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The 2022 EU Survey on Industrial R&D Investment Trends

Insights from the top EU R&D investors

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Abstract

This report presents the results of the 2022 survey of the top 1 000 EU companies by R&D investment in 2020, conducted between June and September 2022. The survey is intended to provide insights into the research and development activities of the R&D investors listed in the 2021 EU Industrial R&D Investment Scoreboard (Scoreboard 2021).

The objective of this survey is to gather future expectations for R&D investment and gain first-hand information on barriers and drivers and the role of various activities that influence the level and direction of R&D investment. The survey addresses financing and collaboration, technology transfer and open innovation, and the effects of COVID-19 and the war in Ukraine.

The response rate stood at 12%. The number of responses increased by 31.5% compared to the previous year, and the respondents accounted for over 26% of the R&D investment of the top 1 000 EU corporate investors in R&D.

The results show a strong recovery in R&D investment after the COVID-19 pandemic, and the respondents expect this positive development to continue in 2022 and 2023. The main drivers of R&D investment are environmental sustainability and digitalisation. The respondents' capital investment is largely driven by technologies to reduce emissions and to adapt to Industry 4.0. The survey thus confirms that innovative EU companies are actively helping to meet the targets set out in the European Green Deal and the green and digital transformation (the Twin Transition).

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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 Elisabeth Nindl (JRC B7 Knowledge for Finance, Innovation and Growth) as the main author. Alexander Tübke and Nicola Grassano (both from JRC B.7), Evgeni Evgeniev (DG R&I.E1), Athina Karvounaraki (DG RTD.G1), Sivasegaram Manimaaran (EISMEA.D1), contributed to the review of this document. The JRC.B and DG R&I.E would like to express their thanks to everyone who has contributed to this project, and in particular to the companies that responded to the survey.

Authors

Elisabeth Nindl

Executive summary

This report analyses the responses to the 2022 EU Industrial R&D Survey of the top 1 000 EU companies by R&D investment in 2020, conducted between June and September 2022. A greater number of companies with less than 2 500 employees responded than in previous years and the overall number of responses was 31.5% higher than last year, resulting in a response rate of 12%.

The respondents reported EUR 53.44 billion of R&D investment in 2021 – an increase of 6.1% compared to the previous year, representing 26.4% of the total R&D investment by the top EU 1 000 companies. The respondents plan to increase R&D investment by more than 7%, on average, in both 2022 and 2023.

Even though general economic prospects have been worsening during the survey period due to the Russian war in Ukraine, the respondents expect sales, profits and employment to increase in 2022 and 2023. This indicates the resilience of innovative EU companies, especially in high-tech segments, such as ICT and health.

The main drivers of R&D and capital investment are environmental sustainability/low-emission technologies and digitalisation/the adaptation to Industry 4.0. This confirms that key EU companies are continuing to bring about the twin green and digital transformation. This is particularly the case for large respondents in medium- and low-tech (often energy-intensive) sectors.

The 2022 survey for the first time asked the companies to report the number of female R&D employees. The 77 companies that answered this question reported 40 484 female R&D full-time equivalent employees. This corresponds to an average 31.9% share of female R&D employees per company (28.9% at the median) and exceeds the proportion of women in the overall business sector's R&D by 10 percentage points, as per recent Eurostat figures.

The innovations brought to the market in 2021 centre around Industry 4.0 technologies. Machine learning and robotics are used by two thirds of the responding companies. Other more specific technologies such as radio-frequency identification systems (RFID), touchscreen interfaces and machine vision are used by around 40% of the respondents.

On average, survey respondents perform 80% of their R&D in the EU. This is due to the sample of respondents that includes a larger number of smaller size class firms than in the past and is at the higher end of the range compared to our previous surveys. The most prominent R&D location for EU-headquartered companies outside the EU is the US, where over 55% of the survey respondents conduct R&D and expect to continue to do so. China is another important location for R&D and more companies will be active in China by 2023. Some responding companies are expecting to cease R&D in the UK, while India is an increasingly attractive R&D location. By 2023, more of this year's survey respondents will conduct R&D activities in India than in the UK.

A wide set of public measures support the respondents' R&D. 85.7% of the respondents use at least one public R&D support instrument. Cash credits are by far the most used public incentive instrument (53.3% of all respondents). Around half of the respondents reported using R&D tax credits that are offered in all but two of the member states where respondents are headquartered.

Respondents actively pursue open innovation activities, primarily R&D alliances (76.6%), followed by mergers and acquisitions (57.6%) and then licensing (46.2%); investment in start-ups via controlled corporate venture capital funds (CVC) was reported by 33% of the respondents. Large companies especially use many means to acquire complementary knowledge. However, 57% of the respondents prefer exclusive technology usage, which limits the scope of open innovation.

The COVID-19 pandemic did not impact R&D investment for over 70% of the respondents, and each 12.5% of respondents either increased or decreased their R&D investment due to the pandemic. On the project level, 72% reported that existing R&D projects were disrupted or delayed, and 21% reported the complete cancellation of existing R&D projects. On the positive side, the COVID-19 pandemic also gave rise to new R&D projects in more than half of the sample. However, these new projects were outweighed by the disruption, cancellation or delay of existing and planned projects.

At the time of the survey, the war in Ukraine did not cause any change in R&D investment for 86% of the respondents. So far, only few effects on research projects can be discerned. Delay of existing projects occurs most frequently in aerospace and defence, construction, health industries and automobiles and parts. Some companies also report that they started new R&D projects that were inspired by the war: this is the case for 80% of the companies in aerospace and defence – but they are also the ones facing the most interruptions. In addition, several companies in the energy sector and in ICT services report new R&D projects that were influenced as a consequence of the war.

1 Introduction

The 2022 EU Survey on Industrial R&D Investment Trends is intended to provide insights into the research and development (R&D) activities of the top EU 1 000 corporate R&D investors listed in the 2021 EU Industrial R&D Investment Scoreboard (SB 2021).[1] Since 2005, this survey has shed light on the R&D strategies of the EU's top 1 000 corporate R&D investors, which are key players in the innovation ecosystem and are therefore important actors in the transformation of the EU's economy.

Owing to timing of the UK's exit from the EU on 31 January 2020, last year's survey was addressed to 720 companies in the EU27 and 280 companies in the UK. However, this year's survey covers 1 000 companies, which were all headquartered in the EU27 and invested more than EUR 2 million in R&D in the financial year 2020.

R&D investment in the SB 2021 and therefore in this survey is defined as the cash investment which is funded by the companies, excluding R&D undertaken for customers such as governments and other companies.[2] It also excludes the companies' share of any associated company or joint venture R&D investment. However, it includes R&D contracted out to other companies and public research organisations such as universities. This definition of R&D can in some cases lead to a considerable divergence between the total R&D that investment companies report in their annual accounts and the R&D investment used for this survey – particularly in sectors characterised by large R&D projects commissioned by public sector and other organisations.

This report is structured as follows: *Section 1* describes the survey implementation and sample composition; S*ection 2* looks at the development of R&D investment and employment of the respondents in 2021, followed by an analysis of their expectations for 2022 and 2023 for key indicators. This also includes an assessment of the locations where the respondents perform R&D. *Section 3* focuses on the R&D investment allocation and its drivers, presents information on the technological drivers of the respondents' capital investment decisions, as well as on the technologies embodied in the goods and services that the companies brought to the market in 2021. *Section 4* analyses the respondents' usage of public incentives and support measures for R&D, whereas *Section 5* looks at open innovation practices. *Section 6* investigates the effects of the COVID-19 pandemic and the war in Ukraine on R&D investment and projects, and the final *Section 7* draws conclusions and relates them to the policy context.

1.1 Survey implementation and sample composition

The top 1 000 EU R&D investing companies from the SB 2021 were invited to participate in the online survey by email in early June 2022. The questionnaire remained open until 9 September; (two reminders were sent at the end of June and the end of July). 78 of the 1 000 companies had to be removed from the sample for various reasons. For 556 of the remaining 922 companies, a personal email address was either available from previous surveys or was found by web search, and the other 366 companies were contacted via functional email addresses. The electronic questionnaire was sent to the CEO/CTO at the headquarters level. 86 companies could not be contacted because the intended recipients' servers rejected the emails, thus reducing the effective sample size to 836. An analysis of company size, sector, technology class and Member State of headquarters shows that there is no systematic bias affecting which companies could be reached.

100 companies completed the questionnaire. This corresponds to a response rate of 12%, which constitutes a 31.5% increase in the sample compared to the 2021 survey. The sample size does not permit comprehensive sectoral analysis, but anecdotal evidence of sectoral macro trends is provided when possible. We instead follow an alternative approach to illustrate differences: we group the companies according to the number of employees into four size classes, and we also use the OECD's technology classifications based on R&D intensity[3] (but combine medium-high and medium-low-tech sectors in one medium-tech sector in order to obtain a sufficient number of observations). The analysis was conducted in an anonymised way and results are published only at an aggregate level (see the privacy statement in the Annex).

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1 Grassano, N., Hernandez Guevara, H., Tübke, A. et al., European Commission, Joint Research Centre, *The 2021 EU Industrial R&D Investment Scoreboard*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/559391.

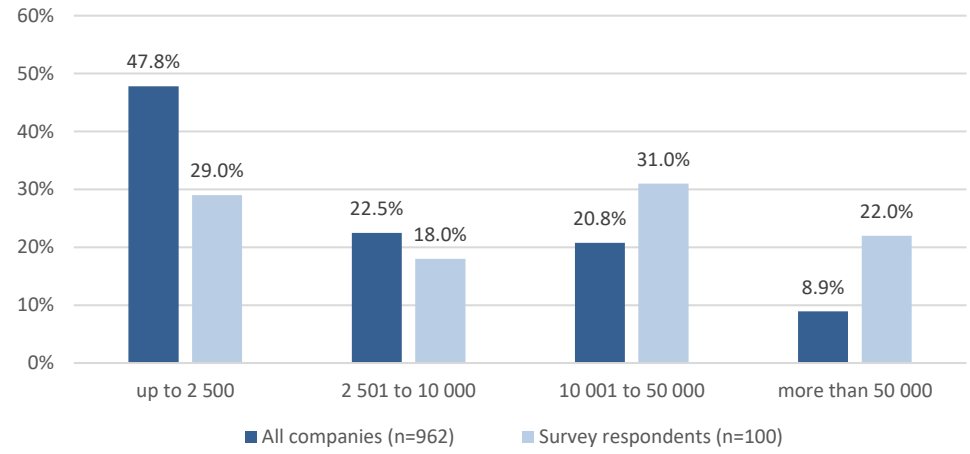
2 This is the definition of R&D used for SB 21 and the survey base of OECD/Eurostat (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, OECD Publishing and Eurostat, Paris and Luxembourg, https://doi.org/10.1787/9789264304604-en.

3 Galindo-Rueda, F. and F. Verger (2016), 'OECD Taxonomy of Economic Activities Based on R&D Intensity', *OECD Science, Technology and Industry Working Papers*, No 2016/04, OECD Publishing, Paris, https://doi.org/10.1787/5jlv73sqqp8r-en

By comparison with the 720 companies in the 2021 survey sample, the share of companies with up to 2 500 employees increased almost by 16 percentage points from 32% to 47.8%. The share of companies in the three larger size classes decreased by 4 to 6 percentage points. However, the distribution of survey respondents across the size classes was almost identical in the 2022 and the 2021 surveys. Overall, the new EU sample contains more small size class firms and fewer larger companies, but the number of small and medium-size enterprises (SMEs)[4] remains low: 17% of the EU top 1 000 (18.8% of the companies actually reached) are SMEs, but only 8% of the survey respondents were SMEs.

Figure 1 shows the distribution of companies for the full sample (data on employment was available for 962 companies) and the survey respondents across the four size classes.

Figure 1 Distribution of companies across size classes



Source: European Commission, JRC/DG-R&I

Table 1 gives an overview of the number of companies and the total R&D investment per sector in the SB 2021 compared with the survey participants. The sector representation is similar to earlier surveys.

Table 1 Sectoral classification

		EU 1000		Companies reached		Survey respondents	
Sector	**ICB3 Classification**	**N**	**share**	**N**	**share**	**N**	**share**
Aerospace & defence	Aerospace & defence	14	1.4%	12	1.4%	5	5.0%
Automobiles & other transport	Industrial engineering; Automobiles & parts	64	6.4%	56	6.7%	9	9.0%
Chemicals	Chemicals	39	3.9%	36	4.3%	6	6.0%
Construction	Construction & materials	34	3.4%	31	3.7%	4	4.0%
Energy	Oil & gas producers; electricity; alternative energy; gas; water & multiutilities; oil equipment; services & distribution	39	3.9%	36	4.3%	9	9.0%
Financial	Real estate investment & services; banks; financial services; non-life insurance; non-equity investment instruments; life insurance	68	6.8%	43	5.1%	2	2.0%
Health industries	Health care equipment & services; pharmaceuticals & biotechnology	190	19.0%	162	19.4%	17	17.0%
ICT producers	Electronic & electrical equipment; technology hardware & equipment	117	11.7%	99	11.8%	9	9.0%
ICT services	Software & computer services; mobile telecommunications; fixed line telecommunications	110	11.0%	91	10.9%	9	9.0%

[4] SMEs are defined as enterprises with up to 249 employees. Source : Eurostat, https://ec.europa.eu/eurostat/web/structural-business-statistics/small-and-medium-sized-enterprises.

Industrials	Industrial engineering; industrial metals & mining; general industrials; industrial transportation	156	15.6%	135	16.1%	16	16.0%
Others	Support services; food producers; forestry & paper; travel & leisure; media; general retailers; beverages; personal goods; leisure goods; household goods & home construction; food & drug retailers; mining; tobacco	169	16.9%	135	16.1%	14	14.0%
Total		1000	100.0%	836	100.0%	100	100.0%

Source: European Commission, JRC/DG R&I.

Table 2 assigns the sectors to the three technology classifications used in the analysis. While the share of responses of companies in high-tech sectors is similar to their share in the number of companies that could be reached, the share of companies in the medium-tech sectors is 10.5 percentage points lower. By contrast, companies from low-tech sectors are over-represented in the survey sample.

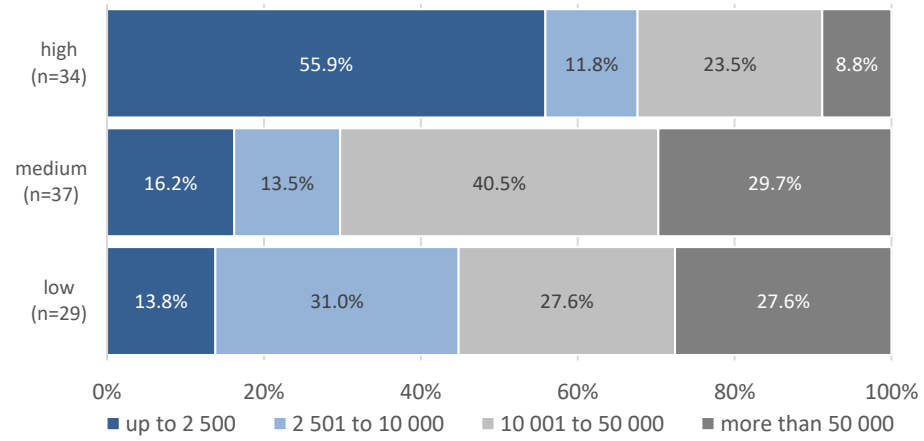
Table 2 Technology classification and ICB3 sectors

Technology classification	ICB3 sector description	Reached (n=836)	Answered (n=100)
High-tech	Pharmaceuticals & biotechnology; healthcare equipment & services; software & computer services; technology hardware & equipment; leisure goods; aerospace & defence.	36.2%	34.0%
Medium-tech	Electronic & electrical equipment; chemicals; general industrials; general retailers; industrial engineering; automobiles & parts; support services; alternative energy; food producers; fixed-line telecommunications; household goods & home construction.	47.5%	37.0%
Low-tech	Industrial metals & mining; forestry & paper; construction & materials; banks; electricity; oil & gas producers; gas, water & multiutilities; mining.	16.3%	29.0%

Note: ICB (International Classification Benchmark) (https://research.ftserussell.com/products/downloads/ICBStructure-Eng.pdf)
Source: European Commission, JRC/DG R&I.

Figure 2 shows the distribution of companies across size classes and technology classifications. Most high-tech companies have fewer than 2 500 employees, while 70% of companies in the medium-tech sectors employ more than 10 000 employees. The respondents from low-tech sectors are distributed rather equally across the size classes, except for the smallest size class companies, which constitute only 13% of the respondents in this group.

Figure 2 Company size and technology classification



Source: European Commission, JRC/DG R&I.

Finally, Table 3 provides an overview of the headquarter countries of the companies in the EU top 1 000 corporate R&D investors, their share in the companies that could be reached for the survey invitation, and their share of the companies that responded to the survey.

Table 3 Overview of headquarter countries

	n	Share total (n=1 000)	Share reached (n=836)	Share answered (n=100)
Belgium	37	3.7%	3.7%	5.0%
Czechia	1	0.1%	0.1%	0.0%
Denmark	64	6.4%	5.1%	3.0%
Germany	294	29.4%	31%	22.0%
Ireland	40	4.0%	3.2%	1.0%
Greece	8	0.8%	0.7%	0.0%
Spain	29	2.9%	2.9%	13.0%
France	149	14.9%	15.4%	15.0%
Italy	42	4.2%	4.6%	9.0%
Luxembourg	21	2.1%	1.3%	1.0%
Hungary	1	0.1%	0.1%	0.0%
Malta	1	0.1%	0.1%	0.0%
Netherlands	63	6.3%	6%	9.0%
Austria	39	3.9%	4.3%	4.0%
Poland	4	0.4%	0.4%	0.0%
Portugal	5	0.5%	0.5%	3.0%
Slovenia	1	0.1%	0.1%	0.0%
Finland	50	5.0%	4.8%	7.0%
Sweden	151	15.1%	15.5%	8.0%

Source: European Commission, JRC/DG R&I.

1.2 R&D investment in 2021

The companies that responded to the survey reported EUR 53.4 billion of investment in R&D activities in 2021. This corresponds to 26.4% of the R&D performed by the top 1 000 EU Scoreboard 2021 companies.[5] The total R&D investment of the survey respondents was 6.1% higher than in 2020. R&D growth varied widely between the individual companies, with smaller firms often showing large relative changes. Individual companies' R&D investment had risen by on average 7.8% and by 2.1% at the median. Of the 100 survey respondents, 56% reported higher R&D investment in 2021 than in 2020; 36% lower; and 8% reported no change.

Table 4 R&D investment growth 2020/2021 (excluding companies with no change in R&D)

Technology class	n	median	mean	Share<0	Share>0
High	33	1.3%	13.2%	30.3%	60.6%
Medium	39	3.7%	5.6%	35.9%	59.0%
Low	28	0.0%	4.5%	42.9%	46.4%
Size class					
up to 2 500	26	7.7%	16.5%	26.9%	65.4%
2 501 to 10 000	20	0.0%	-0.8%	50.0%	35.0%
10 001 to 50 000	30	2.8%	4.8%	40.0%	53.3%
more than 50 000	24	4.5%	9.3%	29.2%	66.7%
Total	100	2.1%	7.8%	36%	56%

Source: European Commission, JRC/DG R&I.

Table 4 summarises the development of R&D investment of the respondents by technology classification and company size at the median and at the mean, and states the proportion of companies that increased or reduced their R&D investment between 2020 and 2021. Across all technology classes, more companies increased rather than reduced their R&D investment, resulting in an overall increase.

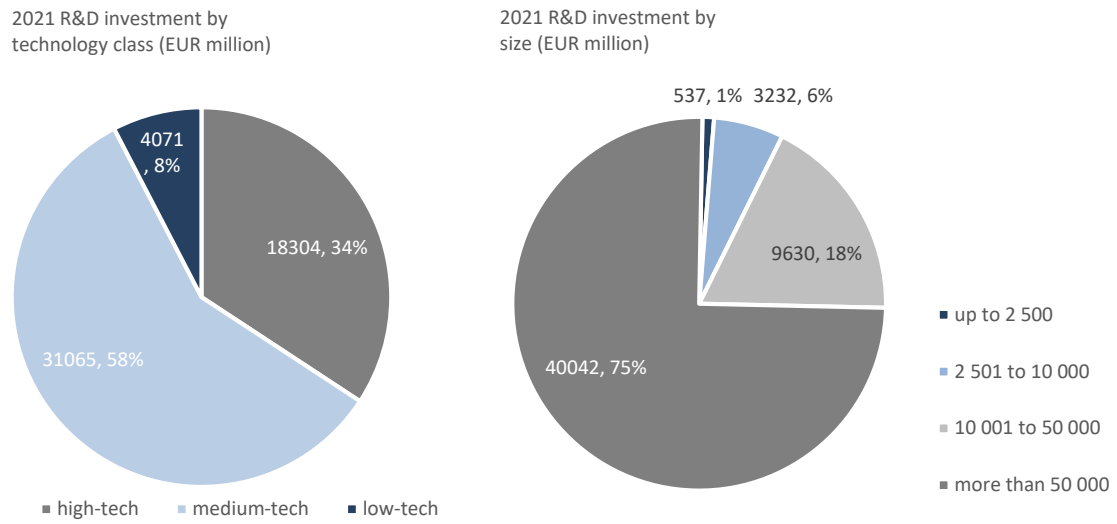
[5] The responding companies invested EUR 50.3 billion in R&D in the survey's 2020 base year. This corresponded to 25% of the R&D investment of the top 1 000 EU corporate R&D investors and 33.4% of the R&D investment of the companies that could be contacted for the survey.

The picture changes for the size classes. Smaller size class and very large companies increased their R&D investment by the highest rate, and these two size classes also had the highest share of companies that increased their R&D investment. By contrast, the two middle-size classes, which contain most of the companies from the medium- and low-tech sectors, showed weaker development, both in the magnitude of growth and the share of companies with an increase in R&D investment.

On a sectoral level, automobiles and parts companies reported a broad and marked increase in R&D (5.3% at the median), and the picture for the energy and health industries sectors was more mixed but still positive. ICT service providers expanded their R&D in 2021 by 10% at the median, and ICT producers by 3.7%. The number of companies in the construction, industrials and other sectors with positive and negative development was balanced. Chemicals companies reported an average 4% reduction in R&D investment compared with 2020. The relatively low number of observations per sector means that more general conclusions cannot be drawn from these figures.

Figure 3 shows the distribution of R&D investment by technology classification and size. The largest share of R&D investment came from large corporations (24% of the companies in the sample were responsible for 75% of R&D investment), which are mostly in medium-tech sectors (which contains 39% of the respondents and accounts for 58% of R&D investment).

Figure 3 2021 R&D investment by technology class and size



Note: N=100 for both figures
Source: European Commission, JRC/DG R&I.

The responding companies allocated approximately 63% of their R&D investment to (experimental) development[6] activities (i.e. systematic work which draws on research and practical experience, and which results in additional knowledge that is directed to developing new products or processes, or improving existing ones). This investment was mostly spent in-house (76%), but a quarter was subcontracted to R&D partners. Health and ICT companies invested the largest shares in development activities (around 75%).

30% of the respondents' R&D investment was spent on applied research (i.e. original investigation that is undertaken in order to acquire new knowledge that is primarily used for a specific and practical aim, or for a commercial objective). 75% of this investment was spent in-house. Low-tech companies allocated around 38% of their R&D investment to applied research – a larger share than high-tech and medium-tech companies.

The respondents allocated 8.1% of their R&D investment to basic research (i.e. experimental or theoretical work to acquire new knowledge of the underlying foundations of phenomena and observable facts, but without any particular application or use in view). Companies spent on average half of their basic research investment in-house, while the rest was contracted out to external research partners.

[6] These definitions are taken from the 'Glossary of terms' in the *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/9789264239012-17-en.

Table 5 summarises the results for the different size and technology classes. Low-tech companies (particularly those in the energy sector) accounted for the highest share of investment in basic research (11.3%, all of it in-house), while high-tech companies allocated most of their R&D investment to (experimental) development work. Companies in the health industries sector allocated 76% of their R&D investment (the highest sectoral share) to (experimental) development, but less than 6% to basic research (of which a below-average share of 41.8% was spent in-house).

The share of R&D performed in-house increases as a product or process innovation gets closer to the utilisation or market stage. Furthermore, there does not appear to be a pattern of companies in particular size or technology classes outsourcing their R&D (outsourcing appears to be determined by companies' individual circumstances or the nature of individual R&D projects).

Table 5 Types of R&D investment – size and technology classes

		Basic research		Applied research		(Experimental) development	
Technology class	**n**	**Share of R&D**	**Of which in-house**	**Share of R&D**	**Of which in-house**	**Share of R&D**	**Of which in-house**
High	27	5.6%	53.9%	20.6%	66.4%	74.7%	73.2%
Medium	27	7.8%	48.6%	31.8%	81.9%	60.4%	72.7%
Low	23	11.3%	48.8%	37.8%	72.6%	50.5%	83.7%
Size class							
up to 2 500	22	10.2%	55.1%	24.5%	71.4%	66.8%	77.8%
2 501 to 10 000	16	9.0%	43.4%	41.8%	67.1%	48.5%	68.4%
10 001 to 50 000	23	8.1%	55.6%	28.4%	81.9%	63.5%	85.5%
more than 50 000	16	4.1%	43.9%	26.4%	72.2%	69.5%	66.4%
Total	77	8.1%	50.7%	29.7%	73.5%	62.6%	76.1%

Source: European Commission, JRC/DG R&I.

1.3 Employment in 2021

In total, the surveyed companies employ 3.8 million full-time equivalents (FTE). The 24 companies with more than 50 000 FTE employ 2.9 million, while the 26 companies in the smallest size class account for 22 500 FTE. The number of FTE grew in 2021 by 2.3% on average (1.2% at the median). 62% of the respondents reported an increase in employment, 35% a decrease and 3% no change. The highest increase was reported by companies in the high-tech sectors and companies with up to 2 500 employees. Companies in ICT services, ICT producers and industrials had the highest growth in employment. Employment also increased in health industries, but to a lesser extent.

By contrast, larger companies had a more moderate increase in employment and some even saw a reduction. Aerospace and defence, chemicals, construction, and (to a lesser extent) automobiles and parts companies reduced their FTE numbers – probably because the COVID-19 pandemic had a large impact on these sectors in terms of sales and profits (SB 2021).

Table 6 Employment growth – technology and size classes

Technology class	**n**	**median**	**mean**	**Share<0**	**Share>0**
High	33	2.3%	5.3%	28.1%	71.9%
Medium	39	0.5%	-0.6%	41.0%	53.8%
Low	28	1.1%	3.1%	35.7%	60.7%
Size class					
up to 2 500	26	6.1%	7.9%	16.0%	80.0%
2 501 to 10 000	20	0.0%	2.4%	40.0%	55.0%
10 001 to 50 000	30	2.3%	0.7%	33.3%	66.7%
more than 50 000	24	-0.9%	-1.6%	54.2%	41.7%
Total	100	1.2%	2.3%	35.0%	62.0%

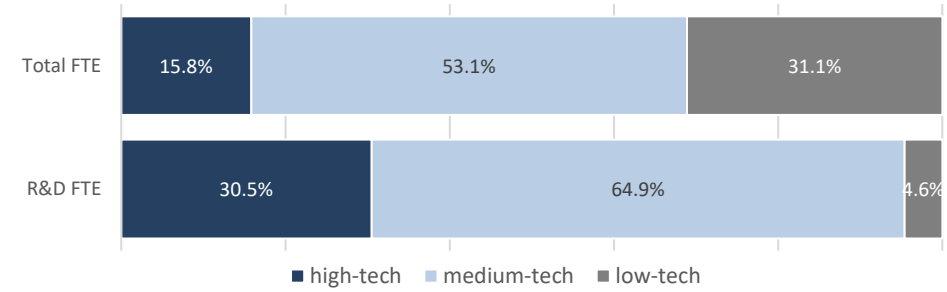
Source: European Commission, JRC/DG R&I.

As Table 7 in Section 2 of this report shows in more detail, the surveyed companies plan a stronger expansion of their workforce in 2022 and 2023.

The survey respondents employ 330 901 FTE in R&D, which corresponds to an average R&D labour intensity of 15.6% (7.1% at the median). 36% of R&D FTE are in the automobiles and parts sector, 18.3% in ICT producers and 16.3% in aerospace and defence. The most R&D-intensive survey respondents in terms of labour are the companies in the aerospace and defence, ICT

services, ICT producers and health industries sectors – between 32% and 16% (at the median) of their FTE work on R&D. The R&D employment share of these high-tech companies is double their share in terms of total employment (see Figure 4).

Figure 4 Employment and R&D employment – technology classes



Note: N=100 for total employment (FTE) and 95 for R&D FTE
Source: European Commission, JRC/DG R&I.

The 2022 survey for the first time asked the companies to report the number of female R&D FTE. The 77 companies that answered this question reported 40 484 female R&D FTE. This corresponds to an average 31.9% proportion of female R&D employees per company (28.9% at the median) and exceeds the proportion of women in the overall business sector's R&D by 10 percentage points. According to Eurostat figures[7], 21.3% of the R&D employees in the EU business sector in 2019 were women. This suggests that the survey respondents employ significantly more women in R&D than the average company. Many respondents did not provide information on this point, however, and some of the respondents (particularly the largest companies in the sample) replied that they do not collect data on gender in R&D.[8]

From a sectoral perspective, health industries' companies stand out with 52% female R&D personnel on average. Chemicals and energy companies also reported high shares of female R&D personnel (37% and 34%). Automobiles and parts, industrials and ICT companies reported lower shares – but it is also worth noting that these sectors saw the lowest number of responses on R&D employment by gender.

[7] Eurostat (last accessed September 2022): https://ec.europa.eu/eurostat/databrowser/view/RD_P_FEMRES__custom_507238/bookmark/table?lang=en&bookmarkId=28c658b2-1b13-4552-adc9-dc95df59f963.

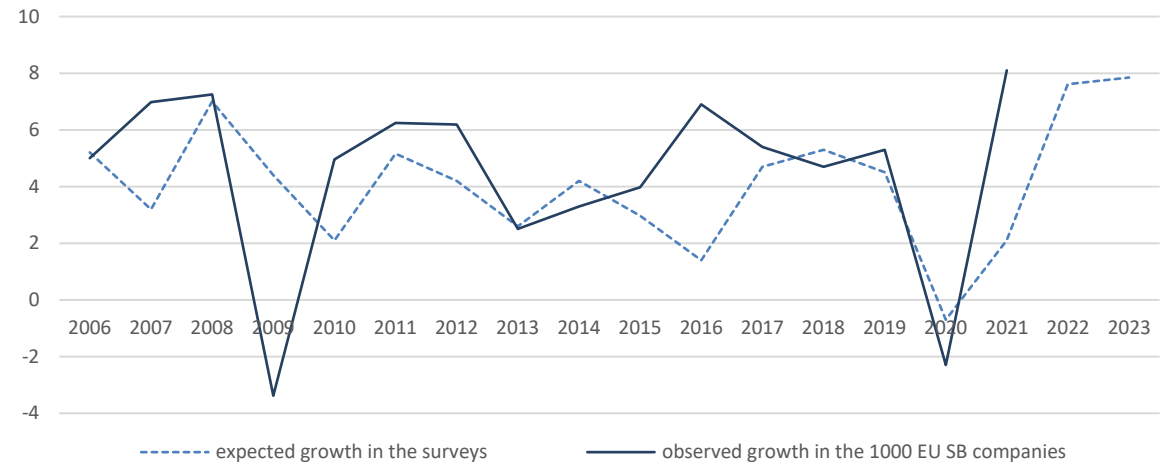
[8] *She figures 2021: gender in research and innovation: statistics and indicator*, European Commission – DG Research and Innovation, Publications Office, 2021, https://data.europa.eu/doi/10.2777/06090).
This report only includes data for the proportions of female R&D employment across all sectors. For the business sector, the report only gives the proportion of female researchers compared to the number of all researchers (rather than the wider category of R&D personnel that was examined by the current survey). This means that no comparison can be drawn between the numbers in that report and those in this survey.

2 Growth outlook - expectations

2.1 Key indicators

Figure 5 shows the respondents' expected growth in R&D investment by comparison with subsequently observed growth reported by Bureau van Dijk. Actual R&D investment by the EU top 1 000 R&D investors grew by 8.1% in 2021 - almost four times faster than the expected growth rate of 2.1%.[9] The average rate of growth in R&D investment of the 2022 survey respondents was 7.8% - which is close to that for the EU 1 000 as a whole. The survey respondents were planning to increase their R&D investment in 2022 and 2023 by 7.6% and 7.9%, respectively. However, the expected growth rates were average values that could have been distorted by very high or very low values for individual companies. The median expected R&D investment growth that is more sensitive to extreme values is forecasted at 5% and 5.5% in 2022 and 2023, respectively.

Figure 5 Expected growth in R&D investment 2022 and 2023



Source: European Commission, JRC/DG R&I.

Table 7 presents details for the financial indicators surveyed, both at the median and mean for 2022 and 2023. The large differences between these two measures are due to the fact that some companies reported very large changes. The median values therefore appear more reliable. Only about 60% of the surveyed companies answered these questions – some respondents stated that these figures were commercially confidential and others referred to the current economic uncertainties.

Table 7 Key financial indicators – expectations for 2022 and 2023

	Outlook 2022			Outlook 2023		
	n	Median	Mean	n	Median	Mean
R&D investment	66	5.0%	7.6%	57	6.0%	7.9%
Net sales	54	14.5%	14.8%	47	10.0%	9.9%
Operating profit	48	11.0%	13.3%	44	8.5%	10.1%
Capital expenditures (CAPEX)	49	3.0%	11.4%	43	1.2%	5.2%
Employment (FTE)	52	3.5%	5.1%	46	2.0%	4.4%
R&D employment (FTE)	51	3.3%	4.6%	45	3.2%	6.6%
Cost of sales/operating exp. (OPEX)	45	6.7%	5.3%	42	3.5%	5.1%

Source: European Commission, JRC/DG R&I.

All the indicators for 2022 are positive. The companies expect strong growth in net sales and operating profits, because sales are forecast to increase much faster than the cost of sales (i.e. operating expenditure – OPEX). Overall employment and R&D employment will also have continued to grow in 2022. The outlook remains positive for 2023, but growth is expected to slow

[9] The actual and expected figures refer to different samples: the actual growth figures relate to the top EU 1 000 companies in each *Scoreboard*, while the expected figures refer only to the companies that responded to the surveys.

down due to weakening economic prospects related to the war in Ukraine. Net sales and profit are expected to continue to grow in 2023; hence, 2022's strong growth in R&D investment and R&D employment will also continue. Capital expenditure will grow at only half the 2020 rate in 2023 due to the low-tech sectors (see Table 8), but this is to be expected after a phase of strong expansion. However, the low number of observations for some variables suggests that these findings should be interpreted with caution.

Companies with up to 2 500 employees expect the highest growth rates in R&D investment (15.7% at the median in 2022; 10% in 2023), R&D employment (7.1% and 6.5% at the median in 2022 and 2023 respectively), and capital expenditure (12.5% both at the median in 2022 and 2023). These figures were influenced by the fact that smaller size class companies are more often active in high-tech sectors. No clear pattern can be discerned for companies in the other size classes. There is some indication that companies in the largest and second size class (2 501 to 10 000 employees) in the sample expect more moderate growth in 2022 and 2023, but they do nevertheless expect some positive growth. Overall, the indicators across all size classes mostly point to positive growth for 2022 and 2023, though some point to zero growth.

Table 8 Expected changes for key indicators by technology class – median

Expected changes in		2022	2023
R&D investment	High (n=25; 20)	8%	8.65
	Medium (n=23; 21)	5%	5%
	Low (n=18; 16)	4%	10%
Net sales	High (n=22; 18)	10.5%	5.5%
	Medium (n=20; 18)	6.5%	6.5%
	Low (n=12; 11)	4%	4%
Operating profit	High (n=20; 17)	8%	6%
	Medium (n=18; 17)	5.5%	5%
	Low (n=10; 10)	2.5%	3.5%
Capital expenditure (CAPEX)	High (n=20, 18)	7%	3.5%
	Medium (n=17; 14)	1.25%	0.62%
	Low (n=12; 11)	1.35%	0%
Number of employees (FTE)	High (n=19; 16)	7%	5.8%
	Medium (n=19; 17)	2%	2%
	Low (n=14; 13)	3%	0%
Number of R&D employees (FTE)	High (n=19; 16)	8.1%	5.65%
	Medium (n=19; 17)	2%	2%
	Low (n=13; 12)	2%	1.5%
Cost of sales/operating expenditure (OPEX)	High (n=19; 17)	6.7%	5%
	Medium (n=16; 15)	2%	3%
	Low (n=10; 10)	10%	4.5%

Note: The number of observations for each technology class before the semicolon refers to 2022, the number after the semicolon to 2023.
Source: European Commission, JRC/DG R&I.

This analysis was also applied using the companies' technological classifications (Table 8). As the analysis of size classes would lead one to expect, high-tech companies expect to increase their R&D investment and employment most (by 8% and 8.65% for R&D investment and 8.1% and 5.6% for R&D employment at the median for 2022 and 2023). These companies also expect the highest growth in net sales (10.5% and 5.5% in 2022 and 2023) and operating profits (8% and 6% in 2022 and 2023). By contrast, low-tech companies expect to increase their R&D investment by 4% in 2022, but are planning a large increase of 10% in their R&D investment in 2023. High- and medium-tech companies have lower expectations for net sales and profits, and expect that their operating expenditure will increase by 10% in 2022 (but only by 4.5% in 2023). This could well reflect increases in energy prices, because many of these companies operate in energy-intensive sectors.[10]

The low number of responses for some sectors means that the results for those sectors can only be treated as indicative. The four companies in the automobiles and parts sector that responded to this question expect very strong growth in R&D

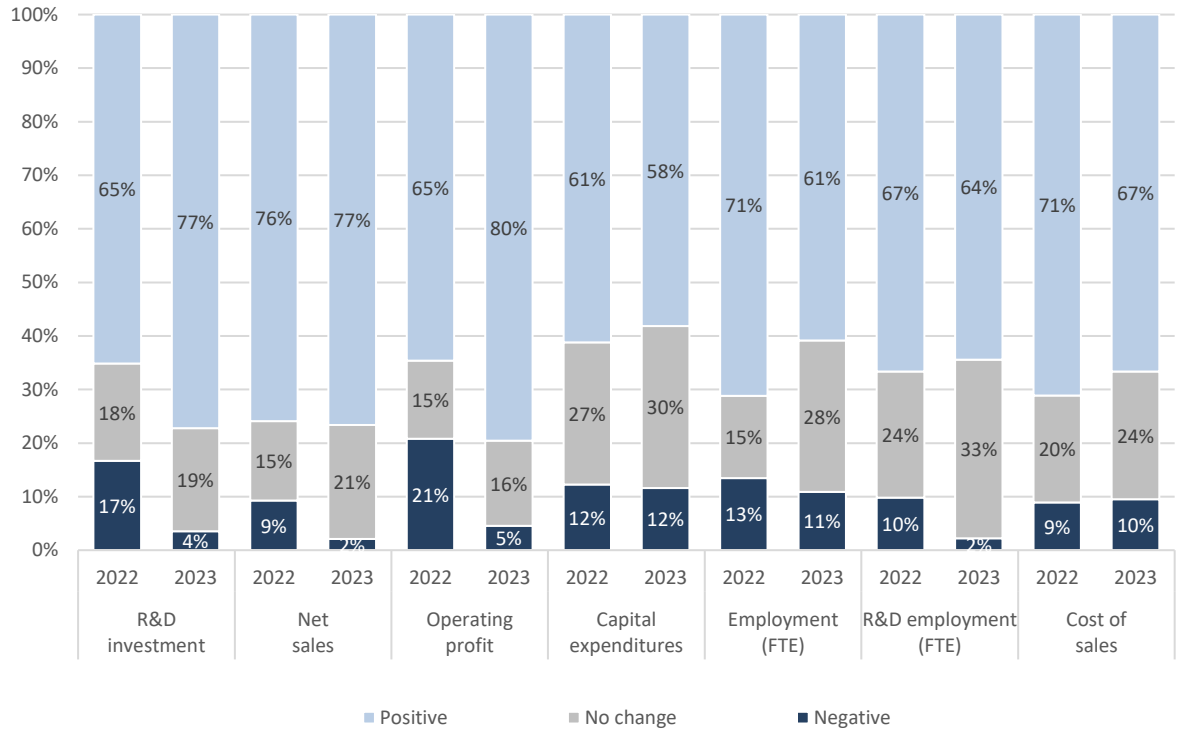
[10] The survey was conducted between June and early September 2022 when the impact of the war in Ukraine on the EU's 2023 economic prospects was still unclear and negative.

investment of around 15% for 2022 and 2023, but these four companies operate in the automobile parts area rather than in automobile production. The energy sector also saw a small number of responses – its four respondents expect their R&D investment to grow by 13% and 15% on average in 2022 and 2023. These sample sizes are so small that one can only cautiously interpret them as possibly indicating that the green and digital transformation of these sectors is under way (such an interpretation would nevertheless be reinforced by other evidence produced by this survey – see Sections 3.2 and 3.3).

High-tech companies in the ICT producers, ICT services and health industries sectors are also planning strong growth in R&D investment of between 8% and 11.5% at the median for 2022. This increase is forecast to continue in 2023, albeit at a lower rate.

Another way to look at R&D investment expectations is to calculate the proportion of companies expecting positive, zero or negative growth. Figure 6 shows these proportions for the set of financial indicators listed in the survey questionnaire. Most companies have positive growth expectations for 2022 and 2023. For all indicators, between 60% and 77% of the companies expected a positive development in 2022. The outlook is very similar for 2023, when even more companies are expecting positive (albeit somewhat lower) growth rates.

Figure 6 Growth expectations 2022/2023



Source: European Commission, JRC/DG R&I.

Taking Figure 6 and Table 8 together, the outlook for net sales and profits is low but positive for respondents from energy-intensive sectors such as construction and energy (and also for ICT producers in 2023). These are also the sectors that expect the largest increase in their cost of sales in 2023. By contrast, health and ICT services companies report the highest growth expectations for net sales and profits in 2023. ICT producers, ICT services and the health industry expect the largest increase in employment (both overall and R&D employment). These high-tech companies appear somewhat decoupled from some aspects of the general economic context – as the European Innovation Scoreboard 2022 has indicated.[11] Such innovative companies can offer solutions to urgent challenges such as the energy crisis, climate change or population ageing – which provide them with commercial opportunities but are problematic for most other companies.

[11] *European Innovation Scoreboard 2022*, European Commission, DG Research and Innovation, 2022/ doi: 10.27777/309907. https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/european-innovation-scoreboard-2022_en

2.2 Location of research

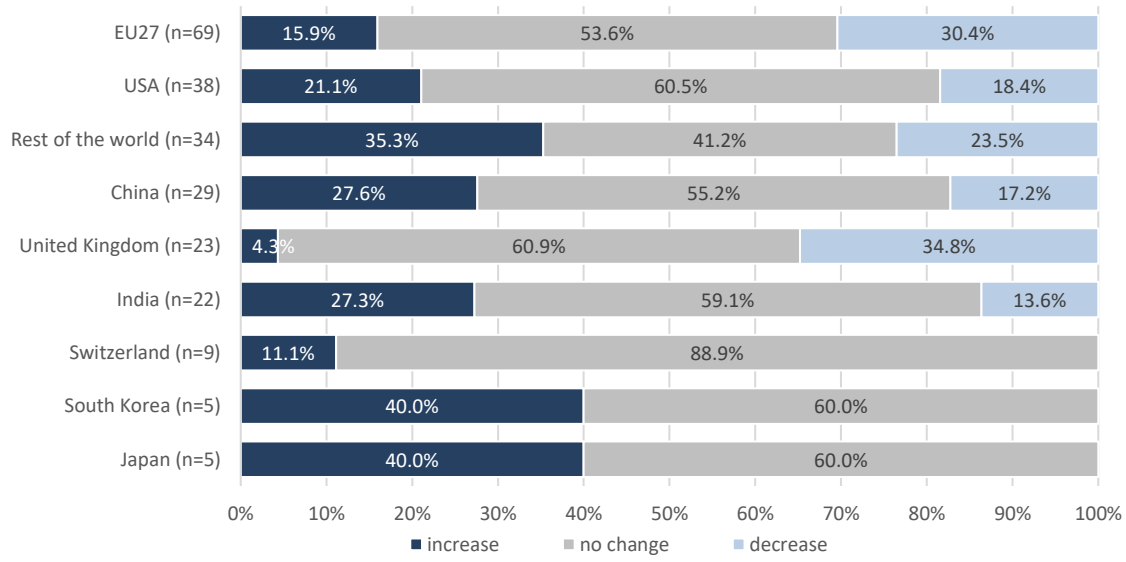
To approximate the amount of R&D investment in home countries (i.e. the country in which a company's headquarters are located), the sampled companies were asked to report the proportion of their overall R&D employment that takes place close to their headquarter. Both on average and at the median, 50% of R&D employment is located close to the headquarter. This figure depends on the company size with the share of local R&D employment decreasing with size. The sample of companies with up to 2 500 FTE employ on average 66.7% of their R&D employees in their headquarter country, 42% for those with 2 501-10 000, 48% for those employing between 10 001 and 50 000; and 34.4% for those employing more than 50 000.

The distribution of research employment between the various technology classes is influenced by the sample composition (see Figure 4), ranging from 57% for high-tech companies to 52% for medium-tech companies and 40% for low-tech companies. 13% of the respondents conducted their R&D activities exclusively in their headquarter country. The most geographically diverse R&D survey respondents are in the aerospace and defence, industrials and ICT producer sectors (companies in these sectors on average employ 24%, 25% and 30% of their R&D personnel in their home country respectively). By contrast, companies from the construction, chemicals and health industries sectors employ the highest proportions of their R&D employees close to their headquarters (80%, 70% and 69% respectively).

On average, the respondents conduct 80% of their R&D activity in the EU's Member States. This share is slightly higher than in the previous years (most probably due to the new sample composition, which has more smaller size class companies).[12] Only a quarter of the responding companies perform R&D only in the EU. Around 13% perform R&D in 2 different jurisdictions, 22% in 3, 11% in 4, and 12% in 5. However, this does not reflect the actual number of countries where R&D activity is located, because the questionnaire also asked about regions. Even if most companies conduct R&D outside their home country or region, the scale of such activity remains marginal over the period covered in the survey. On average, only 5% and 7% of total R&D is performed in the two most important R&D locations outside the EU27 (i.e. the US and the 'rest of the world' countries). Figure 7 suggests some dynamism, but the changes in regions and countries affect only small portions of overall R&D (1-2%).

Figure 7 shows the planned change in R&D investment by location between 2021 and 2023. Most of the companies in the survey are not planning to change the geographical allocation of their R&D. However, around 30% of the companies plan to decrease the share of their R&D that will be conducted in the EU27 and 35% will reduce the share of their R&D that is conducted in the UK. As noted above, the share of R&D affected in these locations is only a small fraction of the surveyed companies' total R&D investment.

Figure 7 Geographical distribution of R&D investment – change between 2021 and 2023



Source: European Commission, JRC/DG R&I.

[12] This year's question was worded differently from past surveys, so it is not possible to draw conclusions about the number of countries in which the companies perform R&D. The respondents had 11 countries/regions to distribute their R&D.

As Table 9 highlights, the most prominent R&D location for EU-headquartered companies outside the EU is the US, where over 55% of the respondents conduct R&D and expect to continue to do so. China is another important location for R&D and more companies will be active in China by 2023 (43%). Around 50% of the companies also conduct R&D in countries that were not listed individually but were grouped in the 'rest of the world' category.

Table 9 Location of R&D activities – share of companies with activities in a certain location

	USA	Rest of the world	China	United Kingdom	India	Switzer-land	South Korea	Japan
2021 (n=85)	56.5%	50.6%	40.0%	36.5%	28.2%	12.9%	5.9%	7.1%
2022 (n=73)	56.2%	49.3%	41.1%	31.5%	30.1%	13.7%	6.9%	8.2%
2023(n=67)	55.2%	50.7%	43.3%	28.4%	31.3%	13.4%	7.5%	7.5%

Source: European Commission, JRC/DG R&I.

Two trends that had already been observed in the past have continued to appear in the 2022 survey: the increasing attraction of India as an R&D location for EU companies and the decreasing role of the UK. 28% of the companies already conducted R&D in India in 2021 and this will rise to 31.3% by 2023, by which time more survey respondents will conduct R&D in India than in the UK.[13] The falling share of EU-headquartered companies that conduct R&D in the UK is primarily down to high-tech companies (50% of the high-tech companies in the sample performed R&D in the UK in 2021, this share will decrease to 39.1% in 2023). This trend is not limited to high-tech companies, however; medium- and low-tech companies will also have stopped carrying out R&D in the UK between 2021 and 2023.

Companies in the health sector are particularly active in the UK and the US (50% and 71% of these companies carry out R&D in the UK and US respectively). However, while they will reduce their R&D in the UK, they plan to increase it in the US. ICT producers are particularly well represented in the US (86% conduct R&D activities there) – but India is also an interesting R&D location for 71% of ICT producers. Overall, India is growing in popularity for R&D and especially for respondents in the large and very large size classes (e.g. in the automobiles and parts sector, and the aerospace and defence sector).

[13] The shares of R&D investment were similar for the UK and India – both received on average around 1.5% of the total R&D investment of the responding companies.

3 Investment allocation: Drivers and technologies

3.1 Investment allocation

Only 57 of the sampled companies responded to the questionnaire's request for information on the distribution of their overall investment expenditure across different categories in 2022. This was quite a low response, but does provide some insights. We selected R&D investment and investment in machinery and equipment for our analysis, because these forms of investment were the most reported. The distribution was highly skewed so both the median and mean values are presented in Table 10.

The smallest companies (up to 2 500 employees) in the sample allocate over 40% of their total investment to R&D, but the largest companies also allocate a considerable proportion of their overall investment to R&D (30.5% at the median). A rather diverse pattern can be seen for the two intermediate classes – some companies invested very large amounts in R&D and drove up the mean, but the median company planned to invest 15% and 25% of its total investment in 2022 in R&D.

Table 10 Investment in R&D and machinery & equipment as a proportion of total investment

		R&D		Machinery & equipment	
Technology class	**n**	**Median**	**Mean**	**Median**	**Mean**
high	23	44%	50.2%	8.5%	13.4%
medium	16	30.7%	33.6%	12.5%	20.9%
low	18	15%	25.9%	42.5%	36.1%
Size class					
up to 2 500	22	41.5%	46.8%	5%	14.9%
2 501 to 10 000	15	15%	29.4%	32%	33.6%
10 001 to 50 000	14	25%	34.5%	10%	22.3%
more than 50 000	6	30.5%	33.9%	22%	25.2%
Total	57	33.9%	37.8%	10%	22.7%

Source: European Commission, JRC/DG R&I.

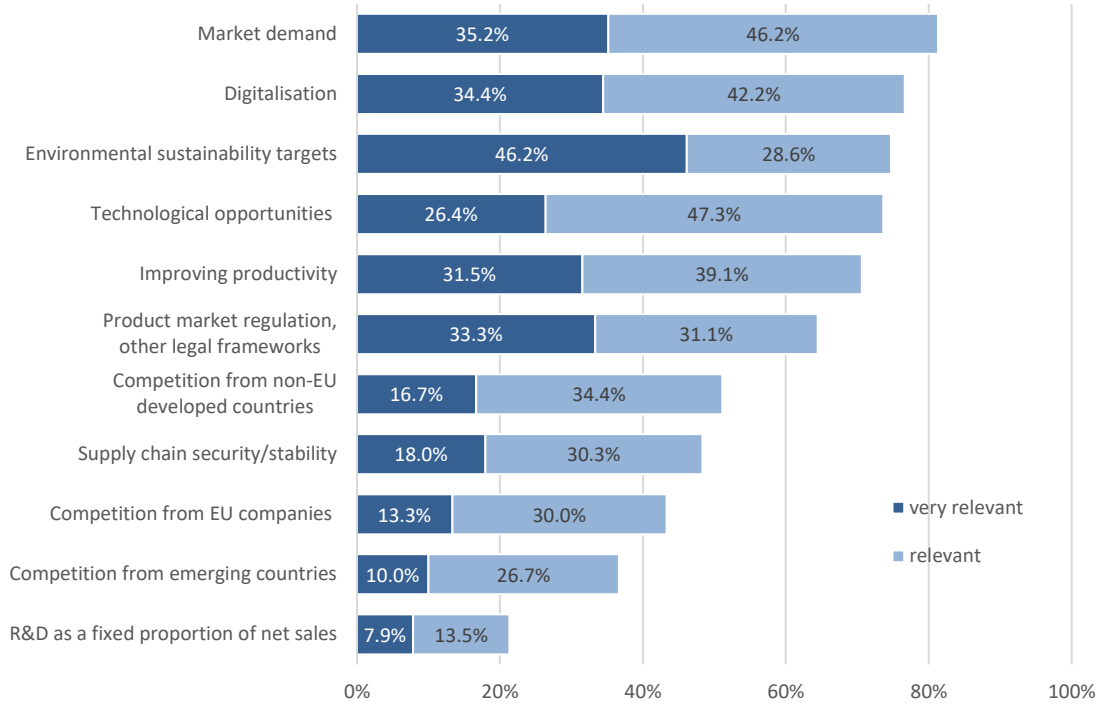
Companies in the ICT services (70%), ICT producers (56%), and automobiles and parts (40%) sectors invested the largest shares in R&D, followed by health companies (37%, all values at the median). Industrial and 'other' companies invested the most in machinery and equipment (43.5% and 45% respectively). The same would appear to the case for companies in aerospace and defence, and construction, but the number of responses for the two last groups was very low and needs to be treated with caution.

Analysing the sample according to technology classes gives additional insights into the companies' investment behaviour. R&D investment decreases with technology intensity, but investment in machinery and equipment increases. This is because the low-tech firms in the sample are in capital-intensive sectors that involve large-scale energy-intensive production processes (e.g. in construction and metals) or energy generation and provision itself.

3.2 Drivers of investment – the Twin Transition

The major factors driving the R&D investment of the surveyed companies are the need to respond to changes in market demand, digitalisation, environmental sustainability targets, and opportunities to increase productivity. 46% of the respondents cited environmental sustainability targets as the main reason for the changes they expected to make to their R&D investment plans.

Figure 8 Drivers of R&D investment change



Note: there were between 89 and 91 observations for each category.
Source: European Commission, JRC/DG R&I.

Figure 8 shows the ranking of investment drivers that are relevant or highly relevant to the companies. As might be expected, changes in market demand are the main determinants of investment, but digitalisation and environmental sustainability targets ranked second and third — higher than investment to increase productivity. This is an important indication that EU companies are responding to the Twin Transition objectives, especially as regards the need to finance and invest in the Twin Transition.[14]

As in previous editions, market demand is the decisive element for 81% of the companies, followed by digitalisation with 76%. Environmental sustainability is relevant or highly relevant for the R&D investment of 75% of the surveyed companies; this constitutes up 10%-points on last year's survey results. The roles of technological opportunities ('technological push'), product market regulation and competition have not greatly changed. The 2022 survey contained a new question on supply chain security and stability, which turned out to be (highly) relevant for 48% of the respondents' R&D investment decisions.

The sectoral breakdown of the responses gives some interesting insights. All the respondents from the automobiles and parts, chemicals, construction and energy sectors stated that environmental sustainability targets are highly relevant or relevant drivers of their investment changes. This is also the case for 87.5% of the companies in the industrials sector and 80% of those in the 'others' category. Most ICT producers identified digitalisation as a relevant driver, but most of the ICT services companies see it as a highly relevant driver. The respondents from the automobiles and parts, construction and energy sectors also stated that digitalisation plays a crucial role – to a lesser extent did companies in high-tech classes such as aerospace and defence or health industries.

Table 11 summarises the results (relevant and highly relevant) according to technology class. There are many similarities for all companies, but there are also some interesting differences. Most importantly, environmental sustainability targets are far more relevant for medium- and low-tech companies than for high-tech companies, and this is reflected in these companies' capital investment decisions (see Section 3.3).

[14] Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., *Towards a green and digital future,* EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, https://op.europa.eu/en/publication-detail/-/publication/58c3af16-f692-11ec-b976-01aa75ed71a1/language-en.

The exploitation of technological opportunities matters more for companies in the lower tech sectors, and the same holds for R&D investment that is intended to improve productivity. More than half the respondents – across all technology classes – stated that product market regulations and other legal frameworks influence their R&D investment decisions. The influence of competition varies. 62% of the companies in the high-tech sectors consider that competition from companies in other non-EU developed countries is crucial. By contrast, the companies in the medium-tech sectors are concerned with competition from companies in other EU countries. Competition from developing countries has less influence on R&D investment decisions, but is more relevant for companies in the medium- and low-tech sectors. Maintaining R&D as a fixed proportion of net sales is most relevant for high-tech companies. Finally, supply chain security/stability is a (highly) relevant driver of R&D investment for 57.6% of the medium-tech companies and for 48.3% of the high-tech companies. Companies in the low-tech sectors reported that supply chain concerns are less relevant for their R&D investment decisions.

Table 11 Drivers of R&D investment change in 2022 by technology class

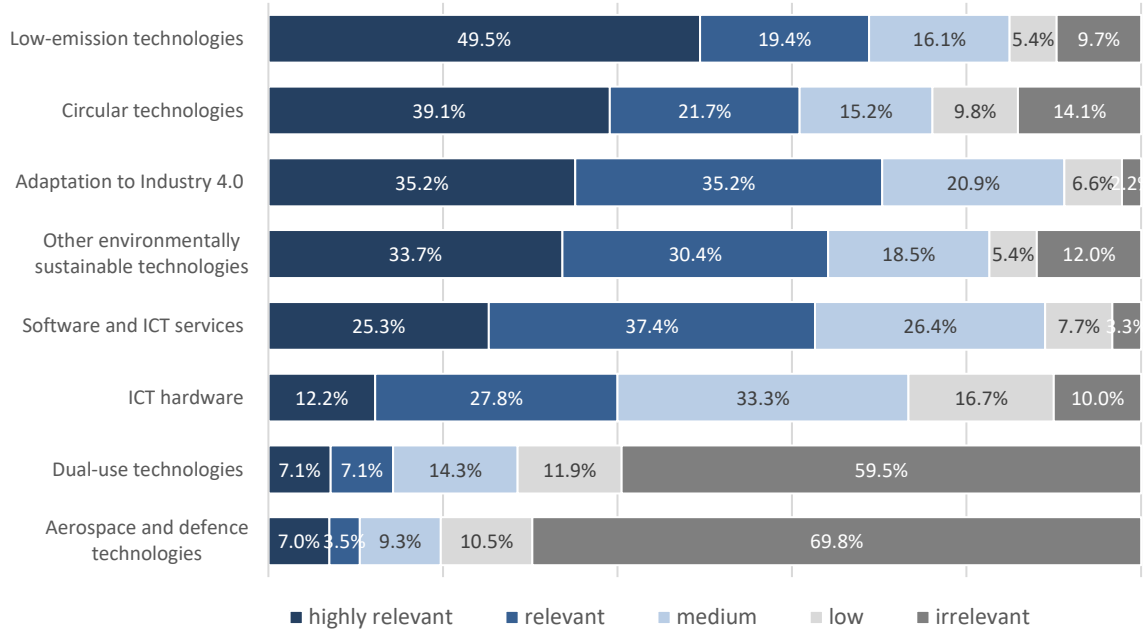
	High-tech	Medium-tech	Low-tech
Change in market demand	**80.0%**	**88.2%**	**74.1%**
Digitalisation	72.4%	82.4%	74.1%
Investment to achieve environmental sustainability targets	46.7%	**88.2%**	**88.9%**
Exploiting technological opportunities (technology push)	63.3%	76.5%	**81.5%**
Improving the company's productivity	64.5%	70.6%	**77.8%**
Meeting product market regulation and other legal frameworks	62.1%	64.7%	66.7%
Competition from non-EU-headquartered companies in other developed countries (e.g. US, UK, Switzerland, South Korea, Japan, etc.).	**62.1%**	50.0%	40.7%
Supply chain security/stability	48.3%	**57.6%**	37.0%
Competition from companies headquartered in the EU	31.0%	55.9%	40.7%
Competition from non-EU companies located in emerging countries (e.g. China, India, etc.)	27.6%	**41.2%**	**40.7%**
Maintaining R&D as a fixed proportion of net sales	34.5%	18.2%	11.1%

Note: the number of observations per category lies between 29 and 30 for the high-tech companies, 33 and 34 for the medium-tech companies and 27 observations for the low-tech companies.
Source: European Commission, JRC/DG R&I.

3.3 Capital investment for future competitiveness

The sampled companies were asked to assess the relevance of capital investment in certain technologies for future competitiveness. Adaptation to Industry 4.0 (digitalisation) and environmental sustainability are the main drivers of capital investment (this is in line with the findings from the previous sections). As Figure 9 shows, low-emission technologies are considered to be the most important area for capital investment, followed by circular technologies that can be used for different phases of production (e.g. sustainable design, circularity of production processes, and recycling). At the same time, 70.4% of the respondents see adaptation to Industry 4.0 as highly relevant or relevant for capital investment decisions – including fields such as artificial intelligence, robotisation, augmented reality, additive manufacturing, cloud computing and other technologies.

Figure 9 Capital investment in technologies for future competitiveness



Note: The number of observations per category varies between 84 and 93.
Source: European Commission, JRC/DG R&I.

Capital investment in ICT software and services is (highly) relevant for both environmental sustainability and adaptation to Industry 4.0. This was confirmed by 63% of the respondents. ICT hardware is currently considered to be somewhat less relevant, but still influenced the capital investment of 40% of the companies to a high degree.

On the sectoral level, the responses confirm the importance of greening in the construction, energy, chemicals, automobiles and parts, and industrials sectors of EU-headquartered Scoreboard companies. 87-100% of the respondents agree that low-emission technologies, circular technologies and other environmentally sustainable technologies are the most relevant drivers of their capital investment. Investment in software is also very important.

As regards the ICT sector, 88% of the responding ICT producers consider low-emission technologies and other environmentally sustainable technologies (75%) to be relevant or highly relevant, while 100% of the ICT software companies reported adaptation to Industry 4.0 as the most important driver of capital investment (66% and 55% cited software and ICT services investment and ICT hardware respectively as important). This sector currently attaches less importance to environmental sustainability. 67% of the respondents in the health industries sector rated capital investment in software as (highly) relevant. The other categories in the questionnaire were of less relevance for the responding companies in this sector, but over two thirds of the companies selected the 'other' answer option and some identified biotechnology as a driver of capital investment.[15]

Table 12 summarises the results for the three different technology classifications and the four size classes. The companies in the high-tech sectors consider ICT software, services and hardware and adaptation to Industry 4.0 to be of most relevance for their future competitiveness. The medium- and low-tech companies consider that environmental sustainability is absolutely crucial and, as noted above, in conjunction with Industry 4.0. The differences in the relevance of certain forms of capital investment appear to be determined by the technology classes rather than by company size. Circular, low-emission and sustainability capital investment is not relevant for the high-tech firms because they purchase energy as a service from outside, but it remains to be seen how much the energy crisis will affect them indirectly in the future.

[15] Vezzani, A., *Top EU R&D investors in the global economy. Benchmarking technological capabilities in the health industry*, European Commission-JRC, Seville, 2022. This recent study highlights the important and growing role of R&D investment in biotech in the EU.

Table 12 Capital investment (highly relevant + relevant) – by technology and size classes

	Technology classes			Size classes			
	High	**Medium**	**Low**	**up to 2 500**	**2 501 to 10 000**	**10 001 to 50 000**	**more than 50 000**
ICT hardware	50.0%	42.4%	24.0%	44.0%	15.8%	48.1%	47.4%
Software and ICT services	59.4%	69.7%	57.7%	64.0%	57.9%	63.0%	65.0%
Adaptation to Industry 4.0	60.0%	71.4%	80.8%	62.5%	63.2%	74.1%	81.0%
Low-emission technologies	32.3%	82.9%	92.6%	32.0%	75.0%	88.9%	81.0%
Circular technologies	23.3%	74.3%	85.2%	20.8%	75.0%	85.2%	61.9%
Other environmentally sustainable technology	33.3%	80.0%	77.8%	36.0%	68.4%	81.5%	71.4%

Note: The number of observations per category varies between 84 and 93.
Source: European Commission, JRC/DG R&I.

Overall, sustainability and digitalisation are not only considered to be important drivers of the companies' expected R&D investment decisions, but also drive related non-R&D capital investment that are aimed to ensure the companies' future competitiveness. This proves that innovative EU companies have already taken on board the transformative role of research, development and innovation in achieving sustainable competitiveness – as envisaged in the EU growth strategy.

3.4 Technologies embodied in new goods and services

The companies were asked whether they produced new goods or provided new services in 2021 using one or more of a list of technologies. Most of the respondents answered this question and thereby provide an interesting picture of the current and future status of technology application.

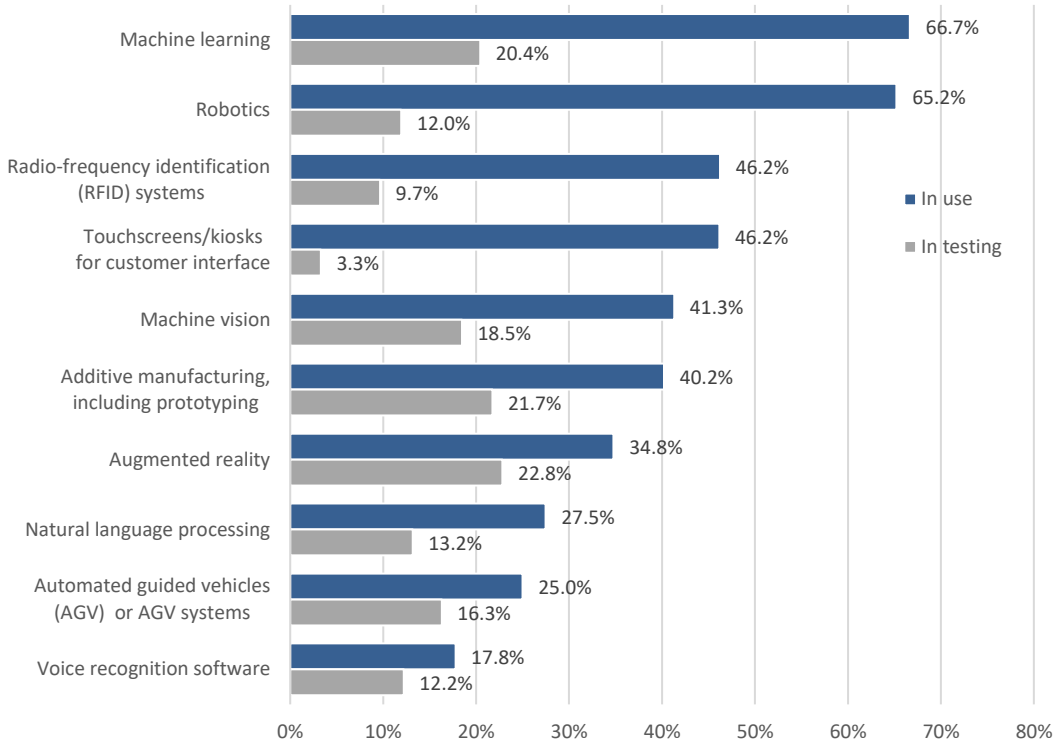
The innovations brought to the market in 2021 centre around Industry 4.0 technologies. As Figure 10 shows, machine learning and robotics are already used by two thirds of the responding companies and they are in testing in another 20% and 12% respectively. Other more specific technologies such as radio-frequency identification systems (RFID), touchscreen interfaces and machine vision are used by around 40% of the respondents.

From a sectoral perspective, machine learning is used in the goods and services of 89% of ICT services companies, 88% of energy producers, 78% of ICT producers, and 71% of industrial companies and companies in the automobiles and parts sector.

Robotics are used by all industrial companies, 80% of chemicals companies, 75% of ICT producers, and aerospace and defence companies and 57% of companies in the automobiles and parts sector. Additive manufacturing (3D printing) is widely used by companies in aerospace and defence (100%), chemicals (60%), automobiles and parts (57%), and industrials (54%), but this technology is either in testing or not (yet) deployable in the other sectors. RFID and touchscreens are mostly used by aerospace and defence companies, companies in the 'others' category, industrials and by ICT producers. Touchscreens are more prominent in chemicals, construction and industrials.

Automated guided vehicle (AGV) technologies and systems are currently in use or in testing in 44% of the respondents. The most intensive use of AGV in 2021 was reported by the ICT producers (62.5%), aerospace and defence (50%), and industrials (41%). Only 14% of automobiles and parts companies already use AGV, but 57% are currently testing this technology.

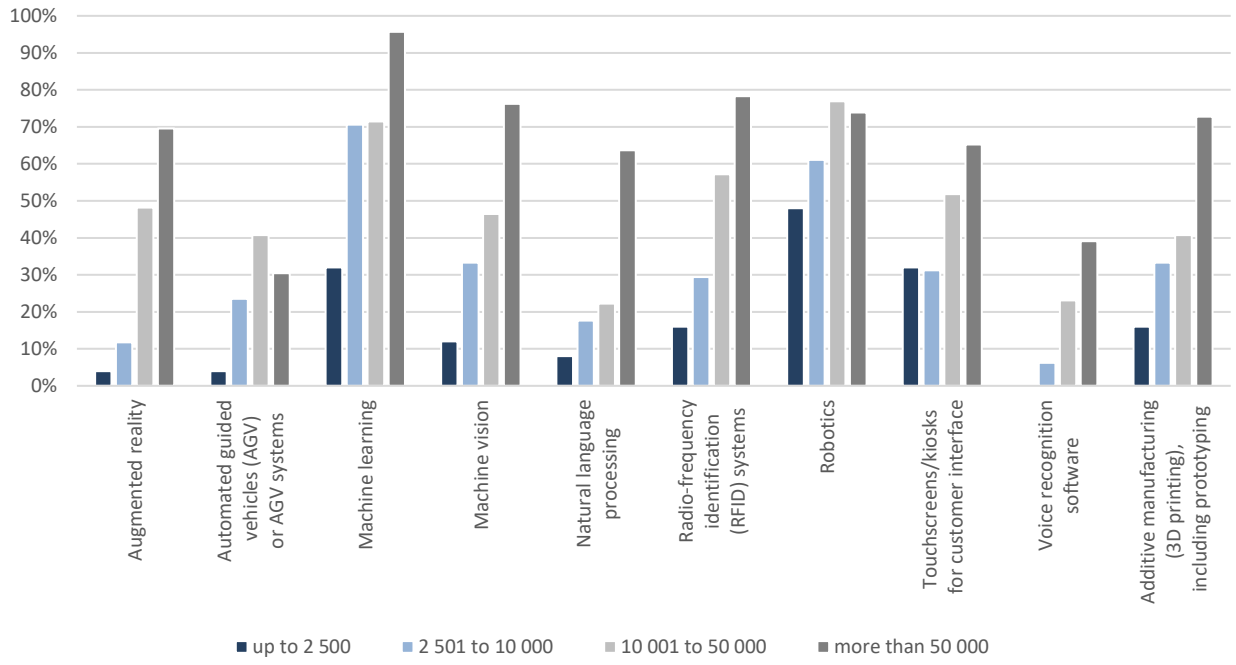
Figure 10 Technologies embodied in new goods and services, 2021



Note: the number of observations per category varies between 90 and 93.
Source: European Commission, JRC/DG R&I.

The larger the company by number of employees, the greater the number of the listed technologies that are likely to be already embodied in its goods and services. Figure 11 shows which technologies are already used in the products and services provided by companies according to the four size classes. Companies with more than 50 000 employees are leading the implementation of new technologies (with the exception of automated guided vehicles) both in the share of applicants and in the breadth of technologies.

Figure 11 Technologies in new goods and services in 2021 – size classes



Note: the number of observations per category varies between 90 and 93.
Source: European Commission, JRC/DG R&I.

4 Public incentives and support for R&D

Companies can benefit from a wide range of public measures that are intended to support their R&D efforts. In 2019, financial support in the form of tax measures exceeded direct R&D funding in the EU for the first time – 58% of total government support to business R&D in 2019 was in the form of tax support (SRIP 2022[16]).

KPMG and EY issue overview reports[17] in alternate years on the R&D support measures currently available across jurisdictions worldwide – with a focus on tax measures. The OECD does the same[18] for the OECD countries. Tax support for R&D has gained in prominence in recent years. Many researchers have shown how effectively well-designed R&D tax credits and subsidies can stimulate R&D and innovation – a 2022 summary of the relevant literature[19] provides detailed evidence on a wide set of industrial policy measures.

In this year's survey questionnaire, we asked the companies to state which types of R&D support measures they use. Companies are usually eligible only for a subset of possible support instruments, depending on a number of criteria including the tax laws applicable in the countries where their headquarters are located and/or they are carrying out R&D.[20] Our questionnaire contained a list of 15 different instruments (based on EY's 2020 report). Table 13 shows how many of them are available in the countries where the survey respondents have their headquarters.

Table 13 Public incentives for R&D investment across headquarter countries

	Number of available instruments	Share of using companies	Average number of instruments used by company
Austria (n=4)	3	75.0%	5.3
Belgium (n=5)	9	100.0%	6.0
Denmark (n=3)	5	66.7%	2.5
Finland (n=7)	4	100.0%	3.1
France (n=14)	7	100.0%	3.8
Germany (n=17)	3	88.2%	2.4
Ireland (n=1)	6	100.0%	1.0
Italy (n=8)	3	87.5%	3.9
Luxembourg (n=1)	7	100.0%	7.0
Netherlands (n=8)	9	75.0%	3.2
Portugal (n=3)	5	100.0%	3.7
Spain (n=13)	7	100.0%	5.2
Sweden (n=7)	2	14.3%	2.0
Total (n=91)	70	85.7%	3.8

Note: The number of instruments per country is taken from KPMG's 2021 report.
Source: European Commission, JRC/DG R&I.

The number of available instruments varies considerably across countries, ranging from 9 in Belgium and the Netherlands to just 2 in Sweden. The proportion of companies that use at least one of those support instruments is generally very high, and only respondents headquartered in Sweden make minimal use of the available support. As can be seen from the average number of instruments used by companies, they can claim R&D support in the jurisdictions in which they carry out R&D. As an example, the survey respondents from Austria and Italy on average benefit from 5.3 and 3.9 R&D support measures respectively – even though only 3 different instruments are available in Austria and Italy.

The most widely provided R&D support instruments worldwide (taking into account the respondents' affiliates in locations other than the headquarters country) are cash grants, tax credits, tax deductions, patent-related incentives and loans (see EY 2020 and KMPG 2021). As Figure 12 shows, these are also the instruments that are most used by the survey respondents:

16 Science, research and innovation performance of the EU 2022; https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/support-national-research-and-innovation-policy-making/srip-report_en

17 KPMG 2021: Global R&D Incentives Guide https://home.kpmg/us/en/home/insights/2021/05/tnf-kpmg-report-overview-of-r-and-d-tax-incentives-by-country-2021.html; EY 2020: Worldwide R&D Incentives Reference Guide, https://www.ey.com/en_id/tax_law_guides/worldwide-r-and-d-incentives-reference-guide-2020.

18 OECD tax incentives data base: https://www.oecd.org/sti/rd-tax-stats.htm.

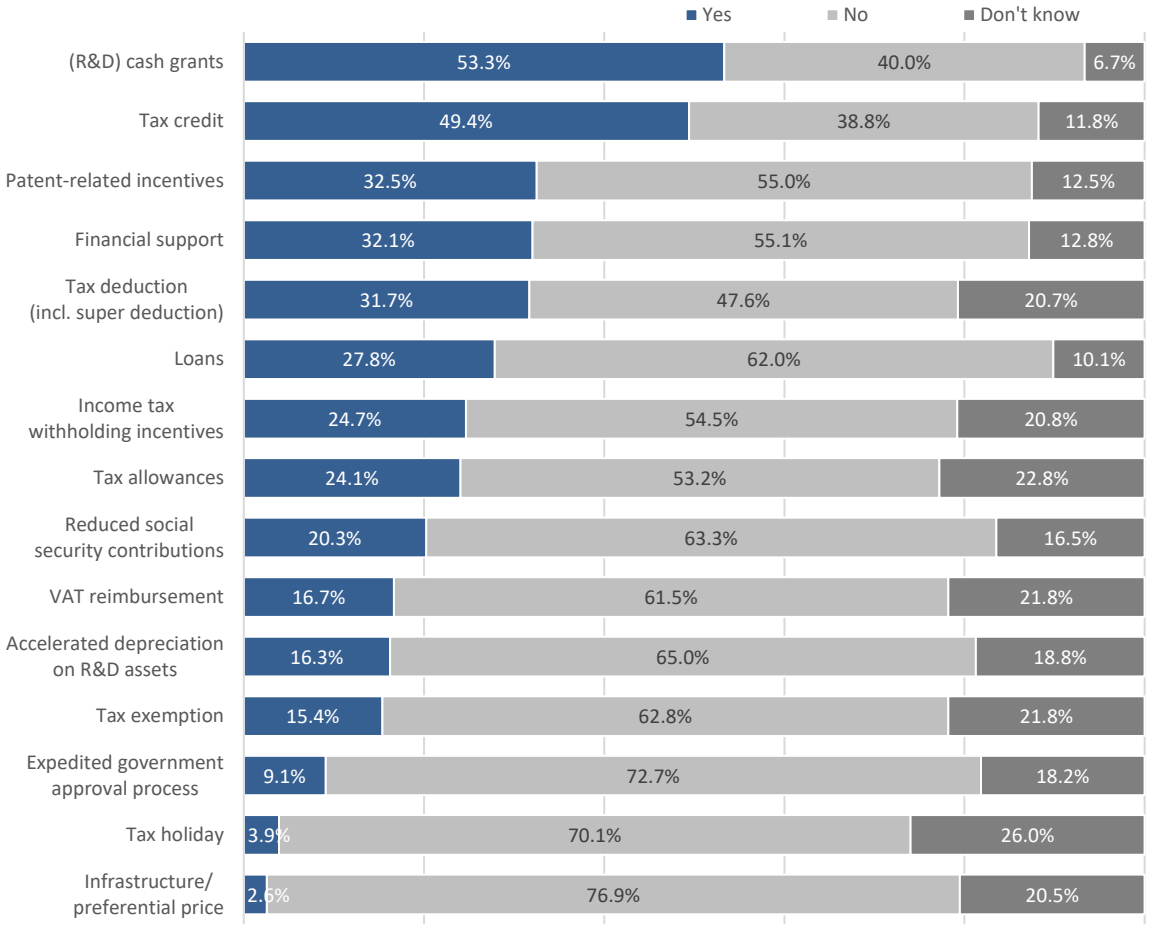
19 Criscuolo, C. et al., 'Are industrial policy instruments effective?: A review of the evidence in OECD countries', *OECD Science, Technology and Industry Policy Papers*, No 128, OECD Publishing, Paris, 2022, https://doi.org/10.1787/57b3dae2-en.

20 For example, some instruments are capped at certain levels, and some are available only for young companies, specific technologies or expenditure categories, etc.

53.3% of the respondents received cash grants, 49.4% claimed tax credits, and 32.5% benefited from patent-related incentives. 32.1% of the respondents also received financial support (defined as contributions to investment costs, guarantees or a capital increase in the case of venture capital funding). The other instruments were less used, partly because they were less available.

All the largest respondents in the sample use some of the R&D support measures, but this share is between 77% and 85% for the other size classes. Larger companies are more likely to have R&D activities in different jurisdictions and are therefore more likely to choose from a wider variety of support instruments. However, no insights could be obtained when we looked for a potential correlation between the (approximate) number of R&D locations and the number of support instruments used.

Figure 12 Public support measures for R&D used in 2021



Note: the number of observations per category varies between 78 and 90.
Source: European Commission, JRC/DG R&I.

The respondents use 3.8 different support measures on average, but those in high-tech sectors use significantly more (4.4 instruments on average). This could be for various reasons, such as specific measures for high-tech industries, company size (some instruments are available only for SMEs) and age (some instruments are specifically designed to support employment growth in young and/or R&D-intensive firms). The sectoral analysis confirms this: companies in health industries use 4.7 instruments on average, and aerospace and defence companies use 4.3 – but only 60% of the companies in the automobiles and parts sector use public financial R&D incentives and they use only 3.3 instruments on average. However, the low number of respondents from this sector suggests that this result is only indicative and needs to be taken with care.

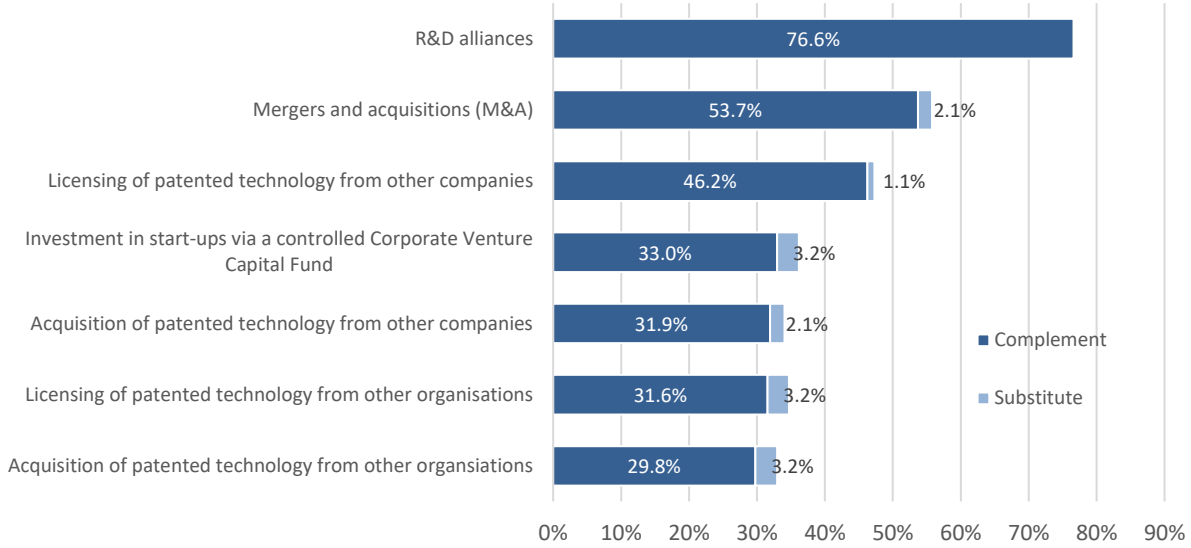
Overall, the use of some R&D support instruments is surprisingly low. In 2021, all but two countries with companies responding to the survey (Finland and Sweden) offered R&D tax credits, but only half of the respondents reported that they had used them. Even if eligibility criteria for tax credits vary and depend on various criteria such as R&D expenditure type and when support is limited to a maximum eligible R&D amount, one would expect that companies would use all available support instruments to finance their R&D. However, the survey reveals that some respondents do not exploit the full potential of public support for their R&D.

5 Open innovation

An open innovation model is characterised by the use of purposive inflows and outflows of knowledge to accelerate innovation and expand the markets for external use of innovations. By contrast, firms operating in a closed innovation model internalise their R&D activities and commercialise them through internal development, manufacturing and distribution.

The survey was designed to ascertain whether, how and to what extent the companies in the sample were active in open innovation in 2017-2021. The questionnaire asked whether the companies applied certain strategies and, if so, whether they did so in a way that complemented or substituted own R&D. The results show that the respondents are often engaged in open innovation activity, but almost always as a complement to their own internal research. This does not come as a surprise because a base internal absorptive capacity is required in order to apply external R&D results.

Figure 13 Open innovation activities 2017-2021, share of companies



Note: the number of observations per category varies between 93 and 95. Other organisations refer to higher education institutions, research and technology offices, etc.
Source: European Commission, JRC/DG R&I.

R&D alliances are the most common form of open innovation activity. They are defined as innovation-based relationships between two or more partners that pool their resources and coordinate their activities to reach a common goal. 76.6% of the respondents had participated in R&D alliances in the previous 5 years. The second most common form was mergers and acquisitions (M&A), which were concluded by 57.6% of the respondents (two respondents also reported M&A activity as a substitute for their own research). The third most common form was the licensing of patented technology from other companies (46.2%). The other four options were implemented by between 33% of respondents (investment in start-ups via a controlled corporate venture capital funds (CVC)) and 29% of respondents (acquisition of patents from other organisations such as higher education institutions). Overall, the respondents preferred licensing-in of technology to its acquisition.

Table 14 shows that larger corporations are more active in open innovation than smaller size class ones. This is particularly visible in investment in start-ups via controlled CVC funds: over two thirds of the companies with more than 50 000 employees had invested in start-ups in the previous 5 years. The figure for the larger corporation supports the findings from SB 2021[21] that 62% of the largest R&D investors in the world invested in start-ups via CVC funds at least once in 2000-2020. The survey results also show that start-up investment complements own R&D rather than acting as a substitute for internal efforts. The total amount of CVC remains low, however. In the SB 2021, the CVC investment of EU-headquartered companies amounted to only 2.4% of their total R&D investment.

[21] European Commission, Joint Research Centre, Grassano, N., Hernandez Guevara, H., Tübke, A. et al., *The 2021 EU industrial R&D investment scoreboard*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2760/559391

Table 14 Open innovation activities – size classes

	up to 2 500	2 501-10 000	10 001 – 50 000	More than 50 000
Mergers and acquisitions (M&A)	41.7%	30.0%	75.9%	59.1%
Investment in start-ups via a controlled CVC fund	8.3%	35.0%	25.0%	68.2%
R&D alliances	62.5%	70.0%	85.7%	86.4%
Acquisition of patented technology from other companies	20.8%	10.0%	42.9%	50.0%
Acquisition of patented technology from other organisations	25.0%	15.0%	32.1%	45.5%
Licensing of patented technology from other companies	29.2%	30.0%	59.3%	63.6%
Licensing of patented technology from other organisations	12.5%	25.0%	31.0%	59.1%

Note: the number of observations per category varies between 93 and 95. Other organisations are higher education institutions, research and technology offices.
Source: European Commission, JRC/DG R&I.

This analysis reveals the rather low share of companies that license or acquire patented technology from higher education or research institutions. This could be an indication that technology transfer between the business corporations and research institutions does not work so effectively.

The survey further investigates technology licensing: overall, 66% of the respondents license-in technology, 52% license-out and 30% cross-license technology. As with open innovation more generally, the level of licensing activity is related to company size rather than to technology class (even if high-tech companies are slightly more active than the medium- and low-tech companies). Table 15 gives an overview of the proportion of companies that actively license technology. It also shows that quite a substantial share of licensed technologies are incorporated in standards.

Table 15 Licensing of technology – size classes

	n	License-In	Standards	License-Out	Standards	Cross-license	Standards
up to 2 500	26	50.0%	38.5%	53.8%	21.4%	8.0%	50.0%
2 501 to 10 000	20	70.0%	14.3%	30.0%	16.7%	21.1%	0.0%
10 001 to 50 000	27	59.3%	37.5%	51.9%	21.4%	29.6%	37.5%
more than 50 000	22	90.5%	42.1%	68.2%	53.3%	63.6%	50.0%

Source: European Commission, JRC/DG R&I.

In general, the respondents did not report significant barriers in technology licensing. About a third reported difficulties in identifying companies to whom their technology could be licenced as well as in negotiating contracts with the implementers of their technology. Most of the companies with these problems have fewer than 2 500 employees and are in the health industries or ICT producers categories. By contrast, legislation on intellectual property rights, rules of standard development organisations and antitrust rules/technology transfer guidelines do not prevent these companies from licensing in and out.

57% of the respondents have only limited openness to sharing technology and knowledge because they prefer to develop exclusively in-house (rather than license in) the technology that they use. This is particularly the case for high- and low-tech respondents; only 37% of medium-tech respondents have such a strategic preference.

Table 16 Barriers to technology licensing

	Licensing-out		Licensing-In	
	n	Share yes	n	Share yes
Identifying companies with whom our technology could be licensed	82	32.9%	83	26.5%
Successfully negotiating contracts with users of our technology	82	34.2%	83	33.7%
Legislation on intellectual property rights	81	16.1%	82	20.7%
Rules of standard development organisations	82	8.5%	82	9.8%
Antitrust rules (specifically technology transfer guidelines)	79	13.9%	82	13.4%
Strategic preference to exploit own technology exclusively	82	57.3%		

Source: European Commission, JRC/DG R&I.

6 External context

2021 was marked by the COVID-19 pandemic and the economic outlook for 2022 and 2023 is dominated by the impact of the Russian invasion of Ukraine on markets around the world and in the EU in particular. At the same time, these crises create opportunities to address some long-standing challenges (in particular, to boost digitalisation and to reduce the dependence of the EU's economy on fossil fuels). The survey questionnaire was therefore designed to ascertain the extent to which COVID-19 and the war in Ukraine have an impact on the companies' R&D investment and projects.

6.1 Effects of COVID-19 on internal R&D

Overall, the survey respondents did not report any significant COVID-19 impact on their in-house R&D investment. 71% did not report any change in their in-house R&D expenditure, 12.5% reported an increase and 12.5% reported a reduction (the remainder of the sample said that they did not know). Around a quarter of the respondents in the automobiles and parts, and industrials sectors reported a decrease in R&D investment. By contrast, it is interesting to note that over 75% of the respondents in the health industries, ICT producers and ICT services sectors did not report any changes in R&D investment due to COVID-19. Respondents that did increase their R&D investment tended to be in the smaller size class and high-tech companies, while those with a decrease were more likely to be in the medium- and low-tech sectors. Table 17 summarises the results by size and technology classes.

Table 17 Change in R&D investment due to COVID-19 – technology and size classes

Technology class	n	Increase	No change	Decrease	Don't know
High	32	21.9%	68.8%	6.3%	3.1%
Medium	37	8.1%	73.0%	13.5%	5.4%
Low	27	7.4%	70.4%	18.5%	3.7%
Size class					
up to 2 500	26	19.2%	61.5%	15.4%	3.8%
2 501 to 10 000	20	10.0%	85.0%	5.0%	0.0%
10 001 to 50 000	28	10.7%	71.4%	10.7%	7.1%
more than 50 000	22	9.1%	68.2%	18.2%	4.5%
Total	96	12.5%	70.8%	12.5%	4.2%

Source: European Commission, JRC/DG R&I.

The picture looks different when we look at COVID-19's impact on R&D at the project level. It is important to note that the relevant question allowed for multiple answers (i.e. companies could indicate that they had both cancelled and initiated projects). 72% of the respondents reported that existing R&D projects were disrupted or delayed, and 21% reported that they had completely cancelled existing R&D projects. 56% reported a cancellation or delay of planned R&D projects. COVID-19 had the greatest impact on the R&D projects of medium-tech companies, which reported more of an impact in every respect.

On the positive side (albeit to a lesser extent than the disruptions or delays in existing projects or cancellations and delays of planned projects), COVID-19 also inspired many new R&D projects in more than half of the respondent companies. Large companies in particular (e.g. in the automobiles and parts, aerospace and defence, chemicals, and energy sectors) developed and began to realise new ideas. Furthermore, more than half of the companies in the health and ICT producers sectors developed and started new R&D projects.

Table 18 Effect of COVID-19 on R&D projects – size classes

	Technology Classes			Size Classes			
	High	**Medium**	**Low**	**up to 2 500**	**2 501 to 10 000**	**10 001 to 50 000**	**more than 50 000**
New R&D projects inspired by the pandemic were started	46.9%	61.1%	37.0%	38.5%	31.6%	59.3%	65.2%
Planned R&D projects were cancelled or delayed	53.1%	62.2%	50.0%	42.3%	55.0%	64.3%	60.9%
Existing R&D projects were cancelled	15.6%	27.8%	18.5%	19.2%	21.1%	18.5%	26.1%
Existing R&D projects were disrupted or delayed	71.9%	75.0%	67.9%	76.9%	65.0%	70.4%	73.9%

Source: European Commission, JRC/DG R&I.

6.2 The war in Ukraine

During the time of the survey from June to September 2022, 86% of the respondents do not report any net change in their in-house R&D expenditure as a consequence of the war in Ukraine, and only 6% reported an increase. No company expects a decrease in in-house R&D expenditure as a consequence of the war. Only a few effects on R&D projects can be discerned so far. A third of the respondents stated that existing R&D projects had been delayed or disrupted, and 20% reported that planned R&D projects had been cancelled or delayed. Only 9% of the respondents had had to cancel existing R&D projects. Delays to existing projects were most common in the aerospace and defence (80%), construction (66.7%), health industries (43%), and automobiles and parts (43%) sectors. These sectors (except for health) also reported that planned research projects had been cancelled or delayed.

15.9% of the respondents also reported that they had started new R&D projects as a result of the war. 80% of aerospace and defence respondents had done so, but they were also the ones whose operations had been most disrupted by the war. Several energy and ICT services companies also reported that they had started new R&D projects in response to the war. Overall, the impact of the war on R&D was still limited at the time of the survey and mostly confined to a few specific sectors.

7 Conclusions

By addressing the previous year's Scoreboard EU 1 000 firms (*Scoreboard* 2021), the objective of this survey is to gather future expectations for R&D investment in 2022/2023 and gain first-hand information on barriers and drivers and the role of various activities that influence the level and direction of R&D investment. The survey addresses financing and collaboration, technology transfer and open innovation, and the effects of COVID-19 and the war in Ukraine.

The survey response rate stood at 12%. The number of responses increased by 31.5% compared to the previous year, and the respondents accounted for over 26% of the R&D investment of the top 1 000 EU corporate investors in R&D.

The results show a strong recovery in R&D investment after the COVID-19 pandemic, and the respondents expect this positive development to continue in 2022 and 2023. The main drivers of R&D investment decisions are environmental sustainability and digitalisation (particularly in the medium- and low-tech sectors). The respondents' capital investment is largely driven by technologies to reduce emissions and to adapt to Industry 4.0. Therefore, the survey confirms that innovative EU companies are actively helping to meet the targets set out in the European Green Deal and the green and digital transformation (the Twin Transition).

The respondents actively practise open innovation, but the means they use vary according to company size. Companies in all size classes participate in R&D alliances, but it is mainly large companies that invest in start-ups via controlled CVC funds as well as mergers and acquisitions.

R&D alliances remain the main form of open innovation, followed by M&A and licensing. The fact that non-corporate sources for new technologies are on the radar screen and used on a comparable scale to corporate sources underlines the importance of public-private partnerships, technology transfer organisations and spin-offs. Start-ups and CVC activities are clearly newer instruments that complement in-house R&D.

Most of the respondents use public-sector support for R&D. This is particularly the case for large companies and high-tech companies, which take up many different support measures. About half of the respondents use tax credits, which is the second highly used R&D support instrument.

The 2022 survey for the first time asked the companies to report the number of female R&D FTE. The 77 companies that answered this question reported 40 484 female R&D FTE. This corresponds to an average 31.9% share of female R&D employees per company (28.9% at the median) and exceeds the proportion of women in the overall business sector's R&D by 10 percentage points, as per recent Eurostat figures.

This 2022 survey also addressed the impact of the COVID-19 pandemic and the war in Ukraine. COVID-19 had a mixed impact on the respondents' R&D. In terms of numbers of projects, many existing and planned projects were delayed and some were cancelled, but many companies reported that COVID-19 had caused them to start new R&D projects. R&D investment expenditure was less affected by the pandemic, however. Most of the respondents did not report any change, and those that did report a change were equally split between those who reported that they had increased their investment expenditure and those who had decreased it. The war in Ukraine so far appears to have had a negative impact only in some sectors such as construction, aerospace and defence, energy, and chemicals. Very few of the respondents reported any R&D activity in Russia so direct disruptions have so far remained limited.

Regarding policy measures, most of the respondents use some incentives and public-sector support for R&D. This is particularly the case for large and high-tech companies, which take up more types of different support measures than the average. However, there is high heterogeneity between the use of the different instruments and per Member State. While about half of the respondents use tax credits, which is the second most highly used R&D support instrument offered in almost all EU Member States, this survey does not allow to understand if there are information gaps or administrative burdens or whether these firms do not need such support because they are already leading R&D players.

Further information on R&I analyses and EU policies is available at:

https://iri.jrc.ec.europa.eu/home/

and

https://research-and-innovation.ec.europa.eu/strategy/support-policy-making_en

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