CHAPTER II.2

HAS THE EUROPEAN CORPORATE R&D LANDSCAPE BECOME INCREASINGLY MORE CONCENTRATED IN a FEW HAPPY ‘SUPERSTARS’?

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1. Introduction

Social exclusion and rising inequality are phenomena that could potentially be the most important challenges facing the EU and the world at large, threatening its political and societal stability and future prosperity. Most of the attention in the inequality debate focuses on the rising income inequality among individual citizens, and polarisation in the labour market (for example, McAfee and Brynjolfsson, 2016).

Disruptive innovations and technological progress, such as the rise of robots, are often seen as the culprits for the increasing income inequality and loss of jobs – with young tech geeks becoming billionaires overnight by selling their apps, or start-ups, while older low-skilled factory workers find their jobs are being replaced by robots. Aghion et al. (2015) argue that although innovation partly accounts for the surge in income inequality, it also fosters social mobility, at least when the innovations come from new inventors.

While most of this discussion on inequality is at the level of individual citizens, another strand of recent literature has looked into how unequal the corporate landscape has become. Both technological change, especially the Digital Revolution, and globalisation are predicted to lead to 'winner takes most' industries, dominated by a few superstar firms. As the importance of large fixed investments driving scale and scope advantages grows, and network effects become more prominent, sectors will become increasingly concentrated in a small number of firms, leaving an increasingly unequal corporate landscape. This is particularly true for digital sectors.

This superstar firm model has been checked recently in theUnited States by Autor et al. (2016) who looked at the concentration of sales and employment. They found a remarkably consistent upward trend in concentration in each sector over the period studied (1982-2012). In manufacturing, the sales-concentration ratio[7] increased from 38% to 43%; in finance from 24% to 35%; in services from 11% to 15%; and in the retail trade from 15% to 30%. They also found that employment concentration grew, although notably more slowly than sales concentration. The pattern suggests that firms may attain large market shares with a relatively small workforce, as illustrated by companies such as Facebook and Google.

Autor et al. (2016) found that the industries which became more concentrated over time were also those in which productivity – measured either by output per worker, value-added per worker, total factor productivity (TFP), or patents per worker – increased the most. These findings suggest that a positive productivity-concentration relationship will most likely feature in any plausible explanation of rising industry concentration.

Other evidence supporting the positive link between concentration and productivity comes from the OECD. Using a harmonised cross-country, firm-level database for 24 countries, Andrews, Criscuolo and Gal (2017) show an increasing productivity gap between the global frontier and laggard firms. They define global frontier firms as the top 5% of firms in terms of labour productivity levels, within each two-digit sector, in each year, across all countries since the early 2000s. All other firms are defined as laggards. Between 2000 and 2013, global frontier firms displayed larger labour productivity growth rates than laggards in the manufacturing sector. Repeating this exercise using multi-factor productivity (MFP) estimates suggests that this productivity divergence remains after checking the ability of frontier firms to charge higher mark-ups, supporting the idea that divergence in productivity is technology driven.

7 i.e. the share of the four largest firms in total sector sales (CR4).

Since the growing concentration of superstars in the corporate landscape seems to be at least partly driven by divergences in productivity and the adoption of new technology, it is important to look at the corporate R&D landscape: **would we see similar growing trends in concentration in corporate R&D and how would changes in R&D concentration feed into rising sales and employment concentration?**

The speed, depth and breadth of technology change, large investments sunk into building R&D capacity, and the need to access networks and alliance partners for innovation are all characteristics that would predict R&D races increasingly characterised as 'winner takes most', where incumbent firms are the most likely winners in the innovation race (Schumpeter Mark II). However, the speed at which the latest technological innovations are either being diffused or spill over voluntarily or involuntarily will lead to the catching up and dissipating of previous leadership positions. If the diffusion process happens fast enough, the difference between leaders and laggards should shrink.

At the same time, the fluidity of the R&D environment needs to be recognised where the competences, network positions and technology leaderships of incumbents can be quickly overturned by radically new technology avenues. This will disrupt the incumbent leaders, creating room for new winners (Schumpeter Mark I). Even if the R&D landscape remains concentrated, new tenants will inhabit the top level.

An important issue for the policy discussion is to examine whether the 'superstar R&D firms' are either incumbent market leaders exploiting their market power, or incumbent R&D superstars exploiting their superior innovative capacities and experience, or new superstar firms introducing radically new innovations. Just how the concentration of R&D in fewer firms will impact the overall innovative performance of nations will depend on who these R&D superstars are, how they can obtain, maintain and expand their superstardom and how contestable these superstar positions are.

Evidence on the concentration of the R&D landscape and trends therein is very thin. Recently, Rammer & Hünermund (2017) have examined this for Germany. They provide several interesting findings suggesting an increasing concentration in the German R&D landscape. They have found that the share of German firms that are innovation active has dropped over time. In particular, many small and medium-sized firms have stopped investing in innovation. As a consequence, the inequality among innovation activities has grown over time in Germany: since the mid-1990s, the Gini coefficient for the distribution of business-sector innovation expenditure has been exhibiting a rising trend. At the same time, they have identified high stability among the group of firms with the largest R&D budgets in Germany. In the 12 years between 2003 and 2015, nine out of 10 companies remained in the top 10 of the largest R&D spenders, and even changes in rankings were only marginal in the top 10.

In this contribution, we will look at the concentration of the R&D landscape and trends therein in Europe. We have used various editions of the European Commission's Joint Research Centre Scoreboard of the largest R&D spenders worldwide which provides R&D profiles across all sectors and regions. We will examine the inequality in R&D expenditure by European Scoreboard firms, its concentration in a few leading firms and the trends therein. We will compare the (trends in) inequality and the concentration of R&D expenditure with the sales and the employment figures in Scoreboard firms. We will compare Europe with other world regions, and look at specific trends in high- and medium-tech sectors, focusing on several selected important sectors, most notably biopharma, vehicles and parts and ICT. Finally, we will look at incumbency among the top R&D spenders, concluding with a summary of the main findings and some tentative policy implications.

2. Methodology and information sources

The study uses the EC-JRC-IPTS R&D Scoreboard[8] of the largest R&D spenders in the world, for various years from 2005 to 2015. The various year editions were made compatible and top firms linked across them.

The R&D Scoreboard has the advantage that for individual firms it covers their R&D expenditure, sales and employment, for several years and for companies from all sectors and all countries[9]. Among the 2500 firms featured in the 2016 Scoreboard, 1075 are European (representing a total of EUR 223 billion of R&D expenditure or an estimated 95% of total corporate R&D spending in Europe[10]).

The R&D Scoreboard only covers the largest R&D spenders, which means that we will only characterise R&D distribution in the top part of the R&D size distribution, omitting the part with the lowest spenders. Focusing only on the Scoreboard firms in the total distribution of R&D-active firms is likely to generate less inequality than the total set of R&D-active firms and will give an upward bias in levels of concentration.

We will calculate various concentration and inequality indicators, similar to concentration and inequality measured in economic analysis. **For concentration**, we will look at the share of the top 10% (decile) of the distribution. As regards **inequality**, we will calculate both the Gini coefficient and the **Theil** coefficient. The Theil coefficient for inequality can be broken down into subgroups, which enables a check to be made as to whether the overall inequality is due to high inequality within certain groups and/or because of differences between groups. We will do a Theil decomposition analysis to create two groups: the P10% and P90%. A Theil decomposition into deciles of the R&D expenditure distribution will allow us to investigate in more detail to what extent the overall inequality is due to the difference between the upper decile and the rest, and hence the concentration among top spenders.

8 European Commission, DG Joint Research Centre, 'The EU Industrial R&D Investment Scoreboard', 2017. See http://iri.jrc.ec.europa.eu/Scoreboard.html.

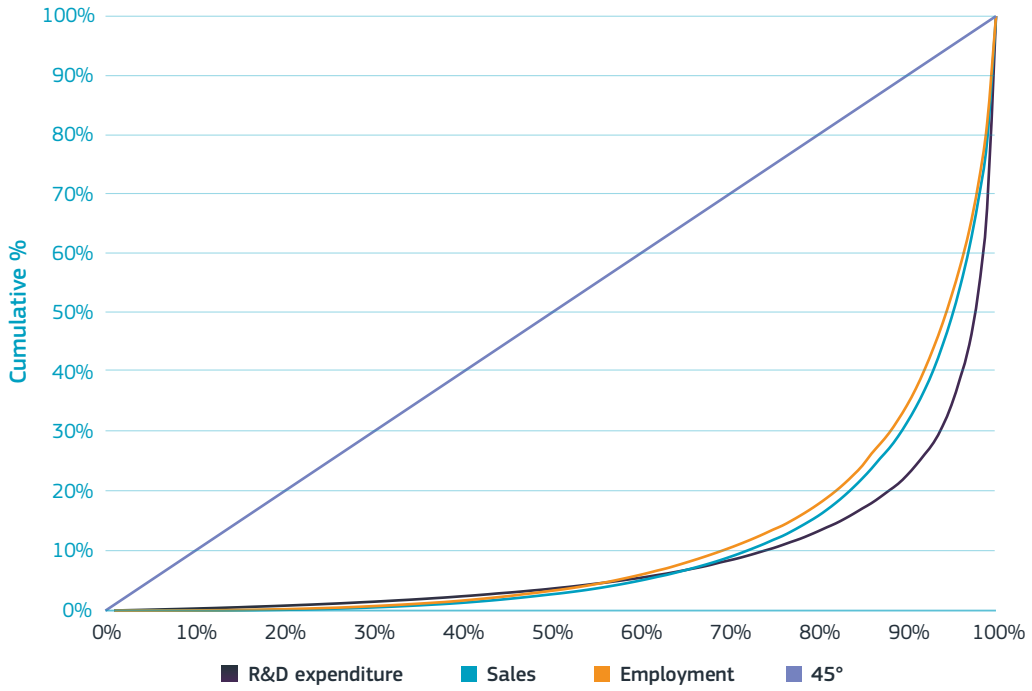
9 The Scoreboard consolidates R&D expenditure, sales and employment information at the firm's headquarter country. It also classifies the firms according to the sector where they carry out the majority of their activities.

10 The European perimeter used in this study is the EU plus Switzerland and Norway, all members of the European Research Area. Switzerland has 58 companies in the 2015 Scoreboard and Norway has 12. The EU-28 has 1000 companies, with the UK and Germany the most represented with 276 and 217 companies, respectively. France has 117 and Sweden 83. All other countries have less than 100 companies in the 2015 Scoreboard.

3. How unequal and concentrated is the European corporate R&D landscape among a few star firms? Substantially, more so than sales and employment

The distribution of R&D expenditure among European Scoreboard firms is highly uneven (Figure II.2.1). The distribution of European Scoreboard firms' sales and employment is also highly unequal, although less so than their R&D expenditure. This is confirmed in Figure II.2.2 by the Gini and Theil coefficients (columns 3 and 4), which are highest for R&D and lowest for employment.

Figure II.2.1 Characterising the distribution of 1075 European R&D Scoreboard firms, 2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_1.xlsx

The inequality of R&D is mostly driven by the concentration at the top. The Theil decomposition between the top 10% and bottom 90% groups for European R&D Scoreboard expenditure shows that most of the inequality in R&D expenditure is due to inequality between the top 10% and the bottom 90% (71%) rather than inequality within each groups (see column 5 in Figure II.2.2). This confirms that most of the inequality in the corporate R&D landscape is due to concentration in the top decile. This is much less the case for European Scoreboard firms' sales and employment, where only 37% and 33%, respectively, of the inequality is due to between group inequality and there is much higher inequality within the bottom 90% than there is for R&D (column 7).

The high between component of overall inequality of R&D expenditure correlates to a high concentration of R&D expenditure in the top decile of the distribution. This is confirmed in column 2 of Table 1, which shows the share of the top10% of the firms in total Scoreboard R&D, sales and employment.

The top 10% of European Scoreboard firms (i.e. the largest 107 firms) represent 77% of all European Scoreboard R&D expenditure. For sales and employment, the share of the top 10% is also substantial but nevertheless smaller than for R&D.

The Theil decomposition shows that even within the top 10% (column 6 in Figure II.2.2) there is substantial inequality in R&D expenditure and sales, although somewhat less so for employment. This would suggest that even within the top 10% there is a still considerable concentration in only a few firms. The top 1% of R&D spenders in the European Scoreboard (i.e. the 11 largest firms) (column 1 in Figure II.2.2) represents 32% of all European R&D Scoreboard expenditure or 42% of the top 10%. This concentration of R&D expenditure in a few firms in the top group is much less so for sales and employment among Scoreboard firms: for sales, the top 1% represents 21% of total Scoreboard sales; for employment, 18%.

The leading group of R&D spenders are much less dominant in employment and sales than in R&D. While the top 10% of European R&D spenders represent 77% of total European Scoreboard R&D, they only represent 51% of total European Scoreboard sales and 46% of total European Scoreboard employment (Figure II.2.3). This shows that the companies which spend the largest amounts on R&D are relatively leaner on employment and sales.

Figure II.2.2 Inequality in the distribution of European R&D Scoreboard firms, 2015

	1	2	3	4	5	6	7
	N	Share Top 1%	Share Top 10%	Gini[1]	Theil[2]	% BTW[3]	Theil Top 10%	Theil Bottom 90%
R&D expenditure	1074	32%	77%	0.83	1.78	71%	0.52	0.51
Sales	893	21%	68%	0.80	1.39	37%	0.56	1.25
Employment	893	18%	65%	0.78	1.28	33%	0.40	1.28

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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard
Notes: [1]The Gini coefficient measures the area between the 45° line and the distribution of the variable (R&D expenditure, sales, employment) as a share of the total area below the 45° line (see Figure II.2.1). It ranges between 0 (for perfect equality) to 1 (perfect inequality). [2]The Theil index is measured as follows: $T= 1/N * (\Sigma i\ (xi / xM) * \ln (xi / xM))$ where xM is the mean value. The Theil index can be decomposed as follows: $T= \Sigma j\ sj\ Tj + \Sigma j\ sj * \ln (xMj / xM)$ with j groups (i.e. 2 groups: the top 10% the bottom 90%, respectively); the first part represents the weighted sum of the within-group Theils and the second part, each group's weighted contribution to the between-group inequality. [3]The % of inequality explained by the inequality between the top 10% and the bottom 90%.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_2.xlsx

Figure II.2.3 Top European R&D Scoreboard firms and their shares in sales and employment[1], 2015

	R&D expenditure	Sales	Employment
Top 1% R&D spenders	32%	11%	10%
Top 10% R&D spenders	77%	51%	46%

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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard
Note: [1]Percentages are calculated based on top R&D spending firms with non-missing values in employment and sales (N=893) respectively. There are no non-missing values in the top decile.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_3.xlsx

4. Comparing Europe-North America-Asia: higher R&D inequality and concentration in Europe than in North America and Asia

A comparison with the North American Scoreboard firms indicates whether or not the concentration of R&D expenditure in just a few firms is a bigger phenomenon in North America or Asia than in the EU. Figure II.2.4 compares some key statistics on the distribution of R&D Scoreboard firms in Europe with North America and Asia. For the comparison across regions, we have used a constant number of Scoreboard firms in each region (i.e. 750, which is the number of Asian firms in the sample).

The Theil R&D coefficient shows a smaller inequality in the R&D landscape in North America and Asia than in Europe. In addition, the concentration of R&D expenditure in a few firms is less pronounced in North America and Asia than in Europe. The top 10% of firms (i.e. the 75 largest firms) represent a smaller share of total Scoreboard R&D in North America and Asia than in Europe. For the top 1%, this difference is only marginal.

In contrast to Europe, North America's sales and employment distribution among Scoreboard firms is more unequal than in Europe, especially sales distribution, as shown by the higher Theil coefficients.

Figure II.2.4 Comparing inequality and concentration of R&D Scoreboard firms by region

	Europe	North America	Asia
N	750	750	750
Theil R&D expenditure	1.51	1.45	1.15
Theil sales	1.20	1.54	1.15
Theil employment	1.05	1.28	0.89
% between Theil R&D expenditure	74%	71%	71%
% between Theil sales	31%	41%	47%
Share of Top 1% in R&D expenditure	27%	26%	25%
Share of Top 10% in R&D expenditure	73%	70%	65%
Share of Top 10% in sales	63%	72%	61%
Share of Top 10% in employment	58%	66%	55%

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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_4.xlsx

5. Sectoral comparisons of inequality and concentration in the corporate R&D landscape in Europe: a higher concentration in high-tech

In this section, we look at the difference in inequality and concentration between the high-tech, medium-tech and low-tech sectors. Most of Europe's Scoreboard R&D expenditure is found in medium-tech sectors (52%). Only 38% is located in high-tech sectors, and 10% is located in low-tech sectors.

The Theil coefficients (Figure II.2.5) show a higher inequality in high tech compared to medium tech and especially compared to low tech. This higher inequality holds true not only for R&D, but also for sales and employment.

Furthermore, the concentration of R&D expenditure in top firms is much lower in low-tech sectors compared to high- and medium-tech sectors. This is true for the share of the top 10%, but is even more pronounced for the top 1%. In high and medium tech, a much higher concentration of R&D is noted in the top 1% than in low tech.

Figure II.2.5 Comparing inequality and concentration in European R&D Scoreboard firms for high-, medium- and low-tech sectors

	High-tech	Medium-tech	Low-tech
N	438	553	174
Theil R&D expenditure	2.00	1.73	1.06
Theil sales	1.68	1.25	0.95
Theil employment	1.57	1.22	0.81
Share of Top 1% in R&D expenditure	33%	34%	15%
Share of Top 10% in R&D expenditure	84%	75%	61%
Share of Top 10% in sales	78%	65%	54%
Share of Top 10% in employment	77%	65%	50%

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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_5.xlsx

6. Trends in inequality and concentration: has the corporate R&D landscape become more concentrated over time? No

The Scoreboard data enables a comparison to be made over time from 2005 until 2015. As the number of firms included in the Scoreboard exercise has changed over time, we will use the same number for each year in the trends analysis. The time-comparable sample contains a somewhat smaller set of 1046 Scoreboard firms every year[11].

For this set, inequality in R&D expenditure, as measured by the Theil coefficient, was lower in 2015 than in 2005. Thus, the Scoreboard data do not signal rising inequality in R&D; on the contrary, inequality in R&D seems to have fallen. Nevertheless, it remains at high levels and, in addition, the downward trend seems to have stopped since 2011. Inequality in sales and employment among these Scoreboard firms also declined from 2005 to 2015, although with a period of increasing inequality, particularly for sales between 2009 and 2014.

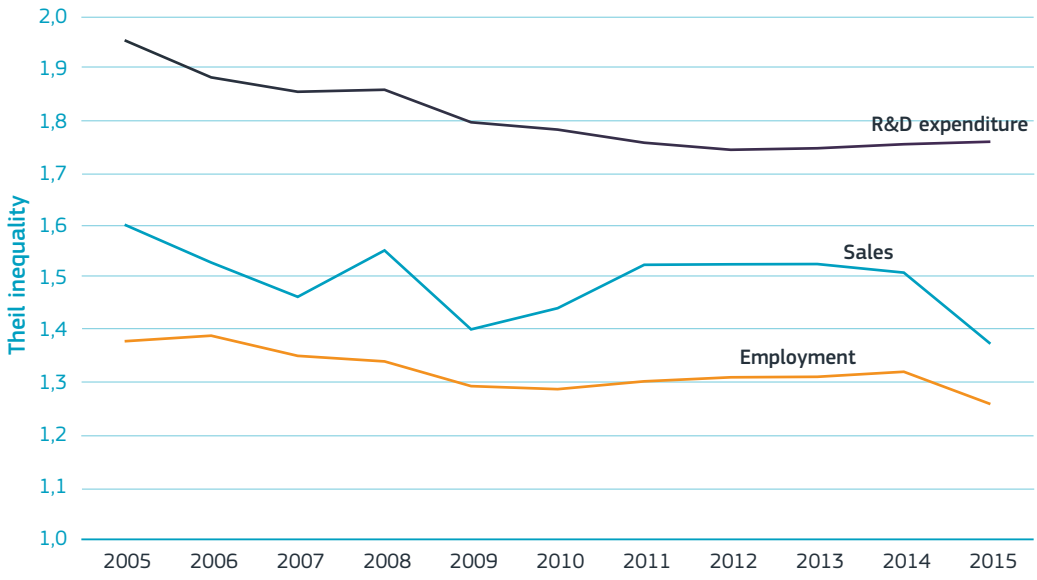
The concentration of R&D expenditure remained fairly stable at high levels, with only a small drop in the share of the top10% (from 81% to 77%) and of the top 1% (from 35% to 32%). While the share of the top 10% continued to trend downwards until 2012, since then it has remained stable. Since 2012, the share of the top 1% has started to move slightly upwards. This corresponds with the end of the downward trend in Figure II.2.6 since 2011. All this suggests that since 2012, the super-top R&D spenders have forged ahead, leaving an even more concentrated R&D landscape in Europe than before.

For North America, the time-comparable sample includes 503 Scoreboard firms every year. This set shows a slight upward trend in inequality in R&D expenditure (Theil-R&D coefficient ranging from 1.18 in 2005 to 1.22 in 2015). In addition, the concentration is fairly stable over time for North America: the share of top 10% firms in R&D remained at 65% across the time period under consideration.

Inequality (as measured by the Theil coefficient) of R&D expenditure has declined over time, both in the high-tech and medium-tech sectors, while remaining consistently low in low tech. The concentration of R&D expenditure (as measured by the share of the top 10%) has gone down in the medium-tech sectors while remaining persistently high in high tech. Although lower in low tech, there is a slight increase in concentration over time in these sectors.

11 The time-comparable 1046 firms each year are not a panel of 1046 firms traced over time. The 1046 firms included for each year in the analysis of the distribution for that year may differ each year.

Figure II.2.6 Trends in inequality among European R&D Scoreboard firms, 2005-2015



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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU R&D Industrial R&D Invesment Scoreboard
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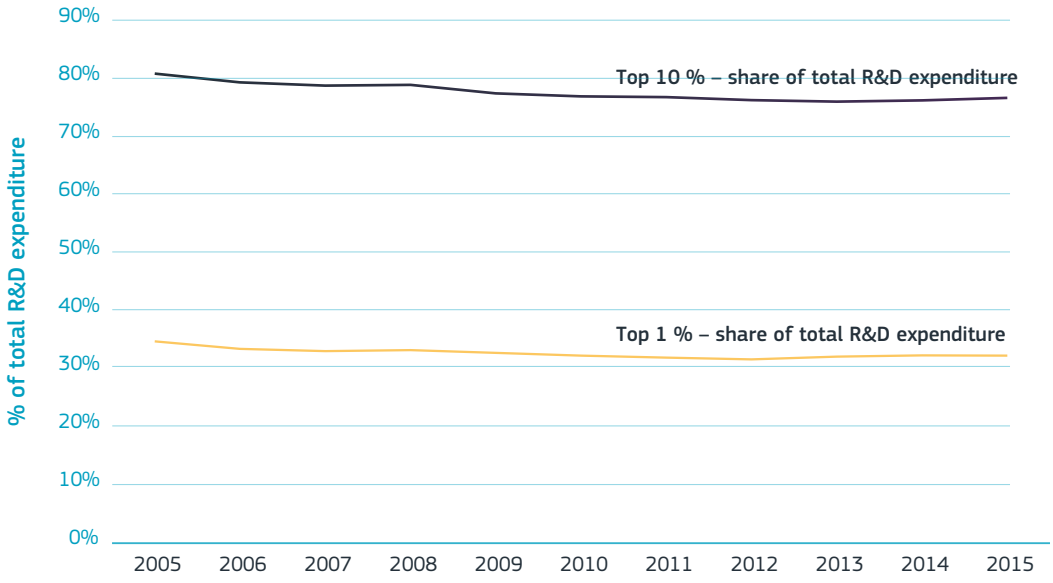
Figure II.2.7 Trends in concentration of R&D spending among European R&D Scoreboard firms, 2005-2015



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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU R&D Industrial R&D Invesment Scoreboard
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_7.xlsx

Figure II.2.8 Trends in inequality and concentration in European R&D Scoreboard firms for high-, medium- and low-tech sectors

	R&D expenditure				
	Theil		Top 10%		N
High-tech	2.07	1.85	84%	83%	292
Medium-tech	1.89	1.69	81%	74%	528
Low-tech	1.00	1.03	57%	60%	168

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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_8.xlsx

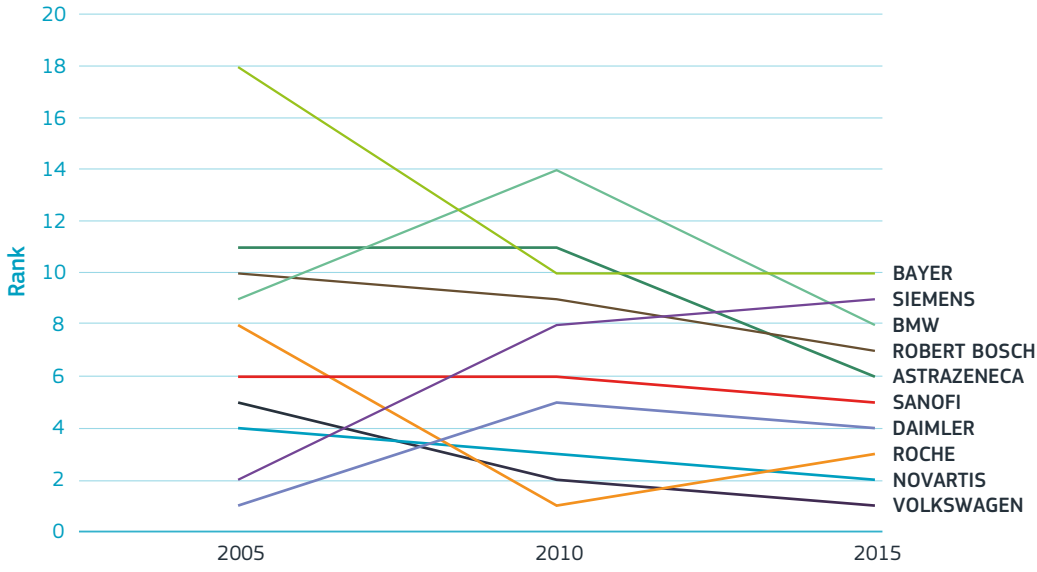
7. Trends in inequality and concentration of R&D, incumbent vs. new leaders: a strong incumbency profile among R&D leaders

An important issue is to examine whether the 'superstar R&D firms' are incumbent R&D leaders or new leading R&D firms. In this section, we consider which of the leading R&D firms in Europe in 2015 were already leading, in this case, before 2010 and 2005. Identifying the incumbency status of top firms in the Scoreboard is a cumbersome exercise, requiring the firms' history and their entry in the Scoreboard to be tracked over time. We do this exercise for those European Scoreboard firms that belong to the top 10/20.

When looking at the top 10 largest R&D spenders in Europe in 2015, it can be noted that their ranking among the largest R&D spenders has remained very stable over time. Only two were not the top 10 in 2010 (AstraZeneca and BMW) and only AstraZeneca and Bayer did not join the top 10 in 2005. In 2015, all of the top 10 had already been in the top 20 in 2005 and 2010.

There was also significant stability in the top 20 in 2015: 17 firms already belonged to the top 20 at that time (representing 92% of R&D expenditure among the top 20). When looking back further, to 2005, there were six 'new' top 20 firms which had yet to join the top 20 in 2005. However, these six firms represented only 17% of the R&D expenditure of the top 20 in 2015 (20% of employment). Only two of the six did not belong to the top 50 in 2005.

Figure II.2.9 Comparing the past rankings of the European R&D Scoreboard top 10 companies in 2015



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Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU R&D Industrial R&D Invesment Scoreboard

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_9.xlsx

8. Trends in inequality and concentration of R&D, incumbent vs. new leaders in selected sectors

When considering the trends and stability in R&D leadership, it is more relevant to look at the ranking of firms within sectors. Figures II.2.10 and II.2.11 provide some key statistics on trends for three major sectors in the European R&D landscape: biopharma, cars and parts and ICT.

For **biopharma**, the time-comparable sample includes 150 European Scoreboard firms. In this group, the top 10% firms represented 84% of total Scoreboard R&D spending in this sector in 2015. Thus, the European R&D landscape in pharma and biotech is very skewed, which is not surprising, in view of the high economies of scale and scope in R&D in this sector (for example, Henderson and Cockburn, 1996). Although the inequality in R&D spending has fallen, particularly more recently, it remains considerable. The inequality of sales and employment among Scoreboard firms has also declined over time. The concentration of R&D, as measured by P10% (as well as P1%, not shown) has gone down but only very slightly and remains at a high level. This suggests that the decline in inequality in R&D is only marginally due to the drop in difference between the top 10% and the rest.

The digital sectors are often portrayed as being 'winner takes all'. Indeed, the distribution of R&D spending among European **ICT** Scoreboard firms is indeed significantly unequal, although less than in pharma and biotech. The top 10% represents 74% of total sector R&D spending. In ICT, although expected, there is no trend of increasing inequality and concentration is evident in either R&D, sales or employment among European Scoreboard firms. The trend is one of declining inequality and concentration – a downward trend that is far more pronounced than in pharma/bio. Nevertheless, the levels of concentration and inequality in R&D remain high.

In **cars and parts**, the inequality and concentration of R&D is less pronounced compared to pharma, although in this sector, both inequality and concentration of R&D has risen over time. Inequality in sales has also increased, although not in employment.

To understand the impact of concentration on top firms, it is important to look at the type of top firms – i.e. whether they are incumbent or new firms. We have done this exercise for those European Scoreboard firms that belong to the top 10 in three sectors: pharma, cars and ICT (see Figure II.2.10).

In **Bio/Pharma**, the high concentration of R&D expenditure is characterised by a very strong incumbency effect. Of the 10, only one firm (in 8th position) did not belong to the top 10 in either 2010 or 2005. Although the sector did see substantial new entries in its Scoreboard, typically in biotech, none of these made it into the top 10.

We can see a similar story with **Cars**. In this sector, too, the dominance of the 10 largest R&D spending firms is high (than Pharma and ICT). Also in this sector, there is a high incumbency effect.

The dominance of the 10 largest R&D spending firms is least pronounced in the **ICT** sector. In addition, the incumbency effect is smaller. Nevertheless, in view of the rapid changes in technology in this sector, a smaller incumbency effect may have been expected.

Figure II.2.10 Trends in inequality and concentration of European R&D Scoreboard firms for pharma, cars and ICT

	Pharma / Bio / Med (N = 150)		Cars and Parts (N = 43)		ICT (N = 260)	
	2005	2015	2005	2015	2005	2015
Theil R&D expenditure	1.95	1.84	1.13	1.26	1.92	1.55
Theil sales	1.74	1.52	1.14	1.26	1.80	1.55
Theil employment	1.58	1.45	0.91	0.84	1.67	1.46
Share of Top 10% in R&D expenditure	85%	84%	65%	69%	80%	74%

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_10.xlsx

Figure II.2.11 Incumbent European R&D leaders in pharma, cars and ICT

	European R&D Scoreboard, 2015		
	Bio / Pharma	Cars and Parts	ICT
Share of Top 10 in 2015	79%[12]	88%[13]	55%[14]
2010 Top 10 - share in 2015 Top 10	95%	94%	82%
2005 Top 10 - share in 2015 Top 10	95%	94%	78%
New share in 2015 Top 10	0%	0%	0%

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Bruegel calculations on the basis of EC-JRC-IPTS, EU Industrial R&D Investment Scoreboard
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/partii/partii_2/figure_ii_2_11.xlsx

12 The top 10 includes Allergan in 8th position, a United States firm in 2015 classified as European because its HQ is in Ireland. In 2010 and 2005, it was still categorised as United States. Allergan is the only top 10 firm which did not belong to the top 10 in 2010 and 2005. If Allergan was excluded from the European rankings (i.e. treated as non-European throughout the time period), UCB would enter the top 10. In this scenario, the top 10 would include 80% of total 2015 European bio/pharma R&D. As UCB was also in the top 10 in 2010 and 2005, the share of top 10 in 2015 from the top 10 in 2005 or 2010 would be 100%.

13 In 2015, the top 10 includes Delphi, in 10th position, which was a United States-based firm in 2005 and 2010, but in 2015 became a UK-based firm. Dropping Delphi (i.e. treating it as non-European throughout), introduces Valeo (France) into the top 10 for 2015. Delphi and Valeo are very similar with respect to their R&D expenditure in 2015, 2010 and 2005 – both just dropped out of the top 10 in 2010 but would have been in 10th position in 2005. Replacing Valeo with Delphi would therefore leave identical numbers in the table.

14 The top 10 in 2015 includes Seagate, in 8th position, a United States company classified as European because it moved its HQ to Ireland in 2010. In 2005, it was still classified as American. Seagate was not in the top 10 in 2010 or 2005 (even if it had been classified as European). Dropping Seagate (i.e. treating it as non-European throughout) introduces Schneider (FR), thus leaving very similar numbers (55%, 83% and 79%, respectively).

9. Concluding remarks on trends in inequality and concentration in corporate R&D in Europe

As recent research has shown a trend in the growing concentration of corporate sales and employment among a few 'superstars' – a trend which seems to be at least partly (digital) technology driven – it is important to look at the corporate R&D landscape and its concentration in superstars. Furthermore, R&D 'races' are increasingly expected to become "winner takes most", in view of high economies of scale, scope and network economies, especially in digital technologies. At the same time, incumbents' technology leaderships can be quickly overturned by radically new technology avenues. This will disrupt the incumbent leaders, creating room for new winners. Even if the R&D landscape may still be concentrated, new tenants will inhabit the top.

In this contribution, we have looked at the concentration of the R&D landscape and trends therein in Europe. We have used the 2005 to 2015 editions of the EC-JRC Scoreboard of the largest R&D spenders worldwide, which allows for analysis of each year's R&D expenditure, sales and employment of 1047 European Scoreboard firms.

Our main findings can be summarised as follows:

- R&D expenditure by European Scoreboard firms is very unevenly distributed. This is confirmed by the Gini and Theil coefficients for R&D.
- The distribution of sales and employment in European Scoreboard firms is also very unequal, although less so than their R&D expenditure.
- Most of the inequality in R&D expenditure is due to the difference between the top 10% and the bottom 90% of spenders. This is much less so for sales and employment in European Scoreboard firms.
- R&D expenditure by European Scoreboard firms is concentrated in a few firms: the top 10% of European Scoreboard firms represent 77% of all European Scoreboard R&D expenditure. The top 1% of R&D spenders account for almost one-third of all European R&D Scoreboard expenditure.
- For sales and employment, the concentration in the top 10 and top 1% is also substantial, although less pronounced than for R&D.
- While the top 10% of European R&D spenders represent 77% of total European Scoreboard R&D, they only represent 51% of total European Scoreboard sales and 45% of total European Scoreboard employment. This indicates that the top R&D companies are relatively leaner on employment and sales compared to non-top firms.
- Inequality in the R&D landscape is somewhat higher in Europe than in North America and Asia. In contrast to Europe, the North American sales and employment distribution among Scoreboard firms is more unequal than the European, especially for sales distribution.
- When looking at the trend in inequality and concentration over time, from 2005 to 2015, the Scoreboard data do not signal

increasing inequality in R&D: on the contrary, the trend is downward. Nevertheless, this declining trend still leaves high levels of inequality and, furthermore, seems to have stopped since 2011. Since 2012, the top 1% of R&D spenders has forged ahead, leaving a more concentrated R&D landscape than before.

- When looking at the top 10 largest R&D spenders in Europe in 2015, this group of top leading R&D firms shows an extremely strong incumbency profile: almost all of the R&D expenditure by the top 10 (top 20) leading firms in 2015 can be accounted for by incumbent leaders which already belong to the group of top 10 (top 20) leading firms in 2005.

- In addition, the inequality in Scoreboard firms' sales and employment fell from 2005 to 2015, although indicating a period of increasing inequality, particularly for sales, between 2009 and 2014.

- The distribution of R&D expenditure across European Scoreboard firms in pharma and biotech is most unequal. Although the inequality in R&D spending has shrunk, particularly more recently, it remains at a high level, and the concentration in a few firms is high in this sector. This high concentration is characterised by a very strong incumbency effect. Although the sector saw substantial new entries in its Scoreboard in biotech, none of these made it into the top 10.

- The digital sectors are often portrayed as being "winner takes all". Indeed, the distribution of R&D spending among European ICT Scoreboard firms is very unequal, but less so than in pharma and biotech. In addition, the concentration of R&D spending in the top 10% firms is high, but not as high compared to pharma, and the incumbency effect is also smaller than in pharma. In ICT, although expected, no trend can be seen of increasing inequality and concentration, either in R&D, sales or employment.

At this stage, the main message from the analysis seems to be that the European R&D landscape is highly unequal and concentrated in a few superstars in the European corporate R&D landscape, and is much higher than for sales and employment. Furthermore, there is a strong incumbency effect for these R&D superstars. Whether this concentration in a few incumbent firms is a reflection of differences in R&D advantages for large incumbent firms or it reflects barriers for new leading firms to grow into superstar status remains to be further explored. Evidence of declining inequality and concentration is a positive sign, but its high incumbency characteristic, its slow downward pace and particularly its loss of momentum more recently, requires further monitoring and analysis to understand its implications for the overall performance of the corporate R&D system.

Clearly, further analysis of this important dimension is needed. We hope that the analysis presented here instigates more work on more data. Further analysis using datasets that cover the full distribution of R&D active firms, beyond the Scoreboard firms, is actively encouraged.

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