following with about half of Japan's R&D.
- Overall, the EU companies lead the automotive sector. They have much larger R&D investment, larger sales, larger profitability and more employees than their competitors. There are 9 EU companies among the top 20 companies by R&D investment, and 4 EU companies among the top 9 companies by EV sales.
- Japanese companies are still the sector's second R&D investor but over the past 10 years their number in the *Scoreboard* decreased significantly and their volume of R&D increased much less than that of their EU counterparts.
- Compared with the 2012 *Scoreboard*, in 2021 the automotive sector includes less EU companies, the same number of US companies and many more Chinese companies. Some of the new companies such as Tesla and Rivian only operate in the EV market.
- Over the past 10 years, the automotive companies' R&D intensity has grown worldwide, but more rapidly for the US and Chinese companies. Consequently, in 2021, the US and Chinese companies reduced significantly their R&D intensity gap with the EU in the automotive sector.
- The shift to electric mobility and the digitalisation of the automotive industry increases competition, with the arrival of new pure EV automotive companies and players from ICT industries. This is challenging the

leadership of the EU, which needs to react, taking the new business opportunities and overcoming the barriers arising in the reshaped value chain of the automotive industry.

— The US companies dominates the semiconductor sector, especially in the high R&D-intensive segment of chip design. They have the largest number of companies and their R&D investment and net sales are larger than those of the other world regions together (6 times more R&D investment 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, R&D investment in semiconductors has increased significantly across all world regions but especially in China: the Chinese companies' R&D investment multiplied by seven in this period. However, in 2021, Chinese companies' R&D investment was still much lower than that of their US, South Korean, Taiwanese and EU counterparts.

— The average R&D intensity of the EU companies is larger than that of Chinese, Japanese, Korean and Taiwanese companies, suggesting they operate in the high R&D-intensive segment of the semiconductor value chain.

— Semiconductor manufacturing is very capital intensive as can be seen from the very high capital investments of the US, Taiwan and South Korea. The advent of 5G and other demands mean that TSMC alone announced in January 2022 that it would make capital investments of USD 40 bn to USD 44 bn during 2022. This illustrates the scale of investment needed to remain world class in this industry.

— Semiconductors is a strategic sector where EU companies are underrepresented in key segments of the value chain, i.e. chip design and manufacturing. There is a need to stimulate the creation and scale-up of more EU companies, identifying the most promising and critical technologies for development in the EU, and attracting investment in selected high value-added segments of the supply chain. In this context, the EU launched in 2022 the European Chips Act aiming to increase resilience to supply chains disruptions and to increase its global share in manufacturing.

3 Scoreboard dynamics between 2012 and 2022

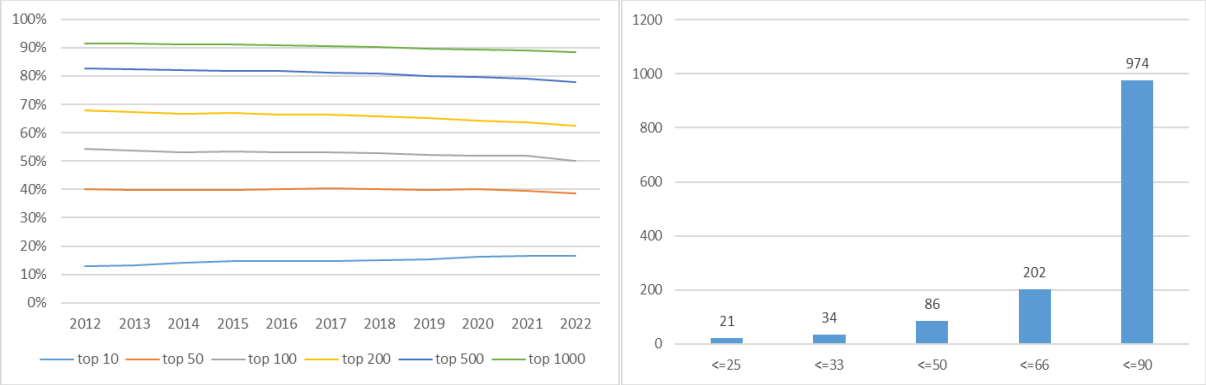
This chapter describes the dynamics of the *Scoreboard* between 2012 and 2022 in terms of changes in the number of companies and R&D invested. The approach is geographic and sectoral, and the focus is on the four main investor regions (the US, the EU, Japan and China) as well as the three major R&D investor sectors, namely ICT, health and automotive. The chapter describes more general decade long trends and it provides an analysis of the dynamics between the two end years of the period under scrutiny. It encompasses an assessment of the top 10 and top 50 R&D investors worldwide, of rank changes in the common set of *Scoreboard* 2012 and 2022 (1228 companies), and of the companies entering and exiting these two *Scoreboards*.

3.1 General R&D trends over 10 years in the main geographical regions and industrial sectors

Concentration[60] of the number of companies and R&D investments

Throughout the last decade, the EU Industrial R&D Investment Scoreboard has been weighted towards the largest companies in the sample. The top 50 companies invest around 40% of the total R&D of all 2500 companies. Below the top 50 the concentration in terms of R&D investment starts to decrease, with the top 100 companies investing in R&D somewhat more than half of the total 2500 Scoreboard companies. The top 500 firms invest 80% of the total R&D (Figure 3.1, left). In terms of number of companies, a mere 85 firms invest half of the total and the first 200 companies about two-thirds.

Figure 3.1 Concentration total R&D investment in *Scoreboards* 2012-2022

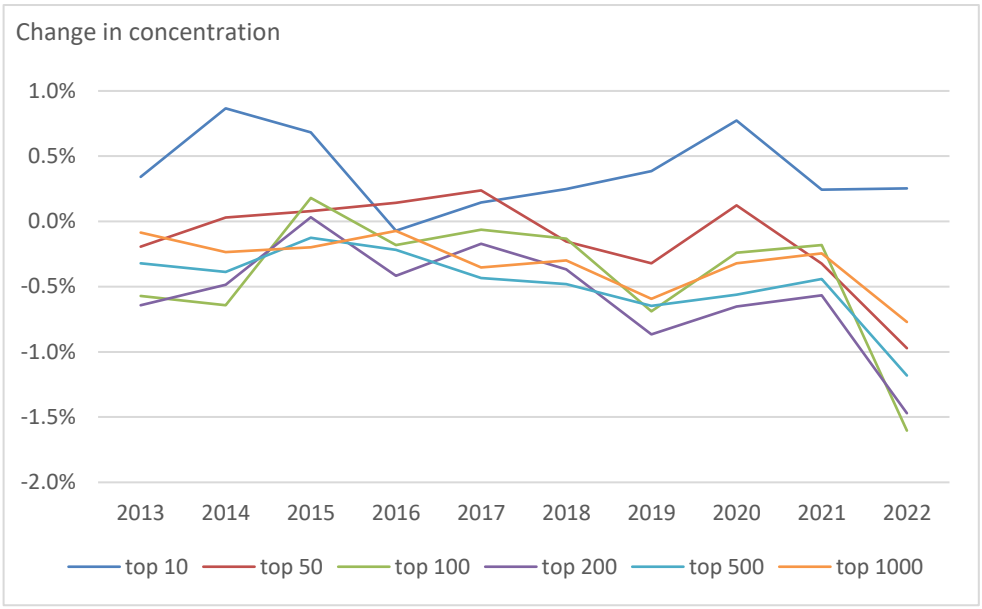


Note: Left panel: Share of R&D invested by the top k (k=10, 50,...) R&D investing companies *Scoreboards* 2012-2022; Right Panel: Number of companies accounting for 25%, 33%,... of the total R&D investments in *Scoreboards* 2012-2022, average
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

The differences in the cumulative shares of R&D investment of the first k companies (k ranging from 1 to 2500) from one year to another over the analysed period are minor. The significant skewness of the distribution is clearly visible also from the 10-year average shares (Figure A 1 in Annex 3), showing that global R&D is concentrated in a rather limited number of companies. However, apart from the top 10, the concentration seems to have slightly decreased over time, which, together with the overall significant increase of the R&D expenditures points towards some decrease of the concentration (Figure 3.2, Table A 1).

[60] Defined as the cumulative share of R&D investment across companies

Figure 3.2 Year-on-year changes in the cumulated shares of R&D investment in SB2012-2022



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

Number of companies – main geographical regions

The largest share of the top 2500 R&D investors was headquartered in the US throughout the whole period. They are also the most numerous in almost every quintile group, as well as in the top 10, top 50 and top 100 (see Figure 3.3). The number of EU companies decreased overall by a net[61] 13 companies on average per year. While in the top 500 the decrease was only marginal (1.2 companies on average per year), the number of EU companies in the lowest quintile group almost halved, from 103 companies in 2012 down to 56 by 2022. The main reason behind this are mergers and company reorganisations, as well as R&D investment being too low to reach the threshold of the 2500, implying relatively low growth amongst small up-and-coming companies (Table 3.1).

Table 3.1 Main reasons for EU companies exiting the *Scoreboard*

Number of companies	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
M&A, ownership*	9	12	20	8	15	7	6	6	10	8
Too low R&D	0	16	4	6	2	2	1	0	2	3
Liquidation	2	3	1	1	0	0	0	0	1	
Other **	6	4	0	4	8	2	2	3	5	7
Total	17	35	25	19	25	11	9	9	18	18

*: reorganisations mainly, HQ change, name change

**: mainly data related, such as still undisclosed data at the cut-off date

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

The main increase in the number of Chinese companies took place in the lower quintiles as well as in the ranks 101-500). The increase in their number in the top 100 is also large (5 times), and in 2022 there were 16 Chinese companies in this group. Of the four main regions, Japan lost the largest number of companies in the *Scoreboard*, on average 18 companies exited every year. They lost ground in every quintile as well as in the top 10, 50 and 100 (Figure 3.3 and Figure A 2 in Annex 3). A more detailed analysis on sectors is provided in Section 3.3.

[61] The difference between the number of companies entering and exiting the *Scoreboard*.

Figure 3.3 Main changes in the number of companies by country/region

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

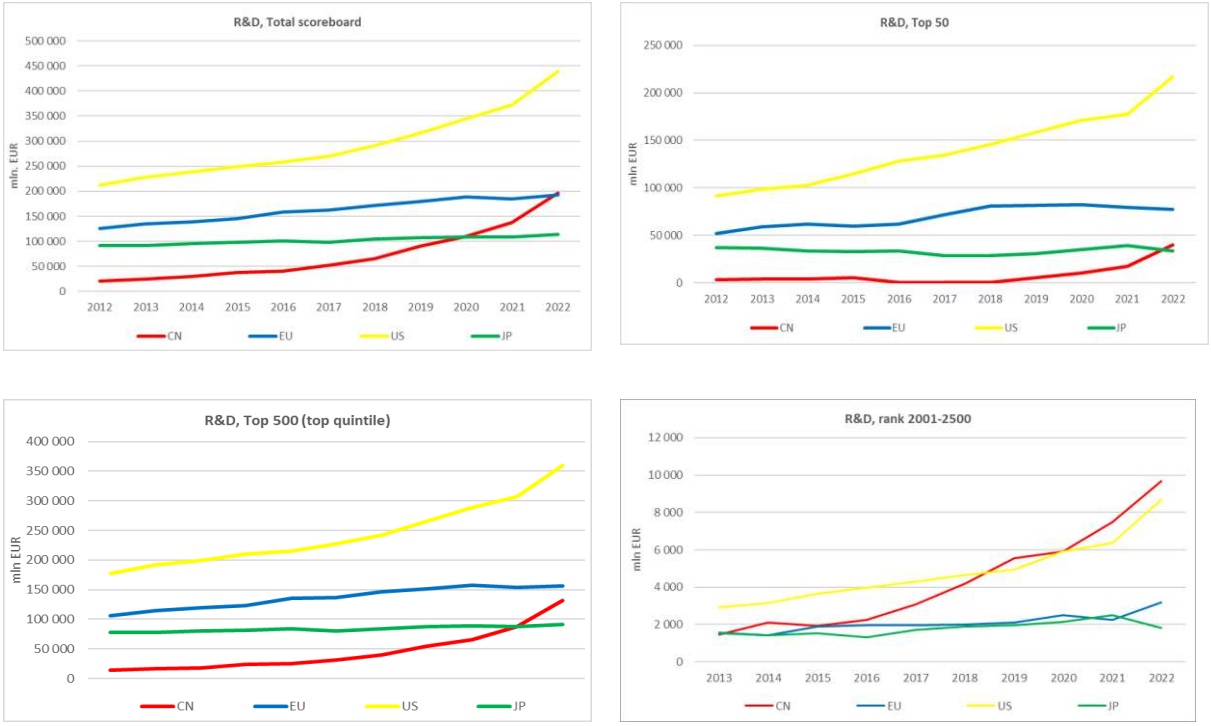
R&D investment – main geographical regions

The US is by far the largest R&D investor of the last decade, both overall and in every quintile groups, except for the lowest quintile where it was overtaken by China in 2018. This means that the largest percentage of the cohort of the 500 smallest R&D investors just reaching the *Scoreboard* threshold is nowadays from China. EU headquartered companies have been strongly represented in the top 50 and top 100, but are overtaken by China for the 101-500 ranks onward. The 10-year compound annual growth rate (CAGR) of R&D investment of EU companies in the *Scoreboard* (4.3%) is moderate, and below that of the entire *Scoreboard* (7.2%), the US (7.5%), and China (25%) – with the latter having invested massively in R&D and overtook the EU in 2022, being now the second largest R&D investing region after the US. Chinese R&D has significantly increased overall in the *Scoreboard*,[62] only in the top quintile the increase was somewhat smaller. The growth of in Chinese companies' R&D investment in the top 50 is impressive (CAGR of 29%), but their main increase is in the group of the top 51-100 companies[63]. Japanese companies dropped out of the top 10 in 2016/2017, and Japanese R&D investment seems to have been almost stagnating overall (Figure 3.4).

62 Especially since 2018, which may to some extent stem from a certain improvement of the data disclosure – see methodological annex for further details

63 This group already has a much lower share in total R&D than the top 50; see Figure 3.1.

Figure 3.4 Main developments of R&D by country/region, EUR million



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

3.2 Now and then: Top rankings in the 2012 and 2022 *Scoreboards*

Top 10

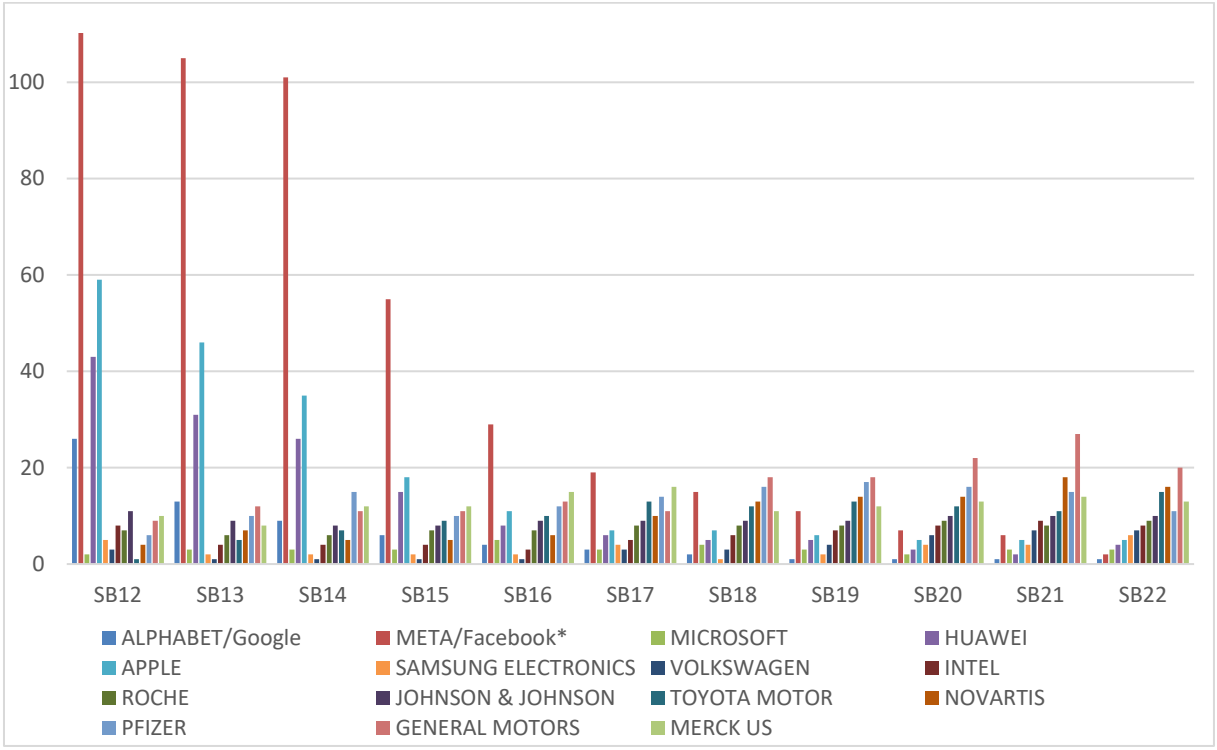
15 different companies appear in the top 10 of both the 2012 and the 2022 *Scoreboard*. At first sight, this shows a rather high turnover[64], with 5 new companies in the top 10 in 2022. However, apart from Facebook/Meta the same 9 companies have populated the top 10 since the *Scoreboard* 2017 (Figure 3.5). Furthermore, their investment share of the 2 500 companies is rather stable and has even increased slightly, as seen in Figure 3.2. This points to a stability in R&D investments of the key R&D investors. Their total R&D investment was EUR 182.2 billion in *Scoreboard* 2012, which represents a compound average growth rate (CAGR) of 9.3% since 2012, higher than that of the entire *Scoreboard*, which was 7.2% (Table 3.1). The highest CAGR was registered by Facebook/Meta (52%), followed by Apple (25%), Huawei (20%), and Alphabet (20%). Acquisitions made by these companies played a significant role in this impressive growth[65]. The other companies of the top 10 had single digit R&D growth.

Facebook/Meta, Apple and Huawei have seen the greatest improvements of their rankings during the assessed period, with Meta encountering the sharpest increase in its ranking, starting with a jump from the 297th position to 105 in the 2013 Scoreboard and to rank 55 in 2015 from the 101st rank of the previous year (Figure 3.5).

64 The number of companies that are no longer present in the group in a certain year compared to a previous year.

65 https://tracxn.com/d/acquisitions/acquisitionsbyApple, https://en.wikipedia.org/wiki/List_of_mergers_and_acquisitions_by_Apple, https://www.titlemax.com/discovery-center/lifestyle/everything-facebook-owns-mergers-and-acquisitions-from-the-past-15-years/, https://en.wikipedia.org/wiki/List_of_mergers_and_acquisitions_by_Meta_Platforms, https://en.wikipedia.org/wiki/List_of_mergers_and_acquisitions_by_Alphabet

Figure 3.5 Changes in the rankings of the *Scoreboard* 2022 top 10 companies, 2012-2022



*: Facebook/Meta ranked 297 in 2012. Lowest rank is 110 for a better readability.

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

As previously mentioned, the average annual growth rate of R&D investment by the 2 500 *Scoreboard* companies was 7.2%, which resulted in a close to doubling of the total R&D investment since 2012, reaching EUR 1 094 billion in the 2022 *Scoreboard*. About one fifth (19.6%) of the overall increase came from the top 10 investors in the 2022 *Scoreboard*. The 16.7% R&D investment share of the top 10 in 2022 is rather high and has increased since over the past 10 years (13.7%).[66]

In the top 10 of the 2012 *Scoreboard* the US was present with 5 companies, followed by Switzerland with 2, as well as South Korea, Japan, and Germany with one company each. By 2022, the US dominance continued (6 companies), one of the Swiss companies (Novartis) dropped out together with Toyota, the only Japanese company in the top 10. One Chinese company (Huawei) got into the group; South Korea and the EU are represented with one company each. Sector-wise the ICT sectors (producers and services) dominate with 7 companies out of 10, accounting for 77% of the total of the top 10 R&D investment. This is a radical change compared to 10 years ago, when the amount of R&D investment of top 10 was more evenly distributed among the health (41%), ICT (32%) and automotive (27%) sectors (Table 3.2)[67].

Table 3.2 Top 10 investors in R&D in 2012 and 2022, EUR million

RANK 2022	RANK 2012	COMPANY	COUNTRY	SECTOR	R&D 2022	R&D 2012*	CAGR, %
1	26	Alphabet	US	ICT services	27 867	4 558	19.8
2	297	Meta	US	ICT services	21 768	343	51.5
3	2	Microsoft	US	ICT services	21 642	8 662	9.6
4	43	Huawei	CN	ICT producers	19 534	3 122	20.1
5	59	Apple	US	ICT producers	19 348	2 145	24.6
6	5	Samsung Electronics	KR	ICT producers	16 813	7 604	8.3

66 12.8%, using the original SB2012 series. Note: for intertemporal comparisons of the 2012 and 2022 figures we used the R&D investment series of the 2012 *Scoreboard* expressed in original currency and applied the 2022 euro exchange rates.

67 Note that Amazon is not included in the 2022 top 10. This is because Amazon accounts do not separate its R&D and content investments so its R&D cannot be included. However, we estimate that Amazon invests more than Alphabet in R&D so it would be at #1 were it to be included. This addition would increase the top 10's R&D and the US share of R&D, and it would mean J&J dropping out of the 2022 top 10 and the number of ICT companies accounting for 8 of the top 10.

7	3	Volkswagen	DE	Automobiles & o.t.	15 583	7 203	8.0
8	8	Intel	US	ICT producers	13 412	7 372	6.2
9	7	Roche	CH	Health industries	13 261	7 810	5.4
10	11	Johnson & Johnson	US	Health industries	12 991	6 664	6.9
15	1	Toyota Motor	JP	Automobiles & o.t.	8 691	6 029	3.7
16	4	Novartis	CH	Health industries	7 983	7 998	0.0
11	6	Pfizer	US	Health industries	10 239	7 775	2.8
20	9	General Motors	US	Automobiles & o.t.	6 975	7 173	-0.3
13	10	Merck US	US	Health industries	9 134	6 957	2.8
TOTAL TOP 10					**182 219**	**74 584**	**9.3**
TOTAL TOP 2500					1 093 860	545 757	7.2
SHARE OF TOP 10 IN TOTAL TOP 2500, %					16.7	13.7	

*: recalculated figure using 2022 national currency exchange rates to euro (see **Table A 1** in Annex 2)

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

Top 50

As stated earlier (Figure 3.1, left) the top 50 is the group of companies in the *Scoreboard* that accounts for the largest average share of R&D investment for the key sectors (i.e. automotive, ICT, health), i.e. around 40% of total R&D investment. These 50 companies may therefore be considered the backbone of the *Scoreboard* (Figure 3.6).

14 companies (i.e. 28% of the total) 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* previously under these names. However, two of the predecessors of Stellantis (Fiat and Peugeot) as well as one of Abbvie (Abbot) were already included also in 2012, in or close to the top 50 (Abbot ranked 35th, Peugeot 45th , and Fiat 52nd). This turnover does not seem to be high over such a long time span, which again highlights the persistence in the top 50.

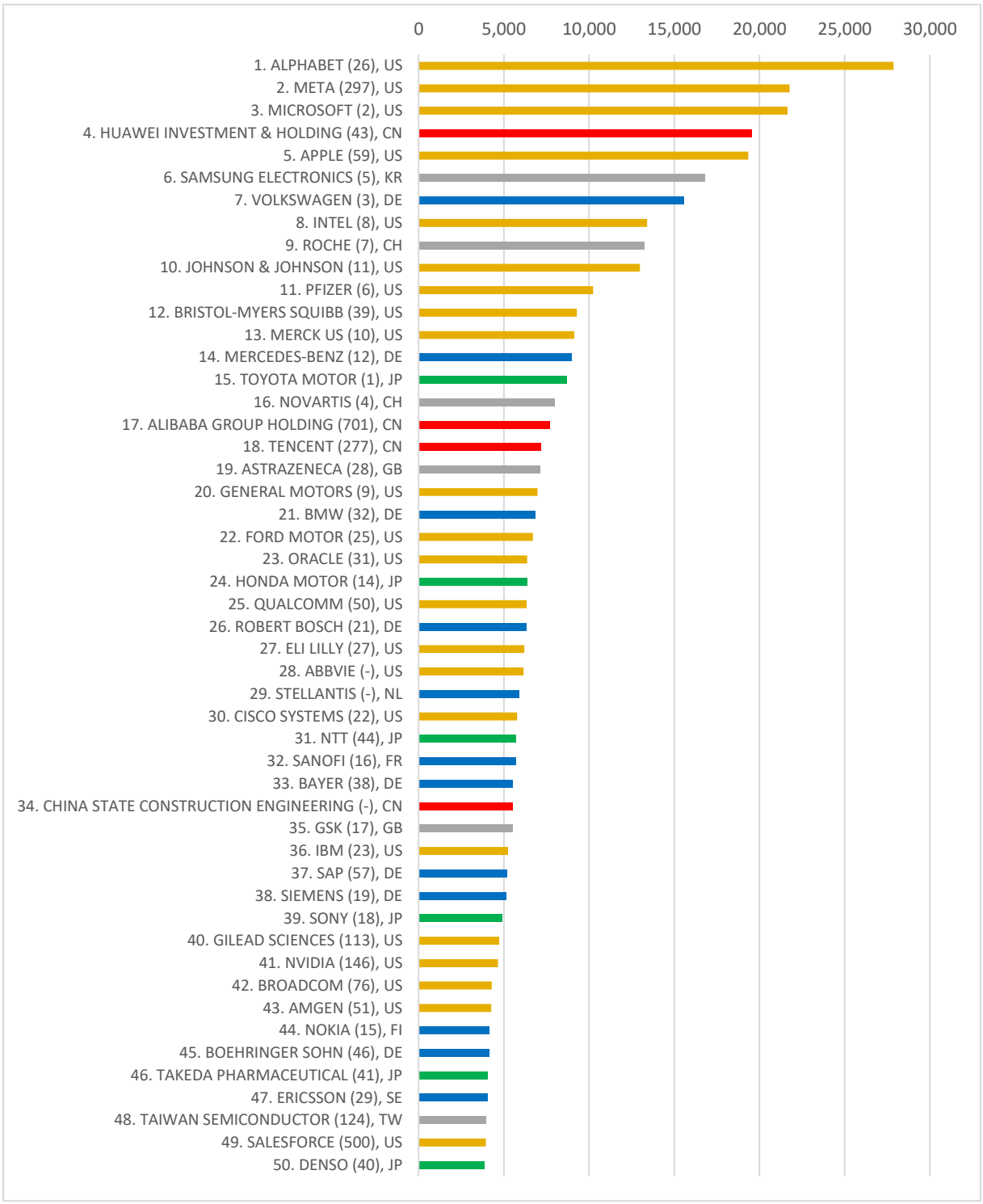
Among the 14 entrants, the ICT sectors dominate with 9 companies. They are followed by health (3) as well as construction and automotive with one each. The share of ICT companies R&D in the total top 50 increased significantly to 52% in 2022, from 36% in 2012. Although increasing in terms of number, the R&D share of health companies in the top 50 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.

Region wise, similarly to the top 10, the top 50 is dominated by US companies, mainly ICT firms, but also from the health sector, in line the strength of these two sectors in the US economy. Their share in the top 50 is lower than in the top 10, stressing that US tech companies are top ranked in the *Scoreboard*. The US presence has strengthened also 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 R&D of the *Scoreboard*. (Table 3.2).

The main exiting companies are from Japan, their number in the top 50 of the 2022 *Scoreboard* 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.

There are currently 12 EU companies in the top 50, which is one company less than 10 years ago (Airbus, ranked 60 in 2022). 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 other EU headquartered companies present in 2012 are still there also in 2022. 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. Moreover, with the exception of SAP (ranked 57th in *Scoreboard* 2012) and Stellantis (already discussed) every EU company that is in the top 50 in *Scoreboard* 2022 was also in the top 50 10 years ago. However, the ranks of EU companies in this group has worsened, mainly due to the previously mentioned strong US presence in the top half. The EU is still the second largest R&D investor of the group of 50 behind the US. However, the average growth of EU R&D investments in the group is moderate (CAGR of 4%), less than half of the US growth (9%) or that of the total *Scoreboard* (7.2%). The growth of EU R&D investment is driven mainly by the automotive sector (CAGR 7%).

Figure 3.6 Top 50 investors in R&D in 2022 (rank 2012 in parentheses), EUR million



Colour code: US = ochre, China=red, EU=blue, Japan=green, RoW=grey

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

Although China is now number 2 after the US in the *Scoreboard* with respect to companies and R&D, its presence in the top 50 with only 4 companies is still modest. However, it seems that its investments have expanded rapidly, it has already overtaken Japan. Its presence is increasing, mainly in the two ICT sectors (Figure 3.6 and Table 3.3).

Table 3.3 Top 50 investors in R&D in *Scoreboard* 2012 and 2022 by region and by sector

	number of companies						R&D investment*						
	EU	US	JP	CN	RoW	Total	EU	US	JP	CN	RoW	Total	Total, %
							2012						
Automotive	5	2	4	0	0	11	23 081	11 852	15 663	0	0	50 597	23%
Health industries	3	6	1	0	4	14	10 356	32 865	2 179	0	24 343	69 744	32%
ICT producers	4	4	2	1	2	13	14 886	17 735	5 569	3 122	11 101	52 412	24%
ICT services	0	4	2	0	0	6	0	22 033	3 914	0	0	25 947	12%
Others	1	2	3	0	0	6	3 249	7 229	9 966	0	0	20 444	9%
Total	13	18	12	1	6	50	51 572	91 715	37 291	3 122	35 444	219 143	
							2022						
Automotive	5	2	3	0	0	10	43 643	13 685	18 910	0	0	76 239	18%
Health industries	3	8	1	0	4	16	15 331	63 005	4 065	0	33 855	116 256	27%
ICT producers	3	6	0	1	2	12	13 323	53 815	0	19 534	20 790	107 462	25%
ICT services	1	6	1	2	0	10	5 168	86 842	5 732	14 878	0	112 620	27%
Others	0	0	1	1	0	2	0	0	4 902	5 509	0	10 411	2%
Total	12	22	6	4	6	50	77 465	217 348	33 609	39 921	54 645	422 988	
						CAGR	4%	9%	-1%	29%	4%	7%	

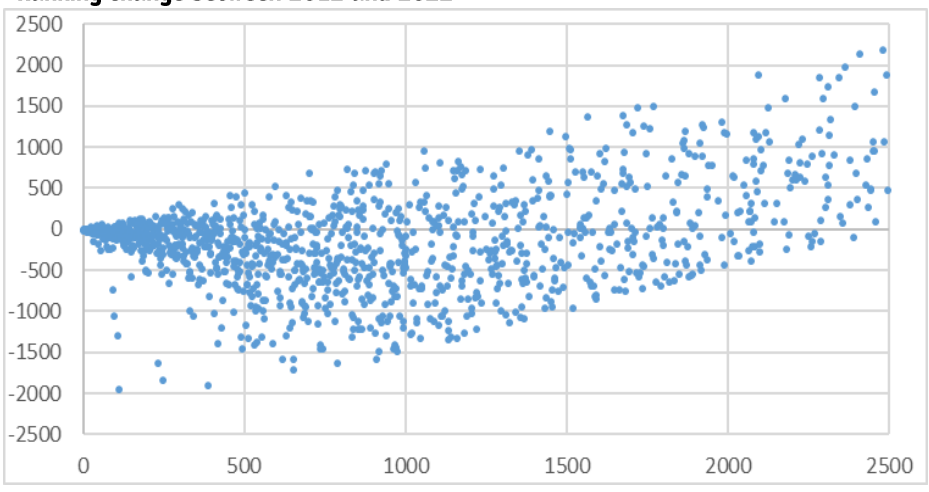
*: for R&D for 2012 figures were recalculated using 2022 national currency exchange rates to euro
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

3.3 Now and then: ranking changes, entry and exit

Ranking changes

Of the top 2500 investors in R&D in the 2022 *Scoreboard*, the same 1228 companies appear in both the 2012 and 2022 *Scoreboards*. These companies invested a total of EUR 843.6 billion in R&D in 2021, i.e. 77.1% of the total 2022 *Scoreboard*. The volatility of the ranking change increases towards the lower ranks of the first quintile, then it becomes more stable (Figure 3.7). This illustrates the logical fact that while a change of a certain magnitude in the R&D expenditure of the top 500 companies tends to induce a smaller change in their rankings, in the four lower quintiles[68] even a small change can trigger a rather large change in the ranking position. In other words, companies in the four lower quintiles invest significantly less in R&D than their higher ranked counterparts and therefore have larger effects in terms of ranking change, i.e. higher impact of an extra euro of R&D investment on the ranking change.[69]

Figure 3.7 Ranking change between 2012 and 2022



Note: Horizontal: ranking in 2012, vertical change in ranking between 2012 and 2022
Source: The 2022 EU Industrial R&D Investment Scoreboard, European Commission, JRC/DG RTD.

[68] And especially as of the 1000th position onwards.

[69] In financial terms, while the companies ranked 500-2500 in the 2022 *Scoreboard* invested between EUR 50 and 360 million in R&D in 2021, the top quintile, except for the top 50, invested between EUR 360 million and EUR 3.7 billion. This represents a six-fold difference for the bottom 2000 companies and a more than nine-fold difference for the group of companies ranked 51 to 500.