The European Commission's science and knowledge service

Joint Research Centre

European Commission

The EU vs US corporate R&D intensity gap: investigating key sectors and firms

Pietro Moncada-Paternò-Castello and **Nicola Grassano**,
JRC B3 Territorial Development (Seville, Spain)

7th CONCORDI conference,
Seville 25-27 September 2019

European Commission

Background

- R&D driver of innovation and technological change, firm competitiveness, growth, spillovers & job creation effects

- Renewed policy importance of increasing the level of investments in R&D (and in other knowledge capital components) to exit the crisis – European Union priority on jobs, growth and investment.

- deficit in the EU's overall company R&D intensity - compared with that of competing economies

European Commission

Related literature

- Structural versus intrinsic effects in R&D intensity:
  - 'structural effects' (e.g. Guellec & Sachwald, 2008; Mathieu & van Pottelsberghe, 2010; Moncada-Paternò-Castello et al., 2010).
  - ' intrinsic effects ' (Pianta, 2005; Erken and van Es, 2007; Foster-McGregor et al., 2013)
  - 'mixture of both structural and intrinsic effects' (Duchêne et al., 2011; Reinstaller & Unterlass, 2012; Chung, 2015).
  - 'other factors': e.g. firms' age (Cincera & Veugelers, 2013), framework conditions (Aghion, 2006; de Saint-Georges & van Pottelsberghe, 2013; Veugelers, 2015).
- inconclusive evidence mainly due to differences in the nature of the data and their comparability, use of different measurement instruments and indicators (Duchêne et al.,2010;Lindmark et al. ,2010) .

Related literature

- Direction and magnitude of the R&D intensity gap between countries:
  - widening of corporate R&D intensity gap (Duchêne *et al*., 2011; Veugelers, 2013; Chung, 2015).

- Dispersion vs. concentration in R&D investment among firms:
  - globally, corporate R&D is concentrated in a small number of large companies and of high R&D intensity sectors (Reinstaller & Unterlass, 2012; Hirschey et al., 2012; Montresor & Vezzani, 2015).

Aim of the paper

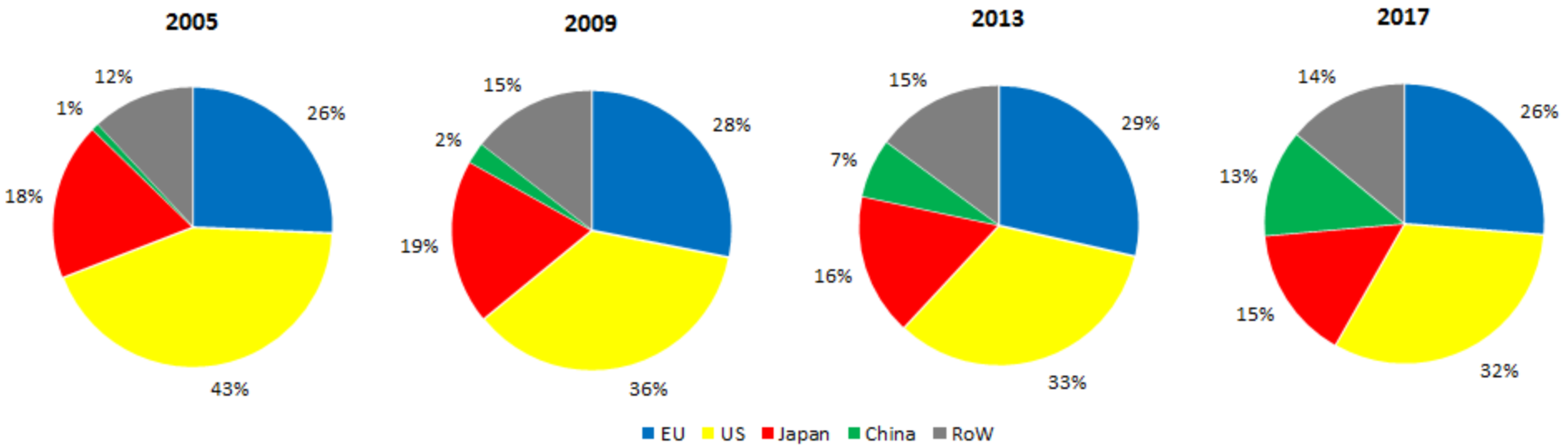
To go deep into both the structural (i.e. sectoral) and intrinsic (i.e. firm level) components of the gap, addressing two main questions:

- (i) To what extent does sector composition affect the aggregate EU R&D intensity gap in relation to the US?
- (ii) Which *sectors* and *firms* are key to the EU R&D intensity gap vis-à-vis the US?

European Commission

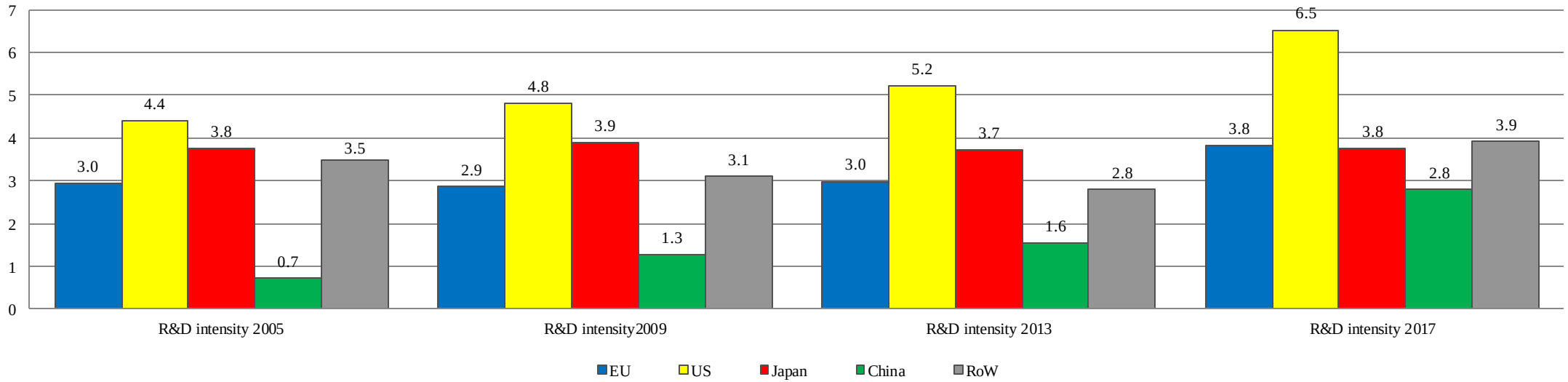
Data

- EU R&D Scoreboard (editions 2006, 2010, 2014 and 2018.)
- Four EU R&D Scoreboard editions with 1250 firms each edition



European Commission

R&D intensity trends



- The majority of the largest EU companies, by net sales, in the EU R&D Scoreboard operate in lower-tech sector groups compared to their US counterparts
- This has consequences for total R&D intensity, which is as a result greatly influenced by the (lower) level of R&D intensity of the sectors to which these companies belong, and a higher net sales growth path

European Commission

Decomposition of corporate R&D intensity

- To calculate the relative contributions of each of the two effects to the total difference in R&D intensity between economies, we have followed the decomposition approach of Haveman and Donselaar (2008), Erken and van Es (2007), Lindmark *et al.* (2010), Moncada-Paternò-Castello *et al.* (2010) and Cincera and Veugelers (2013).

- $RDIx - RDIz = \sum_i RDI\ \mathrm{z,i}\ (\mathrm{Sx,i} - \mathrm{Sz,i}) + \sum_i S\ \mathrm{x,i}\ (\mathrm{RDI\ x,i} - \mathrm{RDIz,i})$

- - X is the first sample (in our case the US, Japan, China or Rest of World);
- - Z is the second sample (in our case, the EU sample);
- - RDI stands for R&D intensity (R&D/Y), where Y is the overall amount of net sales of companies from all sectors ($\sum yi$) operating in a given economy; and
- - S is the share of the sector i in terms of net sales within a given economy (yi/Y).

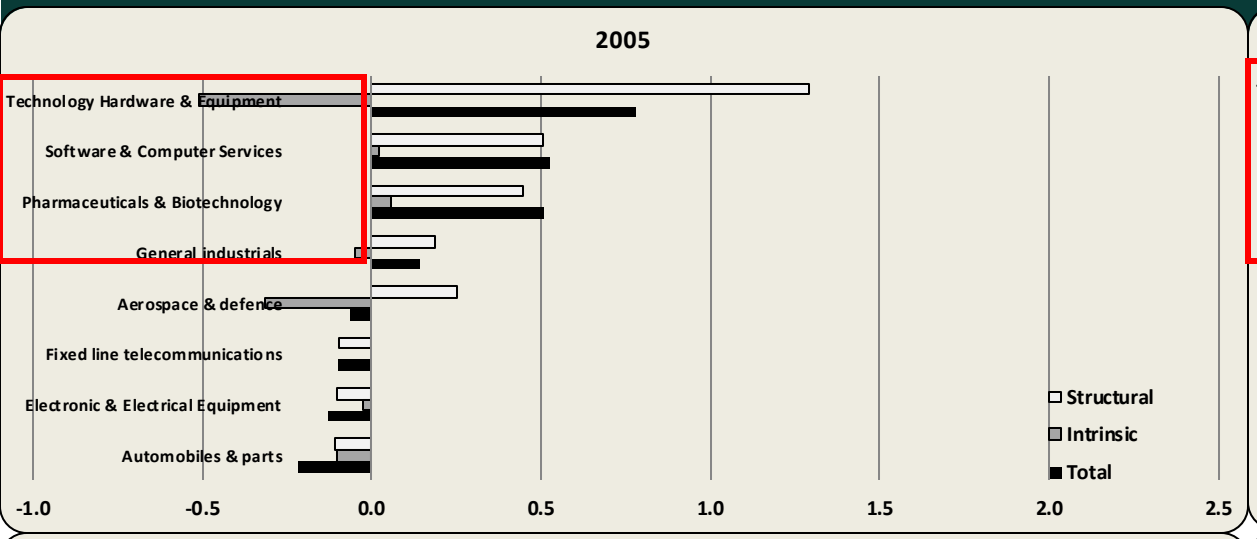
Decomposition of corporate R&D intensity

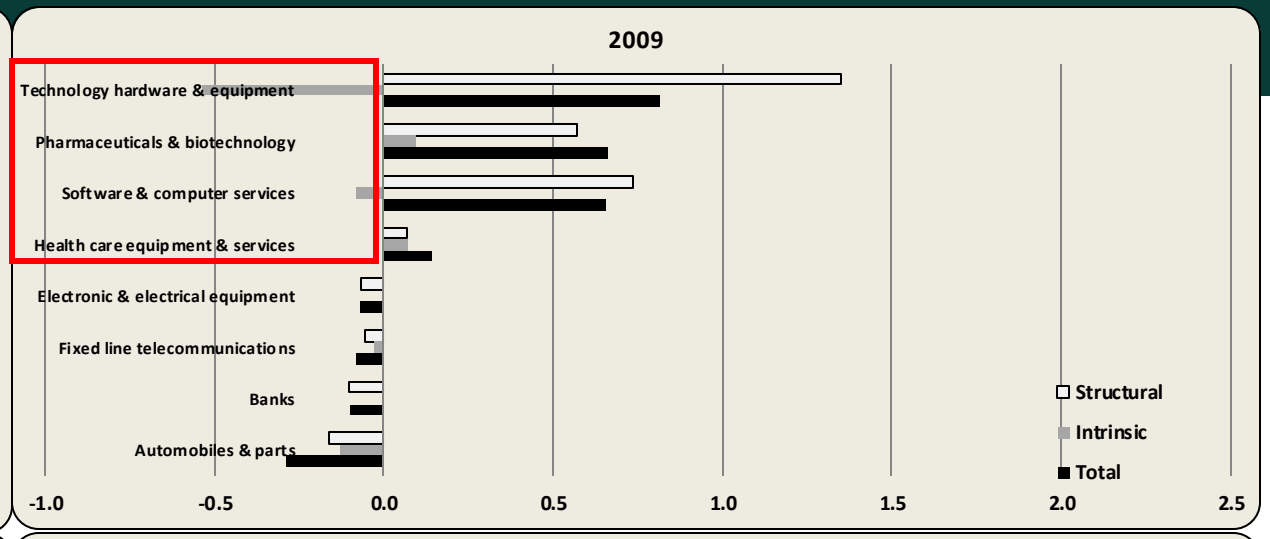
		no of companies	overall	structural	intrinsic
US	2005	541	1.45 %	2.36 %	-0.91 %
	2009	448	1.95 %	2.70 %	-0.75 %
	2013	412	2.23 %	3.35 %	-1.12 %
	2017	391	2.69 %	3.13 %	-0.44 %
Japan	2005	227	0.81 %	2.23 %	-1.42 %
	2009	238	1.04 %	1.77 %	-0.74 %
	2013	205	0.74 %	1.52 %	-0.77 %
	2017	192	-0.07 %	0.96 %	-1.03 %
China	2005	10	-2.23 %	-1.32 %	-0.91 %
	2009	30	-1.59 %	-0.68 %	-0.91 %
	2013	85	-1.44 %	-0.33 %	-1.11 %
	2017	155	-1.18 %	0.15 %	-1.34 %
RoW	2005	148	0.54 %	1.55 %	-1.01 %
	2009	180	0.24 %	1.48 %	-1.24 %
	2013	185	-0.19 %	1.08 %	-1.27 %
	2017	175	0.08 %	1.65 %	-1.57 %

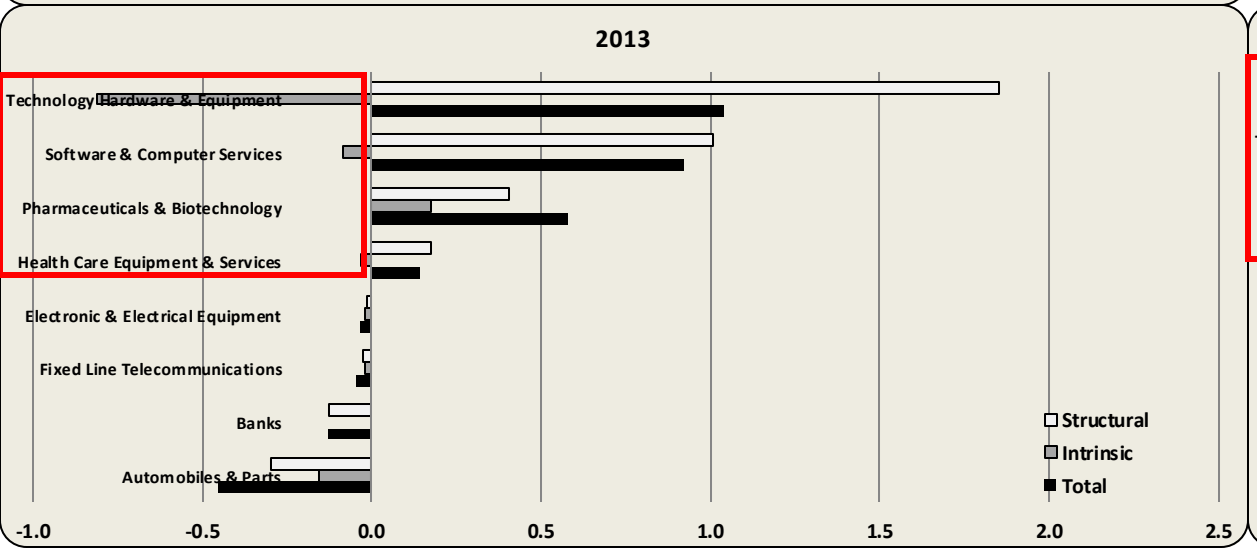
Note: number of EU companies 2005=321; 2009=351; 2013=355; 2017=327

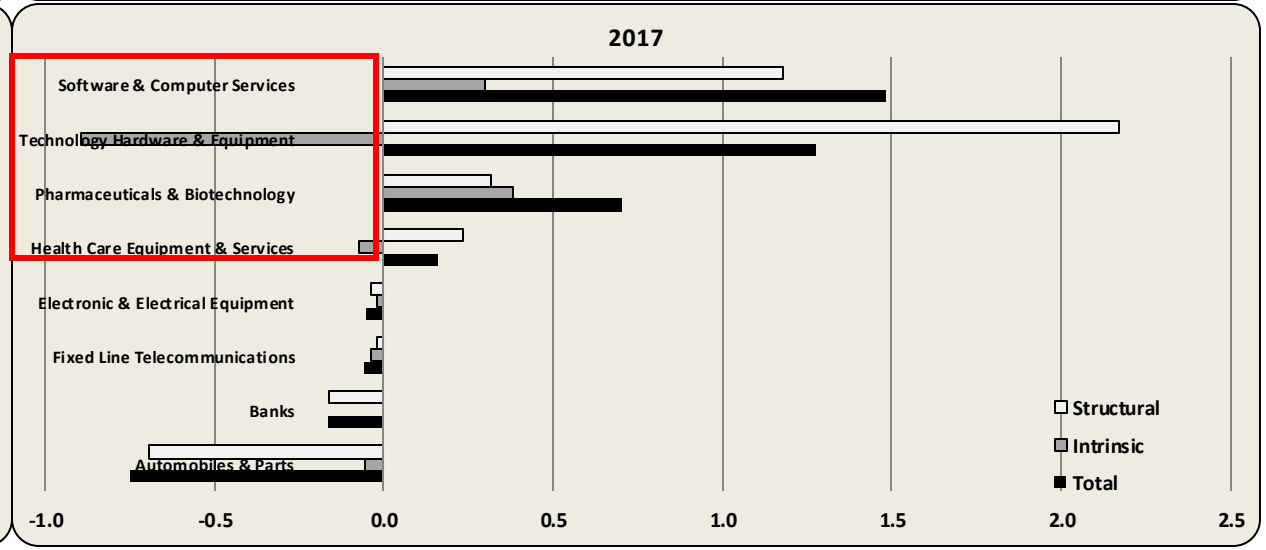
European Commission

Key sectors









European Commission

Key firms

- we construct an index which captures the differences in R&D intensity and in the share of net sales.
- $Impact\ INDEX = \theta ij\ (RDI\ ij - RDIj)$
- where RDIj $= \frac{RDi}{NSi}$ is the aggregate sectoral R&D intensity; θi is the measure of the firm's relative size, in terms of its net sales as a share of total sector net sales.
- The index can be negative or positive, indicating respectively a negative or a positive effect of R&D intensity and share of net sales performance of a firm on the aggregate R&D intensity of the sector.

Key firms

	YEAR 2005	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Health Care Equip. & Services	**EU**	**4.5**	**1.1**	**0.7**		**12**
	Carl Zeiss	10.4	19.5	8.4	49.5	
	BioMerieux	13.1	11.1	3.8	32.7	
	Dragerwerk	6.6	9.2	6.2	13.5	
	B Braun Melsungen	3.2	8.3	11.4	-14.2	
	Gambro	2.9	6.7	10.2	-15.7	
	Fresenius	1.9	12.6	29.8	-76.5	
	US	**7.3**	**3.4**	**2.0**		**35**
	Guidant	16.8	10.1	4.4	41.6	
	Medtronic	9.9	18.7	13.9	35.5	
	Boston Scientific	10.8	11.4	7.7	27.2	
	Becton Dickinson	5.0	4.6	6.6	-15.1	
	Baxter International	5.4	9.0	12.1	-22.8	
	Fisher Scientific International	0.8	0.7	6.9	-44.6	

	YEAR 2017	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Health Care Equip. & Services	**EU**	**3.9**	**1.4**	**1.4**		**11**
	Carl Zeiss	10.7	21.4	7.9	53.3	
	Dragerwerk	8.9	8.6	3.8	19.0	
	Elekta	11.9	5.1	1.7	13.5	
	Coloplast	3.5	2.7	3.1	-1.5	
	Essilor International	2.9	8.1	11.1	-11.6	
	Fresenius	1.8	23.0	50.1	-106.8	▼
	US	**2.9**	**3.3**	**7.3**		**25**
	Medtronic*	7.5	22.1	8.6	39.5	▼
	Boston Scientific	11.0	9.8	2.6	21.0	
	Edwards Lifesciences	16.1	5.4	1.0	13.0	
	Dentsply Sirona	3.8	1.5	1.1	1.0	
	Teleflex	3.9	0.8	0.6	0.6	
	Mckesson	0.1	1.2	59.8	-171.8	

Key firms

	YEAR 2005	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Pharmaceuticals & Biotechnology	**EU**	**14.8**	**17.5**	**3.5**		**38**
	Schering	18.6	5.3	4.2	16.2	
	Elan	54.8	1.1	0.3	11.5	
	UCB	20.2	2.7	2.0	10.8	
	Merial	7.7	0.7	1.3	-9.4	
	AstraZeneca	14.1	15.4	16.1	-10.6	
	Merck DE	12.1	3.8	4.6	-12.2	
	US	**15.7**	**23.3**	**6.5**		**77**
	Eli Lilly	20.7	7.3	5.6	27.8	
	Merck US	17.5	9.3	8.4	15.2	
	Schering-Plough	19.6	4.5	3.6	14.3	
	Pfizer	14.5	18.0	19.5	-22.9	
	Johnson & Johnson	12.5	15.3	19.2	-60.9	
	Abbott Laboratories	8.2	4.4	8.5	-63.8	

	YEAR 2017	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Pharmaceuticals & Biotechnology	**EU**	**14.0**	**19.9**	**5.5**		**46**
	Astrazeneca	24.1	11.9	6.9	70.0	
	Boehringer	17.0	8.1	6.7	20.5	
	Sanofi	15.5	14.4	12.9	20.4	
	Perrigo	3.4	0.4	1.5	-16.1	
	Mylan	6.5	1.7	3.7	-27.4	
	Bayer	11.2	13.6	17.0	-47.1	
	US	**18.9**	**22.8**	**7.9**		**61**
	Merck US	25.3	14.5	10.8	69.4	▲
	Bristol-Myers Squibb	28.7	8.5	5.6	54.5	
	Celgene	30.5	5.6	3.5	40.7	
	Pfizer	14.1	10.5	14.1	-67.9	▼
	Abbott Laboratories	7.9	3.1	7.4	-81.0	
	Johnson & Johnson	13.8	15.0	20.5	-104.3	

Key firms

	YEAR 2005	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Software & Computer Services	**EU**	**10.5**	**2.4**	**0.7**		**18**
	SAP	12.8	42.3	34.7	80.0	
	Dassault Systemes	27.7	10.1	3.8	65.6	
	Symbian	47.5	3.1	0.7	25.2	
	Wincor Nixdorf	4.5	3.0	7.1	-42.7	
	TietoEnator	3.5	2.3	6.9	-48.1	
	LogicaCMG	1.4	1.4	10.9	-99.0	
	US	**10.8**	**13.5**	**5.5**		**80**
	Microsoft	14.9	27.5	20.1	80.7	
	CA	20.5	3.3	1.7	16.7	
	Oracle	13.0	7.8	6.5	14.1	
	SunGard Data Systems	6.3	1.0	1.8	-8.1	
	Unisys	6.8	1.6	2.6	-10.7	
	IBM	5.9	22.5	41.3	-204.2	

	YEAR 2017	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Software & Computer Services	**EU**	**11.6**	**4.5**	**1.5**		**22**
	SAP	14.2	39.7	32.6	83.4	
	Ubisoft Entertainment	45.2	9.3	2.4	80.6	
	Dassault Systemes	17.9	6.9	4.5	27.9	
	Amdocs	6.7	2.6	4.5	-22.1	
	Sopra Steria	2.7	1.2	5.3	-48.0	
	Atos	1.0	1.4	17.6	-188.4	
	US	**14.2**	**25.5**	**11.7**		**90**
	Facebook	19.1	9.9	7.3	35.6	
	Workday	42.5	1.2	0.4	10.9	
	Electronic Arts	25.6	1.7	0.9	10.6	
	Microsoft	13.3	18.7	19.9	-17.6	▼
	Hewlett Packard Enterprise	5.1	1.9	5.2	-47.4	
	IBM	6.5	6.5	14.3	-111.1	

Key firms

	YEAR 2005	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Technology Hardware & Equipments	**EU**	**13.7**	**11.8**	**2.5**		**22**
	Ericsson	16.9	21.6	17.6	55.5	
	Infineon Technologies	18.4	9.8	7.4	34.3	
	STMicroelectronics	17.5	10.4	8.2	30.9	
	Bull	4.3	0.4	1.3	-12.0	
	Oce	7.2	1.5	2.9	-19.0	
	Nokia	11.6	31.5	37.2	-77.8	
	US	**9.5**	**25.7**	**11.9**		**146**
	Intel	13.3	11.3	8.1	30.6	
	Cisco Systems	13.4	7.3	5.2	20.3	
	Texas Instruments	15.0	4.4	2.8	15.6	
	Apple	3.8	1.2	2.9	-16.3	
	HP	4.0	7.7	18.1	-98.3	
	Dell Technologies	0.8	1.0	11.6	-100.6	

	YEAR 2017	R&D intensity	% R&D	% Net Sales	Impact Index	# firms
Technology Hardware & Equipments	**EU**	**15.9**	**8.0**	**2.0**		**17**
	Nokia	21.2	32.2	24.1	129.3	▲
	NXP Semiconductors	16.8	8.5	8.0	7.4	
	Dialog Semiconductor	21.6	1.6	1.2	6.7	
	ASML holding	12.8	7.6	9.4	-29.2	
	Seagate Technology	11.4	6.7	9.3	-41.4	
	Arris	8.2	2.9	5.7	-44.3	
	US	**10.2**	**24.6**	**15.7**		**72**
	Intel	20.9	17.3	8.4	90.1	▲
	Qualcomm	24.5	7.2	3.0	42.9	
	Broadcom	18.7	4.3	2.4	20.1	
	Dell Technologies	6.0	6.3	10.6	-43.5	
	HP	2.3	1.6	7.0	-55.0	▼
	Apple	5.1	15.3	30.8	-157.3	

Findings

Concerning the firms' contribution to the R&D intensity gap, the firms' distribution in R&D intensity within the four key sectors reveals that:

- compared to the US, in the EU sample:
  i) firms are less numerous;
  ii) there are less large firms (by R&D investment);
  iii) there are less small firms (by R&D investment);
  iv) there are less large R&D investors that hold a high share of net sales;
  v) the sector's R&D intensity is superior, except in the Pharmaceuticals & Biotechnology sector.

- There are few companies – in the four sectors and for the values examined - which determine the intrinsic R&D effects in the EU vs US R&D intensity gap. Few of them (37.5 %) are present in both years considered.

Findings

- there is a coexistence of firms with different R&D investment strategies and efficiencies.

- the relative impact of top R&D investing firms on the overall EU R&D intensity gap depends heavily on their presence in the high R&D intensity sectors and their size. Of course, the larger the number of firms and their aggregate size in high R&D intensity sectors, the bigger their impact on the aggregate (all sectors) R&D intensity result.

- high sensitivity of sector performances to R&D intensities in a few EU and US firms. They also reveal a general high heterogeneity of R&D intensity within the same sector in both regions, and also a significant dynamic of firms entering and exiting the group of six firms that are ranked for their positive or negative impact on aggregate R&D intensity in the EU and in the US.

Conclusions

- EU companies lag behind US (and Japanese) companies in terms of R&D intensity. The gap between the EU and US has widened over the period studied, while it has remained fairly stable between the EU and Japan. In contrast, the R&D investment gap between the EU and China is positive, although it has reduced by half over the four years under consideration.

- As a novel contribution to the state of the art in the literature, this paper identifies the sectors and the firms which are 'key' to EU R&D intensity performances and to differences with the US group of firms. The decomposition of sectoral R&D intensity shows that Technology Hardware & Equipment, Software & Computer Services, Pharmaceuticals & Biotechnology, and Health Care Equipment & Services account for the bulk of the negative EU structural R&D intensity gap.

- Only some 'key' firms – for their positive or negative impact on aggregate R&D intensity in both economies and the four sectors mentioned – are the same across the years considered and without showing appreciably different growth paths. On the other hand, within the group of such key firms, there is a much higher dynamic of entry and exit across the years within the four sectors. This study also found that there is a high heterogeneity distribution of R&D intensity for firms within the same sector, indicating the coexistence of firms with different R&D investment strategies and efficiencies.

Any questions?

You can find me nicola.grassano@ec.europa.eu

European Commission