

Are European firms falling behind in the global corporate research race?

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Executive summary

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TECHNOLOGICAL PROGRESS, SUCH as robotics and artificial intelligence, is often blamed for the loss of jobs and rising income inequality. It is also linked to increasing inequality in the corporate landscape as superstar firms forge ahead in winner-takes-most markets.

OUR ANALYSIS SHOWS that in most sectors there is a high degree of concentration among a few top companies in research and development spending. R&D spending is much more concentrated than sales and employment. In 2015, for example, the top 10 percent biggest spenders on R&D, accounted for 71 percent of the R&D spending of the 2500 companies that spend most on R&D. This concentration is most obvious in the high-tech biopharma and digital sectors, though it is also true for other sectors, such as the vehicles sector. US companies are overrepresented among these R&D superstars, especially in digital sectors where they take up half of the top slots.

OVER THE LAST decade, there has been little evidence for increasing concentration in the global R&D landscape. On the contrary, a slight decline is discernible. Slight increasing concentration can only be detected in digital sectors, with in particular the top 1 percent of R&D spending firms in these sectors forging ahead.

ALTHOUGH THE OVERALL concentration of R&D spending among a few leading firms might not be changing much over time, R&D leaders are slowly losing their positions to new R&D-leading firms. Digital Services is the most turbulent high-tech sector. The US and China are more likely to produce new R&D leaders that take over some of the top positions from incumbent R&D leaders. This poses difficult questions for Europe, which is at risk of losing out in terms of R&D leadership in more technologically advanced sectors.

1 Concentration of the corporate landscape

There is some evidence that markets are becoming more winner-takes-all, with the best performers surging ahead and taking a greater share of the rewards. In the United States, sales are becoming more concentrated among fewer firms (Autor *et al*, 2016). Employment is also becoming more concentrated, though more slowly. The pattern suggests that firms might attain large market shares with relatively small workforces, a phenomenon that is most marked among digital companies. Increasing corporate concentration has a broader social relevance because it might fuel rising income inequality within societies. The best-performing firms pay higher wages to fewer employees and so sales concentration could be driving greater wage inequality. According to Bloom (2017) wage gaps *between* companies rather than within companies are the real drivers of income inequality.

In this respect, the European Union is different to the US. Unlike in the US, recent evidence shows the trend in the EU is not towards greater sales concentration (Dotting *et al*, 2017). If anything, it is declining, which might correlate with the deregulation of product markets and more vigorous anti-trust enforcement in the EU.

In the US, greater concentration is particularly notable in the high-tech sectors where technological change is more rapid (Autor *et al*, 2016), raising the question of whether technology is the lever that superstar firms use to win market share. To answer this question, we need to look at the corporate research landscape: how concentrated is corporate R&D? Is there a trend of increasing concentration among a few corporate R&D spenders? If there is greater concentration of corporate R&D, to what extent will the impact on the economy be determined by who the R&D superstars are? Are they incumbent market leaders exploiting and protecting their market power, incumbent R&D superstars exploiting their superior innovative capacities and experience, or new superstar firms introducing radically new innovations? In the first case, the speed of technology change might be hampered, in the second case, disruptive technologies might be hampered.

‘Greater concentration in high-tech sectors where technological change is more rapid raises the question of whether technology is the lever superstar firms use to win market share.’

2 How we assess concentration of corporate R&D and what we expect to see

We look at trends in the concentration of R&D worldwide. We expect to see significant – and increasing – concentration of corporate R&D. The speed, depth and breadth of technological change and the need to access networks and partners are all factors that would predict greater concentration of corporate R&D over time. Furthermore, we can expect the most likely winners to be the incumbent R&D investors, because they are the companies that already have stocks of knowledge, networks of customers and partners, the capital to invest in R&D and the capacity to deliver innovations more efficiently to customers.

However, as technological innovations are diffused, other firms can take advantage of them, resulting in them catching up with the incumbent leaders and chipping away at incumbent R&D leadership positions. If the diffusion process happens quickly enough, differences between leaders and laggards can shrink rapidly, reducing the concentration of corporate R&D. In addition, incumbents’ R&D competences, networks and technology leadership can be quickly overturned when new disruptive technologies emerge, such as the biotech revolution in pharma, the digital revolution in information and communication technologies, and the electric motor and autonomous driving revolution in car manufacturing. Such disruption of incumbent positions creates space for new R&D leading

firms, riding on the latest technological waves, displacing incumbents¹.

To measure the trends in concentration of corporate R&D, we use the EU Industrial R&D Investment Scoreboard² of the world's largest R&D spenders. By tracing the corporate R&D leaders in the EU Industrial R&D Investment Scoreboard over the period 2005 to 2015, we can assess whether the top R&D spenders are incumbents or new leading R&D firms. We can also see which countries and regions produce the leading R&D firms, comparing Europe with the US and Asia, including China³.

To the best of our knowledge, there are virtually no studies that look at the concentration of corporate R&D globally. What is well documented is the high concentration of R&D expenditure in a few firms within individual countries. For instance, the OECD (2017) shows that the top 50 R&D spenders represent as much as 70 percent of all corporate R&D in small countries like Denmark and Belgium. In large countries like Germany, France and Japan, and even in the US, the top 50 account for more than half or close to half of all corporate R&D. Evidence on the *trends* in concentration of the R&D landscape within countries is only available for Germany. Rammer and Schubert (2017) and Hünermund and Rammer (2017) find that innovation has become more concentrated over time in Germany. At the same time, they find that the group of firms with the largest R&D budgets in Germany is highly stable.

It is important to note that the EU Industrial R&D Investment Scoreboard only covers the largest R&D spenders worldwide, which means that we will only be characterising the R&D distribution among the biggest spenders, thus underestimating the overall inequality of corporate R&D. But these largest spenders in the Scoreboard are responsible for more than 80 percent of total corporate R&D⁴.

3 A very concentrated global corporate R&D landscape

In 2015, the most recent year covered in the 2016-17 edition of the R&D Investment Scoreboard, the distribution of Scoreboard firms' R&D expenditures was highly skewed (Table 1). The top 10 percent biggest of spenders (ie the top 250 Scoreboard firms) accounted for 71 percent of all Scoreboard R&D spending. The top 1 percent (ie the top 25) accounted for more than a quarter. Sales and employment of Scoreboard firms are also highly concentrated, though to a lesser extent than their R&D expenditures.

US companies took up the greatest share of the 2500 Scoreboard spots in 2015 (Figure 1), and the greatest share of top 10 percent spots. The US weight in the top 10 percent is even greater than its overall weight among all 2500 Scoreboard firms.

With 664 firms, Europe came second in the overall 2015 Scoreboard. With 75 places, Europe also has a higher share of the top decile of R&D spenders than its overall share of the Scoreboard. In 2015, there were 2.5 times more Chinese companies than German companies in the Scoreboard, but Chinese scoreboard firms were still less likely to be among the top

1 As Schumpeter predicted in his Mark I model, in *The theory of economic development (Theorie der wirtschaftlichen Entwicklung, 1911)*. In this model, "the doing of new things or the doing of things that are already being done in a new way" comes from the entrepreneurs, or wild spirits. By contrast, in *Capitalism, socialism and democracy* (1942), Schumpeter's Mark II model identified the large corporation as the driver of innovation, arguably predicting a greater concentration of corporate R&D.

2 Published annually by the European Commission, <http://iri.jrc.ec.europa.eu/scoreboard.html>.

3 Scoreboard firms are allocated to countries/regions on the basis of the location of their headquarters.

4 In this Policy Contribution we report the major results of our analysis. More detailed results can be found in Veugelers and Kalcik (2018).

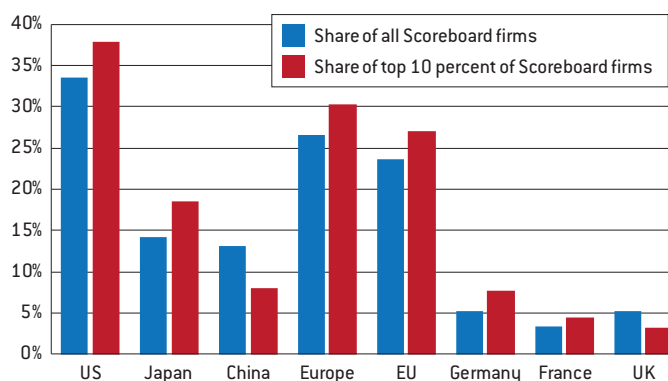
decile of R&D spenders. Nevertheless, Chinese firms occupied in 2015 as many top decile spots in the Scoreboard as German firms (20 places each).

Table 1: Concentration within the top 2500 global R&D spenders, 2015

	Share of top 1%	Share of top 10%
R&D	27%	71%
Sales	22%	66%
Employment	18%	61%

Source: Bruegel on the basis of EU Industrial R&D Investment Scoreboard.

Figure 1: Country/region shares of Scoreboard firms (2015)



Source: Bruegel on the basis of EU Industrial R&D Investment Scoreboard.

The three largest sectors in the scoreboard are ICT/digital (broadly defined as electronics, hardware, services and software), biopharma and vehicles. Digital and biopharma are high-tech sectors in the OECD classification while vehicles is a medium-tech sector⁵.

Table 2: Concentration of corporate R&D in selected sectors (2015)

		All	Biopharma	All ICT/digital	ICT/digital services	Vehicles
Top 1%	R&D share	27%	25%	31%	34%	20%
Top 10%	R&D share	71%	83%	70%	71%	73%
	Empl. share	42%	64%	51%	37%	48%
	Sales share	50%	75%	60%	51%	64%

Source: Bruegel on the basis of EU Industrial R&D Investment Scoreboard.

Table 2 shows that in biopharma, R&D spending is most concentrated. The top decile of the R&D distribution accounts for 83 percent of total scoreboard R&D spending in this sector. Biopharma sales and employment are also more concentrated than sales and employment in other sectors, illustrating the importance of R&D for competitiveness in this sector. Four companies (Novartis, Roche, Johnson & Johnson and Pfizer) account for 22 percent of all sectoral R&D spending. The US and Europe dominate in this sector: of the top decile of biopharma R&D spenders, 43 percent are US-headquartered, and 40 percent are headquartered in

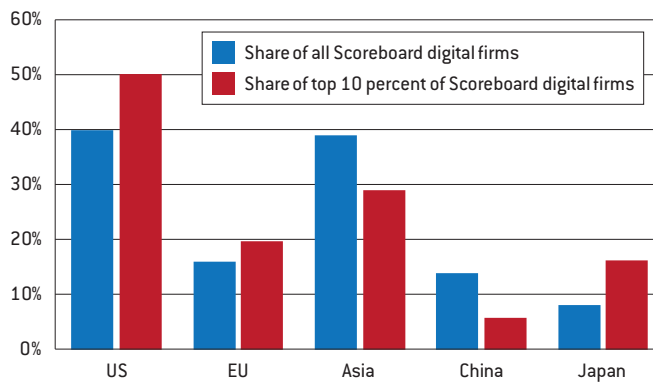
5 There are 852 scoreboard firms active in digital (37 percent of all scoreboard R&D), of which 297 firms are in digital services and software, representing 12 percent of all scoreboard R&D. Biopharma accounts for 369 scoreboard firms (19 percent). Vehicles accounts for 15.5 percent of all Scoreboard R&D. Other sectors are too small to look at individually, with too few scoreboard firms for a meaningful sectoral analysis.

Europe including Switzerland.

The ICT/digital sectors are often portrayed as being ‘winners take all’, especially the services/software sectors. Indeed, the distribution of R&D spending among ICT/digital firms is more concentrated than average. The top 10 percent of R&D spending firms represent 70 percent of total sector spending (Table 2). Six companies (Samsung, Intel, Alphabet, Microsoft, Huawei and Apple) account for 24 percent.

Global digital R&D spending is dominated by US and Asia-based companies, each taking 40 percent of the total of 852 slots occupied by digital sector companies in the 2015 Scoreboard (Figure 2). At the top end, US companies are even more dominant, with half of all the top decile digital scoreboard slots. EU companies take only 16 percent of the digital scoreboard slots, though the EU is relatively well represented at the top end. Asia, by contrast, is less well represented at the top end: Asian companies occupy only 28 percent of the top 10 percent of slots. Chinese companies occupy just 6 percent of these top-end slots.

Figure 2: Digital scoreboard firms by country/region (2015)



Source: Bruegel on the basis of EU Industrial R&D Investment Scoreboard.

The top 10 percent of digital R&D spenders have a greater share of sales than average (Table 2), reflecting the importance of R&D power in digital markets (but to a lesser extent than in biopharma). The top 10 percent digital R&D spenders have a much lower share of employment than biopharma, reflecting the leaner employment profile of digital firms. This is especially the case for digital services.

The digital sector is also distinctive in that, at the top end, R&D spending is much more concentrated among only a handful of companies. This is most evident for digital services/software, with the top 1 percent of firms accounting for 34 percent of sector R&D.

Vehicles is the most prominent sector for corporate R&D in the EU, accounting for about one quarter of total EU Scoreboard R&D. EU companies take 22 percent of this sector’s places in the Scoreboard, and account for 46 percent of global vehicles R&D. Of the 15 top companies for R&D in this sector, eight are European. Asian firms are the most numerous in the Scoreboard in this sector (61 percent). But Asian firms take only five of the 15 top spots, four of which are held by Japanese firms. The US accounts for only 15 percent of the Scoreboard firms and R&D in this sector, and only two of the top fifteen positions.

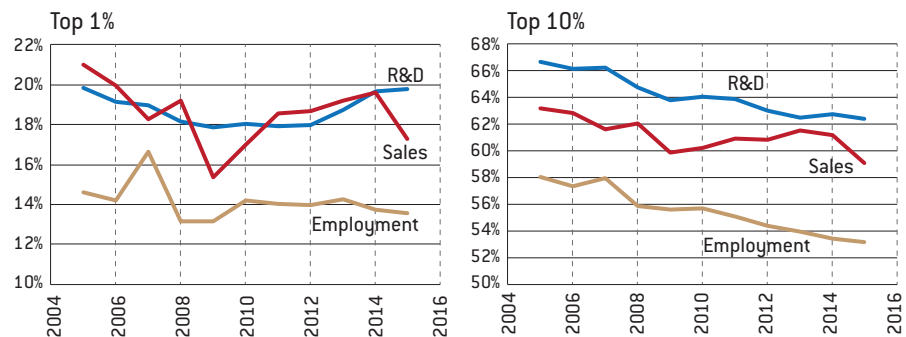
4 Trends in concentration of corporate R&D

The Scoreboard data allows changes in the concentration of corporate R&D to be tracked over time, from 2005 to 2015. As the number of global firms covered by the Scoreboard has changed over time, we work with the same number of firms for each year⁶.

Contrary to expectations, our evidence does not show a trend of rising R&D concentration, at least not on average. The concentration of R&D expenditure, as measured by the share of total R&D spending accounted for by the top 10 percent of spenders (Figure 3, right panel), has declined over time, although only slowly and concentration remains high. A similar trend is seen in terms of concentration of employment by Scoreboard firms. However, the concentration of the sales of Scoreboard firms, while declining before the crisis, increased post-crisis, dipping again in 2015.

While the top 10 percent's share of overall R&D expenditures has declined, the share taken by the top 1 percent has since 2012 started to increase (Figure 3, left panel).

Figure 3: Trends in shares of Scoreboard employment, sales and R&D by, top 1 percent and top 10 percent of firms



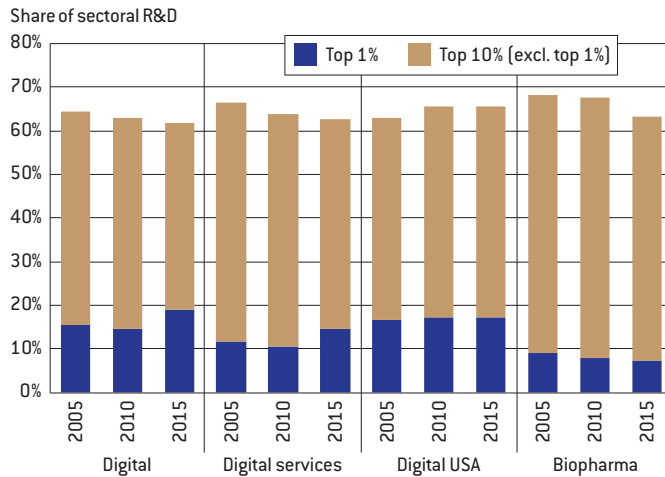
Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data.

Figure 4 zooms in on the trends in the two major sectors in the Scoreboard: biopharma and digital. For biopharma, the time-comparable sample contains 213 Scoreboard firms. For this sample, the R&D share of the top 10 percent (as well as of the top 1 percent), has gone down, particularly more recently, but it is still considerable. For the digital sector, the time comparable sample contains 475 Scoreboard firms. For this set, R&D concentration, measured by the share accounted for by the top decile of R&D spending firms, declined only slightly. By contrast, the share of the top 1 percent of digital firms went up from 15 percent to 19 percent. This increasing share for the top 1 percent of R&D spenders has been realised without increasing shares of sales or employment (Veugelers and Kalcik, 2018) and reflects an increasing focus on R&D on the part of the uppermost level of digital companies. This recent increasing concentration in the top 1 percent is most evident for the US and in digital services.

Figure 5 shows how the share of R&D spending of Chinese firms has grown. While only one top 10 percent firm in 2005 was Chinese (PetroChina), by 2015, 12 were. All other countries/regions lost share at the top. Germany suffered relatively the most, with German firms taking 15 top 10 percent slots in 2005, declining to nine in 2015.

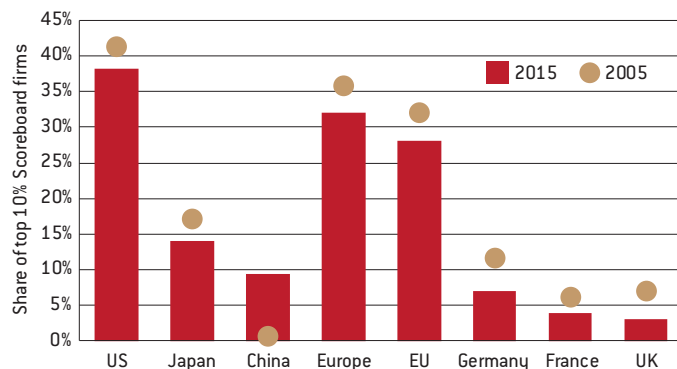
⁶ The 2015 Scoreboard included 1337 firms that could be tracked over time. This subsample accounts for 94 percent of total 2015 Scoreboard R&D expenditure. By focusing on this time-comparable sample, we are excluding smaller firms included in the Scoreboard, resulting in lower concentration compared to the full sample in every year (except for 2005).

Figure 4: Trends in concentration of R&D expenditures, by sector



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data.

Figure 5: Trends in shares of regions/countries in the top 10 percent Scoreboard firms



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data. Note: Trends are calculated using the time comparable data set.

5 New versus incumbent firms at the top of the corporate R&D landscape

In a highly concentrated corporate R&D landscape, it is important to know who occupies the top R&D rankings. Are the corporate R&D leaders incumbent R&D leaders in their sectors, or are they new R&D-leading firms?

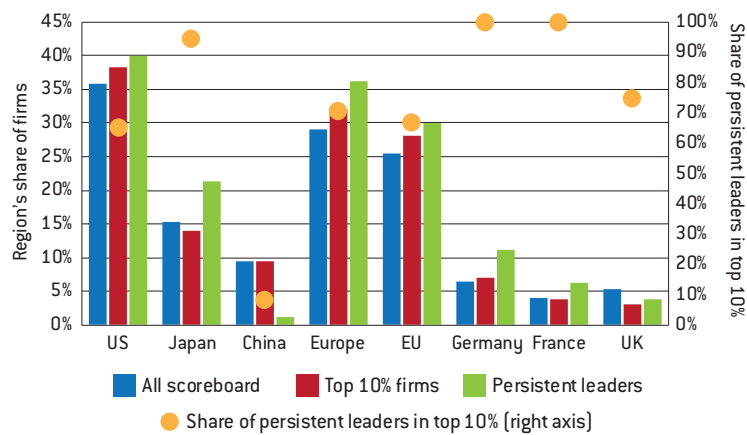
In order to find out, we looked at which of the R&D-leading firms in 2015 were already R&D-leading firms previously. Eighty-three Scoreboard firms were persistent R&D leaders (ie firms that were among the top 10 percent of R&D spenders in their sector almost the entire time from 2005 till 2015⁷). These persistent R&D leaders make up about 6 percent of the sample of companies in any given year. Among the persistent leaders, the age distribution is highly skewed towards older firms, with 88 percent founded before 1975. Alphabet (parent

⁷ We allowed for one lapse in leadership during the time period.

company of Google) is the largest persistent young R&D leader, having been established in 1998⁸. It is a prominent example, but is exceptional in the Scoreboard.

The largest number of persistent R&D leaders (39 percent) comes from the US (Figure 6). US dominance is even more notable among persistent R&D leaders than in the Scoreboard in general and among top 10 percent firms. EU and Japanese companies also make up a larger share of persistent R&D leaders than of companies in general in the Scoreboard and of top 10 percent leading companies. Japan, Germany and France are the most overrepresented as hosts to persistent leaders, with the highest shares of top 10 percent firms that are persistent leaders (Figure 6, right axis). China still has to make its mark in this group of persistent R&D leaders.

Figure 6: Persistent leaders among Scoreboard firms, shares of countries/regions (2015)



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data.

Only nine firms in the time-comparable Scoreboard sample are new R&D leaders, ie companies that have entered the Scoreboard as one of the top 10 percent of R&D spenders in their sector and have stayed among this leading group up to 2015⁹.

The overwhelming majority of Scoreboard firms in the time-comparable sample are persistent R&D non-leaders: 85 percent never belonged to the top 10 percent of R&D spenders in their sector in any year from 2005 to 2015. The remaining companies (8.8 percent) are switchers that have moved in and out of the top group during the period 2005-15.

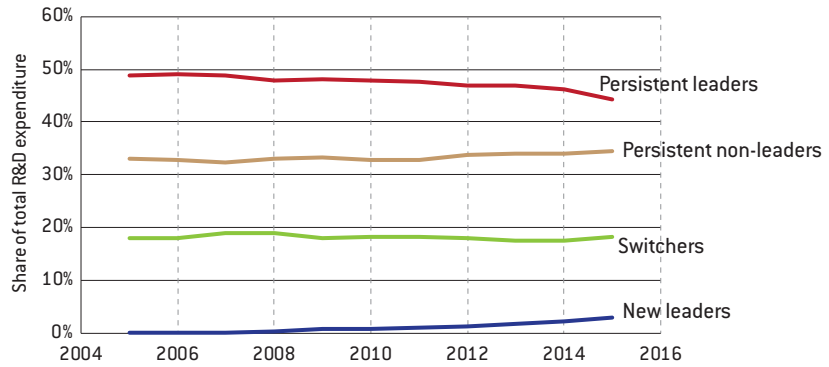
Figure 7 provides strong evidence that large incumbent firms retain their advantages as persistent R&D leaders. Such incumbents account for about half of overall Scoreboard R&D spending each year. In the time-comparable 2015 sample, they accounted for 47 percent of total R&D, representing only 6 percent of Scoreboard firms. At the top of the R&D distribution, persistent R&D leaders accounted for 78 percent of R&D spending by the top 10 percent in 2015.

However, the data does not provide support for the idea that the R&D incumbency advantage increases over time. The share of total R&D spending by persistent leaders has eroded over time, especially more recently, though only slightly. Persistent leaders are gradually losing their share mostly to new R&D leaders. This rise of new R&D leaders is however only recent and still very modest. In 2015, new leaders accounted for 4 percent of all R&D, and 6 percent of spending by the top 10 percent of R&D spenders.

8 Alphabet was incorporated in 2015, but represents a corporate restructuring of Google, which was founded in 1998.

9 The largest of these new R&D leaders are Huawei and Facebook. Among the nine new R&D leaders, four are Chinese, illustrating the rise of China in corporate R&D: after Huawei come CRRC China, China Railway Construction and China State Construction Engineering.

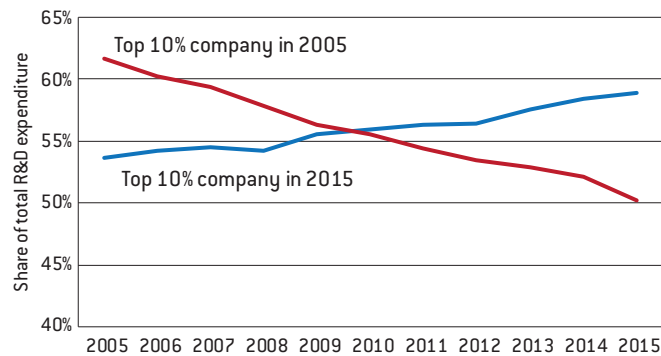
Figure 7: Trends in share of total R&D expenditure, company types



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data.

Figure 8 further illustrates the persistence in R&D leadership. The firms that were among the top 10 percent of R&D spenders in 2015, responsible for 58 percent of overall R&D expenditures in 2015, were already responsible for 52 percent of overall spending ten years before in 2005. The top 10 percent of R&D spenders in 2005, responsible for 61 percent of overall R&D spending in that year, still accounted for 47 percent of all Scoreboard R&D in 2015.

Figure 8: R&D shares of early leaders and recent leaders over time



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data.

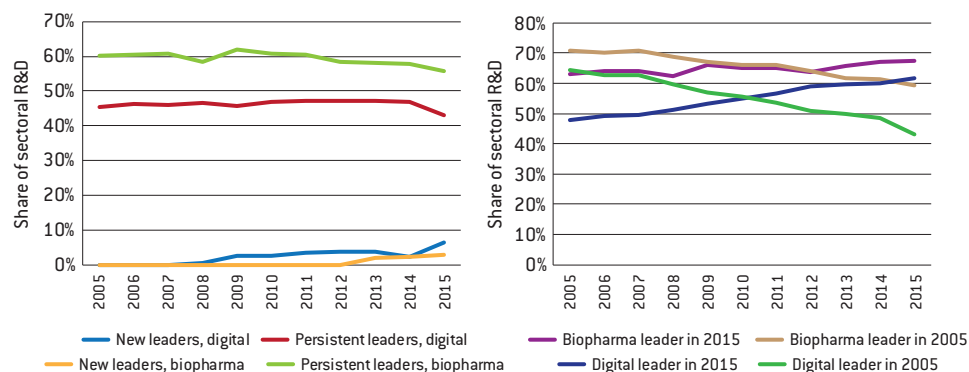
All the evidence suggests that R&D leadership is persistent. There is some turbulence among the R&D-leading firms, but this is relatively modest: breaking into top R&D positions is not easy for non-incumbents.

In biopharma, there are 14 persistent R&D leaders (Novartis, Roche, Johnson & Johnson, Pfizer, Merck, Bristol-Myers Squibb, Sanofi, AstraZeneca, Bayer, GSK, Eli Lilly, Amgen, Boehringer and Takeda). Despite the wave of new firms in the sector, brought in by the biotech revolution which started around 1975, Amgen is the only ‘young’ firm in this group of persistent leaders. All other persistent leaders were established before 1975. This small group of persistent leaders accounted for about 60 percent of sector R&D during the last decade. The right panel of Figure 9 shows that biopharma companies that were R&D leaders in 2005 have seen their R&D shares reduced somewhat since 2005, but still commanded high shares in 2015 (from 71 percent in 2005 to 63 percent in 2015). Similarly, the R&D leaders in 2015 already held a substantial share in 2005 (59 percent).

The top 10 percent of R&D-spending firms in biopharma are more or less equally divided between the Europe and the US, and have been since 2005. The first 10 places in the 2015 ranking were taken by old, incumbent firms from Europe and the US. Of the top 10 percent of R&D spenders in this sector, about one quarter are firms established after 1975 as part of the biotech wave. These ‘young’ firms accounted for 17.5 percent of R&D spending by the top decile of R&D spenders in the sector in 2015.

The largest young biotech R&D spenders are all from the US: AbbVie (ranked 11th in 2015)¹⁰, Amgen (13), Celgene (14) and Gilead Sciences (16).

Figure 9: Incumbency in R&D leadership, biopharma and digital



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data. Note: numbers are calculated from the time-comparable subsample, which has 202 biopharma firms and 466 digital firms.

Digital sectors are typically expected to be more turbulent. The speed of technological change in these sectors is thought to empower new players to contest the positions of established players. The Scoreboard data however does not fully confirm this, certainly not at the top end. Incumbency is also important for R&D in digital sectors, though to a lesser extent than in biopharma.

In the digital sector, there are 25 persistent R&D leaders. These include Samsung, Intel, Alphabet, Microsoft, Cisco, Oracle, Qualcomm, Siemens and IBM. Compared to biopharma, these persistent leaders command a lower share of their sector’s R&D spending (Figure 9 left panel), but their share is still substantial and has not declined substantially over time. However, the age distribution of these persistent leaders is different from biopharma. While persistent leaders in biopharma with the exception of Amgen were ‘old’, in digital, 28 percent of the persistent leaders were created after 1975¹¹. While in biopharma the new (biotech) firms have so far not established themselves substantially at the top of the R&D distribution, new digital Scoreboard firms have. The largest young persistent leader is Alphabet, which was created (as Google) in 1998, and was in 2015 ranked as the third largest R&D spender in digital. Other examples of young persistent leaders are Microsoft, Cisco, Oracle and Qualcomm. There are also young new leaders. Together, new leaders account for 6 percent of sector R&D in 2015, a small share but nevertheless double the share of their peers in biopharma (Figure 9, left panel)¹².

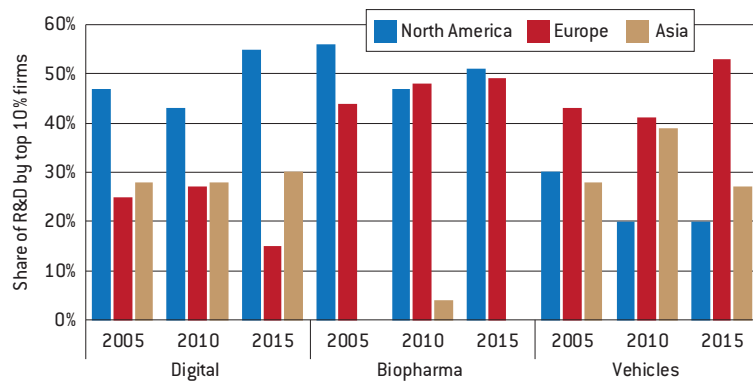
Another illustration that R&D leadership is more challenging in digital sectors is the declining share of R&D spending that the top 10 percent of companies in 2005 command over time (Figure 9, right panel). This share has substantially eroded from 64 percent in 2005 to 48 percent in 2015. The share held by the 2015 top 10 percent of R&D spending firms, responsible for 64 percent of

10 Abbvie operates since 2013 as a spin off from Abbott Laboratories. Although Abbvie can be considered a young firm, Abbott Laboratories was established in 1888.
 11 In general, the digital sector has a younger age structure, with 40 percent of its Scoreboard companies being old (created before 1975) and 28 percent created after 1990.
 12 The most prominent examples of young new leaders are Huawei, Apple and Facebook. They took in 2015 respectively 5th, 6th and 12th positions. The first four positions are all taken by persistent leaders.

sector R&D in 2015, was only 43 percent in 2005, illustrating their more recent prominence as R&D leaders.

Figure 10 looks at how the share of Europe at the top R&D distribution has changed over time in the three most important sectors: digital, biopharma and vehicles. In the digital sectors (Figure 10, left panel), the new and young R&D leaders all come from the US and China and have been able to displace some of the incumbents. Consequently, European firms have lost out substantially at the top in digital sectors, having been displaced by US and Asian (primarily Chinese) new leading firms. This is different in biopharma. In this sector (Figure 10, middle panel) the top 10 percent of R&D spenders continue to be US and European firms. Even though most of the new leading firms are from the US, they have not made significant inroads into the top 10 percent and the regional balance has therefore not changed much; it has perhaps even evolved to be more favourable to European firms.

Figure 10: Share of country/region in top 10 percent R&D spending, by sector



Source: Bruegel on the basis of EC-JRC-IPTS R&D scoreboard data. Note: numbers are calculated from the time-comparable subsample, which has 202 biopharma firms, 466 digital firms and 99 vehicles firms.

For the vehicles sectors, there are only 99 firms in the time-comparable sample, which makes the trend and incumbency analysis for this sector less robust. Nevertheless, some specific characteristics can be noted. In this sector, European firms are dominant at the top of the R&D distribution and increasingly so, with US firms retrenching. The incumbency effect is substantial and stable over time. The sector has eight persistent R&D leaders (VW, Toyota, GM, Daimler, Ford, Honda, Bosch and BMW) that accounted for half of sector R&D in every year covered by the Scoreboard. Furthermore, all of these persistent leaders are ‘old’ in a sector that in general has few new firms in the Scoreboard. There are however some recent signs of turbulence. Tesla Motors entered the Scoreboard in 2010. It is still not among the top 10 percent of sector R&D spenders, but is fast building its share, being ranked 32 in the sector in 2015. Electric motors and autonomous driving could shake up this sector in the next decade.

6 Conclusions

Although it is often claimed that sectors for which R&D matters most for growth are becoming increasingly ‘winners take most’, the data we have analysed does not show increasing concentration of R&D spending over time. On the contrary, the trend has been one of slow decline in concentration, reminiscent of the diffusion of technological know-how leading to erosion of incumbent leading R&D positions. However, the trend is only modestly downward and seems to have stopped more recently. Since 2012, R&D spending has become more concentrated

among the top 1 percent of R&D spenders. The US is most strongly represented at the top, but together with Europe and Japan has been losing ground to China.

The data shows that persistent leaders take up most of the top rankings for R&D spending and account for the major share of sectoral R&D. Companies that were among the R&D leaders in the past are still responsible for a high share of their sector's R&D currently. The US is home to most of these persistent R&D leaders, particularly in ICT/digital sectors. But the EU is also relatively well represented as the home base for persistent R&D leaders, particularly in biopharma and vehicles.

Global biopharma R&D in particular is highly concentrated among a few persistent R&D leaders from the US and Europe. The biotech revolution in the 1970s saw the creation of new companies that are now part of the EU Industrial R&D Investment Scoreboard, but few of these companies have made it into or close to the top decile of sectoral R&D spenders. Those that have succeeded are all US based. Over time, concentration in this sector has lessened, but only slowly. The large incumbent R&D spenders in this sector, from both the US and Europe, seem to have been successful in addressing the biotech challenge.

In ICT/digital sectors, R&D concentration and persistence in R&D leadership are high. But compared to biopharma, there is more turbulence and churn in R&D leadership positions, with new R&D leaders emerging. In digital services in particular, new firms are taking over top 10 percent slots. But more recently, concentration of R&D spending in the top 1 percent of spenders has risen and turbulence at the top has cooled. As the new and young leading R&D firms in digital sectors are all from US and Asia (particularly China), Europe has lost out in terms of top R&D shares.

Further analysis is clearly needed to answer whether this concentration of R&D among few incumbent firms reflects the R&D advantages large incumbents have or reflects the barriers new firms face in growing into R&D superstars. The evidence of declining concentration is a positive sign, but continued dominance of the incumbents and the slow pace and unsteady momentum of the declining concentration trend require further monitoring and analysis to understand their implications for the overall performance of the corporate R&D system to deliver innovation-based growth to the world economy.

Nevertheless, some issues for policy can be highlighted at this stage. For innovation policy, it is important to recognise that overall corporate R&D performance depends on a handful of firms. Getting to know who these few leading R&D firms are and how their R&D position in their sector develops over time will matter crucially for the overall innovative performance of countries, regions and the world at large. Understanding the innovation efficiencies incumbent leaders and/or new leading firms might enjoy will matter for assessing the power of innovation to generate growth.

For competition policy, it is important to understand whether the highly concentrated R&D landscape and trends therein are associated with leading R&D firms enjoying innovative advantages, how contestable existing leading positions are, how R&D leaders can turn their R&D weight into market power and how that might impact long-term overall consumer welfare. It is important to know if leading firms use their dominant R&D positions to raise entry barriers against more efficient new innovators. This will involve a more vigorous anti-trust analysis and merger analysis, assessing dynamic efficiency advantages when incumbent R&D leaders are pursuing potential acquisitions. Perhaps most important in this respect are merger cases in which incumbent R&D leaders take over currently still small, but potentially new R&D leaders. These merger cases are currently typically too small to be on the radar for EU competition policy authorities. They should not be.

For EU policymakers in particular, this analysis contains a wake-up call. Although the EU seems to fare relatively well in hosting large incumbent R&D leaders, it seems to be less well placed to host entrepreneurial talents riding on new technology shifts to displace incumbents and take up new leading R&D positions. With the US, and more recently China, hosting most of the new R&D leaders, especially in digital sectors but also in other sectors, the weaker creative-destruction power of the EU corporate R&D system could contribute to a

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shifting regional R&D pattern to Europe's detriment. As technological progress continues to send shock waves through the global R&D landscape, the EU needs to beef up its capacity to activate its entrepreneurial spirits to generate the next generation of new leading firms. At the same time, it will also be important for the EU that its large incumbent R&D leaders respond rapidly to the challenges from new technology waves to leverage their cumulated advantages. The redirection of corporate R&D in the vehicles sector from the classic combustion engine to electric and digital technologies will be a critical test for the EU.

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