

# Trends at the frontier in Corporate R&D in the digital era

ARC 2018  
Brussels

*Reinilde Veugelers*

*Full Professor at KULeuven, Senior  
Fellow at Breugel*



# **Predicted rising inequality/concentration**

- **Rising income inequality and falling labour share**
- **Observed growing concentration in corporate sector of sales and employment (Autor et al (2016) for US (1982-2012), De Loecker and Eeckhoudt, 2017)**
- **Rising concentration especially perceived in digital sectors, cf Big Tech – Competition Policy Cases**

## Higher Concentration and (digital) technology innovation

### **Growing concentration in product markets and its positive or negative impact associated with innovation**

- 'Autor et al (2016) : More concentration in industries where productivity increases and technical change is higher
- Andrews, Criscuolo & Gal (OECD, 2017) show an increasing productivity gap between the global frontier and laggard firms
  - This productivity divergence remains after controlling for the ability of frontier firms to charge higher mark-ups

### **Positive or negative impact of higher concentration associated with innovation**

- ☺ Disruptive innovation by Superstar firms with higher productivity (Schumpeter Mark II)
- ☺ Incremental innovation by incumbents riding on stock of accumulated assets and experience (Schumpeter Mark I) Acemoglu & Hildenbrand (2017) argue that incumbent innovation advantage has increased over time

## **Our Research Questions**

**Does the global corporate R&D landscape become increasingly more concentrated in a few 'superstars'?**

- **Compared to concentration in sales/employment**
- **Who are these innovation superstars: incumbents or new leaders?...**
- **Where are they from? US, Europe, China**
- **Sector-specific trends: digital**

# What do we expect: (digital) technological change is predicted to lead to 'winner takes most' industries

- **Economies of scale & scope** in the R&D process, large sunk investments for building R&D capacity, the need to access networks and alliance partners are all characteristics that lead to R&D races increasing characterized as "winner take most" (Schumpeter Mark I: big firms for R&D)
- **Cumulativeness** of knowledge stocks, learning, where incumbent firms are the most likely winners (Schumpeter Mark I: incumbent firms for R&D).
- Sales Concentration in fewer firms more likely in industries characterized by competition through **sunk R&D investments** (Sutton (1992))

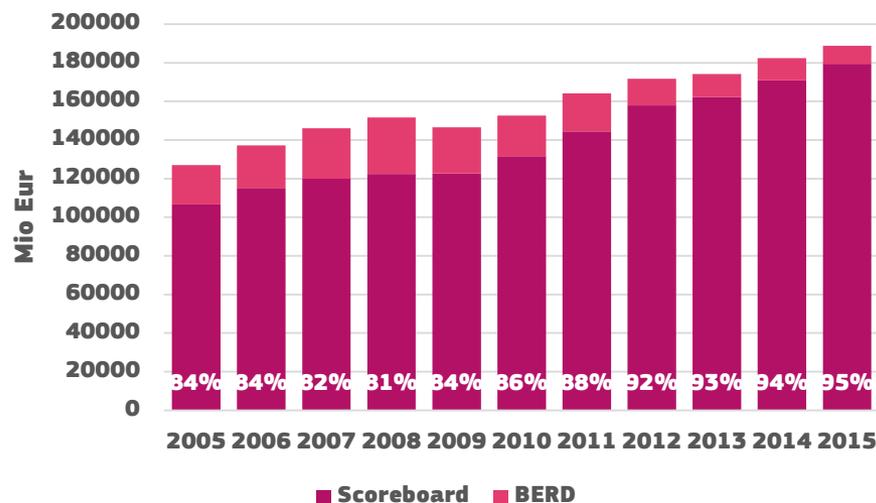
However

- The speed with which the latest technological innovations get **diffused** or spill over voluntarily or involuntarily will lead to catching up and dissipating of previous leadership positions.
- Incumbent technology leaderships can be quickly overturned by **radically new** technology avenues, creating room for new winners (Schumpeter Mark II). Even if the landscape will still be concentrated: turbulence in leadership

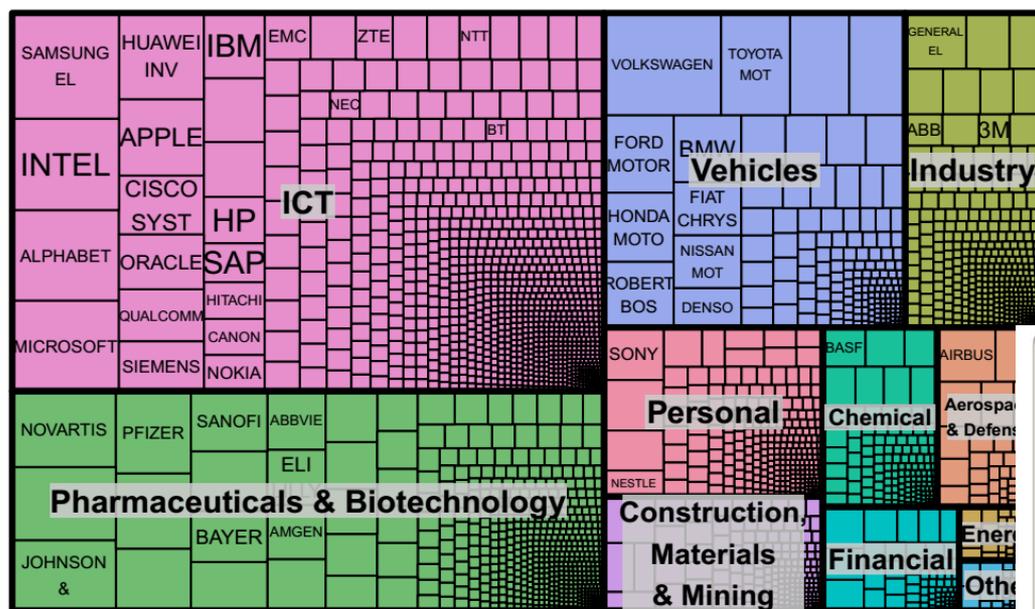
## Our sample: Scoreboard firms: largest R&D spending firms worldwide

- **The scoreboard firms cover >90% of EU BERD**
  - **On average >80% worldwide**
- **We will only be characterizing the R&D distribution in the top parts of the R&D size distribution**
- **Scoreboard sample size increases over time (we construct a constant time-comparable sample)**

Comparison Scoreboard total R&D vs. BERD, EU

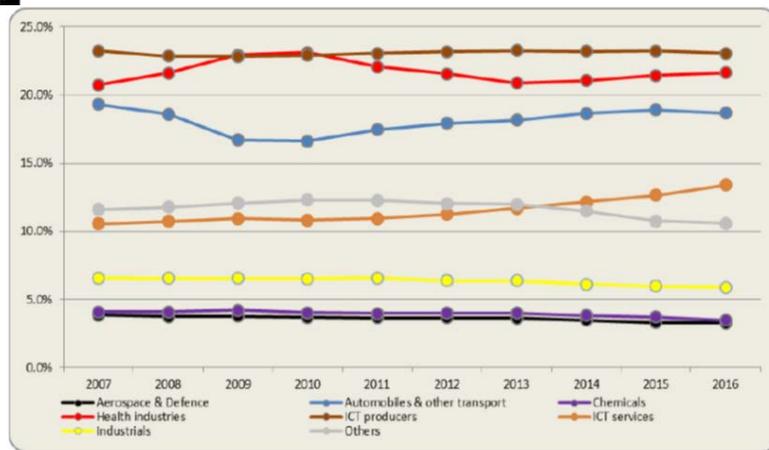


# The top corporate R&D investors and the growing importance of digital



Full list of 2500 JRC  
Scoreboard companies  
by size of R&D  
expenditure, 2015

## EC-JRC-IPTS Industrial R&D Scoreboard (Largest R&D spenders worldwide, 2005 – 2015)



Note: Calculated for a sample of 1697 companies for which data on R&D, Net Sales and Operating Profits are available for the entire period 2007-2016.

Source: The 2017 EU Industrial R&D Investment Scoreboard. European Commission, JRC/DG RTD.



# Corporate R&D concentrated in few firms

- 
- R&D expenditures by Scoreboard firms are **concentrated** in few firms
    - In 2015, the Top 10% of Scoreboard firms represent 71% of all Scoreboard R&D expenditures.
    - The Top 1% of R&D spenders account for 27% of all European R&D scoreboard expenditures.

- R&D expenditures by Scoreboard firms are highly unevenly distributed and concentrated in few firms
- The distribution of sales and employment of Scoreboard firms is also highly unequal and concentrated, but less so than their R&D expenditures.

	INEQUALITY		CONCENTRATION			
	Theil	Gini	Top1%	Share of Top10%	Top10	Top100
<b>R&amp;D</b>	1.47	0.76	27%	71%	14.6%	53.1%
<b>SALES</b>	1.32	0.77	22%	66%	12.4%	47.4%
<b>EMPL</b>	1.14	0.74	17%	62%	9.53%	44.4%

	Theil (total)	% of Theil due to "Between" TOP10-BOTTOM90	% of Theil due to "Within" TOP10&BOTTOM90	Within TOP10% Theil	Within BOTTOM90% Theil
<b>R&amp;D</b>	<b>1.47</b>	<b>71%</b>	<b>29%</b>	<b>0.43</b>	<b>0.38</b>
<b>Sales</b>	<b>1.32</b>	<b>39%</b>	<b>61%</b>	<b>0.56</b>	<b>1.08</b>
<b>Employment</b>	<b>1.14</b>	<b>30%</b>	<b>70%</b>	<b>0.44</b>	<b>1.06</b>

Source: Calculations on the basis of EC-JRC-IPTS R&D scoreboard data, latest version

## High inequality & concentration of R&D in Health & Digital (services)

2015	ALL SECTORS	Bio Pharma	Digital	Digital Services	Cars
N	2498	369	852	297	156
Theil R&D	1.47	1.78	1.50	1.60	1.42
Theil Sales	1.32	1.83	1.59	1.66	1.20
Theil Empl	1.14	1.65	1.30	1.56	0.86
Top1% R&D ShareR&D	27%	25%	31%	34%	20%
Top10%R&D Share R&D	71%	83%	70%	71%	73%
Top10%Sales Share Sales	66%	84%	74%	75%	66%
Top10%Empl Share Empl	62%	76%	67%	72%	52%

Source: Calculations on the basis of EC-JRC-IPTS R&D scoreboard data, latest version



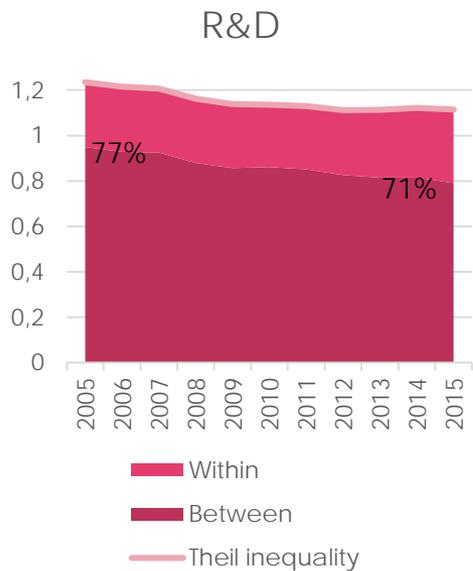
# Trends in Concentration

- 
- No increasing inequality in R&D, on the contrary, the trend is one of **slow decline**.
    - Nevertheless, this downward trend seems to have stopped since 2011.
    - Since 2012, the Top1% R&D spenders have forged ahead.

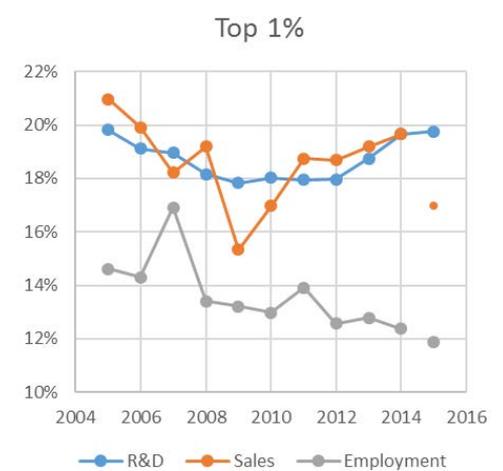
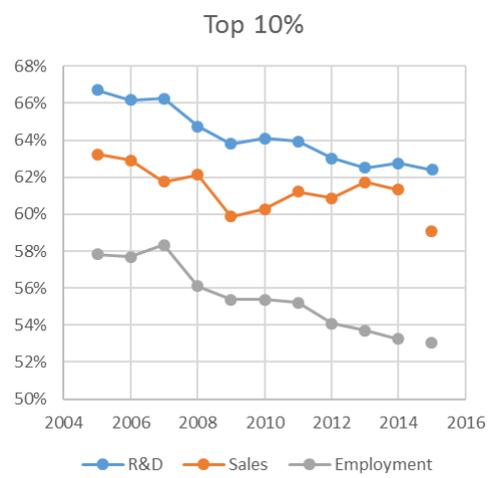


# High inequality/concentration slowly declining over time

Theil decomposition over Top 10% - Bottom 90%



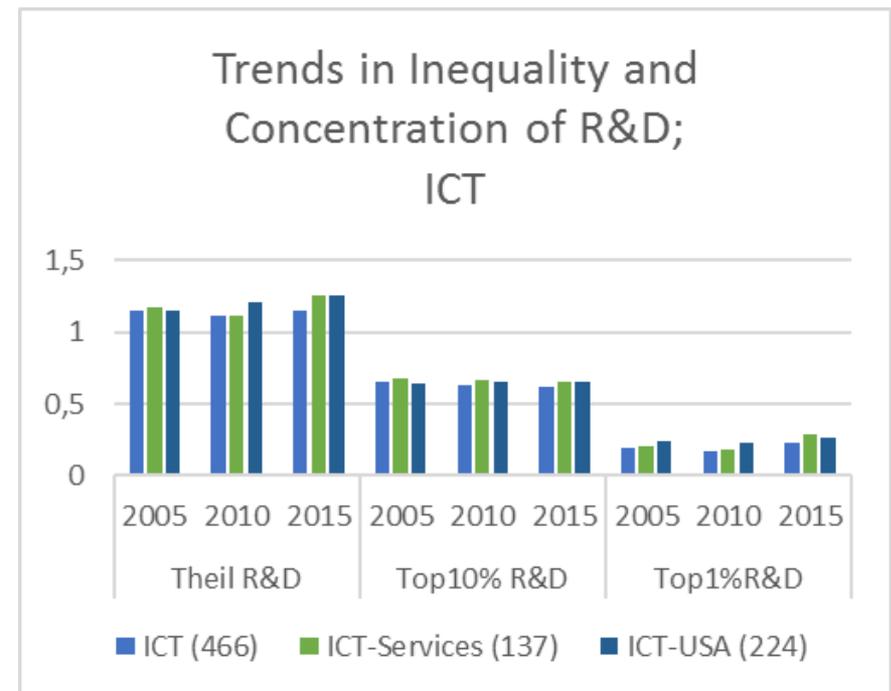
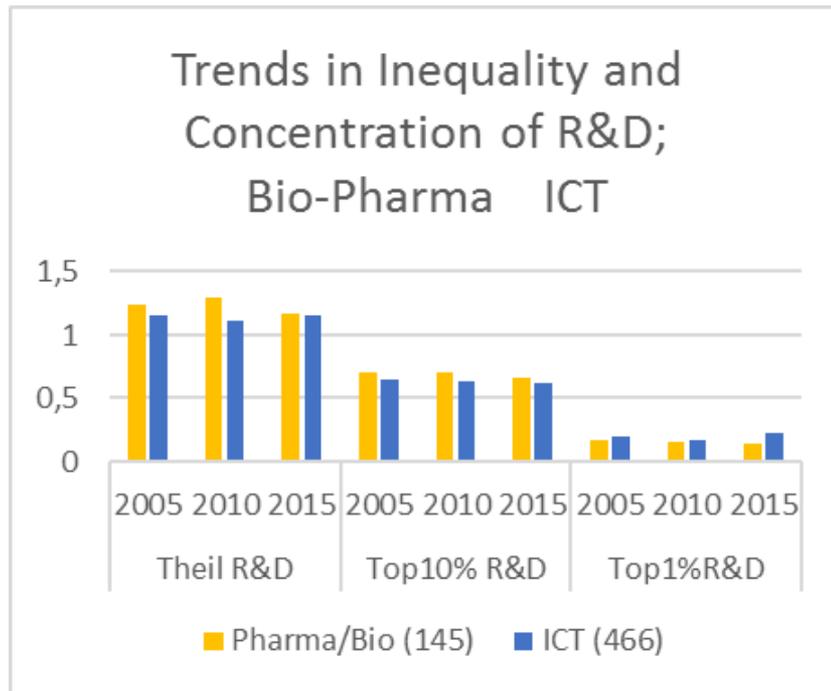
Share of Scoreboard Employment, Sales and R&D Expenditure of the Top 1% and Top 10% of Firms in terms of R&D Expenditure



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

*Global time-comparable sample N=1338*

## In ICT/Digital: decreasing concentration in Top 1% stopped more recently (US digital services)



Source: Bruegel calculations on the basis of EC-JRC-IPTS R&D scoreboard data, latest version



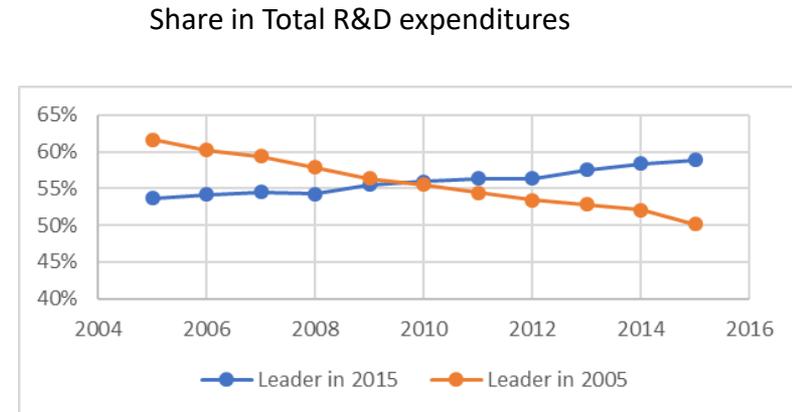
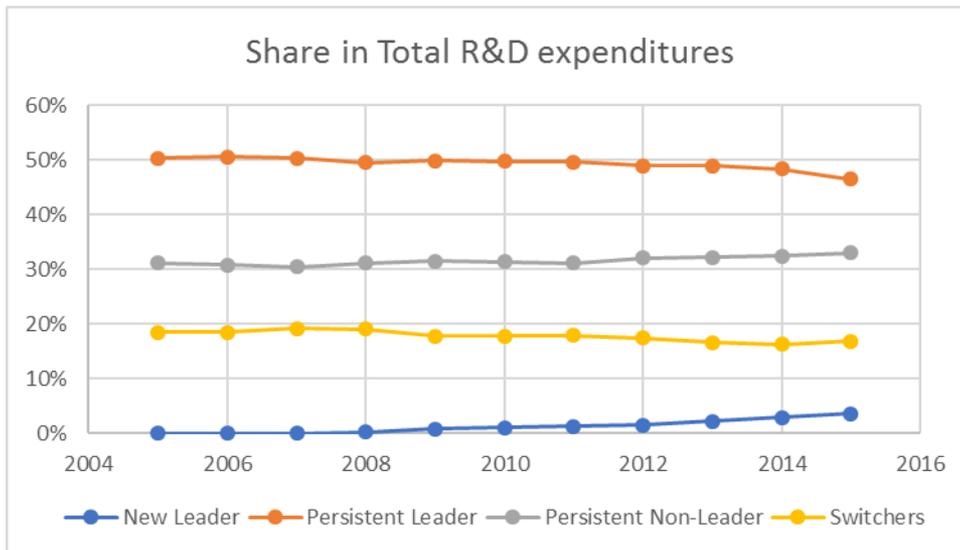
# Corporate R&D concentrated in few incumbents: Schumpeter Mark II

- 
- When looking at who inhabits the top, the data show a strong **incumbency** advantage
    - Those few firms that have been able to be a Top10% leading R&D firm within their sector throughout the period covered, represent more than half of the corporate R&D worldwide.
    - Incumbency is also demonstrated by the high share which leaders in 2005 can still command in 2015 and vice versa.

# Persistency in R&D leadership

Among the 1314 time traceable Scoreboard companies

- 6% (N=83) are persistent leaders (i.e. belonged to the Top 10% across almost the entire time from 2005 till 2015, ie 10 or 11 times).
- 83% are persistent non-leaders, ie never belonged to the Top10%.
- Only 9 firms are “new leaders”, ie companies entering the Scoreboard in the Top10% and stay among the group of leaders in all years until 2015 (one lapse allowed).
- The rest are switchers, ie moving in and out of top leadership position.



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

## Persistency of Leadership in Digital

Digital (N=466)	Share of sector R&D 2005	Share of sector R&D 2015
Persistent top 10% firms (5%)	46%	43%
Old firms (40%)	62%	40%
Youngest firms (28%)	9%	19%
Top 10% firms in 2005	64%	48%
Top 10% firms in 2015	43%	62%

Next to Alphabet, Microsoft, Cisco, Oracle and Qualcomm as young persistent leaders, there is also in 2015 **Huawei** in 5<sup>th</sup> position, Apple in 6<sup>th</sup>, Facebook in 12<sup>th</sup> position. None of these young new R&D leaders are EU.

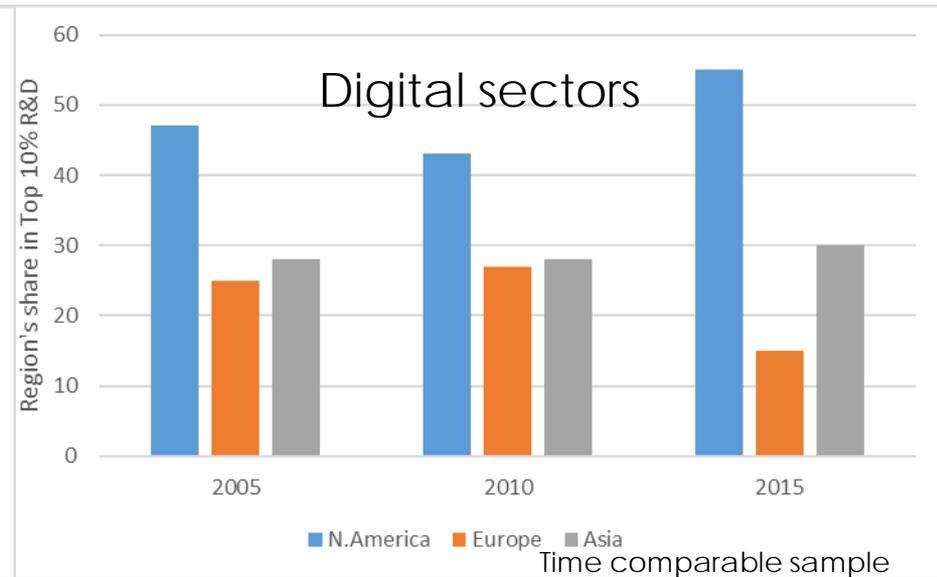
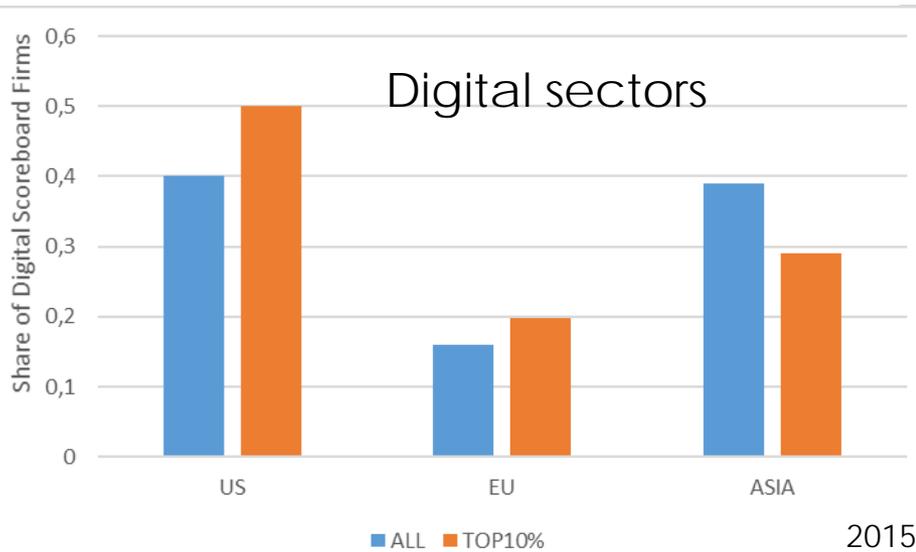
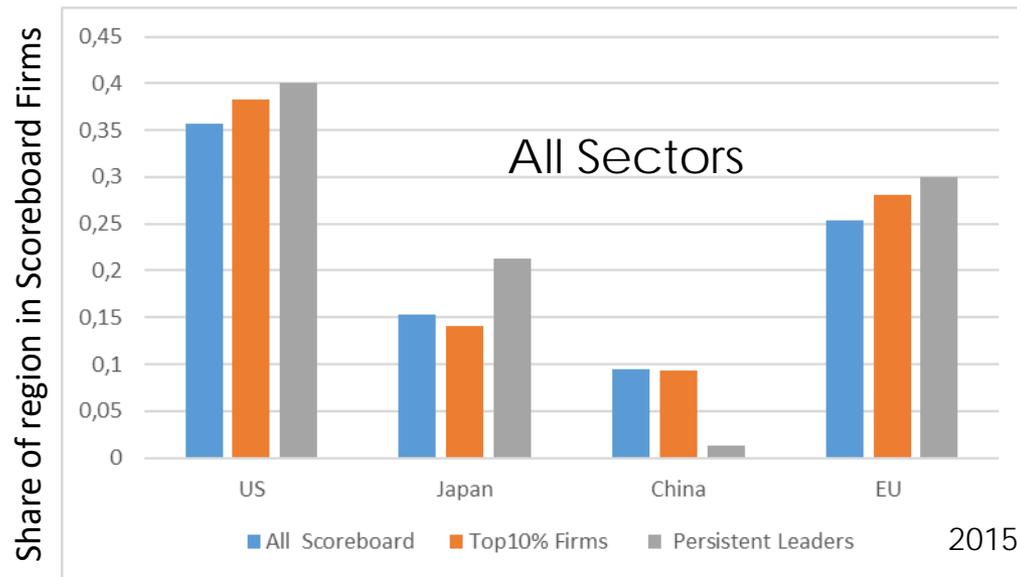
## Persistency of Leadership in BioPharma

Bio/Pharma (N=145)	Share of sector R&D 2005	Share of sector R&D 2015
Persistent top 10% firms (7%)	60%	54%
Old firms (48%)	85%	76%
Top 10% firms in 2005	68%	63%
Top 10% firms in 2015	57%	63%

There are 11 persistent R&D leaders (Novartis, Roche, J&J, Pfizer, Merck, BristolMyersSquibb, Sanofi, AstraZeneca, Bayer, GSK, EliLilly) in BioPharma. All of these persistent leaders are “old”.

A few young (biotech) firms made it close to this group of 10: Abbvie; Amgen, Celgene, and Gilead Sciences. All of these companies are US.

# EU's position at the (digital) corporate R&D frontier





# Corporate R&D concentration: beyond R&D

- *Also innovative output in the form of patents are highly concentrated.*
  - In 2014, the top 10% of corporate R&D investors accounted for 61% % of IP5 patent families (inventions patented in the five top IP offices) (68% of Scoreboard R&D)
  - The top 1% of corporate R&D investors accounted for 15% of IP5 patents families

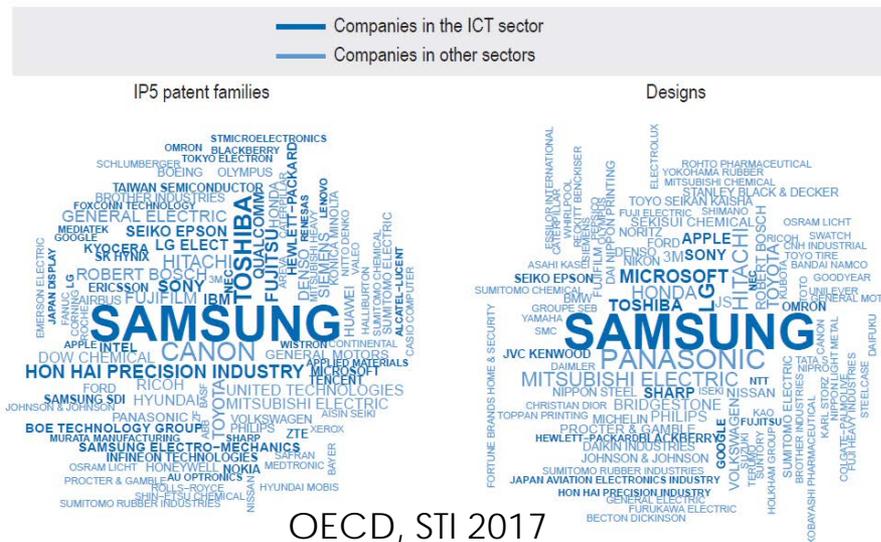
Source: OECD, STI 2017

# The digital patent landscape concentrated in few

The digital patent landscape is highly concentrated in top R&D investors

Top corporate R&D investors in the “Computers and electronics” industry are, by far, the most reliant on intellectual property (IP) rights and account for about one-third of total patent filings by top R&D investors.

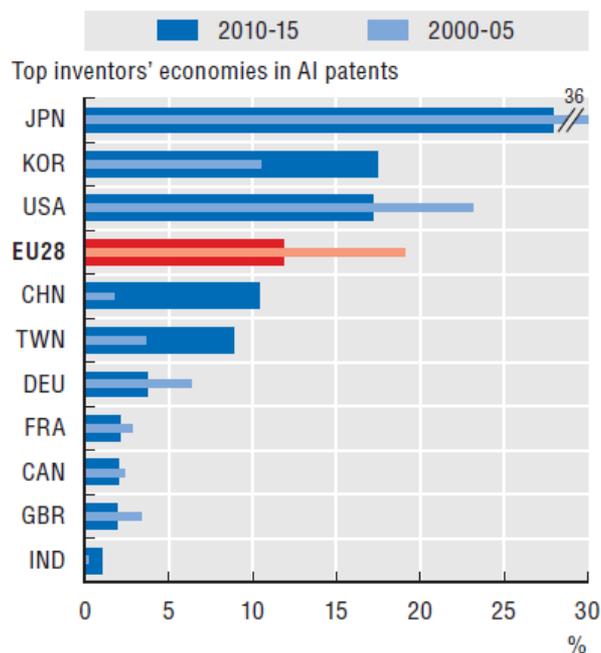
They account for the ownership of about **75% and 55% of global ICT-related patents and designs, respectively**



Top corporate R&D investors with IP (12-14)

# Artificial Intelligence: concentrated in few

The development of **AI-related technologies**, as measured by inventions patented in the five top IP offices (IP5), increased by 6% per year on average between 2010 and 2015, twice the average annual growth rate observed for patents in every domain.



The development of AI technologies is concentrated.

Top 2000 corporate R&D investors own 75% of the IP5 patent families related to artificial intelligence (AI).

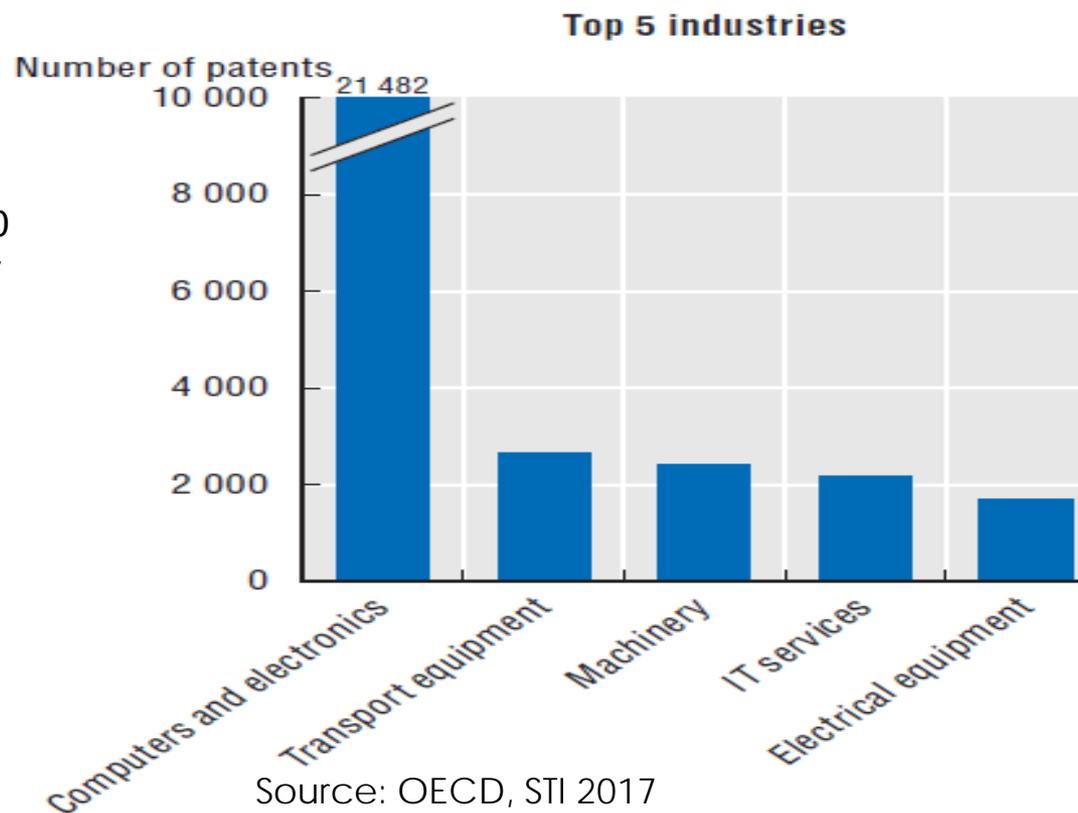
R&D corporations based in Japan, Korea, Chinese Taipei and China account for about 70% of all AI-related inventions belonging to the world's 2000 top corporate R&D investors and their affiliates, and US-based companies for 18%.

Source: OECD, STI 2017

# Artificial intelligence

“Computers and electronics”, accounts for 64% of the AI portfolio of top R&D players, but AI patents are also in other sectors: “general-purpose-technology”

Artificial intelligence patents by top 2 000 R&D companies, by sector, 2012-14



## Summing up highly concentrated corporate R&D landscape

- R&D expenditures by Scoreboard firms are concentrated in few firms
  - R&D concentration stronger than for Sales and Employment.
- The Scoreboard data do not signal increasing concentration in R&D, on the contrary, the trend is one of slow decline.
  - Nevertheless, this downward trend still leaves high levels of concentration and furthermore seems to have stopped since 2011.
- The Scoreboard data show a strong incumbency advantage:
  - Those few firms that have been able to be a Top10% leading R&D firms throughout the period covered, represent more than half of the corporate R&D worldwide. Incumbency is also demonstrated by the high share which leaders in 2005 can still command in 2015 and vice versa.
- The EU is relatively well represented as the home base for persistent R&D leaders, particularly in biopharma and vehicles.

# What do we find in digital sectors ?

- The distribution of R&D spending among **digital** Scoreboard firms is indeed highly concentrated, but less than in other high-tech (Pharma).
- The incumbency effect is smaller than in Pharma, there is more turbulence at the top.
- We see no trend of increasing concentration
- 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.

# Implications

The evidence of declining concentration is a positive sign, but its high incumbency characteristic, its slow downward pace and particularly its losing momentum more recently, requires further monitoring and analysis to understand its implications for overall corporate R&D and growth performance;

Especially in digital technologies

Especially in new digital technologies (AI)

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 shifting regional R&D pattern to Europe's detriment.

# Policy implications

- ▶ For **innovation policy**, it is important to recognise that overall corporate R&D performance depends on a handful of firms.
  - ▶ Understanding the innovation advantages and barriers 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 the impact of a highly concentrated R&D landscape
  - ▶ Are trends therein associated with leading R&D firms enjoying innovative advantages, how contestable are existing leading positions are, do leading firms use their dominant R&D positions to raise entry barriers against more efficient new innovators, how R&D leaders can turn their R&D weight into market power

Thanks for  
your  
attention !

- ▶ [Reinhilde.Veugelers@kuleuven.be](mailto:Reinhilde.Veugelers@kuleuven.be)
- ▶ <https://feb.kuleuven.be/reinhilde.veugelers>
  
- ▶ [Reinhilde.Veugelers@Bruegel.org](mailto:Reinhilde.Veugelers@Bruegel.org)
- ▶ [bruegel.org/author/reinhilde-veugelers/](https://bruegel.org/author/reinhilde-veugelers/)
  
- ▶ Veugelers, R., 2018, Are European firms falling behind in the global corporate research race? Bruegel Policy Contribution 18-06, Bruegel, Brussels.