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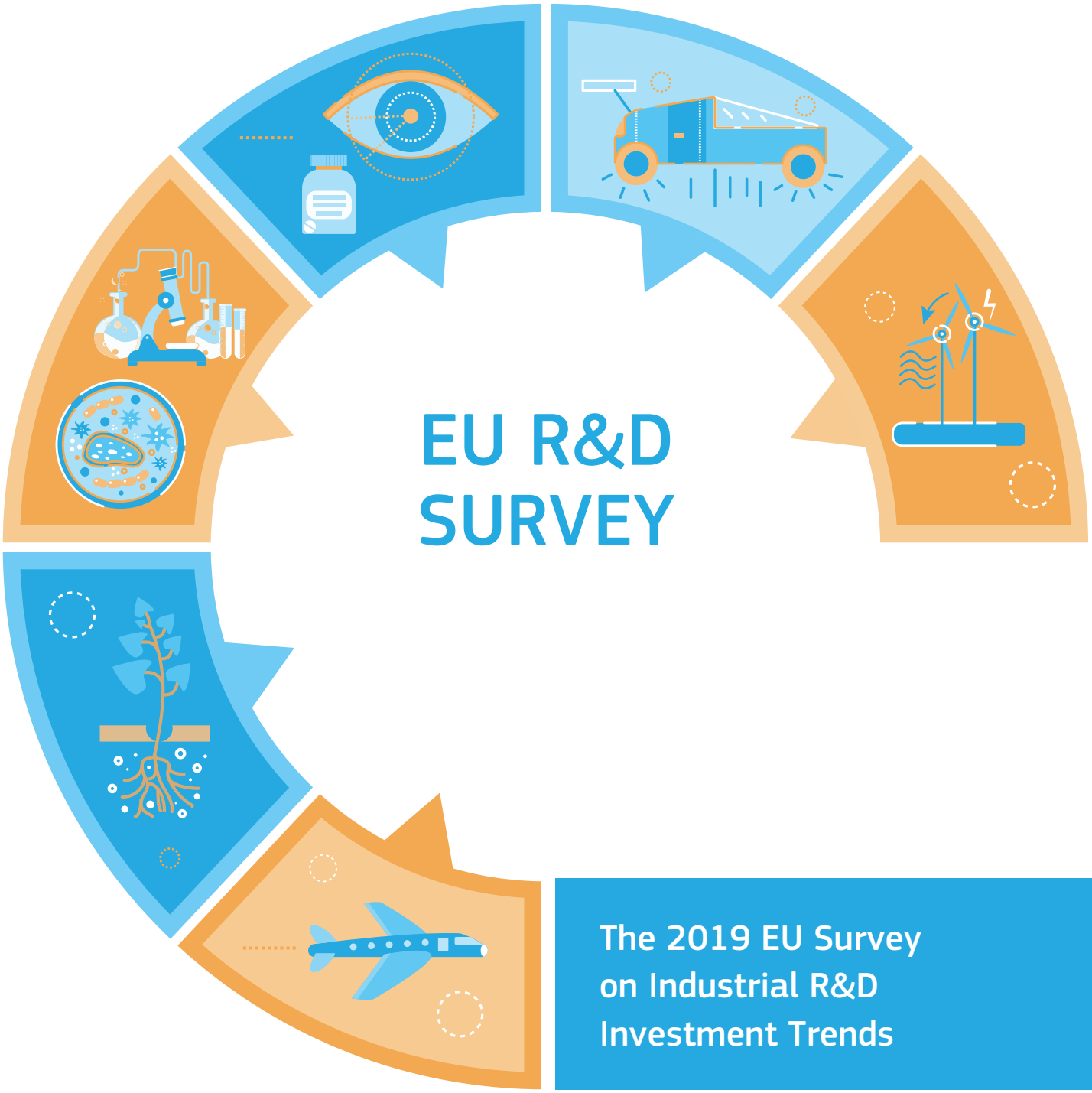

EU R&D SURVEY

The 2019 EU Survey on Industrial R&D Investment Trends

EUR 30005 EN

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GLORIA activities aim to improve the understanding of industrial R&D and Innovation in the EU and to identify medium and long-term policy implications.
The project was coordinated under the leadership of Alessandro Rainoldi (Head of B.3 Territorial Development) and Doris Schröker (Head of DG RTD.F1 Industrial R&I Agendas and Business Intelligence). This document was produced by Lesley Potters and Nicola Grassano (JRC.B) as the main authors. Alexander Tübke from JRC B.3 and, Alex Talacchi and Emilia Chehtova from DG RTD.F1 made contributions to the design and review of the survey.

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EU R&D SURVEY

The 2019 EU Survey on Industrial R&D Investment Trends

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0 EXECUTIVE SUMMARY

Executive summary

The 131 EU companies participating in this year's EU Survey on Industrial R&D Investment Trends expect R&D investment to increase by 4.6% per annum in 2019 and 2020. This is slightly below the 5.4% that was expected last year, but still high from a historic perspective. Companies in the 'Health Industries' and 'ICT producers' sectors expect their R&D to increase the most.

90% of all participating companies have both environmental and social sustainability policies in place, while the rest plan to introduce them in the next five years. Due to the European Green Deal and climate action priority of the Commission, this year's survey asked participating firms about the sustainability efforts of their companies. Companies that had environmental sustainability policies in place also had social sustainability policies in place (and vice versa). Only two companies indicated they do not have either an environmental or social sustainability policy in place, and are not planning to implement this within the next five years.

Sustainable technologies are considered among the most relevant technologies for remaining competitive in the future. Together with Artificial Intelligence (AI) and Big Data, these technologies have been identified as the most relevant for future competitiveness. While sustainability technologies are specifically relevant for companies in sectors that have a big impact on the environment (either as a provider or supplier of sustainable solutions), AI and Big Data are expected to have a positive impact on competitiveness in a wide range of sectors.

Health Industries and Industrials invest the smallest proportion of net sales in environmental sustainability. Companies from the ICT sectors have the highest environmental sustainability intensity[1]. While the average R&D intensity for all participants in the survey is 3.5%[2], this environmental sustainability intensity is 1.0%. Less than half the companies provided an estimation of the company's investments in environmental sustainability, indicating that many companies still do not keep track of this information or find it difficult to provide even a rough estimate.

This year's expectations on the impact of Brexit on R&D strategies are much more negative than last year. The proportion of firms expecting no impact decreased from 52% to 37%, while the group expecting a relevant impact on their R&D strategies multiplied from 4% to 16%. In particular, firms that indicated last year that the impact depends on negotiations became more negative, with almost half of them now expecting a relevant impact – a clear indication of how the situation has evolved over the past year. This information was gathered over the period March-June 2019, during which insecurities about implementation of the Brexit process increased significantly.

72% of all R&D is performed within the EU, which is similar to previous editions. This proportion has been stable for many years, and is still not showing any sign of erosion or offshoring of the R&D base to other regions. In fact, the absolute amount of R&D within the EU is expected to grow by 2.5% per annum over the next two years, from €25 billion to €26 billion, while the

[1] Also calculated as a percentage of net sales in 2017.

[2] This is calculated from R&D investments for the year 2018, as expressed in the questionnaire, over net sales for the year 2017 as published in the 2018 R&D Scoreboard.

proportion of firms with R&D activities in all four main regions (EU, US, Asia and RoW) remains very high.

For the first time since the start of the survey, R&D investment growth in China is expected to be in single digits (8.1% compared with 21.3% in the previous survey). The highest R&D increase in percentage points is expected in India (+10.4%, similar to last year). This year's expected increase of 'only' 8.1% is the lowest expected for China since the start of the survey, although still well above average expected R&D growth.

One in nine companies in this survey perform R&D in only one country – in line with last year's survey. All these firms perform their R&D exclusively in the country of their headquarters. The headquarters country remains an important location for companies with international R&D activities: almost 80% of the firms have their main R&D location in the country of their headquarters, and perform a higher proportion of their R&D in this location than firms with their main R&D location away from the company's headquarters (68% vs 42%).

The United States is the most popular R&D location for the top EU R&D performers that participated in this survey, followed by Germany and China. Almost half the participants perform R&D activities in the US. For Germany and China, this is around one third of the companies. Within the EU, Germany is followed by the UK, France and Sweden.

1 INTRODUCTION SAMPLE COMPOSITION

1 Introduction - sample composition

The pivotal role played by Research and Development (R&D) activities in European productivity is well recognised among both policymakers and academics. While the Investment Plan for Europe (the 'Juncker Plan') will continue to play an important role in triggering funding and mobilising investment in the real economy, the new 'Green Deal' proposed by President Von der Leyen will steer much of the EU's innovative capabilities, both public and private, towards the main objective of achieving climate neutrality. Understanding the dynamics, strategies, motivations and possible future developments in R&D activities carried out by the top EU private R&D investors is key to the formulation of sound policies in this field.

Since 2006, the EU Survey on Industrial R&D Investment Trends has aimed to shed light on the R&D activities of top EU R&D corporate investors identified through the EU R&D Scoreboard. This is performed via a survey of R&D levels and trends, location strategies, drivers, production strategies and non-R&D activities of these companies, which are responsible for the bulk of private R&D in the EU. The 2019 edition adds a specific focus on the sustainability activities and practices of these companies. The survey forms part of the Global industrial Research and Innovation Analyses (GLORIA) project by the Joint Research Centre (JRC)[3], jointly undertaken with the Directorate-General for Research and Innovation (DG RTD)[4].

The questionnaire for the EU R&D Survey was sent by post to the top operational level (Chief Executive Officer or similar), or previous year's contact person, at the top 1,000 EU companies (EU1000) appearing in the 2018 EU Industrial R&D Investment Scoreboard[5]. In total, 134 responses were received from EU companies; a response rate of 13.4%. The response rate was similar to the previous year (14.2%) and other years the EU Survey has been conducted[6]. Due to mergers and acquisitions in the sample, this year's survey received three replies from non-EU firms: one from the United States, one from Taiwan, and one from Switzerland. These firms[7] have been left out of the analysis (except where stated otherwise), since our main interest is to look at the trends in industrial R&D investment by EU firms. Therefore, the final working sample is of 131 companies.

The participating EU firms have a total R&D investment of €64.0 billion, corresponding to 31% of total R&D investment by EU firms in the 2018 EU R&D Scoreboard. Figure 1 shows the distribution of survey participants (red dots) by R&D investment vis-à-vis the distribution of all EU1000 sample firms (light grey bars). The two distributions are quite similar, so the 2019 Survey is equally representative of large, medium and small firms in terms of R&D investment.

The numbers and sample composition of the responses vary over the years, since there is no obligation to participate. In cases where the sample composition has an impact on the results, or where certain sectors or firms stand out, this is mentioned in the analysis.

[3] https://iri.jrc.ec.europa.eu/home/.

[4] https://ec.europa.eu/info/research-and-innovation/strategy_en.

[5] See 2018 EU R&D Scoreboard and link.

[6] The response rate averages around 16% for all surveys, with a downward trend. Companies indicated in last year's survey that they are experiencing an increasing burden of survey requests.

[7] The non-EU companies received the questionnaire mainly via their EU subsidiaries.

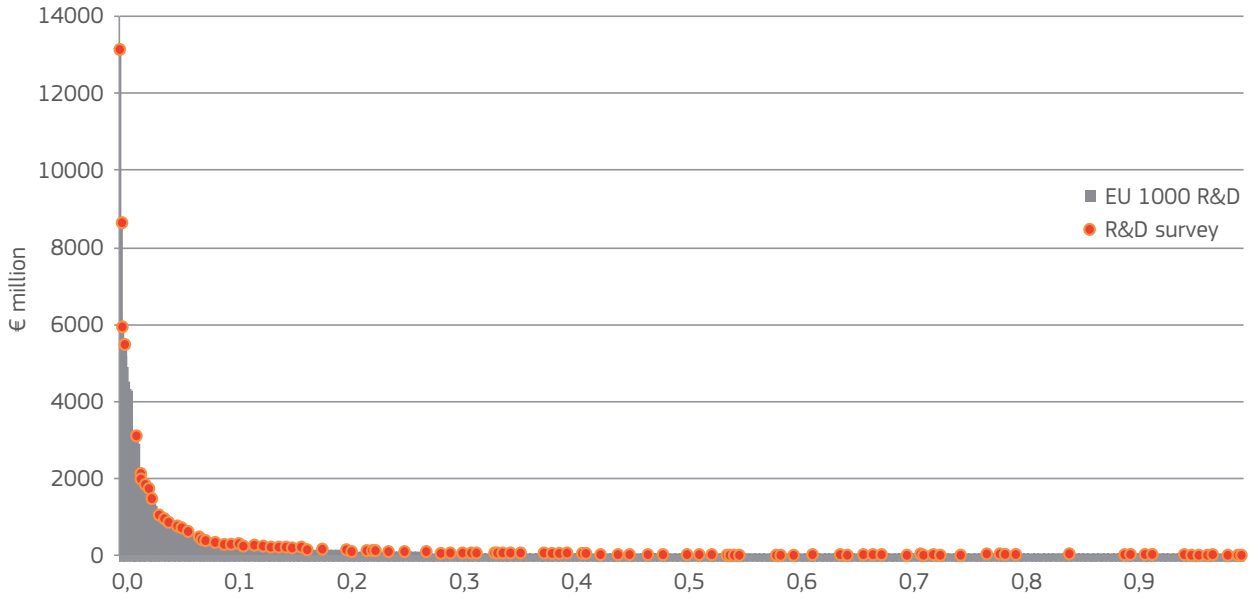

FIGURE 1: DISTRIBUTION OF R&D 2019 EU SURVEY PARTICIPANTS VS TOP EU1000 FROM THE 20178 EU R&D SCOREBOARD
Note: The figure refers to 131 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

1.1 | Company size

The respondents to the survey are – on average – the largest of the large multinationals that constitute most of the EU1000 R&D Scoreboard companies. The average R&D investment of this year's survey respondents is €488.9 million (€495.4 million in the 2018 survey), compared with €206.3 million average R&D investment for EU1000 firms. The respondents have average net sales of €15.9 billion (€6.6 billion for the EU1000 sample) and an average of almost 43,000 employees (around 22,000 for the EU1000 sample).

The sample contains only eight SMEs that have 250 or fewer employees. Using the traditional definition of small, medium and large companies[8] we would classify almost all the sample companies as 'large' companies. In order to increase detail in this report, we classified companies according to four different size classes: 1) up to 2,500 employees; 2) 2,501 to 10,000 employees; 3) 10,001 to 50,000 employees; and 4) more than 50,000 employees.

The participating top EU R&D performers employ 4.5 million employees globally, of which about 5.6% (250,000) are R&D employees. The average number of employees is similar to last year (35,000), and some sectoral differences are in line with earlier surveys. Aerospace (where 36% of total employees are R&D employees) and ICT producers (12.4% of total employees are R&D employees) have high proportions of R&D employees in their workforce, while sectors such as Industrials (2.8% are R&D employees) and Others (1.5% are R&D employees) show low proportions. The sectorial heterogeneity is highlighted in Figure 2, which shows for each sector both the percentage of total number of employees and the percentage of total number of R&D employees represented.

[8] Small enterprises (10 to 49 employees); medium-sized enterprises (50 to 249 employees); large enterprises (250 or more employees).

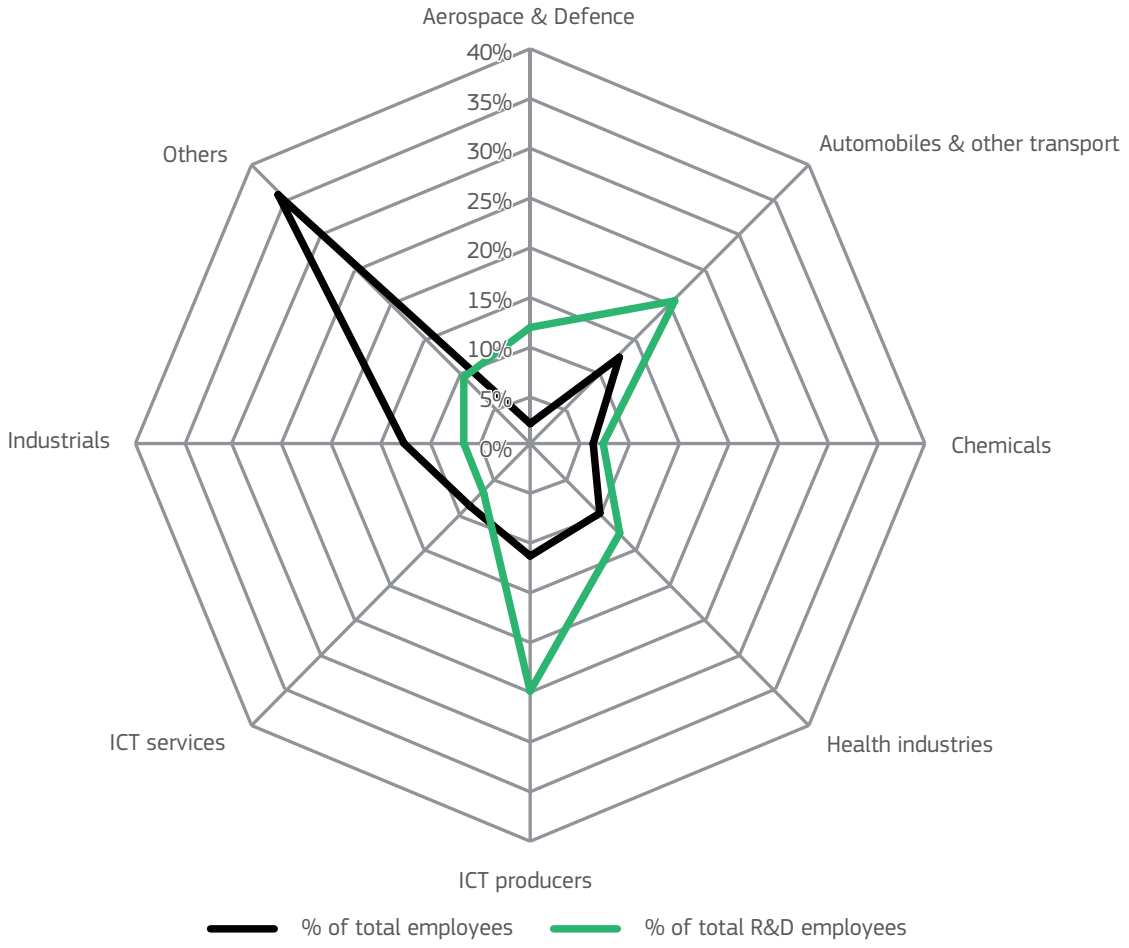

FIGURE 2: TOTAL EMPLOYEES AND R&D EMPLOYEES - PERCENTAGE BY SECTOR
Note: The figure refers to 130 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Apart from the sectors already mentioned, it is worth noting that the sector Automobiles and Other Transport represents a sizable proportion of all R&D employees in the sample. Figure 3 shows the relation between R&D intensity (R&D investments over net sales) and R&D employees as a proportion of the total number of employees. The R&D investments and number of R&D employees are highly correlated, as in previous years, since R&D employees' salaries are part of R&D investments. In fact, the correlation for the whole sample is 77%, compared with 78% last year and 70% the previous year, which also indicates the robustness of the samples.

The sectors with the highest correlation are also similar to previous years: Aerospace and Defence, Chemicals, and ICT producers; while the Others sector shows the lowest correlation, likely due to the mixed character of this sector group.

If we look at the relation between company size and proportion of R&D employees, we see that this is an inverse relationship, with the smaller companies having a higher percentage of R&D employees. This result is due to the presence of some high tech and biotech companies among the 'small' companies, and some big utility companies in the 'large' company group.

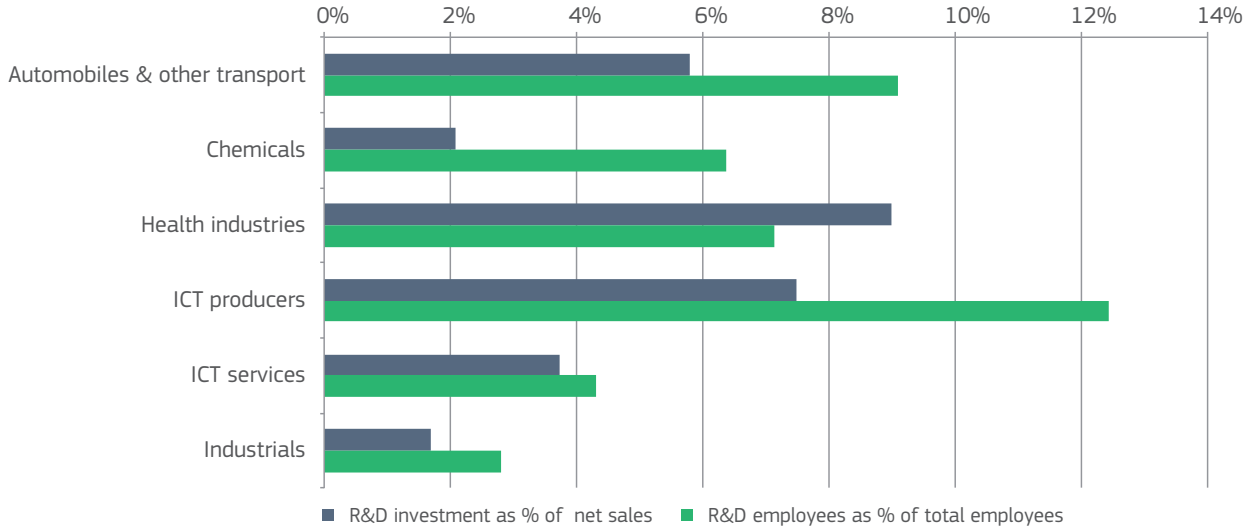

FIGURE 3: R&D INTENSITY AND R&D EMPLOYEES AS A PROPORTION OF TOTAL EMPLOYEES
Note: The figure refers to 127 out of the 131 companies in the sample: Aerospace and Defence (5), Automobiles and Other Transport (8), Chemicals (11), Health Industries (22), ICT producers (10), ICT services (11), Industrials (18), Others (not reported) (42).
Source: European Commission JRC-B (2019).

1.2 | Sector groups

This year's survey will use the following sector groups for some of its analyses (see Table 1). We aggregate Industrial Classification Benchmark (ICB) level 4 sectors into seven broad sector groups (using ICB levels 1 and 2) that can be identified by the reader more easily and are in line with the R&D Scoreboard. An eighth residual category (Others) includes all ICB level 4 sectors with few responses.

Looking at the respondents to this year's survey, the sector group with the highest percentage of replies is the Others sector, while the sector representing the highest share of R&D is Automobiles and Other Transport (as in the sample for last year). The sector distribution, in terms of R&D investment of the respondents, mirrors the R&D distribution of the top EU1000 companies in the R&D Scoreboard, with two notable exceptions: some overrepresentation in the Automobiles and Other Transport sector and some underrepresentation in the Health Industries sector.

Sector	ICB 4 digit name	Companies in the EU Survey (# and %)		Companies in the EU1000 (# and %)		% of R&D in Survey	% of R&D in EU1000
Aerospace & Defence	Aerospace & Defence	5	3.8	24	2.4	1.4	4.4
Automobiles & other transport	Automobiles & Parts	8	6.1	66	6.6	47	29.7
	Commercial Vehicles & Trucks						
Chemicals	Chemicals	11	8.4	41	4.1	5.3	2.7
	Commodity Chemicals						
Health industries	Biotechnology	22	16.8	191	19.1	12.2	22.2
	Health Care Equipment & Services						
	Pharmaceuticals						
ICT producers	Electrical Components & Equipment	10	7.6	108	10.8	12.6	12.9
	Electronic Equipment						
	Semiconductors						
	Technology Hardware & Equipment						
	Telecommunications Equipment						
ICT services	Computer Services	11	8.4	124	12.4	7.2	7.4
	Fixed Line Telecommunications						
	Software						
Industrials	Aluminium	20	15.3	141	14.1	2.9	5.9
	Diversified Industrials						
	General Industrials						
	Industrial Machinery						
	Industrial Metals & Mining						
	Industrial Transportation						
Others	Banks	44	33.6	305	30.5	11.4	14.8
	Beverages						
	Business Support Services						
	Construction & Materials						
	Electricity						
	Food Producers						
	Food Products						
	Forestry & Paper						
	Gas Distribution						
	Gas, Water & Multiutilities						
	Heavy Construction						
	Household Goods & Home Construction						
	Media						
	Media Agencies						
	Mining						
	Oil & Gas Producers						
	Oil Equipment, Services & Distribution						
	Personal Goods						
	Real Estate Holding & Development						
	Tobacco						
Total		**131**	**100**	**1000**	**100**	**100**	**100**

TABLE 1: SAMPLE COMPOSITION
Note: The figure refers to 131 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

1.3 | R&D activities locations

As the companies in our sample are large multinational companies, we know their activities are scattered around the globe. Thus, it is no surprise that the average number of countries in which our companies have their R&D activities located is 11, while the median is six and the mode[9] is four. This means that the average is heavily impacted by the larger firms.

There are also some interesting sectoral differences, as shown in Figure 4. The R&D activities of companies in the ICT producers sector are located, on average, in double the number of countries of companies in sectors such as Aerospace and Defence or ICT services. These latter two sectors also have the highest number of R&D employees. This apparent contradiction can be explained by two different R&D management models. In the Aerospace and Defence sector, in particular, R&D is performed at a limited number of sites and employees need to be co-located.

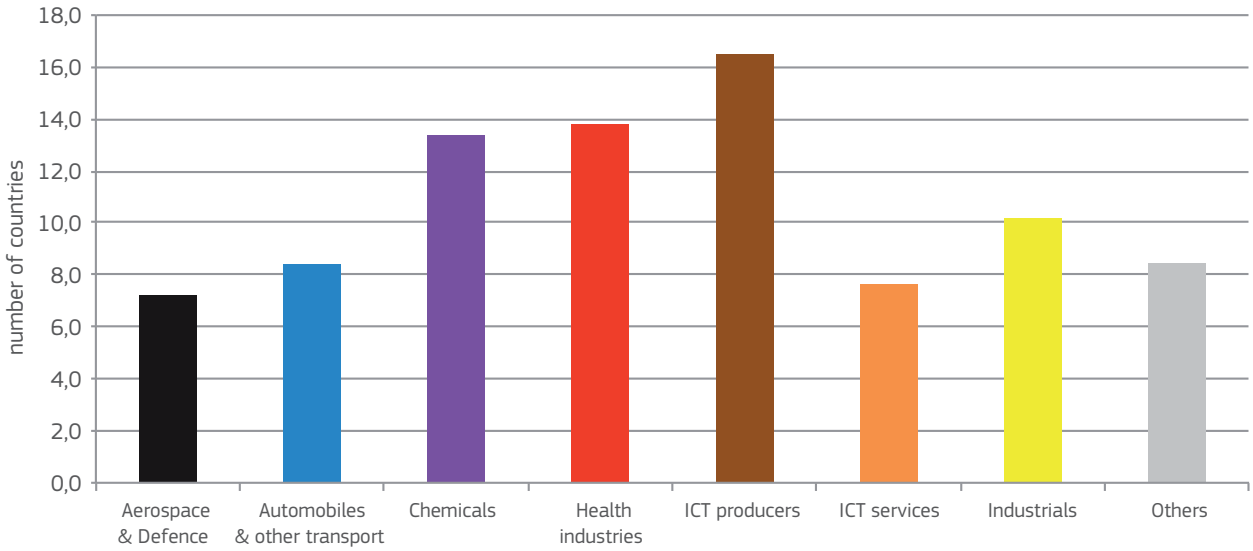

FIGURE 4: NUMBER OF COUNTRIES WHERE R&D ACTIVITIES ARE LOCATED - AVERAGE BY SECTOR
Note: The figure refers to 128 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

On the other hand, also shown in Figure 5, ICT producers source their R&D and knowledge from many different sites, so as not to lose out on developments in one of the several technology hubs around the globe, e.g. in the US, China and the EU. The data we have do not allow further investigation into this tendency. However, it is worth noting that this observation holds true even if we remove from the sample the top 10% and bottom 10% of companies in the distribution by number of R&D locations.

[9] Most frequent occurring observation.

FIGURE 5: R&D EMPLOYEES AND NUMBER OF COUNTRIES WHERE R&D IS PERFORMED, BY SECTOR

Note: The figure refers to 128 out of the 131 companies in the sample: Aerospace and Defence (5), Automobiles and Other Transport (7), Chemicals (11), Health Industries (22), ICT producers (10), ICT services (11) Industrials (20), Others (42).

Source: European Commission JRC-B (2019).

2

R&D INVESTMENT **EXPECTATIONS**

2 R&D investment expectations

The EU R&D Investment Scoreboard provides data on R&D investment by the top EU investing firms, taken from their audited annual reports. The survey complements this information, providing other indicators of their R&D activities: 1) number of R&D employees; 2) number of countries in which R&D activities are performed; 3) planned R&D investment for the following calendar year. In this section, we present these indicators in more detail.

2.1 | R&D forecasts

On average, companies in our sample forecast growth of 4.5% per annum in R&D in 2019 and 2020. 85% of the 111 companies that replied to this question indicated future growth in their R&D investment. Here too, there are differences among sectors, as reported in Figure 6. Health Industries, ICT producers, and Chemicals are the top sectors in terms of planned R&D growth.

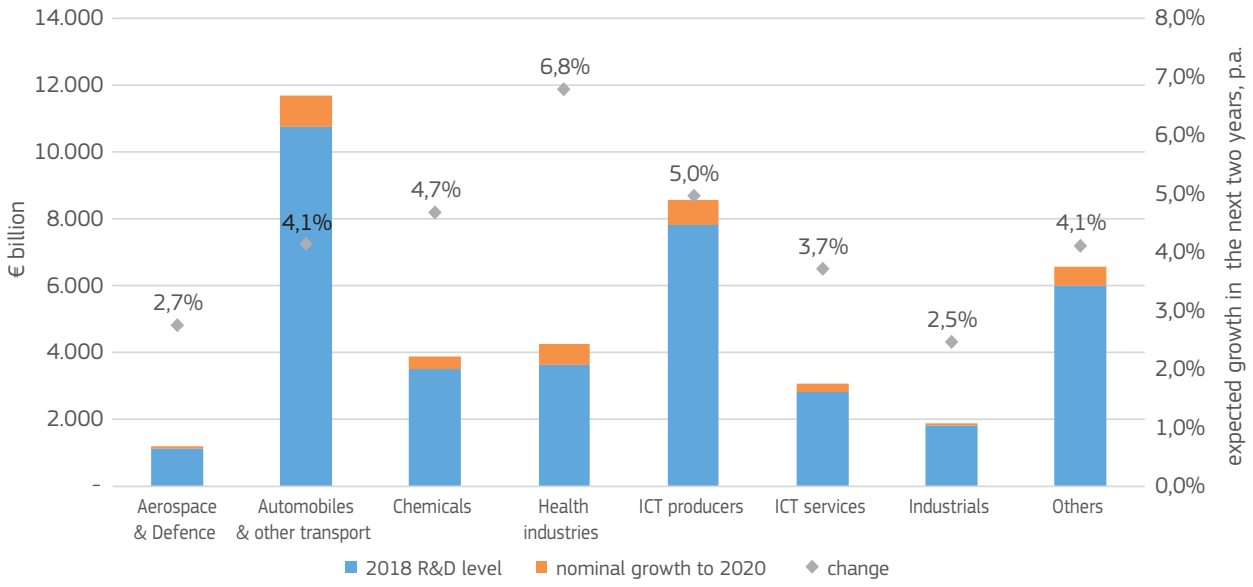

FIGURE 6: FORECAST R&D GROWTH - AVERAGE BY SECTOR
Note: The figure refers to 111 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Looking at the data from the company size perspective, small companies are reporting three times higher expected growth than all the other companies. This is consistent with the idea that small high tech and biotech companies invest heavily in R&D in order to grow. However, we must bear in mind that their starting point – the average 2018 level of R&D – is almost 100 times lower than that of a large company.

Figure 7 combines this year's survey data with past editions of the survey, and several editions of the EU R&D Scoreboard, to check the reliability of the

R&D expenditure changes reported by the surveyed companies. For each year, we compare actual R&D invested and reported by the EU1000 companies with the R&D growth forecast of the survey companies in the previous year.

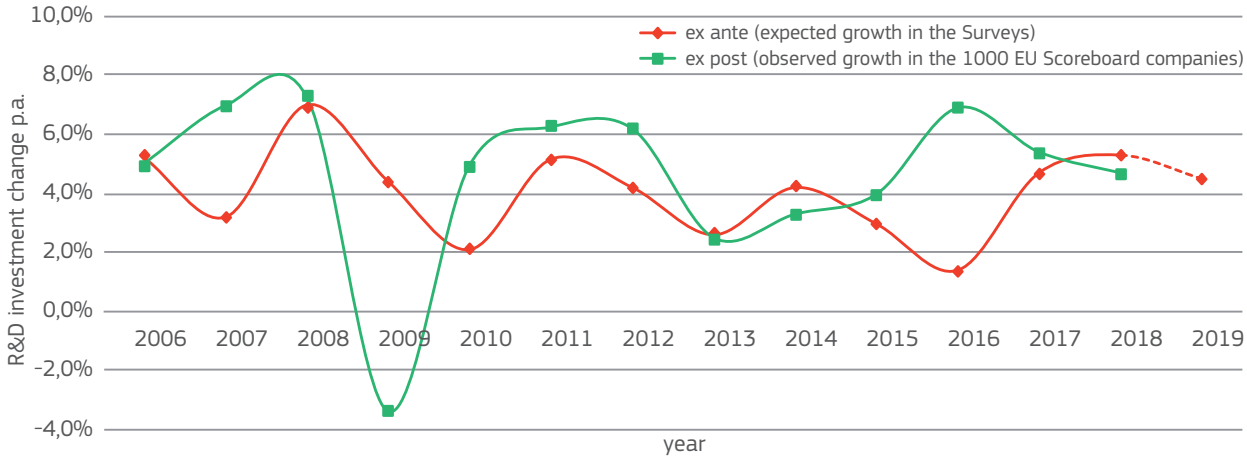

FIGURE 7: EXPECTED (SURVEYS) VERSUS OBSERVED (SCOREBOARDS) R&D INVESTMENT CHANGES
Note: The *ex ante* series refers to the whole sample in each of the 13 surveys (2006-2018). The *ex post* series refers to the top 1,000 EU companies for each of the years. This year, 111 companies replied to the R&D forecast question.
Source: European Commission JRC-B (2018).

We must take into account here that the *ex ante* and *ex post* expectations refer to different samples: the *ex post* observed growth refers to the top EU1000 in each Scoreboard, while the *ex ante* refers to the survey participants (around 15-20% of the top EU1000). Moreover, *ex ante* R&D change expectations are declared in the survey almost 1.5 years before we can compare them with the *ex post* figures published in the annual reports (and consequently in our Scoreboard). This could result in potential differences between the *ex ante* figures expected by our contact persons, often from the R&D departments, and the audited *ex post* figures. Taking all this into account and with a few notable exceptions (e.g. 2009, 2016), predictions have been quite accurate, especially in the past two years.

2.2 | Expected global distribution of R&D investment

72% of R&D by all participating firms is performed within the EU, which is similar to previous editions. This proportion has been stable for many years, and is still not showing any sign of erosion or offshoring to other regions. In fact, the absolute amount is expected to grow over the next two years, as shown by the orange part of the bar in Figure 8. The proportion of R&D performed in the EU, by firms with R&D in the four main economic areas, is 60%. Although this is significantly below the average, it does not automatically follow that globalisation of R&D activities erodes the proportion performed in the EU: these companies spend on average twice as much on R&D within the EU than companies that are not active in all four main regions.

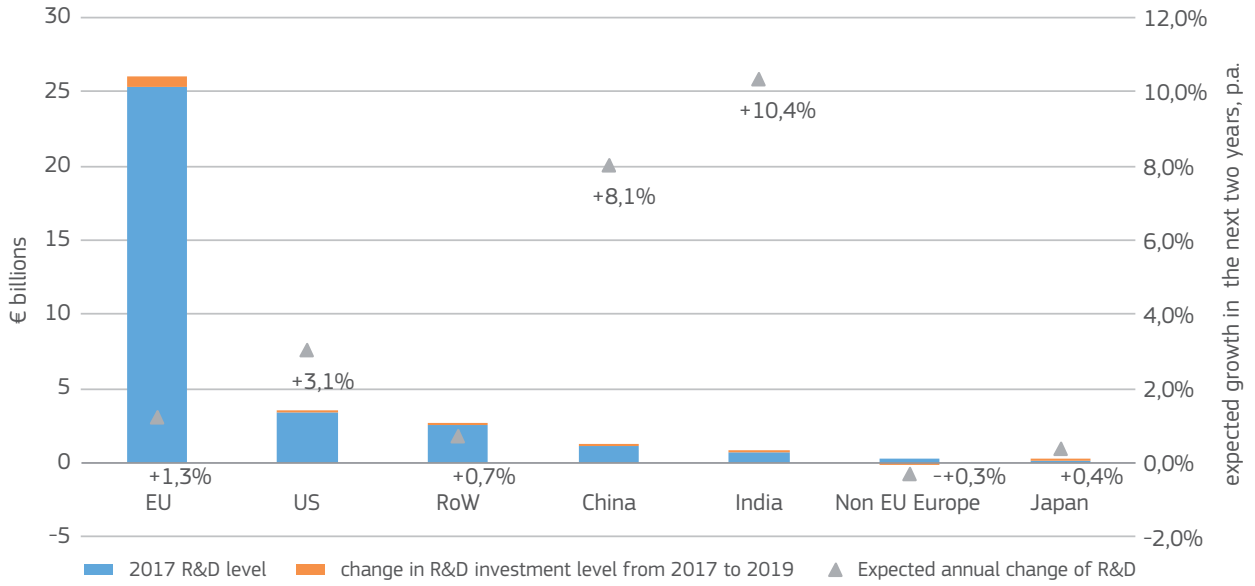

FIGURE 8: EXPECTED ANNUAL CHANGES IN R&D INVESTMENT IN THE NEXT TWO YEARS
Note: The figure refers to 115 out of the 131 companies in the sample. RoW refers to Rest of the World: all countries that are not captured by EU, US or Asia – mainly Norway, Switzerland, countries from South America, Oceania and Russia.
Source: European Commission JRC-B (2019).

For the first time since the start of the survey, the highest R&D increase is expected in India (+10.4%, similar to last year). China normally shows the largest expected increase but, as shown in Figure 8, its expected increase this year is 'only' 8.1% – the lowest since the start of the survey. Last year's expected increase was still 21.3%. For all sectors, a significant growth in R&D activities is expected in India, especially for Automobiles, Chemicals, and Industrials, which all show expected growth rates between 27% and 38%. Unfortunately, the survey does not include information on why companies expect less increase in China, but the recent trade war may be a reason. At sector level, the ICT services and ICT producers sectors expect the least increase (0% and 3% respectively). The largest *absolute* increase outside the EU is expected in the US, with growth expected in all sectors and especially Health Industries.

2.3 | Expected impact of Brexit on R&D strategies

Just as in the last two years, we asked the survey participants the open question on how Brexit will affect the future R&D strategy of the companies. These responses have been grouped, as last year, into different degrees of impact, ranging from no expected impact to relevant impact. Please note that these answers were given over the period March-June 2019, during which insecurities about implementation of the Brexit process increased significantly.

This year's expectations on the impact of Brexit on R&D strategies are much more negative than last year. The proportion of firms expecting no impact decreased from 52% to 37%, while the group expecting a relevant impact on their R&D strategies multiplied from 4% to 16%.

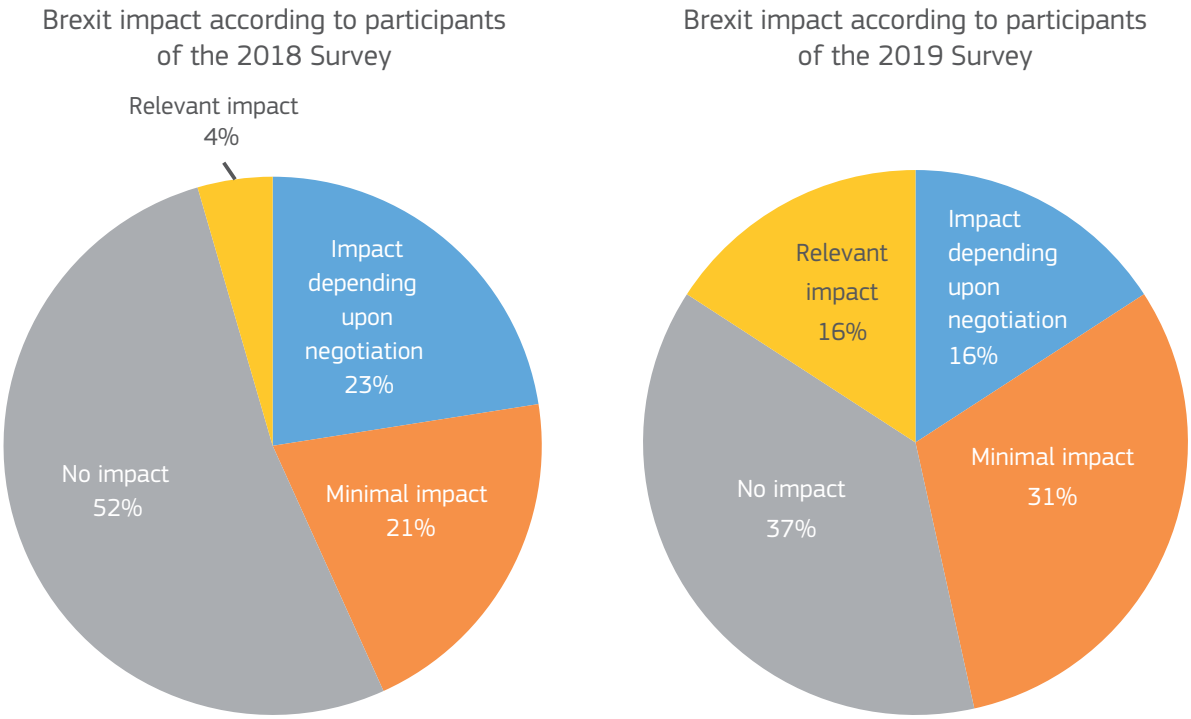

FIGURE 9: A COMPARISON OF THE EXPECTED IMPACT OF BREXIT – 2018 VS 2019
Note: The figure refers to 101 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

There were 69 companies that responded to both this year's and last year's question on the expected impact of Brexit on R&D investments. The following table provides an overview of how firms responded in both years, with the majority repeating last year's answer (main diagonal). Firms that responded last year that the impact depends on negotiations became noticeably more negative, with almost half of them now expecting a relevant impact. This is a clear indicator of how the situation has evolved over the past year.

	Brexit impact in 2019 Survey				
Brexit impact in 2018 Survey	**No response**	**Impact depending upon negotiation**	**No impact**	**Minimal impact**	**Relevant impact**
No response	37%	13%	24%	21%	6%
Impact depending upon negotiation	0%	50%	0%	8%	42%
No impact	17%	2%	48%	21%	12%
Minimal impact	29%	0%	14%	50%	7%
Relevant impact	0%	0%	0%	0%	100%

TABLE 2: CHANGES IN PERCEPTION OF BREXIT IMPACT 2018-2019
Source: European Commission JRC-B (2019).

The expected impact of Brexit on participants' R&D strategies is much more negative for UK-based companies.

As shown in the figure below, the distribution of the impact of Brexit on R&D strategy is different depending on whether or not firms are UK-based (headquarters in UK) and have R&D activities in the UK. For UK firms (upper left), we see that the largest group (almost half the participants) expects a relevant impact of Brexit on R&D strategy, while no companies indicate that there will be no impact. This is in stark contrast with the non-UK companies, where 41% of the companies expect no impact while only 13% expect a relevant impact (upper right).

Looking at firms with or without R&D activities in the UK, we also see significant differences, especially in the proportion of companies that expect a relevant impact (21% vs 5%, respectively) and no impact (23% vs 42%, respectively).

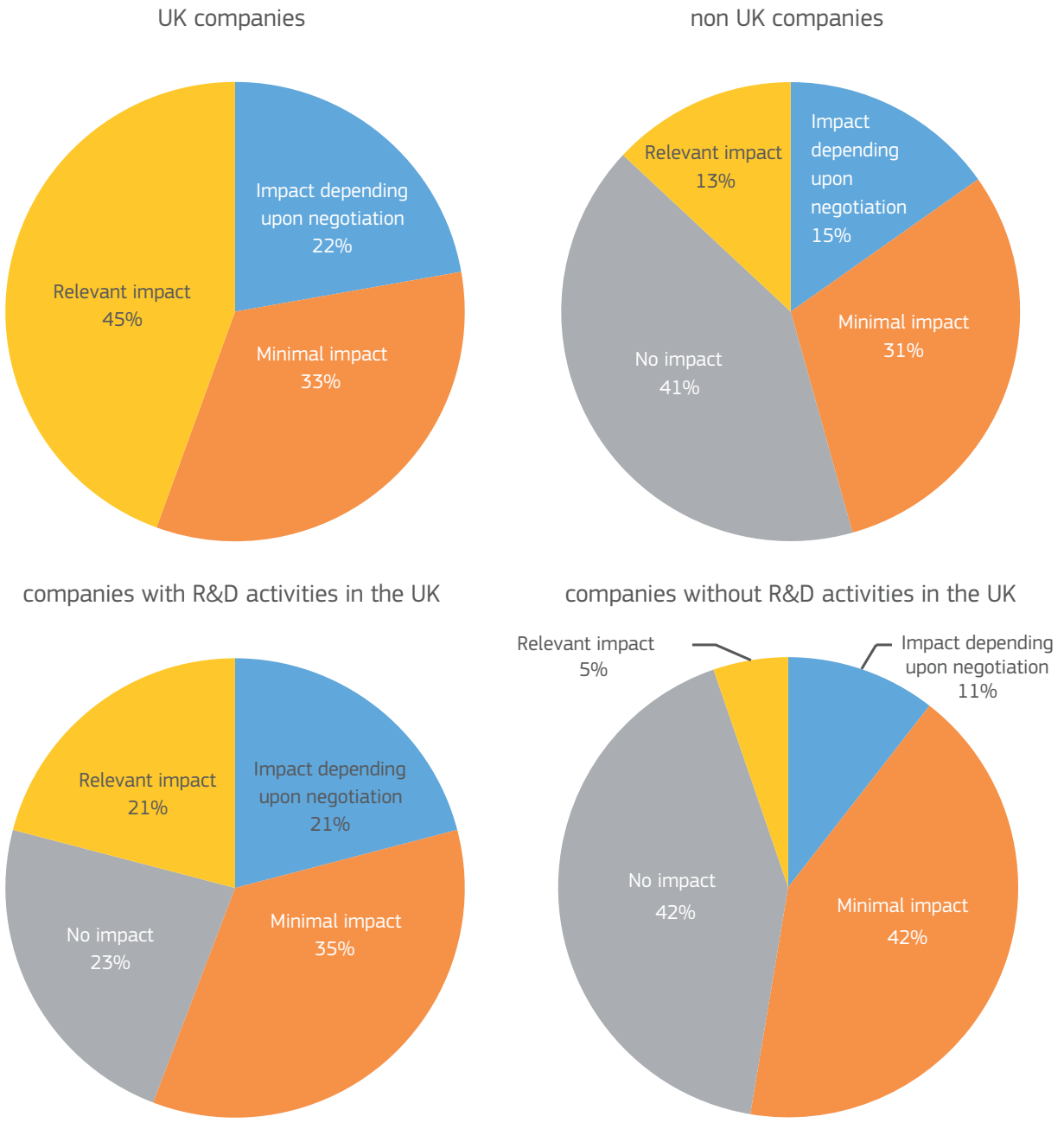

FIGURE 10: EXPECTED IMPACT OF BREXIT FOR DIFFERENT SUBSETS OF FIRMS
Note: The figure refers to 101 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

3 SUSTAINABILITY

3 Sustainability

The new Commission has established the European Green Deal and climate change as top priority, with the objective of making Europe the first climate-neutral continent by 2050. This year's survey dedicated a part of the questions to sustainability and the role this plays for Europe's most innovative companies.

3.1 | Corporate sustainability policies

Almost all responding companies have environmental and social sustainability policies in place, or are planning to introduce them within the next five years. We asked firms whether they have policies in place to ensure the environmental and social sustainability of their activities. Almost 90% of respondents indicated that the company has either an environmental or social sustainability policy in place. In fact, all but two companies have both policies in place.

Environmental\Social	No policy in place, nor planning to implement	Planning to implement < 5 years	Policy in place
No policy in place, nor planning to implement	0%	0%	1%
Planning to implement within 5 years	0%	8%	0%
Policy in place	1%	1%	89%

TABLE 3: CORPORATE SUSTAINABILITY POLICIES IN PLACE
Note: The figure refers to 118 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Only 8% of the companies do not have either of these policies in place, but are planning to introduce one in the next five years.

However, it seems to be even more difficult to estimate the companies' investments in environmental sustainability: less than half the companies answered this question. Furthermore, these estimations vary widely and seem to be unrelated to the amount of R&D expenditure.

3.2 | Environmental sustainability intensity

Besides the sustainability policies that companies have in place, we also asked participants to estimate the amount of investment in environmental sustainability, not limited to R&D investments.

Less than half the companies provided an estimation of the company's investments in *environmental sustainability*. While the average R&D intensity for all participants in the survey is

3.5%[10], this environmental sustainability intensity[11] is 1.0%. This question was answered by less than half the firms, indicating that many companies still do not keep track of this information and find it difficult to provide even a rough estimate, even though 90% of the companies have an environmental sustainability policy in place. The Industrials sector shows the highest proportion of firms (67%) keeping track of these investments, although these investments are among the lowest as a proportion of net sales (Figure 11).

The Health Industries and Industrials sectors invest the smallest proportion of net sales in environmental sustainability. The following table shows a comparison between R&D intensities and sustainability intensities for the different sectors; no clear relation is observed between R&D intensity and environmental sustainability intensity. The participants from the Health Industries, Industrials, and Aerospace sectors show the lowest investments in environmental sustainability as a proportion of their net sales. Further research is needed to investigate the reason behind these results.

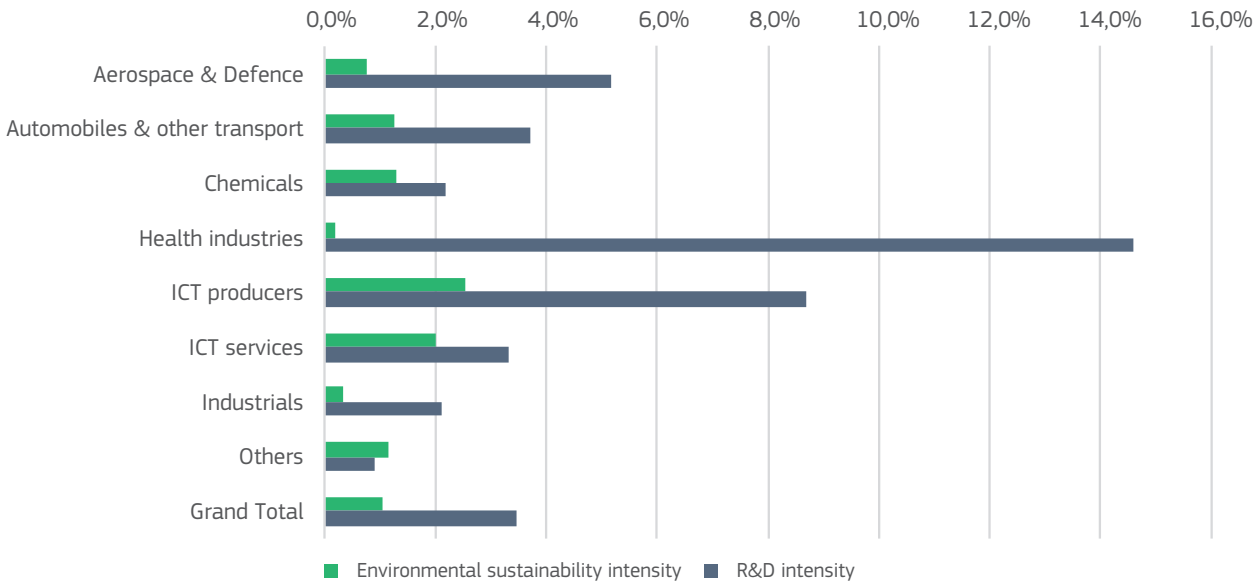

FIGURE 11: R&D INTENSITY VS ENVIRONMENTAL SUSTAINABILITY INTENSITY - A COMPARISON BY SECTOR
Note: The figure refers to 56 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

More than one third of R&D investment is specifically aimed at sustainability. Since this is the first year that we asked this question, we do not have any data available for comparison. Results are very sector-specific: Chemicals has the highest proportion (60%) of R&D investment dedicated to sustainability, while Health dedicates only 1% of R&D to sustainability. As we will see in section 4.1, participating firms from the Chemicals sector also consider sustainability technologies as most important for future competitiveness. The Chemicals sector also considers the pressure to comply with product market regulation among its most important drivers to change R&D investments. This is also the case for Health Industries, but mainly linked to the approval of drugs and – we might deduce – less to sustainability.

Unfortunately, we have too few observations for the Automotive sector to deduce the proportion of R&D dedicated to sustainability.

[10] This is calculated from R&D investments for the year 2018, as expressed in the questionnaire, over net sales for the year 2017 as published in the 2018 R&D Scoreboard.

[11] The total environmental sustainability investments calculated as a percentage of net sales of 2017.

Sector	Proportion of R&D aimed at sustainability
Chemicals	60%
ICT services	33%
Industrials	20%
Health industries	1%
Others	34%
Total average	35%

TABLE 4: PROPORTION OF R&D DEDICATED TO SUSTAINABILITY
Source: European Commission JRC-B (2019).

4

R&D AND COMPETITIVENESS

4 R&D and Competitiveness

4.1 | Technologies for future competitiveness

Sustainable technologies are considered among the most relevant to remain competitive in the future. This year's survey asked the participants about the technologies that they deem relevant to remain competitive in the future. As can be seen in Figure 12, out of the technologies proposed, Big Data, Sustainable technologies and Artificial Intelligence (AI) are considered (highly) relevant by the highest proportion of participants.

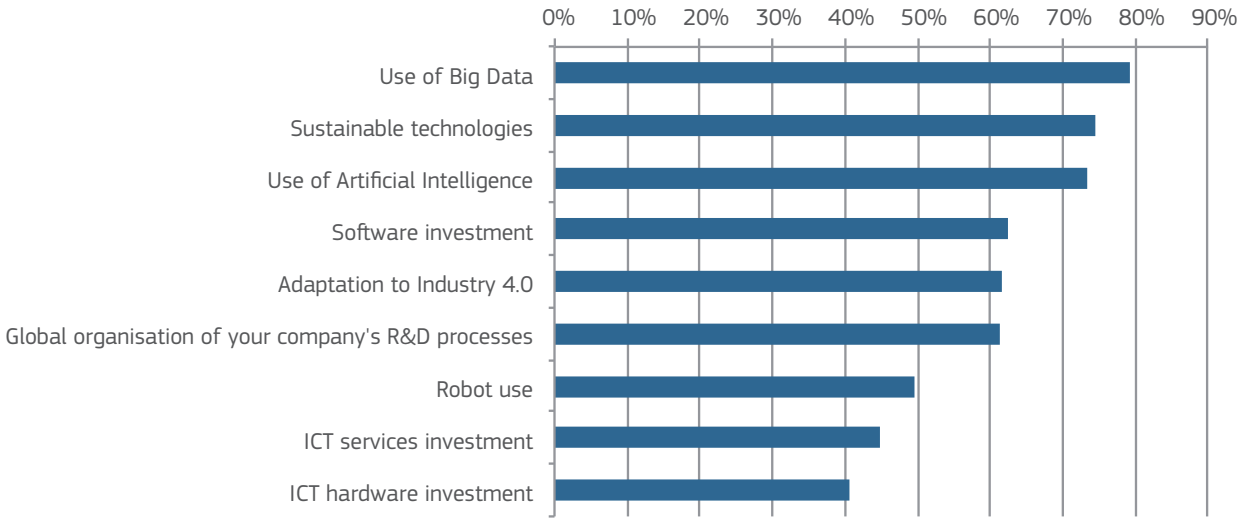

FIGURE 12: PROPORTION OF FIRMS IDENTIFYING DIFFERENT TECHNOLOGIES AS (HIGHLY) RELEVANT TO FUTURE COMPETITIVENESS
Source: European Commission JRC-B (2019).

Big Data and AI can be broadly applied in most sectors. Looking at the sector level, AI and Big Data are also the most widely considered as highly relevant to future competitiveness, being among the top three technologies in six out of eight sectors. These technologies seem to have the most diverse application possibilities. This can also be seen in the joint study by the JRC and OECD into patents in the field of AI, which shows that AI is both widely used but also developed in sectors that traditionally have low ICT intensity[12].

Other ICT-related technologies are considered much less important for future competitiveness. The relevance of other technologies, such as Industry 4.0 (I4.0) and Robotics, is much less widespread. ICT services and ICT hardware technologies are not mentioned among the most relevant technologies for future competitiveness, in any of the sectors.

Sustainable technologies are important both for sectors that provide these technologies and for sectors that use these technologies[13]. Sustainable

[12] Dernis H., Gkotsis P., Grassano N., Nakazato S., Squicciarini M., van Beuzekom B.,Vezzani A. (2019). World Corporate Top R&D investors: Shaping the Future of Technologies and of AI. A joint JRC and OECD report. EUR 29831 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09669-6, doi:10.2760/472704, JRC117068.

[13] greening of and greening by sectors.

technologies are among the top three technologies in Chemicals, Automobiles, Industrials and Others (mainly low R&D intensity sectors consisting of companies in Food, Utilities and Finance). Sustainability in the Automobiles sector has received widespread attention due to public debate in recent years, and investments in sustainability are above average, as we saw in section 3.2. For the upstream Chemicals sector, the production of sustainable chemical technologies can be an important source of competitive advantage when these can be applied in a variety of sectors, including e.g. materials (plastics), agriculture (sustainable fertilisation) and energy (direct power conversions)[14]. For the Industrials sector, it is somewhat surprising to find that this sector reports the lowest intensity of environmental sustainability.

4.2 | Competition

We asked participants to estimate how many main competitors they have in their main market. The following figure indicates that the majority of firms have fewer than 11 competitors.

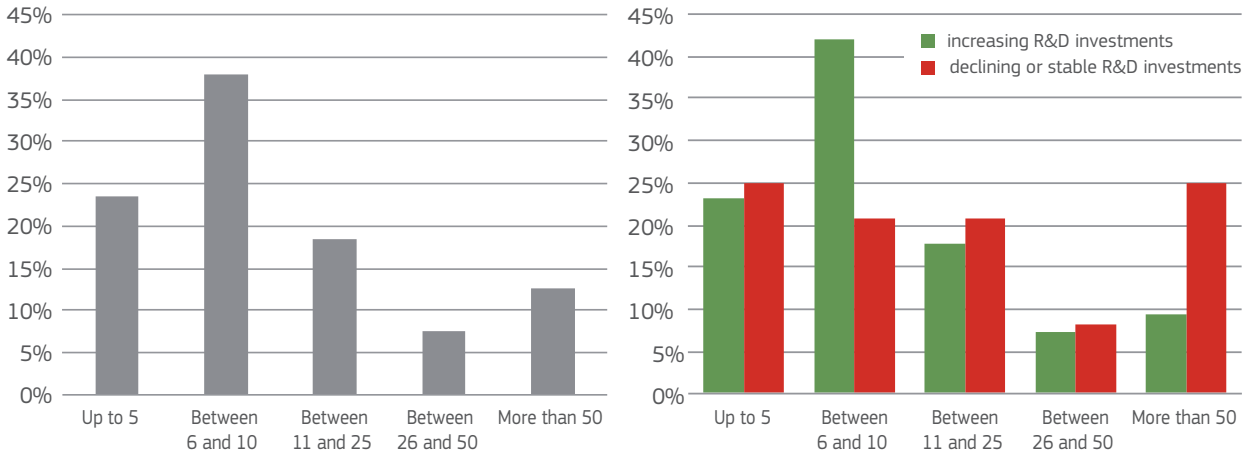

FIGURE 13: PROPORTION OF MAIN COMPETITORS AND R&D EXPECTATIONS
Source: European Commission JRC-B (2019).

When splitting the sample between companies that expect to increase their R&D investments and those that expect to decrease them, we see no clear relation between competition and R&D expectations.

We also asked participants about the strength of competition in their main markets, differentiating between price competition, technological competition (technology pace), and innovation competition (pace of introducing new products or services). These different types of competition are rated very similar in strength, with 70-75% of participants indicating that competition is (very) strong; price competition was mentioned most often as the strongest (75%), and technological competition as the least strong (70%).

However, sectoral patterns can be distinguished. Table 5 indicates which sectors find each type of competition the strongest. Price competition is the strongest in the Automobiles and ICT services sectors. Health industries seem to experience the highest competitive pressure to introduce new (patentable) innovations on the market, and experience much less price competition once the products are on the market.

[14] See: Future technology for prosperity: Horizon Scanning by Europe's technology leaders, August 2019 report.

Price competition	Technological competition	Innovation competition
Automobiles & other transport	ICT services	Health industries
ICT services	Industrials	ICT producers

TABLE 5: TYPES OF COMPETITION EXPERIENCED BY SECTOR
Source: European Commission JRC-B (2019).

5

LOCATION OF R&D **AND PRODUCTION**

5 Location of R&D and Production

5.1 | R&D location

One in nine companies in this survey performs R&D in only one country, while one third of the firms do so in 10 or more countries – both these findings are in line with last year's survey, where this was one in eight and one in three, respectively. The US, Germany and China are the three most popular locations to perform R&D (away from the company's headquarters).

Almost 80% of the firms have their main R&D location in the same country as their headquarters. Interestingly, this is not related to the size of the firm, since the size difference is not statistically significant. The average proportion of these firms' R&D investments in the main R&D location is 68%, significantly different from the 42% for firms with the main R&D location away from the company's headquarters.

Almost 30% of the participants perform R&D in all four main economic regions[15] – this is slightly lower than last year and means that the uninterrupted increase in the proportion over many years has come to a halt, as shown in Figure 14. In the coming years, we will see whether this is the beginning of a new, declining trend or simply some variation in the data.

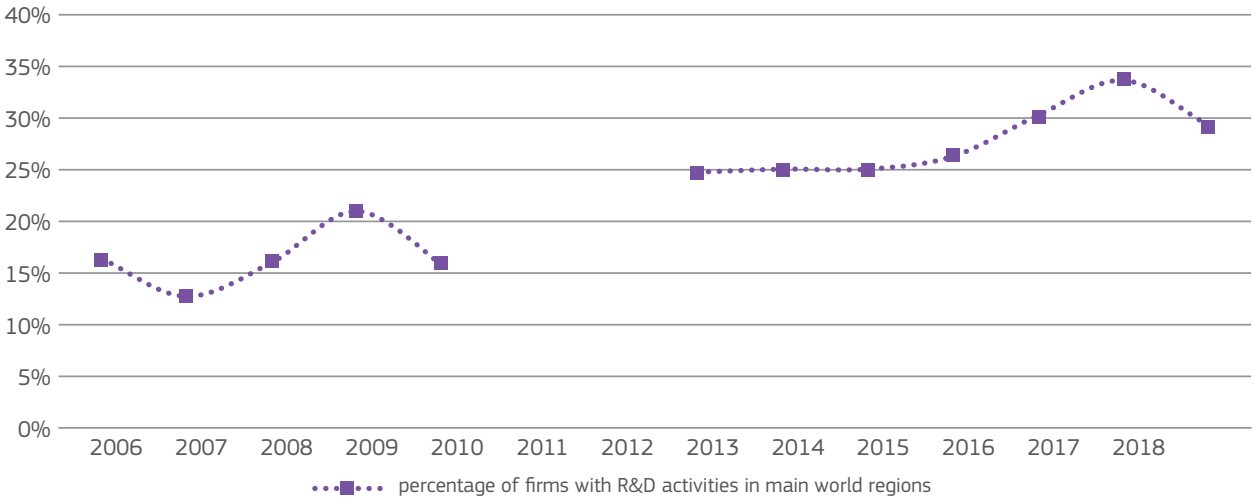

FIGURE 14: GLOBAL PRESENCE OF TOP EU R&D PERFORMERS, PERCENTAGE OF COMPANIES WITH R&D IN ALL FOUR MAIN REGIONS
Note: The figure refers to 113 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

The Automobiles and Other Transport sector performs the largest proportion of its R&D activities within the EU. More than 90% of its research activities take place here. This is related to the very strong dependence of the EU automotive sector on the high specialisation of EU Tier I suppliers and OEMs[16] for the combustion engine[17]. Initiatives to source knowledge on, for example, batteries and electronics

[15] EU, North America, Asia and Rest of the World.
[16] Original Equipment Manufacturers.
[17] Dosso, M., Potters, L. and Tübke, A. Distribution of Industrial Research & Innovation Activities: An Application of Technology Readiness Levels, Industrial R&D – JRC Policy Insights, January 2019.

and related technologies from countries that are strong in these technologies (mainly Asian countries such as China and Korea) are not observed.

R&D activities by EU firms in the ICT producers sector are the most dispersed over the regions, in line with last year. Compared with last year, ICT producers are carrying out an even greater proportion of their R&D in India. This is in contrast to sectors where R&D activities are more concentrated, such as Health Industries and Chemicals.

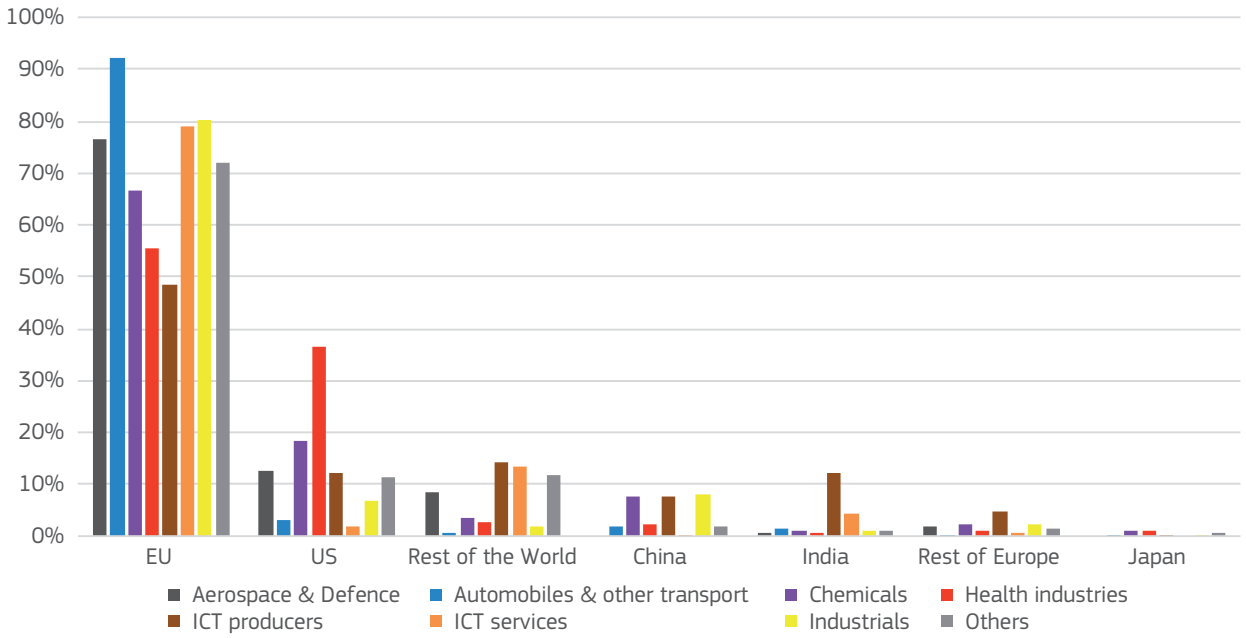

FIGURE 15: DISTRIBUTION OF R&D INVESTMENT, BY WORLD REGION AND SECTOR GROUP
Note: The figure refers to 113 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

5.2 | Most popular countries to perform R&D

Figure 16 shows that Germany is, as in previous surveys, the most important EU location for R&D activities, including for companies that do not have their headquarters in Germany (red bar), followed by the UK and France.

Outside the EU, the US is the most popular R&D location for EU firms. In fact, the US is the most popular location to perform R&D on a global level, with almost half the participants having a top three R&D location there. Outside the EU, the US is followed by China and India, which have been top R&D locations throughout all editions of the R&D Survey.

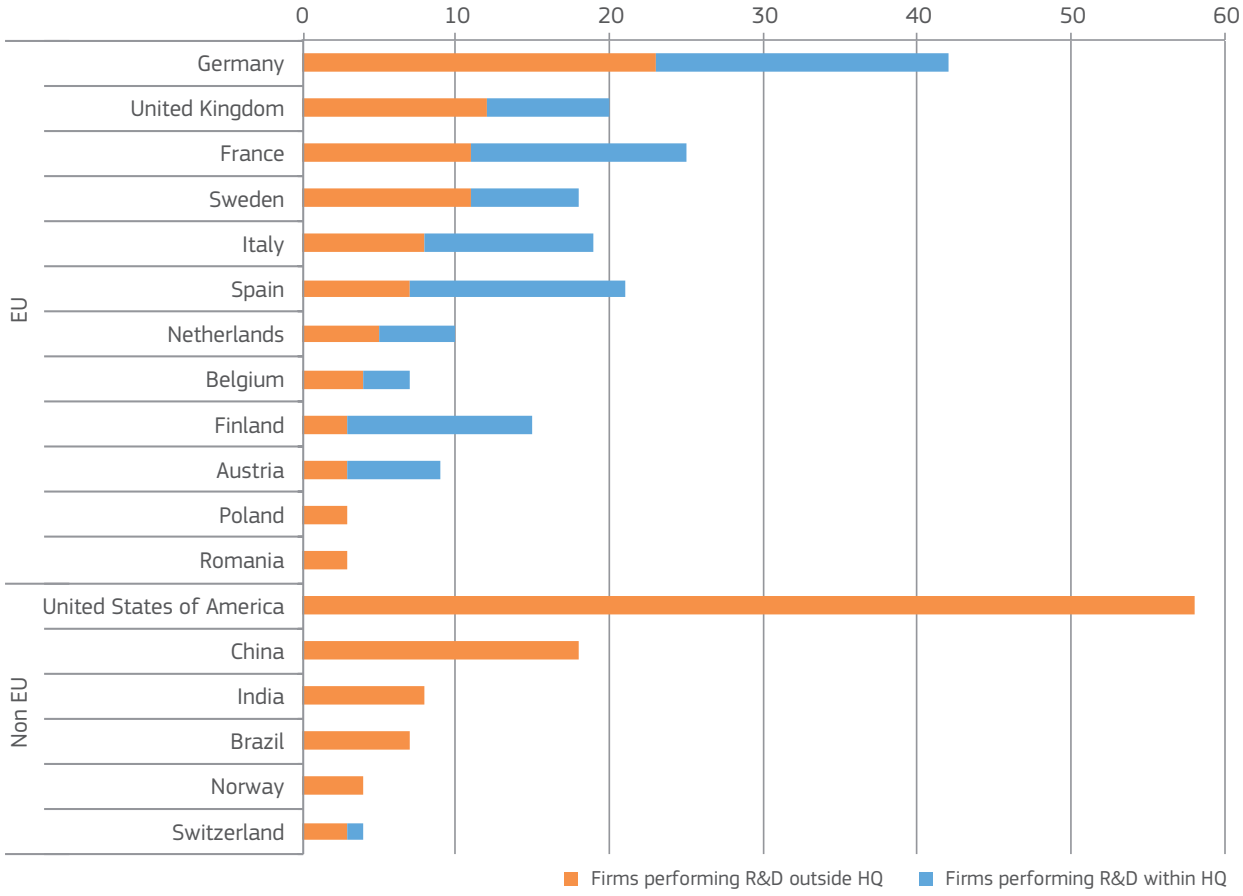

FIGURE 16: NUMBER OF MENTIONS AS A TOP THREE R&D LOCATION
Note: The figure refers to 115 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

5.3 | Factors for R&D location

As in earlier editions of the survey, **the quality and availability of researchers are the two most important factors for R&D location.** Low labour costs for researchers was – as in previous surveys – rated as the least important factor for R&D location.

However, as seen in the past two years, the importance of location factors is strongly related to the R&D strategy of the company. When dividing up the sample of firms into three groups – firms with R&D in only one country, in two to five countries, or in six or more countries – some interesting differences emerge, as shown in Figure 18.

Proximity to technology poles is a more important factor for companies located in many countries. These companies source their knowledge in various parts of the world and want to be connected to the main innovation ecosystems and global innovation networks (GINs).

Access to markets, R&D cooperation opportunities and technology poles are the factors that differ most between different R&D strategies. Participating companies with R&D activities in more than five countries are the most active in sourcing their knowledge from technology poles and find it more important to be close to their markets.

FIGURE 17: PROPORTION OF FIRMS RATING A FACTOR AS (HIGHLY) ATTRACTIVE IN LOCATING R&D
Note: The figure refers to 120 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

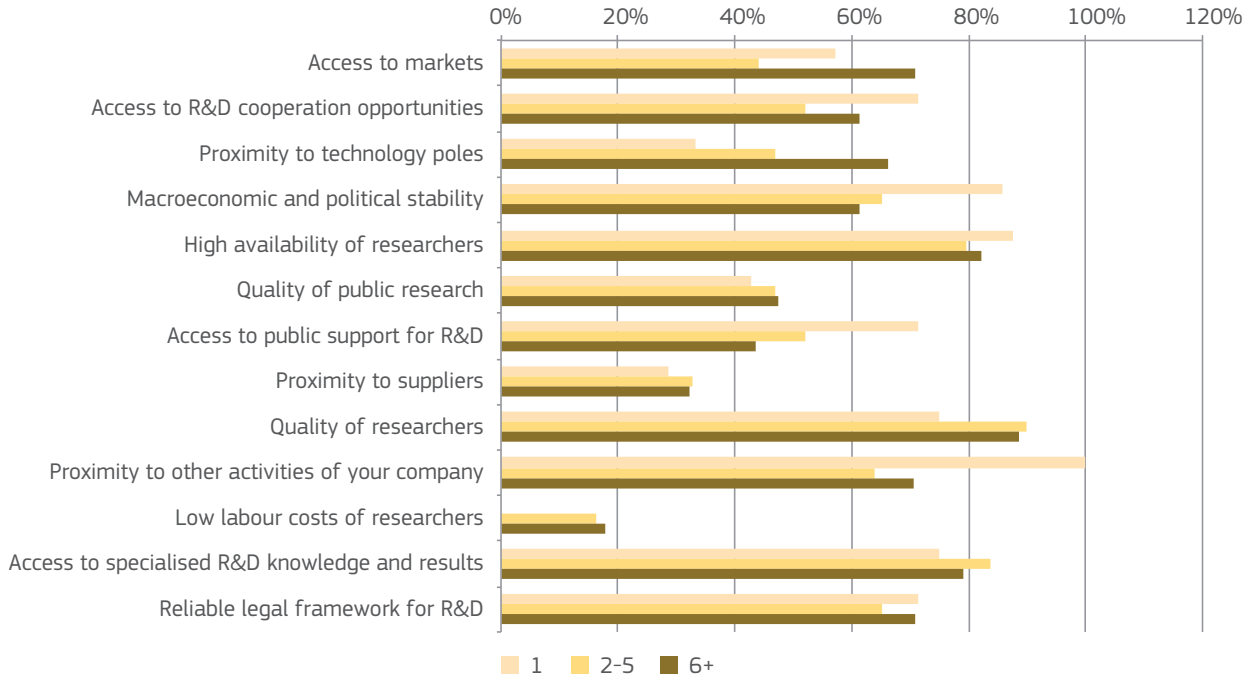

FIGURE 18: PROPORTION OF FIRMS RATING A FACTOR AS (HIGHLY) ATTRACTIVE IN LOCATION – COMPARISON BY R&D STRATEGY
Note: The figure refers to 115 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

It is interesting to see the high importance attached by participating firms with R&D activities in only one country to access to markets and R&D cooperation opportunities. It seems that these firms are looking for R&D expansion, but have strong requisites on whether to do this. It might be an important lesson for upcoming surveys to learn whether or not firms are considering expansion, or even a condensing of R&D activities in fewer sites.

Location factors that are considered equally important by all participants are a reliable legal framework and access to specialised R&D knowledge.

5.4 | Production location

We see that this year – as opposed to last year – production and R&D activities are similarly dispersed over countries: 11% of the respondents indicated that production activities are concentrated in one country, just as for R&D activities. We do not have data on the total number of production locations, but we can deduce from the data that 83% of the respondents have production activities in three or more countries, similar to R&D activities (81%). In last year's survey, R&D activities were less dispersed than production activities. Since we have analysed this dispersion only for the past two years, it will be important to see whether this is an ongoing trend.

Production activities are more dispersed around the globe than R&D activities. Almost 60% of the companies have their main production location at the company's headquarters (75% within their top three production locations), compared with almost 80% and 85% respectively for R&D activities. This implies that the location of R&D activities is much more influenced by the historical creation of the firm, and that these R&D activities are more difficult to move around the globe. From earlier research, we know that basic R&D activities are more likely to be located at the headquarters, while more development activities are co-located with other production locations. Therefore, locating R&D activities outside the headquarters country means complementing or expanding the home-base knowledge rather than eroding knowledge creation[18].

The top production locations are similar to the top R&D locations, although the UK surpasses France as a production location, as shown in Figure 19. The difference between China and the US is less pronounced for production activities. India is mentioned much less as a top production location than an R&D location, while Brazil is mentioned much more often.

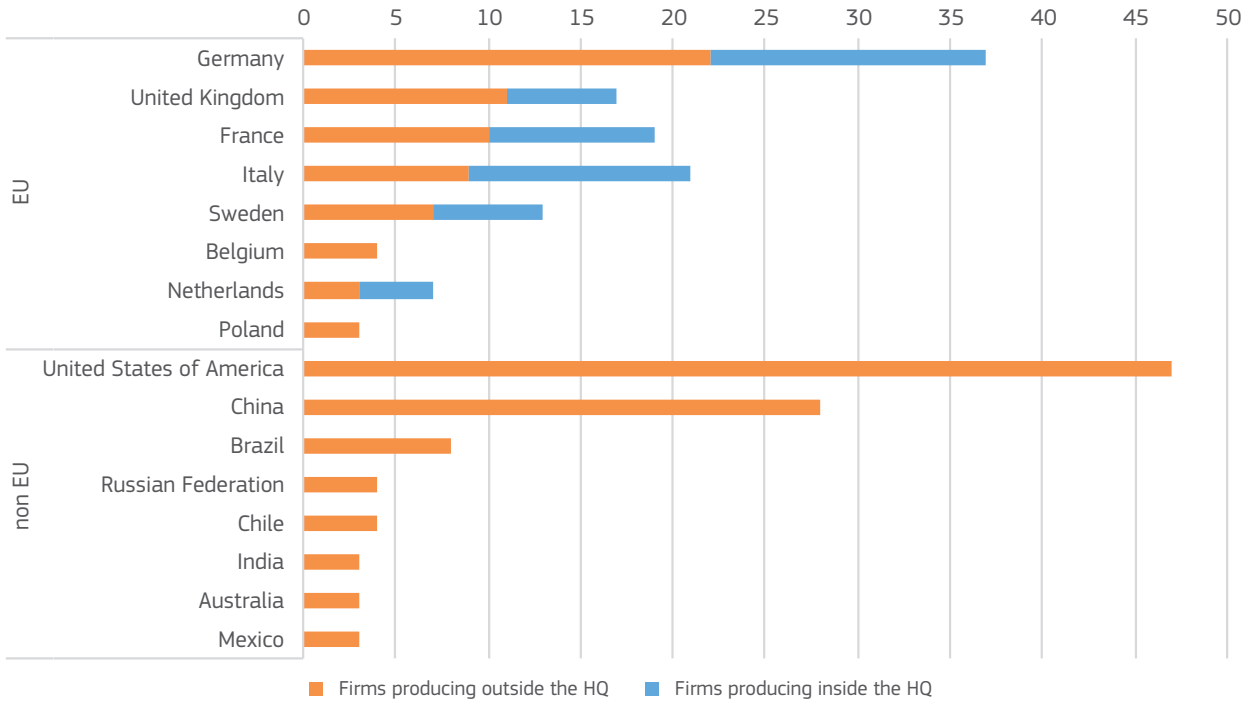

FIGURE 19: NUMBER OF MENTIONS AS A TOP THREE PRODUCTION LOCATION
Note: The figure refers to 115 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

</> See the Summary Report of the 8th IRIMA Workshop on 'Corporate R&D and Innovation Value Chains: Implications for EU Territorial Policy' by M. Dosso, P. Gkotsis, L. Potters and A. Tübke for an overview of state-of-the-art research on this topic.

Access to markets is the most important factor in locating production, even more pronounced than in earlier surveys, as shown in Figure 20. In fact, the top three most important factors coincide with last year's survey, as do the bottom three. Low employment protection is the least important factor in locating production activities – also more pronounced than in earlier surveys. These factors seem to be stable, well-defined business strategy best practices that do not change from year to year.

For ICT producers, access to markets seems to be the least important factor, with only 43% of the firms indicating this as an important factor for locating production, much less than other sectors (where at least 75% of firms indicate this as an important factor). Their products seem to be widely marketable, and the best production locations depend on other factors, such as availability and quality of personnel and specialised production infrastructure and knowledge.

The strong link between companies in the Automobiles sector and their suppliers[19] **is confirmed**, with the highest proportion of firms (80%) indicating that proximity to suppliers is an important factor for locating production. Furthermore, firms in this sector value the availability of good labour, while at the same time being the sector that most highly rates low labour costs as a factor in locating production.

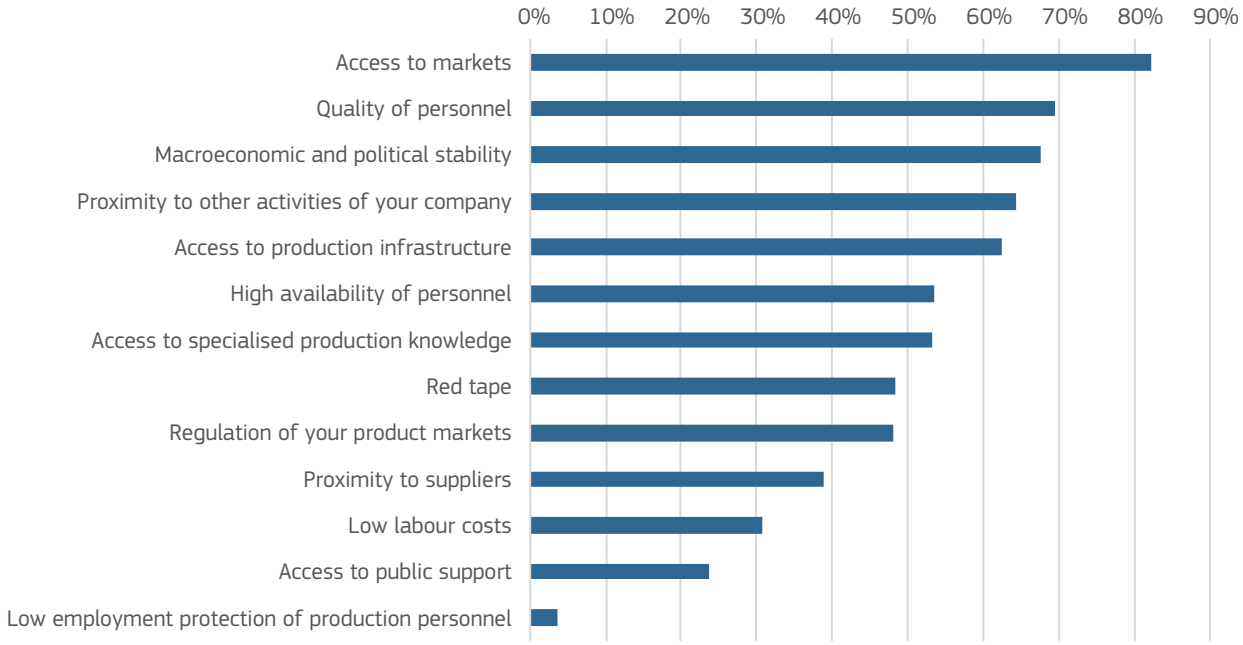

FIGURE 20: PROPORTION OF RESPONDENTS RATING A FACTOR AS (HIGHLY) ATTRACTIVE IN LOCATING PRODUCTION
Note: The figure refers to 112 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Access to public support for production is much more important to companies that decide to produce in China or India. In Figure 21, we again look at production location factors, but this time differentiating by geographical R&D strategy: EU-only firms, or firms with a focus on the US, or on China or India. The factors are shown in order of differences between R&D strategies. One of the least important overall location factors – Access to public support – is much more important as a location factor for companies producing in China or India, where these firms probably benefit from a wide range of public support. EU firms decide to move production activities outside of the EU (to the US, China or India), when these countries offer access to specialised production knowledge.

[19] See also Section 5.1.

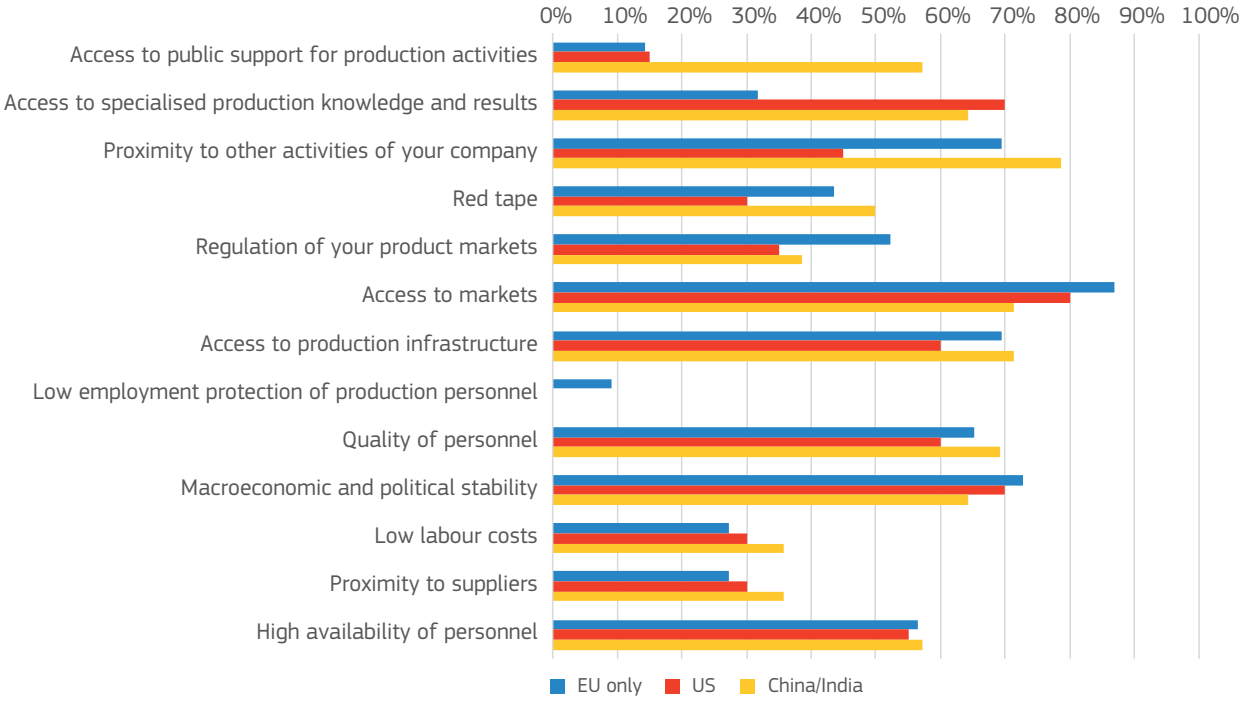

FIGURE 21: PROPORTION OF PARTICIPANTS THAT RATE A FACTOR AS (HIGHLY) ATTRACTIVE FOR PRODUCTION
Note: The figure refers to 67 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Although China has shown impressive growth as a host of R&D activities for EU firms over the years that the EU R&D Survey has been run, it is still mentioned far more often as a production location. This is in stark contrast to the US, Spain and India, which are mentioned more often as a location to perform R&D than for production activities.

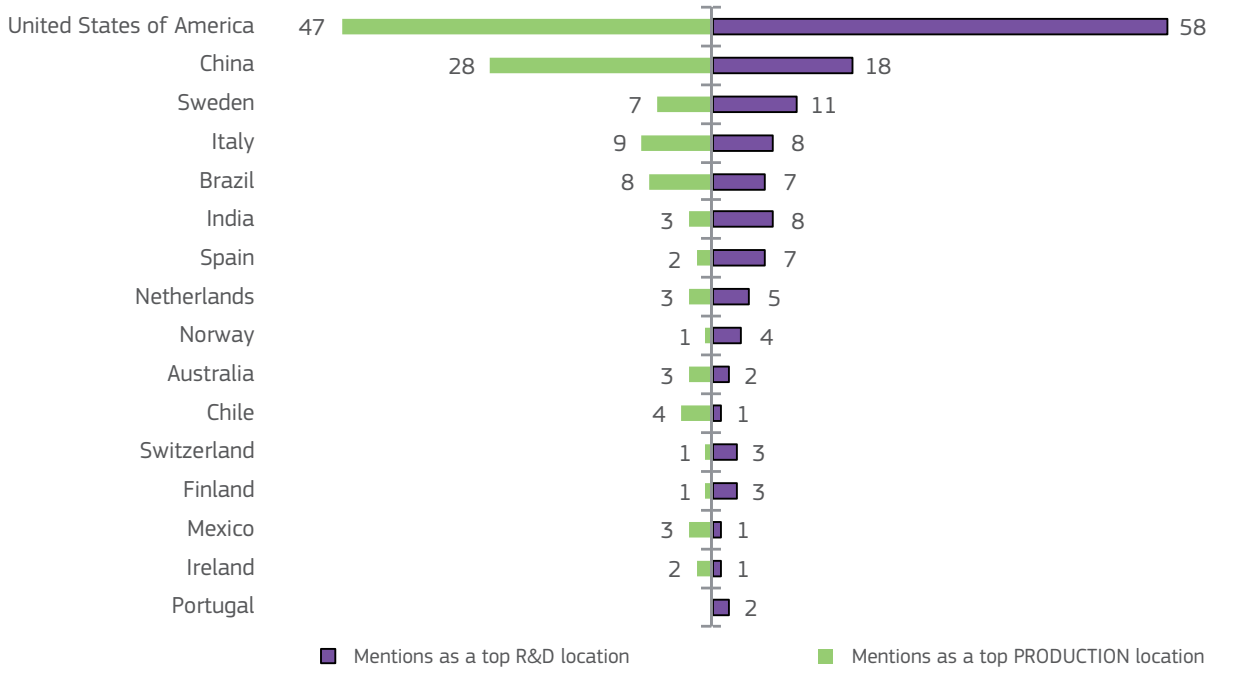

FIGURE 22: POPULAR R&D AND PRODUCTION LOCATIONS
Note: The figure refers to 112 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

6

DRIVERS OF CHANGE **IN R&D EFFORTS**

6 Drivers of change in R&D efforts

As in previous editions of the survey, companies were asked to rate the significance of some potential drivers on the decision whether to change future R&D investment. For each of the drivers included in the survey, Figure 23 shows the percentage of companies that consider them very (4) or highly (5) relevant.

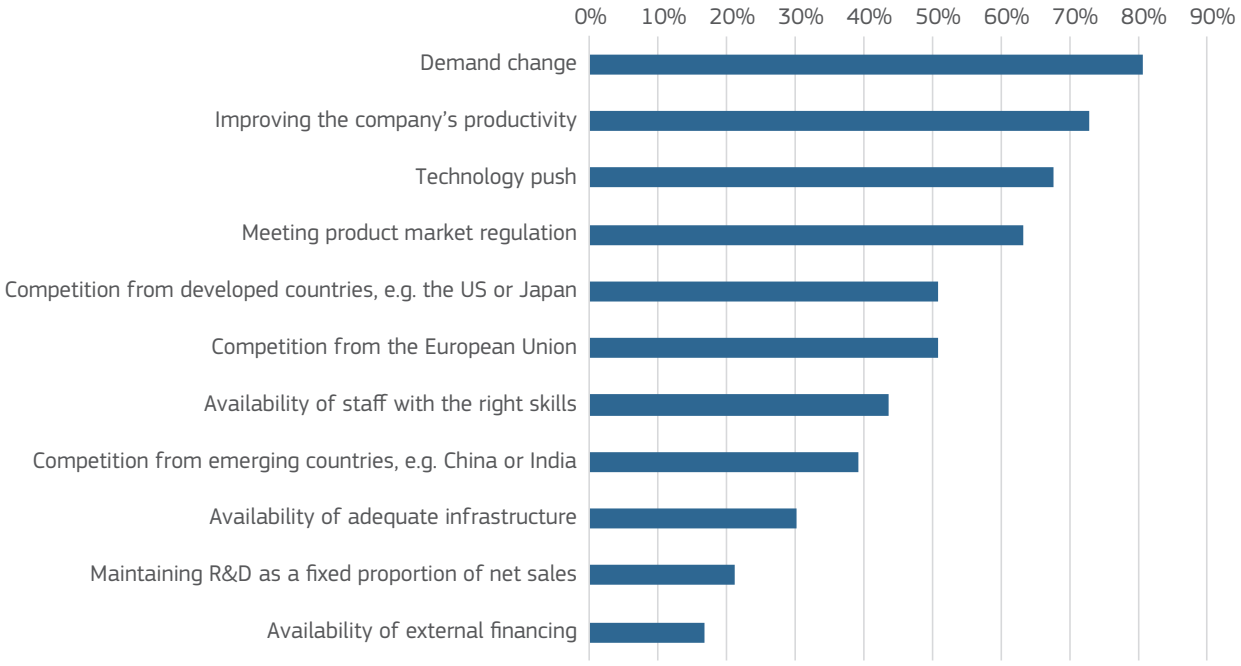

FIGURE 23: PROPORTION OF PARTICIPANTS RATING THE DIFFERENT DRIVERS FOR CHANGING R&D INVESTMENTS AS (HIGHLY) RELEVANT
Note: The figure refers to 124 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Demand change, improving productivity and the chance to exploit technological opportunities are the three main factors driving future changes in R&D investment. This coincides with last year's survey and is a clear indication that R&D investments are driven by profits and technological potential to increase future productivity and sales (through technology push).

6.1 | Size effect

The availability of external finance is among the least important drivers of change for R&D investment efforts. This factor – newly introduced in this year's survey – is of course also due to the participants in the survey being among the largest EU R&D investors, and thus by definition skewed towards larger firms. If we look at the size effect, we see the following: almost one third of firms with up to 2,500 employees indicate that the availability of external finance is an important driver of change in R&D, while this is true of only around 10% of larger companies (more than 10,000 employees). And although there are only five companies with less than 100 employees participating in the survey, all of these firms identify access to external finance as an important driver.

The availability of skilled personnel seems to be much more important as a driver of change in R&D investment for small firms (56% of the group of firms with up to 2,500 employees) than for the largest firms (32%). This could mean that important R&D projects rely on a few individuals in the small firms, and it is not easy for these firms to attract highly skilled workers.

6.2 | Sectoral differences

The Automobiles sector identifies competition from emerging countries such as China and India as especially relevant in changing R&D investment. Sectoral differences are also observed, especially in regard to competition from emerging countries such as China and India. While only 36% of all participants identify this as an important driver, 71% of participants from the Automobiles and Other Transport sector identify this competition as an important driver. This is strongly related to the change from the traditional combustion engine – which has a very strong industrial base in the EU – to electric vehicles, where Korea and China are especially strong.

Market regulations also have a different impact in changing R&D efforts. Especially in the Chemicals and Health Industries sectors, this is considered a highly important driver of change in R&D by around 75% of participants. It relates to the strict regulatory framework around the use of medicines and chemical components. This is also recognised by European Research and Technology Organisations that are proposing more flexibility in EU legislation to provide scope for innovation.[20] As seen in chapter 3, Chemicals is the sector that dedicates the highest environmental sustainability intensity. However, Health Industries has the lowest environmental sustainability intensity, and thus we might deduce that regulations concerning public health have a stronger effect than environmental regulations.

By contrast, less than 30% of the firms in the Automobiles and Other Transport sector see this as an important driver. This is surprising, since this sector is subject to ever-increasing regulations regarding the CO_2 emissions of cars. This could open up debate about increasing the speed with which stricter regulations are introduced.

[20] See: Future technology for prosperity: Horizon Scanning by Europe's technology leaders, August 2019 report.

7

TYPE OF R&D **UNDERTAKEN**

7 Type of R&D undertaken

The respondents were asked to break down their R&D investment among the different R&D activities they carried out in 2018. As in previous editions of the survey, the majority of the R&D effort is dedicated to development activities. As reported in Figure 24, 'Applied research/technology development' (36%); 'Development for adapting products to local markets' (15%); 'Development for market launch' (16%); and 'Development of software/data' (8%) absorb in total 75% of the total R&D investment of our companies. Only about 9% of the total R&D investment is dedicated to 'Basic research'.

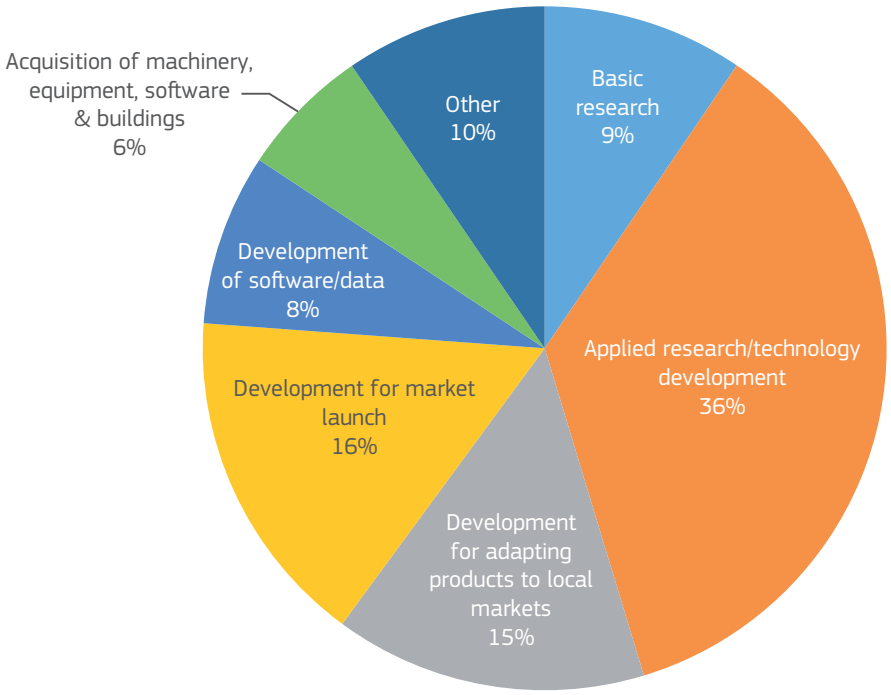

FIGURE 24: PROPORTION OF R&D INVESTMENT, BY TYPE OF INVESTMENT
Note: The figure refers to 111out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

A tendency to focus on the development stages of R&D activities, rather than on basic research activities, has been observed in past surveys and is confirmed this year. On one hand, this may signal the existence of some sort of (optimal) 'division of labour' where the other actors in the innovation ecosystem (mainly universities and public sector research institutes, but also start-ups and disruptive companies) specialise in basic research while the large private companies, which are overrepresented in this survey[21], apply this knowledge and develop new applications. On the other hand, the lack of basic research can negatively affect the 'absorptive capacity' of private companies and, as such, their ability to transform basic research into applied technologies. However, the fact that these are the largest firms is also an indicator of success and survival, implying that this distribution (constant since the first time this question was asked in 2016) may be optimal.

[21] Bear in mind that the respondents to this survey come from the R&D Scoreboard, which lists companies based on R&D expenditure. Many of the larger companies in this specific subsample do not only grow their R&D investments organically, but also through acquisition of start-ups and other firms.

This consolidated tendency by private companies to neglect investment in basic research may call for two kinds of policy intervention (not mutually exclusive). From one side, policy could intervene to strengthen the link between the private sector and other actors carrying out basic research. From the other side, policy could act to incentivise private investment in this area.

Sectoral peculiarities are also confirmed and indicate how companies are positioned within their particular value chains. Sectors such as Automobiles and Other Transport and ICT services show low levels of 'Basic research', indicating reliance on their suppliers for innovative activities. In the Chemicals and Others sectors, there is significantly higher R&D investment in basic research (17% and 14% respectively). This sectoral pattern was also observed last year, reflecting the differences in products sold and in structure of the value chains within these sectors. For example, companies from the Others sector invest mainly in exploration of natural resources as part of their basic R&D activities. A sector with a traditional basic research character, Health Industries, shows a fairly average proportion dedicated to this type of research, partly due to an increasing amount of basic research being outsourced to contract research organisations[22]. Table 6 breaks the total R&D investment for each sector down into the percentages they dedicate to the different R&D activities. However, all sectors devote the majority of resources are development activities.

	Aerospace & Defence	Automobiles & other transport	Chemicals	Health industries	ICT producers	ICT services	Industrials	Others
Basic research	6%	2%	17%	7%	9%	5%	10%	14%
Applied research/ technology development	15%	9%	51%	59%	27%	15%	32%	31%
Development for adapting products to local markets	39%	2%	20%	6%	25%	9%	24%	19%
Development for market launch	40%	12%	7%	9%	17%	37%	17%	11%
Development of software/data	0%	2%	2%	1%	10%	31%	9%	5%
Acquisition of machinery, equipment, software & buildings	0%	2%	4%	2%	11%	2%	6%	15%
Other	0%	71%	0%	15%	2%	0%	1%	4%

TABLE 6: TYPE OF R&D INVESTMENT, BY SECTOR
Note: The figure refers to 111 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

If instead of looking at the sector, we look at the size of the companies, we still get a similar picture: the majority of resources are invested in development activities (Figure 25: Type of R&D investment, by company size). Two interesting facts stands out: i) companies with less than 2,500 employees devote relatively more than the others to basic research; ii) companies between 2,501 and 10,000 employees invest a considerable share of their R&D into the acquisition of machinery, equipment, software and buildings.

[22] See Dosso, M., Potters, L. and Tübke, A. Distribution of industrial research & innovation activities: an application of Technology Readiness Levels, Industrial R&D – JRC Policy Insights, January 2019.

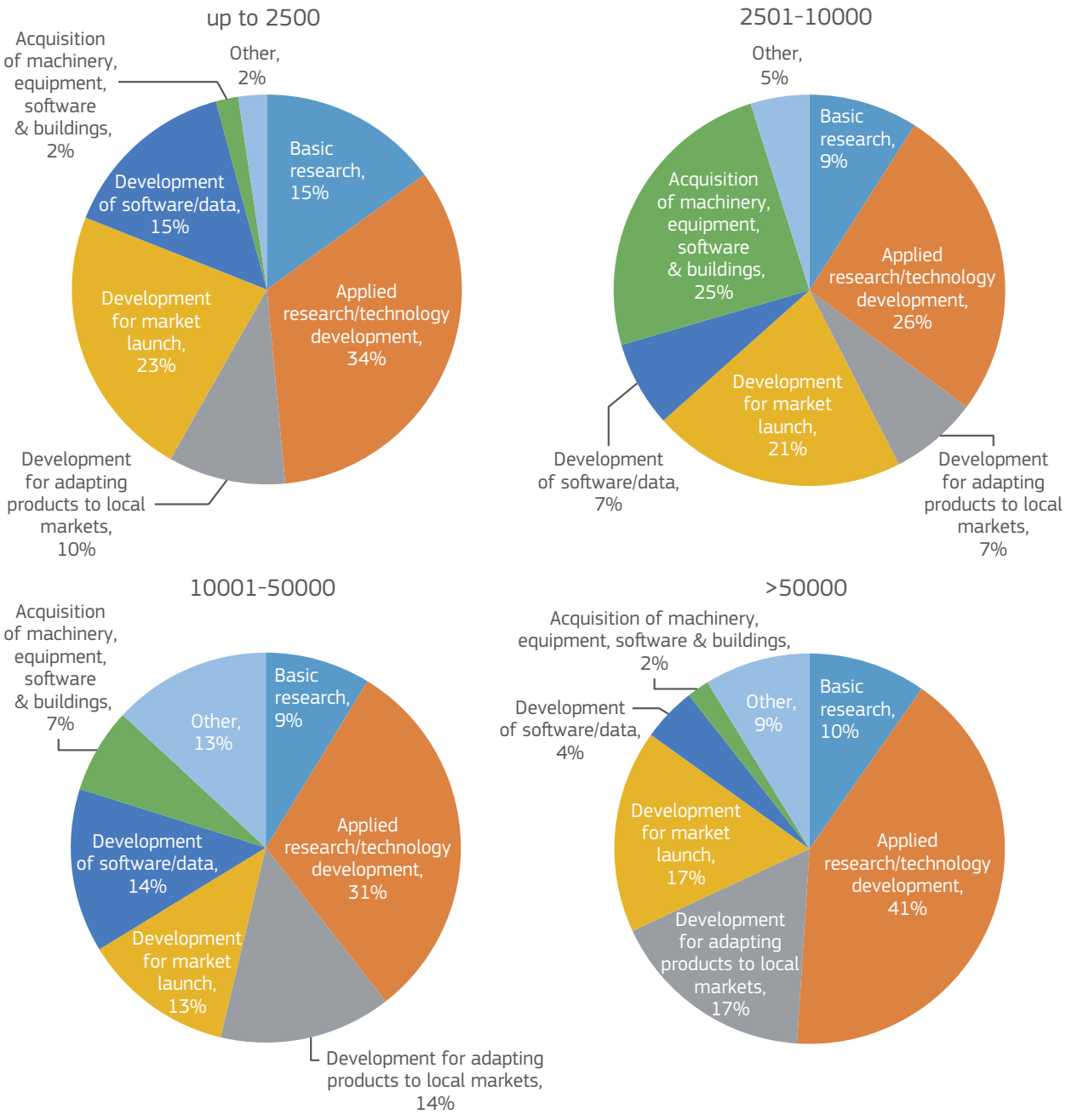

FIGURE 25: TYPE OF R&D INVESTMENT, BY COMPANY SIZE
Note: The figure refers to 111out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

8

NON-R&D **INVESTMENT**

8 Non-R&D investment

The investment in R&D captures only one aspect of the overall innovation effort of a firm. Although probably the most relevant of the activities a firm can put in place to innovate, R&D is only part of the story. To get a full picture of the breadth of the innovation activities of the top 1,000 EU R&D investors, we asked the firms in this year's survey to give some details of their non-R&D innovation activities.

The data collected confirm that only considering R&D causes us to underestimate the innovative effort of a company. If we sum up R&D and non-R&D expenditures for those companies that reported some non-R&D investment, we find that around 20% of their innovative effort does not take the form of R&D investment, as shown in Figure 26.

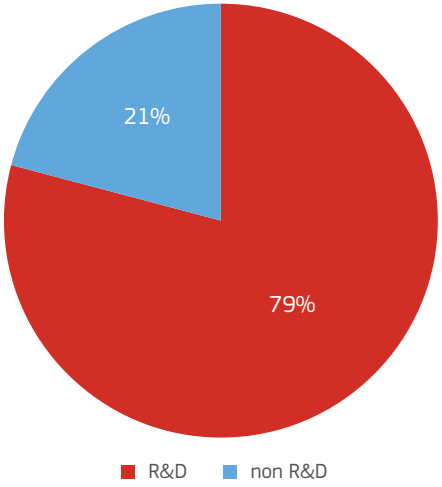

FIGURE 26: INNOVATIVE EFFORT – R&D VS NON-R&D INVESTMENT
Note: The figure refers to 71 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

As shown in Figure 27, there are remarkable differences in non-R&D innovation efforts depending on size. There appears to be a U-shaped relationship, where the smaller companies (up to 2,500 employees and therefore still relatively large compared to SMEs) and the largest firms (above 50,000 employees) have the highest proportion of non-R&D innovation investments out of total innovation investments (R&D and non-R&D).

For the largest firms in particular, the proportion is influenced by companies from sectors with traditionally low R&D intensity, mainly natural resources (Oil & Gas and Chemicals sectors). For the smaller firms, the proportion of non-R&D innovation is mainly influenced by the Health Industries, which consist of smaller pharmaceutical companies.

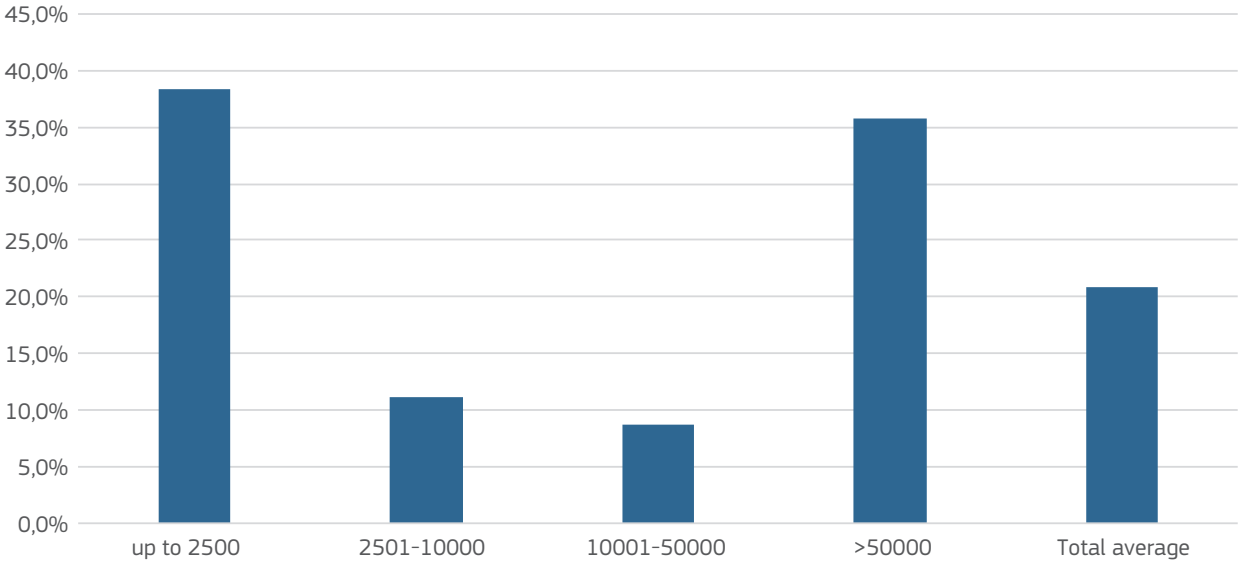

FIGURE 27: INNOVATIVE EFFORT – NON-R&D INVESTMENT AS A PROPORTION OF OVERALL INNOVATION EFFORT, BY COMPANY SIZE
Note: The figure refers to 71 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

Looking at the sector aggregation of these companies, we find that in the Chemicals and Others sectors, non-R&D expenditure represents 22% and 42% of total innovative effort, respectively. This is also closely related to the large, low R&D intensity firms that are active in these sectors. In summary, the sector plays the most important role in the size of non-R&D innovation activities. However, for some sectors, especially Health Industries, there is a clear difference in company behaviour between smaller and larger firms[23].

We can deepen the analysis by disaggregating non-R&D expenditure by type (Figure 28: Non-R&D investment, by type). The majority of non-R&D expenses are

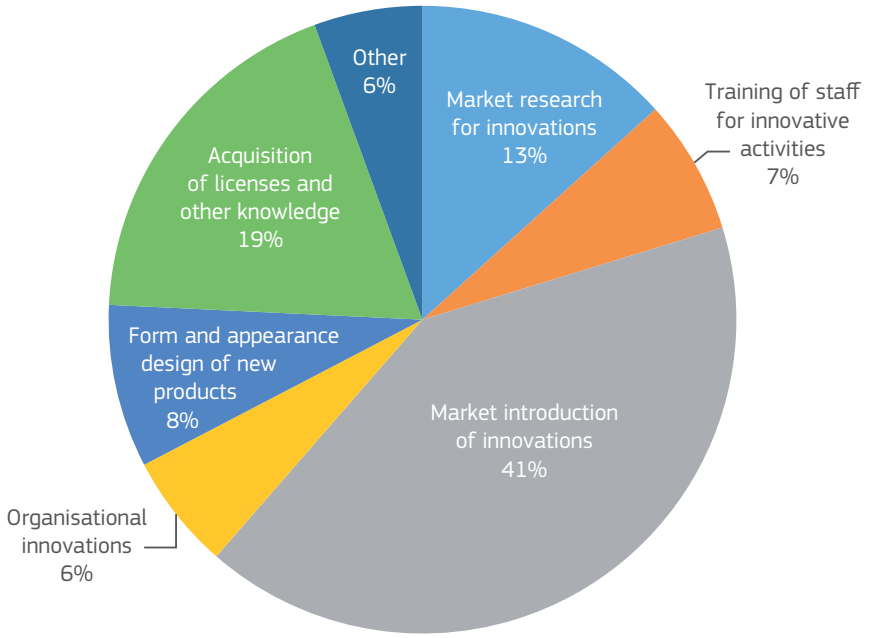

FIGURE 28: NON-R&D INVESTMENT, BY TYPE
Note: The figure refers to 59 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

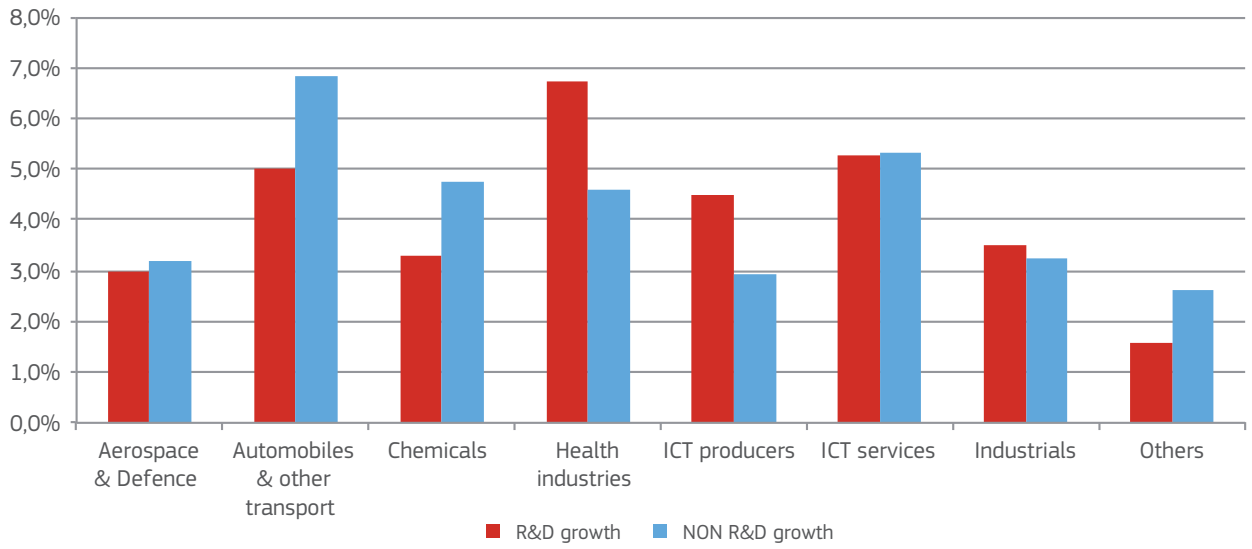

FIGURE 29: R&D VS NON-R&D FORECAST GROWTH, BY SECTOR
Note: The figure refers to 62 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

[23] Unfortunately, dividing the sample into groups based on both sector and size provides little opportunity to see the full picture.

concentrated around the introduction of innovation into the market (41%), while expenditures for the acquisition of licences are driven by Health sector companies.

Looking at expected growth in non-R&D expenditure (Figure 29), it is interesting to note – at least for companies that replied to both R&D and non-R&D expected growth in 2019 – that non-R&D investment will grow more than R&D investment (4% vs 2.6%); this is true for half the sectors included in the analysis. The sample is probably too small to generalise this result, and we do not have evidence from previous surveys to corroborate it. However, the fact that this restricted group of companies plans to increase their non-R&D more than their R&D investment in the coming years signals a tendency to be confirmed in future research.

Finally, Figure 30 sheds some light on the motivations for the expected changes in non-R&D expenditure. Curiously enough (or not), the main drivers of non-R&D investment (demand change and improving company productivity) are also very important drivers of R&D investment. It seems companies use different strategies to achieve similar goals.

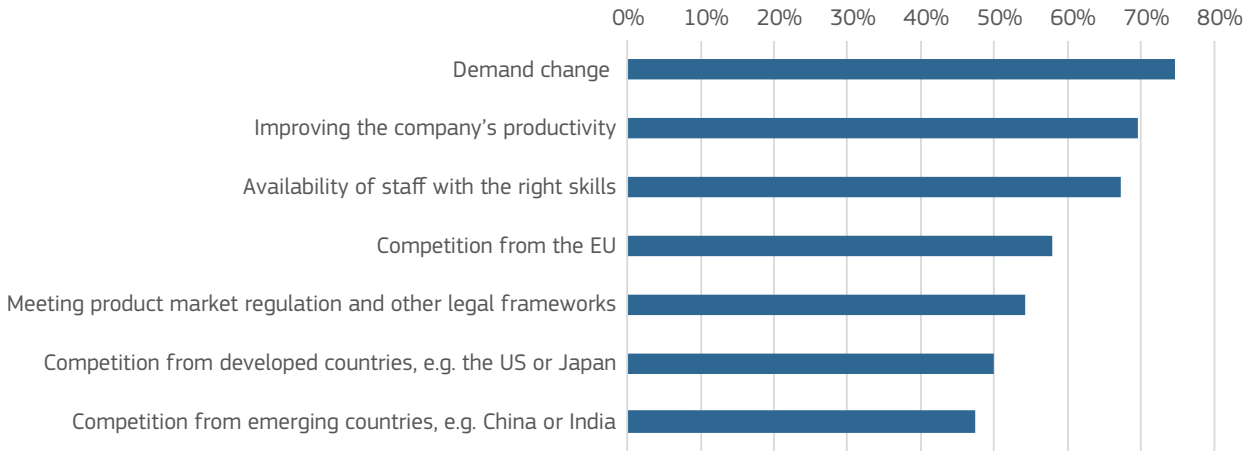

FIGURE 30: DRIVERS OF FORECAST CHANGE IN NON-R&D
Note: The figure refers to 59 out of the 131 companies in the sample.
Source: European Commission JRC-B (2019).

ANNEXES

- **A**: METHODOLOGY
- **B**: QUESTIONNAIRE

Annex A: Methodology

Background and Approach

The European Commission's Global Research and Innovation Analysis (GLORIA)[24] initiative serves to better understand industrial R&D and innovation in the EU and to identify medium and long-term policy implications. GLORIA is carried out by the European Commission's Joint Research Centre (JRC) Directorate B, Growth & Innovation, and the Directorate General for Research Directorate A, Policy Development & Coordination.

The objective of this project is to generate science-based evidence to support policy making in the light of the Europe 2020 strategy and the Investment Plan for Europe initiative by monitoring, analysing and benchmarking the global industrial players in R&D, following the mandate given by Member States of actions to be implemented by the European Commission since 2003. These companies are responsible for very large shares of Europe's total business R&D investments and their global flows.

The present GLORIA surveys tackles the lack of comparable information on business R&D investment trends at the European level by gathering qualitative information on factors and issues surrounding and influencing companies' current and prospective R&D investment strategies. The survey complements other R&D investment related surveys and data collection exercises (e.g. Innobarometer, Eurostat data collection and other on-going surveys).

Link to the R&D Investment Scoreboards

The EU R&D surveys complement the *EU Industrial R&D Investment Scoreboard*[25], which is the main publication of the GLORIA project. The Scoreboard helps the European Commission to monitor and analyse company R&D investment trends and to benchmark, inform and communicate developments in R&D investment patterns.

The Scoreboard and the Survey take different perspectives on the industrial R&D dynamics in companies. The Scoreboard looks at trends ex-post based on the audited annual accounts of companies, whereas the Survey improves the understanding of the Scoreboard companies by collecting ex-ante information. The survey also addresses location strategies, drivers and barriers to research and innovation activities, or perception of policy support measures with a questionnaire agreed between JRC-B and DG-RTD. This questionnaire is printed and mailed by post together with the Scoreboard analysis report and the previous Survey analysis report to the 1 000 European companies. Also, a web-interface and email contacts are made available to allow for paperless participation. The Survey makes efficient use of the direct contacts established with the European Scoreboard companies by adding-on to the Scoreboard mailing when the reports are officially released.

For the 2019 Survey, the response period ran for three months: from 14 March 2019 (mailing of the questionnaires) to 28 June 2018.

[24] See: http://iri.jrc.ec.europa.eu/.

[25] The Scoreboard is published annually and provides data and analysis on the largest R&D investing companies in the EU and abroad (see: http://iri.jrc.ec.europa.eu/research/scoreboard.htm).

Methodology

To improve response rates, the following measures were taken during the survey cycle:

1. The questionnaire was revised and streamlined with a view towards keeping it as short and concise as possible and minimise the burden for the respondent.

2. The questionnaire was sent together with the Scoreboard report to take advantage of this occasion as a door-opener.

3. The cover-letter presented full colour figures and tables with a benchmarking analysis of the company addressed compared to its peers in the same sector.

4. As well as physically sending the questionnaire to each company, an online site was provided to facilitate data entry via the European Commission's EU Survey tool[26], where a pdf version of the questionnaire was downloadable for offline information input.

5. The questionnaire was emailed to the respondents of previous surveys, together with a link to the electronic copy of the latest analysis.

6. The contact database was continuously improved. Respondents who had already participated in previous surveys, or their substitutes in cases where they had left their position, were priority contacts. Returned questionnaires and reminder mailings were resent using the latest contact information on the internet or by contacting the company directly via email or phone.

7. The response rate is closely followed on a regular basis during the implementation. If necessary, measures for improving the response rate are applied, e.g. by adjusting the number of reminders, allowing more time for questionnaire reception, following up selected candidates by e-mail and phone or searching support from former survey participants.

8. Personal contact by phone or email was made with several dozen companies when the deadlines were close, especially for those which had participated in the past.

The response rate has been steadily high over the past five years, taking full advantage of the familiarity of the EU Scoreboard companies with the exercise and their mature approach.[27]

Outliers were detected by analysing the distribution of the dataset in scatter and boxplots and defining upper and lower quartiles ranges around the median, according to the variable(s) analysed. To maintain the maximum information in the data, outliers were eliminated only in extreme cases and after assessing the impact on the result.[28]

One-year growth is simple growth over the previous year, expressed as a percentage: 1yr growth = 100*((C/B)-1); where C = current year amount and B = previous year amount. 1yr growth is calculated only if data exist for both the current and previous year. At the aggregate level, 1yr growth is calculated only by aggregating those companies for which data exist for both the current and previous year.

Two-year growth is the compound annual growth over the two years, expressed as a percentage: 2yr growth = 100*(((C/B)^(1/t))-1); where C = current year amount, B = base year amount (where base year = current year - 2), and t = number of time periods (= 2). 2yr growth is calculated only if data exist for the current and base years. At the aggregate level, 2yr growth is calculated only by aggregating those companies for which data exist for the current and base years.

Unless otherwise stated, the **weighted figures** presented in this report are weighted by R&D investment.

[26] See: https://ec.europa.eu/eusurvey/.

[27] The response rate of the present survey is 16.2%. This is slightly lower compared to the 18.5% of last year due to a two-week shorter response period. The responsiveness per day has been very steady over the past five surveys.

[28] For the systematic detection of outliers, an adjusted methodology from the NIST/SEMATECH e-Handbook of Statistical Methods was applied, see: http://www.itl.nist.gov/div898/handbook/prc/section1/prc16.htm.

R&D Investment Definition

To make the survey as easy to complete as possible and to maximise the response rate, only a short definition of R&D investment is provided in the survey.[29] The definition refers mainly to R&D as reported in the company's most recent accounts. The definition used in the survey is thus closely related to the International Accounting Standard (IAS) 38 "Intangible Assets",[30] based on the OECD "Frascati" manual,[31] and the definition used in the EU Industrial R&D Investment Scoreboards.

Composition of the Responses

The 148 responses were classified according to the ICB classification.[32] Sector classifications of individual companies were cross-checked with the Scoreboards. The sectors were grouped as shown in the following Table 7, which includes the distribution of the responses among the sectors with their respective R&D investment shares.

Sector group	# responses	# EU top 1000 Scoreboard companies	response rate	share of R&D
Aerospace & Defence	5	24	21%	13%
Automobiles & other transport	8	66	12%	31%
Chemicals	11	41	27%	62%
Health Industries	22	191	12%	56%
ICT producers	10	108	9%	37%
ICT services	11	124	9%	27%
Industrials	20	141	14%	19%
Others	44	305	14%	27%

TABLE 7: DISTRIBUTION OF THE RESPONSES BY SECTORS
Source: European Commission JRC-B (2019).

The number of responses by home country is shown in Table 8 below. According to the Scoreboard methodology, the home country is the country of registered office of the company. Similar to our previous surveys, most participants were from companies located in the three biggest Member States.

Country	# responses	R&D investment share
Germany	20	46.28%
Spain	15	6.33%
France	14	5.31%
United Kingdom	14	1.65%
Finland	13	0.82%
Italy	13	3.98%
Sweden	10	0.61%
Austria	8	0.68%
Netherlands	8	2.98%
Denmark	6	1.48%
Belgium	4	0.89%

TABLE 8: DISTRIBUTION OF THE RESPONSES BY HOME COUNTRY OF THE COMPANY
Note: Only information for countries with at least four responses is shown.
Source: European Commission JRC-B (2019).

[29] See Annex B.
[30] See http://www.iasplus.com/standard/ias38.htm.
[31] See "Proposed Standard Practice for Surveys on Research and Experimental Development: Frascati Manual", OECD, Paris, 2002, http://www1.oecd.org/publications/e-book/9202081E.PDF.
[32] ICB, or the Industry Classification Benchmark, as owned and published by FTSE International (see: http://www.icbenchmark.com/docs/ICB_StructureSheet_120104.pdf).

Annex B: Questionnaire

SURVEY ON BUSINESS R&D INVESTMENT

We would very much appreciate your response by **21 June 2019**, **preferably by using the online questionnaire** at:

ec.europa.eu/rdsurvey

Alternatively, you may return this completed form by e-mail (lesley.potters@ec.europa.eu), fax (+34.95.448.83.26), or post[33]. You can find more information about our work on http://iri.jrc.ec.europa.eu.

The information in your response will be treated as strictly **confidential**. It will only be used within this study and in an aggregated form. The European Commission is committed to the protection and privacy of data[34].

We will automatically inform you of the results of the survey once they are available (for that purpose, please ensure that you have provided your e-mail address below).

Name of the company you are responding for: _____

Its primary sectors of activity: _____

Your name: _____

Job title: _____

E-mail: _____

Phone number: _____

The European Commission may follow up this survey with short interviews to clarify major trends revealed in the analysis. If you *do not* wish to be contacted for this purpose, please **tick here** ☐.

DEFINITION OF R&D INVESTMENT

For the purposes of this questionnaire, **'R&D investment' is the total amount of R&D financed by your company** (as typically reported in its accounts). It does not include R&D financed from public sources.

[33] European Commission, JRC Directorate B – Growth and Innovation, Attn.: Lesley Potters, Edificio Expo, Calle Inca Garcilaso 3, E-41092 Seville, Spain, Tel.: +34 954 48.05.81.

[34] See the Privacy Statement on the last page.

A. Corporate background

1. Number of employees in your company in the past year (2018)?

Around _____ (FTE[35]).

2. How many employees have worked on R&D in the company in the past year (2018)?

About _____ (FTE[3]).

3. In approximately how many countries were these R&D employees located in 2018?

In approximately _____ countries.

B. R&D investment levels and trends

4. What was your R&D investment[36] in the past year (2018)?

About € _____ million.

5. How much of this R&D investment would fall into the following categories?

(a)	Basic research (includes exploratory)	_____ %
(b)	Applied research/technology development	_____ %
(c)	Development for adapting products to local markets	_____ %
(d)	Development for market launch	_____ %
(e)	Development of software/data	_____ %
(f)	Acquisition of machinery, equipment, software & buildings	_____ %
(g)	other (please specify):	_____ %
Total		100 %

6. At what average rate do you expect the company to change its overall R&D investment over the next two years (2019 and 2020)?

About _____ % per annum.

[35] Please indicate the number of employees on either permanent or fixed-term contracts in Full-Time Equivalents (FTE), with part-time employees included on a pro-rated basis in line with their contractual working hours.

[36] The total amount of R&D financed by your company (as typically reported in its accounts). It does not include R&D financed from public sources.

C. R&D drivers

7. How relevant are the following drivers for the company's decision to increase or decrease R&D investments? *Please rate on a scale from 1 (irrelevant) to 5 (highly relevant).*

	Irrelevant				Highly relevant
	1	2	3	4	5
(a) Demand change	☐	☐	☐	☐	☐
(b) Exploiting technological opportunities (technology push)	☐	☐	☐	☐	☐
(c) Maintaining R&D as a fixed proportion of net sales	☐	☐	☐	☐	☐
(d) Availability of staff with the right skills	☐	☐	☐	☐	☐
(e) Competition from companies located in:					
(e1) the European Union	☐	☐	☐	☐	☐
(e2) other developed countries, e.g. the US or Japan	☐	☐	☐	☐	☐
(e3) emerging countries, e.g. China or India	☐	☐	☐	☐	☐
(f) Improving the company's productivity	☐	☐	☐	☐	☐
(g) Meeting product market regulation and other legal frameworks	☐	☐	☐	☐	☐
(h) Availability of adequate infrastructure	☐	☐	☐	☐	☐
(i) Availability of external financing (e.g. bank, private equity)	☐	☐	☐	☐	☐
(j) Other (please specify):	☐	☐	☐	☐	☐

D. R&D location strategy

8. Please estimate the distribution of your company's in-house R&D activity among the following world areas in the past year (2018) and two years later (2020)?

Distribution in 2018	R&D carried out:	Expected distribution in 2020
%	in the 28 EU Member States, including the UK[1] [37]	%
%	In the United Kingdom	%
%	in other non-EU European countries[2] [38]	%
%	in the US	%
%	in Japan	%
%	in China	%
%	in India	%
%	in the Rest of the World	%

9. Please state the three countries where your *main R&D activities* are currently located, *ranked by order of importance*, also indicating the share of total R&D spent there:

1. _____ _____% of total R&D	2. _____ _____%	3. _____ _____%

[37] There are currently 28 EU Member States: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

[38] Examples of other (non-EU) European countries are: Switzerland, Norway, Iceland, Albania, Moldova, Turkey, Russia, Belarus and the Ukraine (for further examples see the recognised states in: http://en.wikipedia.org/wiki/List_of_sovereign_states_and_dependent_territories_in_Europe#Recognised_states).

10. Which factors render a country attractive for *locating your R&D*? *Please rate on a scale from 1 (not attractive) to 5 (highly attractive).*

	Not attractive				Highly attractive
	1	2	3	4	5
(a) Access to markets	☐	☐	☐	☐	☐
(b) High availability of researchers	☐	☐	☐	☐	☐
(c) Quality of researchers	☐	☐	☐	☐	☐
(d) Low labour costs of researchers	☐	☐	☐	☐	☐
(e) Access to specialised R&D knowledge and results	☐	☐	☐	☐	☐
(f) Quality of public research	☐	☐	☐	☐	☐
(g) Reliable legal framework for R&D, e.g. Intellectual Property Rights	☐	☐	☐	☐	☐
(h) Macroeconomic and political stability	☐	☐	☐	☐	☐
(i) Proximity to technology poles[39] and incubators[40]	☐	☐	☐	☐	☐
(j) Proximity to other activities of your company	☐	☐	☐	☐	☐
(k) Proximity to suppliers	☐	☐	☐	☐	☐
(l) Access to R&D cooperation opportunities	☐	☐	☐	☐	☐
(m) Access to public support for R&D	☐	☐	☐	☐	☐
(n) Other (please specify):	☐	☐	☐	☐	☐

E. Production location strategy

11. Please state the three countries where your *main production activities* are currently located, *ranked by order of importance*, also indicating the share of total production there:

1. _____	2. _____	3. _____
_____% of total production	_____%	_____%

12. Which factors render a country attractive for *locating your production*? *Please rate on a scale from 1 (not attractive) to 5 (highly attractive).*

	Not attractive				Highly attractive
	1	2	3	4	5
(a) Access to markets	☐	☐	☐	☐	☐
(b) High availability of personnel	☐	☐	☐	☐	☐
(c) Quality of personnel	☐	☐	☐	☐	☐
(d) Low labour costs of personnel	☐	☐	☐	☐	☐
(e) Low employment protection[41] of production personnel	☐	☐	☐	☐	☐
(f) Access to specialised production knowledge and results	☐	☐	☐	☐	☐
(g) Macroeconomic and political stability	☐	☐	☐	☐	☐
(h) Proximity to other activities of your company	☐	☐	☐	☐	☐
(i) Proximity to suppliers	☐	☐	☐	☐	☐
(j) Access to production infrastructure	☐	☐	☐	☐	☐
(k) Access to public support for production activities	☐	☐	☐	☐	☐
(l) Regulation (environmental legislation, red tape…)	☐	☐	☐	☐	☐
(m) Regulation of your product markets	☐	☐	☐	☐	☐
(n) Other (please specify):	☐	☐	☐	☐	☐

[39] "Technology poles" are areas where R&D active companies, institutions and universities are concentrated.

[40] "Incubators" are structures that support innovative start-up companies in order to increase their survival rates.

[41] Referring both to regulations concerning hiring (e.g. rules favouring the disadvantaged, for using temporary or fixed-term contracts, training) and firing (e.g. redundancy procedures, prenotification, severance payments, collective dismissals and short-time work), see the OECD Employment Outlook (10.1787/empl_outlook-2013-6-en).

F. R&D and Competition

13. For the future competitiveness of your company, how relevant are the following R&D (and innovation) investment priorities? *Please rate on a scale from 1 (irrelevant) to 5 (highly relevant).*

	Irrelevant				Highly relevant
	1	2	3	4	5
(a) Software investment	☐	☐	☐	☐	☐
(b) ICT hardware investment	☐	☐	☐	☐	☐
(c) ICT service investment	☐	☐	☐	☐	☐
(d) Sustainable technologies[42]	☐	☐	☐	☐	☐
(e) Robot use	☐	☐	☐	☐	☐
(f) Use of Artificial Intelligence	☐	☐	☐	☐	☐
(g) Use of Big data	☐	☐	☐	☐	☐
(h) Global organisation of your company's R&D processes	☐	☐	☐	☐	☐
(i) Adaptation to Industry 4.0	☐	☐	☐	☐	☐
(j) Other (please specify)	☐	☐	☐	☐	☐

14. What is the approximate number of main competitors at your main product market worldwide?

(a) Up to 5

(b) Between 6 and 10

(c) Between 11 and 25

(d) Between 26 and 50

(e) More than 50

15. How strong is competition in your main product market?

	Very weak				Very strong
	1	2	3	4	5
(a) Price competition	☐	☐	☐	☐	☐
(b) Technological competition (e.g. competition on technological advancements)	☐	☐	☐	☐	☐
(c) Innovation competition (e.g. competition on the introduction of new products and/or services)	☐	☐	☐	☐	☐

G. Non-R&D innovation

16. How much does your company spend on innovation activities that fall outside the R&D definition, so called non-R&D innovation expenditures?

About € _____ million.

[42] Technologies with the aim of reducing the environmental impact, such as more efficient use of energy and materials and a significant reduction in emissions.

17. How much of this non-R&D investment would fall into the following categories?

(a)	Market research for innovations	_____ %
(b)	Training of staff for innovative activities	_____ %
(c)	Market introduction of innovations	_____ %
(d)	Organisational innovations	_____ %
(e)	Form and appearance design of new products	_____ %
(f)	Acquisition of licenses and other knowledge	_____ %
(g)	other (please specify):	_____ %
Total		100 %

18. At what average rate do you expect the company to change its overall non-R&D investment over the next two years (2019 and 2020)?

About _____ % per annum.

19. How relevant are the following drivers for the expected non-R&D investment change noted under question 18? *Please rate on a scale from 1 (irrelevant) to 5 (highly relevant).*

	Irrelevant				Highly relevant
	1	2	3	4	5
(a) Demand change	☐	☐	☐	☐	☐
(b) Availability of staff with the right skills	☐	☐	☐	☐	☐
(c) Competition from companies located in:					
(c1) the European Union	☐	☐	☐	☐	☐
(c2) other developed countries, e.g. the US or Japan	☐	☐	☐	☐	☐
(c3) emerging countries, e.g. China or India	☐	☐	☐	☐	☐
(d) Improving the company's productivity	☐	☐	☐	☐	☐
(e) Meeting product market regulation and other legal frameworks	☐	☐	☐	☐	☐
(f) Other (please specify):	☐	☐	☐	☐	☐

H. Sustainability and R&D

20. Does your company have a policy in place to ensure **the environmental and/or social sustainability**[43] **of its activities?**

	Policy in place	No policy in place, but planning to implement within 5 years	No policy in place -- not planning to implement within 5 years
Environmental sustainability	☐	☐	☐
Social sustainability	☐	☐	☐

[43] For more information, please see the UN Sustainable Development Goals, https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

21. If your company has a policy in place to ensure the environmental sustainability of its activities, could you provide an estimation of the companies' investments in "environmental sustainability"?

About € _____ million.

22. What proportion, if any, of your total R&D investment is specifically aimed at sustainability?

About _____ % of total R&D investment

I. How will BREXIT impact on your R&D strategy in the future?

⇨ _____

_____

_____

_____

J. Your final comments or suggestions

⇨ _____

_____

_____

_____

Thank you very much for your contribution!

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