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YOUNG LEADING INNOVATORS AND THE EU'S R&D INTENSITY GAP

REINHILDE VEUGELERS AND MICHELE CINCERA

Highlights

- Innovation in the European Union remains weak according to a number of key 'input' indicators, especially R&D investment by the business sector, and there are relatively few signs of progress. From a firm-level perspective, Europe's innovation gap relative to the US results from an inappropriate industrial structure in which new firms do not play a significant role, especially in new high-tech sectors.
- This view of a structural EU innovation deficit has many supporters. But it has received little or no thorough empirical investigation. This policy contribution aims to address this 'evidence gap'. We find that compared to the US, the EU has fewer young firms among its leading innovators. But this accounts for only about one-third of the EU-US differential. The largest part of the differential is due to the fact that young leading innovators in the EU are less R&D intensive than their US counterparts. Further unravelling shows that this is almost entirely due to a different sectoral composition. We thus confirm that the EU-US private R&D gap is indeed mostly a structural issue.
- This policy contribution complements the Bruegel policy brief, 'Europe's missing yollies' (2010/06, available via www.bruegel.org), which makes policy recommendations based on our analysis.

Reinhilde Veugelers (reinhilde.veugelers@bruegel.org) is a Senior Fellow at Bruegel and a Professor at the University of Leuven. Michele Cincera (mcincera@ulb.ac.be) is a Professor at the Université libre de Bruxelles.

Telephone
+32 2 227 4210
info@bruegel.org

www.bruegel.org

YOUNG LEADING INNOVATORS AND THE EU'S R&D INTENSITY GAP

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INNOVATION IN THE EUROPEAN UNION remains weak according to a number of key 'input' indicators, especially R&D investment by the business sector. Furthermore, there are relatively few signs of progress, despite the EU's Barcelona target of increasing investment in research to three percent of GDP, which was established in 2000 (EC-Key Figures 2010).

Compared to the United States the EU private R&D deficit primarily manifests itself in ICT goods and services. This correlates with the EU's lower specialisation in these R&D-intensive, high-growth sectors of the 1990s (O'Mahoney & van Ark, 2003; Denis *et al*, 2005; EC Key Figures, 2005; Moncada *et al*, 2009). Further, firm-level evidence suggests that the EU's R&D deficit in the information technology sector may reflect constraints on the rapid growth of new, technology-based entrants in the EU compared to the US[1].

From this firm-level perspective, the continued business R&D deficit seems a symptom rather than a cause of the EU's weakness in innovation; the cause seems rooted in the structure and dynamics of EU industry and enterprise[2]. Europe's innovation gap is a consequence of its industrial structure in which new firms fail to play a significant role in the dynamics of the industry, especially in the high-tech sectors. This is illustrated by their inability to enter markets and to subsequently grow into market leaders. The creative-destruction process encounters significant obstacles in the EU, undermining Europe's growth potential (Aghion *et al*, 2007).

This structural EU innovation-deficit story has many supporters, but has received little or no thorough empirical investigation. This Policy Contribution aims to address this 'evidence gap'. We decompose the latest European Commission Joint Research Centre – Institute for Prospective Technological Studies (JRC-IPTS) Industrial R&D Scoreboard (European Commission, 2008) of leading innovators in terms of global R&D expenditures by age cohort. We compare the innovation profile of young versus old leading innovators in the scoreboard and examine how the contribution of young leading innovators can explain the EU's lagging leading innovation performance.

We find that compared to the US, the EU has fewer young firms among its leading innovators. But this effect only accounts for about one-third of the EU-US differential. The largest part of the differential is due to the fact that young leading innovators in the EU are less R&D intensive than their US counterparts. Further unravelling shows that this is almost entirely due to a different sectoral composition. Young leading innovators in the US are found in R&D-intensive young sectors, with biotechnology and internet being the clearest cases. We thus confirm that the EU-US private R&D gap is indeed mostly a structural issue. Bridging this gap will require the EU to nurture more young firms in young sectors, enabling them to grow to become young leading innovators.

We proceeds as follows: section 1 presents the scoreboard data being used. Section 2 describes the innovation profile of young firms in the scoreboard. Section 3 examines the extent to which young leading innovators can account for the EU-US R&D gap. Section 4 examines the contribution of young leading innovators to the differences in EU-US R&D growth performance. Section 5 summarises the main findings. Box 4 sets out caveats to the analysis and suggestions for further research. Policy conclusions are discussed in the Bruegel Policy Brief, 'Europe's missing yollies' (2010/06, available via www.bruegel.org), which complements this Policy Contribution.

1. Bartelsman *et al* (2004) found that post-entry performance differs markedly between Europe and the US, which suggests a potential indication of the importance of barriers to firm growth as opposed to barriers to entry. Cohen and Lorenzi (2000) argued that the US economy is a more hospitable environment than the EU for new firms to grow. Based on an analysis of the top 1000 global firms in terms of market capitalisation which were listed in Business Week in 1999, they found that information technology was by far the most important sector for explaining the difference in the total number of new giants between the two regions. Cohen and Lorenzi show that of the 355 US firms included in this list, 33 percent were created after 1950. In contrast, of the 181 EU firms in the list, 14 percent were created after 1950. Information technology accounted for more than 70 percent of the difference between the two geographical regions (Cohen and Lorenzi, 2000, p. 125).

2. This has also been diagnosed in the former EU Research Commissioner Janez Potocnik's KfG (Knowledge for Growth) Expert's Group Report (O'Sullivan, 2007) or van Pottelsberghe (2008).

1 THE LEADING INNOVATORS DATASET

We start with the set of firms that belongs to the EU-1000 and non-EU-1000 biggest[3] R&D spenders in the 2008 edition of the EU Industrial R&D Investment Scoreboard[4]. This dataset has been augmented with information on the date of the establishment of firms[5]. The information on the age of firms allows us to distinguish between young and old leading innovators.

As the scoreboard database only records the biggest R&D spenders, 'young firms' are not *small* start-ups. Indeed, the average size for the young firms in our sample is 10,000 employees worldwide. Some top 'young firms' in our sample (by R&D size) are Amgen, Cisco, Google, Microsoft, Oracle and Sun. As it includes (almost) no firms with fewer than 250 employees, the scoreboard dataset is not suited for analysing the small and medium-sized enterprise dimension.

The 'young firms' in our analysis are a group of firms that have managed on their own, ie without being taken over, and in a relatively short time-span since their birth (after 1975), to grow into world leaders deploying substantial R&D resources. We will label them young leading innovators (which we call *'yollies'*) to differentiate from old leading innovators (*'ollies'*).

In addition to the age of firms, the dataset also contains information on the following variables: main industrial sector (according to the Industry Classification Benchmark – ICB), country of origin, net sales, number of employees, and R&D investment for each year for the period 2004-07. The geographic classification of firms is done on the basis of ownership and not by location of the activities[6].

Because data is missing for some firms, the final sample includes 1077 firms. The dataset is representative of 96.1 percent of the R&D carried out in 2007 by the top 2000 global corporations listed in the 2008 industry R&D scoreboard. This is itself representative of more than 80 percent of the total worldwide R&D in the private sector (business enterprise R&D or BERD)[7]. Twenty-nine percent of our sample firms are from the EU, 38 percent from the US, 19 percent from Japan and 14 percent from the rest of the world (RoW)[8].

2 WHY YOLLIES MATTER

2.1 The importance of yollies for R&D, sales and employment

Thirty-four percent of all leading innovating firms in our sample are 'young', ie were born after 1975. Sixteen percent are 'very young', born after 1990. As can be seen from Figure 1 on page 4, the share of yollies in the number of firms is greater than their share in net sales, employment and R&D. Yollies represent 10 percent of net sales, 12 percent of employment and 19 percent of R&D in our sample. Yollies are typically smaller in size, employment and R&D budget than ollies.

Yet yollies are major innovators. As their share of R&D is greater than their share of net sales, yollies are more R&D oriented than ollies. Figure 2 (page 4) illustrates this more clearly by showing the R&D intensity (ie R&D-to-sales-ratio) of firms by age group. The average R&D intensity of yollies is almost twice as high as that of old firms, at 6.3 percent relative to 3.2 percent.

2.2 How young innovative firms shape 'young' R&D-intensive sectors

A number of industry and services sectors are particularly associated with yollies. Table 1 shows the sectors in which yollies are prominently present. The sectors that have an above-average share of R&D done by yollies are identified as 'young

'The EU has fewer young firms among its leading innovators. But this effect only accounts for about one-third of the EU-US R&D differential. The largest part of the differential is due to the fact that young leading innovators in the EU are less R&D intensive than their US counterparts.'

3. By 'big' we mean companies with R&D investment of more than €35m in 2007.

4. The European Commission JRC-IPTS has since 2004 collected annual data on companies investing the most in R&D worldwide (the EU Industrial R&D Investment Scoreboard. See: http://iri.jrc.ec.europa.eu/research/scoreboard.htm)

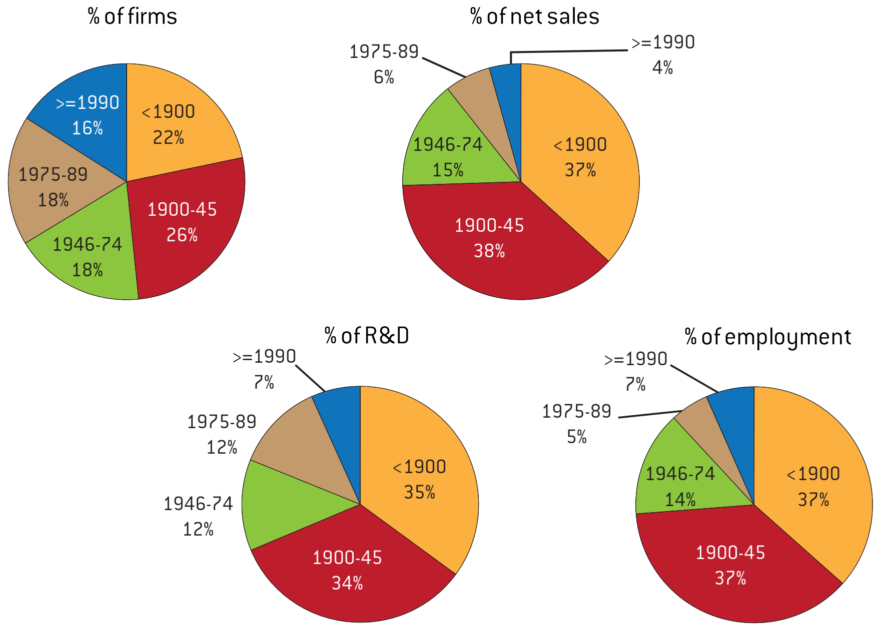
5. Age information has mainly been sourced from the websites of companies. This information has been crosschecked with other databases (eg Amadeus). We use the very first year of the firms' creation, ie *ex-nihilo* creation. In case of a merger and acquisition (14.9 percent of cases), the age of the oldest merged entity is considered.

6. All activities of the firm are presented as consolidated in the scoreboard. We have no information on the geographic and sectoral distribution of firms' activities.

7. See for instance European Commission (2006).

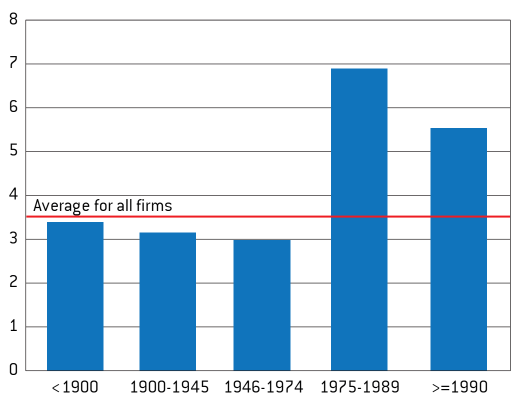
8. Rest of the world (RoW) includes as most important countries Canada (14 firms), China & Hong Kong (10), India (12), Israel (8), Norway (7), South Korea (18), Switzerland (33) and Taiwan (33).

Figure 1: Share of yollies in R&D, sales and employment



Source: Bruegel/European Commission JRC-IPTS.

Figure 2: R&D intensity (RDI) by age class (in %)



Source: Bruegel/European Commission JRC-IPTS.

sectors'. These sectors are internet, biotechnology, software, semiconductors, telecoms equipment, computer hardware, computer services, health equipment and services[9]. Young sectors are therefore basically a health/biotechnology and ICT story[10]. Table 1 also covers the electronics, telecoms services and pharmaceuticals sectors. These sectors are also present in the health/biotech and ICT nexus, and have a sizeable proportion of yollies, but young companies are much less pivotal in total R&D in these sectors.

Internet is essentially a post-1990 sector, as all

Table 1: Yollies and their presence in (young) high-tech sectors (in %)

	Share of yollies	Yollies % of R&D	Yollies RDI	Ollies RDI	Share of sector in total R&D
Internet	100	100	10.9		1
Biotechnology	91	92	26.7	9.2	2
Software	86	88	15.3	13.8	4
Semiconductors	71	53	15.2	13.8	6
Telecom equipment	64	34	13.5	12.0	6
Computer h'ware	63	36	3.8	4.6	4
Computer services	64	13	4.6	5.5	1
Health equipment	26	29	10.6	6.0	1
Average for young sectors	**71**	**52**	**11**	**8**	**29**
Electronics	26	9	6	2	5
Telecom services	30	11	1	2	2
Pharmaceuticals	28	3	15	16	17
Average for all sectors	**34**	**19**	**6**	**3**	

See Appendix A1 for a version of Table 1 with all sectors.

9. It should be noted that travel and leisure also has 50 percent of yollies, but there are only in total 10 companies in this sector (and none in the EU). This sector is therefore not reported in the analysis.

10. Dedicated environment sectors are not yet well represented in the scoreboard.

companies in this sector were born after 1990. Biotechnology and software are also young sectors, with almost no old companies in the scoreboard. The semiconductor sector has a rather high number of yollies, but these are smaller in (R&D) size compared to the older firms in the sector. The same holds for telecoms equipment, computer hardware and computer services.

The telecoms services sector is not particularly characterised by the presence of yollies (despite the deregulation in this sector). The yollies in the sector are also smaller in R&D size.

The pharmaceutical sector is a twin sector with biotechnology. Although about one-third of its leading innovators are young, yollies represent only three percent of total R&D done in this sector.

Young sectors (the first eight rows in Table 1), represent about 29 percent of the R&D performed by the 1077 companies in the dataset. All these young sectors are also high R&D-intensity sectors, ie their R&D intensity is more than twice the total average in the sample. The only exceptions are computer hardware and computer services. Almost all high R&D-intensity sectors are 'young sectors'[11]. The only R&D-intensive sector that is not a young sector is pharmaceuticals. The only ICT sector that is not a young sector or a R&D-intensive one is telecoms services.

With the exception of biotechnology (and internet by default), the young firms within young sectors are not significantly more R&D intensive than their older counterparts in these sectors[12]. This seems to suggest that if we ignore biotechnology and internet, albeit two important sectors, the higher overall R&D intensity of yollies can mostly be attributed to their presence in R&D-intensive sectors rather than to them being more R&D intensive than their older counterparts within their sector. Table 1 shows that old firms in young sectors are also more R&D intensive than average old firms, in response to competition from the young firms in their sector, and/or because they are doing the follow-up innovations on the breakthrough innovations of the young firms. The importance of this sectoral dimension for explaining the difference in R&D intensity between young and old firms is more rigorously examined and confirmed in Box 1.

BOX 1: YOLLIES AND OLLIES, DIFFERENCES IN R&D INTENSITY: A SECTORAL LOOK

Table 1 seems to suggest that the difference in R&D intensity between yollies and ollies is mostly structural, ie due to a stronger presence of yollies in high-tech sectors, rather than intrinsic, ie yollies being more R&D intensive than their older counterparts in their sector. With a decomposition analysis, we can calculate the exact size of both effects (see Annex 2 for a more detailed description of the decomposition exercise):

$$RDI^{y} - RDI^{o} = \sum_{i} RDI_{i}\left(w_{i}^{y} - w_{i}^{o}\right) + \sum_{i} w_{i}\left(RDI_{i}^{y} - RDI_{i}^{o}\right)$$

The first term represents the structural effect and the second term the intrinsic one.

Total difference in $RDI^{y,o}$	Structural effect	Intrinsic effect
7.4	5.8	1.6
100%	78%	22%

Both structural and intrinsic effects are positive, but the structural effect is four times greater[13].

3.3 The importance of yollies for R&D and sales growth

Beyond their contribution to overall R&D, sales and employment, young firms being typically more dynamic can be expected to be even more pivotal contributors to growth in R&D and ultimate sales and employment growth. Table 2 presents the growth performance of yollies compared to ollies and their contribution to total growth. The superior performance of yollies (relative to ollies) is striking when looking at their dynamic R&D performance.

The R&D growth rate of yollies is twice as high as for ollies[14]. Although the differential is somewhat smaller for sales growth, yollies also demonstrate

11. The list of all R&D intensive sectors includes biotechnology, healthcare, internet, pharmaceuticals, semiconductors, software and telecoms equipment, ie all our young sectors minus computer hardware and software and pharmaceuticals.

12. If we consider the pharmaceutical sector as the real 'old' equivalent to biotechnology, even then biotechnology firms would be more R&D intensive than their old pharmaceutical counterparts.

13. As discussed by Jaumotte and Pain (2005), the results of analyses of the R&D deficit into these two components have been shown to be highly sensitive to the level of detail at which industries are compared: 'Typically, the proportion of the gap in R&D intensities explained by differences in industrial composition has been found to rise as the extent of disaggregation rises' (p12). As we are already using a rather aggregated level of sector classification, the weight of the structural effect could be even higher in a more disaggregated analysis.

14. Firms in the 2008 industry scoreboard show on average a strong upward trend in R&D in the period 2004-07, which is different from the stagnant business R&D-to-GDP ratios in the US and the EU.

higher sales and employment growth. Unfortunately, as the weight of yollies in total R&D is small (19 percent, see Table 1), the contribution of yollies to the total growth in R&D remains confined to 30 percent. For sales growth, this figure amounts to 16 percent, for employment 20 percent. These numbers are nevertheless greater than their weight in R&D, reflecting the stronger dynamic performance of yollies.

Table 3 clearly shows that young sectors have a higher than average R&D growth rate, with the exception of telecoms equipment and services. Thanks to this higher growth performance, young sectors, representing 29 percent of total R&D investments in 2007, have a more substantial contribution to total R&D growth (2004-07), amounting to 37 percent.

In the young sectors, the contribution of the young firms to this above-average R&D growth is much more substantial (91 percent) than for the average sector (where it was 31 percent). This is not surprising, as yollies have a greater weight in total in these sectors (see Table 1). But the higher contribution of yollies is also due to a stronger growth performance of yollies in these sectors, especially in biotechnology and healthcare, but also in computer hardware and services. Only in telecoms equipment are the ollies on a par with the yollies. In telecoms services, yollies contribute almost nothing to total R&D growth, but this is not a young sector.

Table 2: R&D, net sales and employees, annual average growth of yollies and ollies (2004-07) (in %)

	Total growth	Growth yollies	Growth ollies	Yollies contribution to total growth
R&D	8	13	7	31
Net sales	9	14	8	16
Employees	3	5	3	20

Notes: growth of Y defined as: $\Delta Y_t = (Y_t - Y_{t-1}) / \left(\frac{(Y_t + Y_{t-1})}{2} \right)$

The time period considered is 2004-07, ie differences are divided by three for an average annual growth percentage (AAGR). The contribution of young firms to total growth is calculated as: $\left(\Delta Y_t^y \left(\frac{w_{t-1}^y + w_t^y}{2} \right) \right) / \Delta Y_t$

For employees, calculations based on only 1009 firms.

3 YOLLIES AND THE EU'S R&D GAP

With young firms being more R&D intensive and being the driving force in young sectors with a high R&D focus, an obvious next step in the analysis is to check if this can explain the gap in the EU's R&D performance relative to the US.

3.1 Yollies by region

Of all yollies in the sample, 58 percent are US owned (218 firms) and 19 percent EU owned (59 firms). Correcting for the overall representation of EU and US firms in the sample, we see that the US with a ratio of 1.5 is 'over-represented' in the population of yollies. Also, the rest of the world (RoW) has relatively more yollies (with a ratio of 1.5). The EU is 'under-represented' in yollies with a ratio

Table 3: R&D and net sales growth (in %) of yollies and ollies by sector (2004-07)

	Total growth in R&D	Growth yollies	Growth ollies	Yollies contribution to total growth	Sector contribution to total R&D growth
Pharmaceuticals	12	18	12	5	24
Biotechnology	14	16	1	98	4
Healthcare	15	18	11	37	2
Computer hardware	7	13	5	58	4
Computer services	2	11	1	47	1
Internet	37	37		100	3
Semiconductors	9	12	7	61	7
Software	12	12	10	90	6
Telecom equipment	12	12	12	33	10
Telecom services	12	3	13	3	3
Electronics	7	17	6	19	4
Average young sector	**13**	**18**	**9**	**91**	**37**

Notes: see Appendix A2 for a version of Table 3 with all sectors[15].

15. Among the 'old' sectors, pharmaceuticals, telecoms services and aerospace and defence have an above-average R&D growth rate, while chemicals, automobiles and electric and electronic equipment are below average.

of 0.65. Japan has a ratio of just 0.08.

Among the leading innovators from the US, more than half are yollies, as Table 4 shows. By contrast, only one out of five leading innovators from Europe is young. For the US, yollies account for 35 percent of total R&D, for the EU a mere seven percent. Japan has almost no young firms among its leading innovators.

Table 4: Presence of yollies by region (2007) (in %)

	EU	US	Japan	RoW	World
% yollies in firms	20	52	1.5	53	34
% yollies in R&D	7	35	0.5	27	19
% yollies in net sales	5	16	1.5	27	11
% yollies in employment	4	19	1.8	34	12

Table 5: R&D intensity of yollies and ollies by region

	World	EU	US	Japan	RoW
R&D intensity	3.6	3.0	4.6	3.7	2.7
Yollies' R&D intensity	6.4	4.4	10.2	1.2	2.7
Ollies' R&D intensity	3.2	2.9	3.5	3.8	2.7

3.2 The innovation profile of young leading innovators by region

As Table 4 shows, yollies' share of R&D is higher than their share of net sales, both in the US and the EU, indicating that in these regions yollies have a higher R&D intensity compared to their older counterparts. But for the US this is more evident, leaving a higher R&D intensity differential for US yollies as compared to the EU, as Table 5 documents. For Japan and the rest of the world this is not the case. The yollies in the rest of the world have almost the same R&D intensity as ollies, while in Japan, yollies have a smaller R&D intensity than ollies.

The R&D intensity of EU companies (three percent) is on average smaller than that of US companies (4.6 percent). With the US benchmarked at 100, the EU's R&D intensity gap is 65 percent. This gap holds both for ollies and yollies. But the difference is more pronounced for yollies. While the EU's R&D intensity gap is 83 percent for ollies, for yollies it is 43 percent.

We further zero in on this gap in R&D intensity as it is the micro-equivalent of the macro business R&D-to-GDP ratio, pivotal since the Barcelona targets and the Lisbon strategy, as well as its successor the EU 2020 strategy.

The lower overall R&D intensity of EU leading innovators compared to the US can be explained by the combination of the following results:

- The EU has fewer yollies than the US. This matters because yollies have a higher R&D intensity;
- The EU-based yollies are less R&D intensive than their US counterparts;
- Also the EU-based ollies are less R&D intensive than their US counterparts.

With a decomposition analysis, we can calculate the exact size of these effects (Box 2 on the next page). This decomposition analysis shows that all three effects contribute to explaining the lower R&D intensity of EU leading innovators. It matters that the EU has fewer yollies than the US, but also that its yollies as well as its ollies are less R&D intensive compared to the US. But the most important component is the second factor, that EU-based yollies are less R&D intensive than US yollies. This factor accounts for 55 percent of the total EU-US R&D-intensity differential. The policy implications of this important finding are discussed in the accompanying Policy Brief.

With respect to Japan, the EU also has a gap in R&D intensity, albeit smaller than the US gap. This gap with Japan is entirely due to the superior R&D -intensity performance of Japan's old companies. The fact that the EU has more yollies than Japan and that they are performing better than their Japanese counterparts is not strong enough to compensate for the superior performance of Japanese ollies.

3.3 A sectoral explanation for the EU-US yollies R&D intensity gap

As the young-intrinsic effect explains most of the difference in EU-US R&D intensity differential, we need to understand better why EU yollies are less

BOX 2: DIFFERENCES IN TOTAL R&D INTENSITY BETWEEN THE EU AND THE US DECOMPOSED BY AGE

The difference in total R&D intensity between the EU and the US can be decomposed by age of firm in the following components (see Annex 2 for the exact formulas):

Structural effect: the difference in shares of the age groups between the US and the EU. A positive structural effect will capture that the EU has fewer companies of the high R&D-intensive type as compared to the US. These are the yollies.

Intrinsic effect: the difference in R&D intensity between the US and the EU for both age groups (young and old). A positive intrinsic effect will capture whether young/old companies in the EU are less R&D intensive than their US counterparts.

Both the intrinsic and the structural effects are indeed positive. In relative terms, the structural effect is the least important as it contributes 34 percent of the EU-US R&D intensity differential. This leaves 66 percent of the R&D intensity EU-US differential explained by the intrinsic effect. This intrinsic effect is to the tune of 84 percent caused by the young firms, ie 55 percent of the EU-US R&D intensity differential is explained by the lower R&D intensity of EU yollies as compared to US yollies.

Total difference in RDI RDI^{US} - RDI^{EU}	Structural effect	Intrinsic effect		
		Total	Young	Old
3.8	5.81.3	2.5	2.1	0.4
100%	34%	66%	55%	11%

BOX 3: DIFFERENCES IN YOLLIES' R&D INTENSITY IN THE EU AND THE US DECOMPOSED BY SECTOR

The difference in the R&D intensity of yollies in the US and the EU (ie the intrinsic effect of Box 2) can be decomposed along the sectoral dimension in the following components (see Annex 2 for the exact formulas):

Structural effect: the difference between the US and the EU in shares of the sectors in which the yollies are located. A positive structural effect will capture that the EU has fewer yollies than the US in high R&D-intensive sectors.

Intrinsic effect: the difference in R&D intensity of yollies between the US and the EU by sector. A positive intrinsic effect will capture whether yollies in the EU are less R&D intensive than their US counterparts within the same sector.

Total difference in RDI^{y} $RDI^{y,US}$ - $RDI^{y,EU}$	Structural effect	Intrinsic effect
3.11	2.87	0.24
100%	92%	8%

Both the intrinsic and the structural effects are positive. But almost all of the difference in yollies' R&D intensity between the US and the EU is due to the structural effect (ie the different sectoral composition).

Although the difference in R&D intensity between the US and the EU for old companies was less important, it was nevertheless responsible for 11 percent of the overall R&D-intensity gap. A similar decomposition exercise can be performed for the ollies:

Total difference in RDI^{o} $RDI^{o,US}$ - $RDI^{o,EU}$	Structural effect	Intrinsic effect
1.19	1.56	-0.37
100%	131%	-31%

The largest factor explaining the difference in the case of ollies is again the positive structural effect, with US old leading innovators more present in high R&D-intensity sectors. But for ollies, the intrinsic effect is negative, ie EU ollies within the same sector are on average more R&D intensive than their US counterparts.

R&D intensive than US yollies. Is it a case of wrong sectoral specialisation? Are EU yollies operating in less R&D-intensive sectors or are EU yollies less R&D intensive when compared to their US counterparts in the same sectors[16]?

Again we use a decomposition analysis to calculate the sizes of these effects (see Box 3).

As Box 3 details, almost all of the explanation for the lower R&D intensity of yollies in the EU as compared to the US can be found in the different sectoral composition. Europe simply has fewer yollies in the high R&D-intensive sectors. Interestingly, this sectoral specialisation story also explains the difference in R&D intensity between the EU and the US for old companies and even more so, as the intrinsic effect for old companies turns out to be negative, ie within sectors old EU leading innovators are performing better than their old US counterparts. Therefore, the reason why EU ollies are performing on average worse than their US counterparts is entirely due to a different sectoral composition. Once corrected for this, EU ollies perform better than their US counterparts. Unfortunately, the ollies differential effect is of only minor importance in explaining the total EU-US differential effect (11 percent, see Box 2).

3.4 Who specialises in young, high R&D-intensity sectors?

To further zero in on the sectoral composition effect explaining most of the EU-US differential in R&D intensity, we look at the sectors in which the EU specialises, ie where relatively more of its leading innovators (young and old), can be found.

Table A.2 in Annex 1 shows the sectors in which EU R&D is over-represented. It confirms the EU specialisation pattern in sectors characterised as medium R&D intensive, found also by Moncada *et al* (2009). These include aerospace, automobiles, chemicals, electrics, industrial machinery, telecoms services. None of these sectors are young or high R&D-intensive sectors. All of them are older, medium R&D-intensive sectors. Furthermore, automobiles, chemicals and electrics are sectors with below-average R&D growth.

When it comes to high R&D-intensive sectors, there are not many sectors where the EU holds a comparative technology advantage. In pharmaceuticals, the EU's Revealed Comparative Advantage index (RTA) is about 1. The only young and high R&D-intensive sector in which the EU is specialised is telecoms equipment.

The US by contrast is specialised in all young, high R&D intensive sectors: biotechnology, computer hardware, computer services, healthcare equipment and services, internet, semiconductors, software and telecommunications equipment. It is also specialised in pharmaceuticals. It therefore specialises in all high R&D-intensive sectors.

The only R&D-intensive sector in which Japan is specialised is computer hardware and services, while the rest of the world is specialised in semiconductors and pharmaceuticals.

3.5 Which sectors drive the R&D intensity gap of EU's young leading innovators?

Overall, while the US has 75 percent of its young leading innovators in high R&D- intensive sectors, the EU only has 52.5 percent of its yollies in these sectors. In which young and high R&D-intensive sectors are there fewer EU yollies? Table 6 on the next page provides a closer look at the sectors in the ICT and health nexus, most of them young and/or high-tech.

The sector most responsible for the structural effect in the EU-US yollies R&D intensity gap (see Box 3) is biotechnology, which is a young and high R&D-intensive sector. In this sector, as Table 6 details, the EU has fewer yollies than the US. In addition, EU biotechnology yollies are much less R&D intensive than their US counterparts. Biotechnology is hence both a structural and an intrinsic story. Also in pharmaceuticals, there are more yollies in the US than in the EU, enforcing the structural effect. The few yollies the EU has in this sector are, however, much more R&D intensive

16. Alternatively to sectoral specialisation, it is more difficult to examine differences in size between EU and US young firms as a reason to explain the difference in R&D intensity in the scoreboard sample, as we only have leading innovators, which are already substantially sized. Within this sample of large leading innovators, the average size of the EU and US yollies does not seem to differ substantially (a US young leading innovator on average has 8300 employees, an EU young leading innovator 8500).

than their US counterparts, counteracting the overall positive intrinsic effect. In healthcare equipment, there are fewer yollies in the EU as compared to the US, reinforcing the structural effect from Box 3.

In the ICT nexus, semiconductors is the sector most responsible for the structural effect in the EU-US yollies RDI gap, while the internet sector is the clearest case of a structural EU yollies problem, as there are no EU leading innovators while in the US, they are all yollies. The EU also has relatively fewer of its yollies in computer hardware and telecoms equipment than the US. However, in software and computer services the EU has relatively more of its yollies than the US, but the Europeans are less R&D intensive than their US counterparts.

Table 6: Health and ICT sectors

	European Union			United States		
	Yollies RDI	Ollies RDI	Yollies as % of firms	Yollies RDI	Ollies RDI	Yollies as % of firms
Pharmaceuticals	25*	15	5	14	15	6
Biotechnology	18	10*	12	27	12*	17
Healthcare	11*	4	5	10	7	4
Computer hardware		6*	0	6	4	7
Computer services	3*	5*	7	6*	6*	1
Internet			0	11		3
Semiconductors	17	16*	10	18	16	20
Software	17	14*	20	15	13	17
Telecoms equipment	18*	13	3	14	11	8
Telecoms services	1*	2	3		1*	0
Electronics	6	6	9	5	5	2
All sectors	4	3	100	10	4	100

Notes: * Disaggregating the data into sectors, geographic areas and age group leaves in many cases few observations for analysis, calling for caution when interpreting results. Cells with less than 5 observations are indicated by *. Young sectors in bold. First box is the health-box, second box is the ICT.

Within most ICT sectors, the difference in R&D intensity between EU and US yollies is small, confirming the low importance of the intrinsic effect overall. In some sectors, EU yollies are even more R&D intensive than their US counterparts. This holds, as Table 6 shows, in telecoms equipment. While the EU ollies too have a higher R&D intensity than their US counterparts, the positive differential is stronger for the yollies in this sector. There are unfortunately relatively fewer yollies and they are smaller in R&D volume, enforcing the overall structural effect from Box 3.

A digression on rest-of-the-world yollies:

Rest-of-the-world (RoW) yollies are concentrated in computer hardware, computer services, electronics, semiconductors and telecoms equipment (53 percent of RoW yollies are in these four sectors). With the exception of electronics, which is a medium R&D-intensive sector, these are young, R&D-intensive sectors. But in all these sectors, RoW yollies have a lower R&D intensity as compared to other yollies. So, while for the EU its yollies R&D-intensity gap with respect to the US is mostly structural, for the RoW the intrinsic effect is more dominant in explaining its yollies R&D-intensity gap with the US.

4 YOLLIES AND THE EU'S R&D AND GROWTH PERFORMANCE

With young leading innovators having a higher R&D and sales growth rate, and being the driving force in young sectors with high R&D growth, a next step in the analysis is to check whether young firms are behind the differential in the R&D growth performance of the EU relative to the US.

4.1 EU-US differentials in growth profile of young leading innovators

Overall, the US has a better R&D growth performance than the EU. Japan, with its 'old' leading firm model records the lowest overall R&D growth, both for its ollies and yollies.

Table 7a: Annual average R&D growth (2004-07) of yollies and ollies by region (in %)

R&D	World	EU	US	Japan	RoW
Total growth	8	7	10	5	13
Growth yollies	13	12	13	7	13
Growth ollies	7	7	8	5	12
Contribution of yollies to total growth	28	10	47	1	28

Table 7b: Annual average net sales growth (2004-07) of yollies and ollies by region (in %)

Net sales	World	EU	US	Japan	RoW
Total growth	9	8	8	7	15
Growth yollies	14	12	13	4	18
Growth ollies	8	8	7	7	14
Contribution of yollies to total growth	27	6	23	1	31

When comparing R&D growth performances within the same age category, the EU only has a small disadvantage relative to the US, both for yollies and for ollies. In the US, yollies have the highest contribution to overall R&D growth, being responsible for almost half of US R&D growth. In the EU by contrast, yollies account for only 10 percent of total EU R&D growth, despite their higher growth rate as compared to ollies, but because of their lower weight. Hence, the superior contribution of yollies to R&D growth in the US is mostly a structural effect, from having more yollies in sectors characterised by high R&D growth, not so much from having yollies with stronger growth performance.

Also on sales growth performance, the differences between the EU and the US are less pronounced when comparing within age categories. In both regions, yollies have a higher differential sales growth performance as compared to the US. The higher contribution of yollies to sales growth in the US is therefore only due to having more yollies. Japan is the only case where ollies have a higher sales growth performance than the yollies, further confirming its 'old' model.

4.2 A sectoral look into the EU-US R&D growth differential

Most of the difference in the contribution of yollies to total growth between the US and the EU is due to the EU having fewer yollies, as on average, the difference in growth performance of yollies in the US and the EU, is not big. To further unravel this effect, the next table looks at the R&D growth performance of US and EU yollies by sector, most particularly for (young) sectors in the ICT and health nexus.

US yollies grow faster than EU yollies in biotechnology and healthcare. And since, on top of this, there are more yollies in the US in these sectors, the contribution of yollies to growth in these

Table 8: Growth rate of R&D (2004-07) and contribution of yollies to total R&D growth Healthcare and ICT sectors

	European Union				United States			
	Ollies growth	Yollies growth	Overall growth	Contribution of yollies to growth	Ollies growth	Yollies growth	Overall growth	Contribution of yollies to growth
Pharmaceuticals	13	30	14	4	9	15	10	7
Biotechnology	8	12	11	78	-13	16	15	103
Healthcare	9	11	9	25	11	19	14	42
Computer hardware	2		2		1	11	7	93
Computer services	9	13	12	84	2	5	2	14
Internet					0	37	37	100
Semiconductors	5	6	5	63	7	11	9	53
Software	12	15	13	53	3	12	12	99
Telecoms equipment	13	21	13	2	13	14	14	65
Telecoms services	18	6	17	3	56	0	56	0
Electronic equipt.	1	22	6	83	4	14	6	34
TOTAL	**7**	**12**	**7**	**10**	**8**	**13**	**10**	**47**

Notes: Growth numbers are average annual growth rates (2004-07). Bold are the young sectors. First box is the health-box, second box is the ICT. In the internet sector the EU has no leading innovators. In the US, there are only yollies and internet has no 2004 value.

sectors is much greater in the US than in the EU. In pharmaceuticals, the EU's R&D growth performance is much stronger than the US. This differential growth performance holds both for ollies and yollies, but it is stronger for yollies. Unfortunately, there are few yollies in this sector.

In telecoms equipment, EU yollies grow faster than US yollies, but unfortunately there are few yollies in this sector, such that their contribution to growth in this sector is almost negligible. In software, EU yollies have grown faster than US yollies, but in this sector especially EU ollies have a strong positive growth differential relative to their US counterparts. In semiconductors, both EU ollies and yollies score below their US counterparts.

6 SUMMARY OF MAIN FINDINGS

Young leading innovators, although typically smaller in R&D size than their older counterparts, have a higher R&D intensity and higher R&D and sales/employment growth rates. They shape 'young sectors' in the health and ICT nexus. All these young sectors are also R&D-intensive sectors, ie their R&D intensity is twice the total average. In these young sectors, old firms are also more R&D intensive, incited by the technological opportunities for new developments, perhaps pursuing follow-up innovations on the breakthrough innovations launched by the young firms and/or stirred by the competition of the young firms in their sector.

Young leading innovators in young sectors are pivotal for understanding the EU's gap in R&D performance as compared to the US. The superior US R&D performance can to a large extent be attributed to young leading innovators playing a more pivotal role in the US R&D landscape. First, the EU has fewer young firms among its leading innovators than the US. But this effect only accounts for about one-third of the US-EU differential. The largest part of the differential (55 percent) is due to the fact that the young leading innovators in the EU are less R&D intensive than in the US. Also, old leading innovators in the EU are less R&D intensive due to the sector composition effect. When comparing within sectors, EU ollies are more R&D intensive than US ollies. But this differential is far less important in explaining the overall gap (11 percent).

Further unravelling why EU-based young leading innovators are on average less R&D intensive than their US counterparts shows that this is almost entirely due (92 percent) to a different sectoral composition. US-based young leading innovators are more present in high R&D-intensive young sectors. When looking within sectors, there are only minor differences in R&D performance of young leading innovators from the EU as compared those from the US.

The major implication from the analysis is that closing the EU-US private R&D gap is mostly a structural issue. It will mean the EU having more yollies, but especially having them in the new (R&D-intensive) sectors. The policy agenda needed to address this structural challenge is daunting. It is discussed in detail in the accompanying Bruegel Policy Brief 2010/06.

BOX 4: THE R&D SCOREBOARD/YOLLIES ANALYSIS, SOME CAVEATS

A number of caveats need to be mentioned, to caution the use of the results as well as to suggest avenues for future research.

On the age classification
The classification of companies into 'young' and 'old' has been done using the date of foundation of the company, or in case of M&A the age of the oldest entity. This creates a bias against rejuvenated older companies (such as Nokia or Syngenta) and sectors that went through technology and/or market transformations (such as telecoms services or media). This could matter for the analysis of EU-US differences if the EU is specialised in these 'transformed' sectors and if the EU would have more of these 'transformed' firms. Nevertheless, the analysis shows that these transformed sectors are not highly R&D intense, and that these older, transformed firms, in terms of their collective weight, do not offset the EU's 'yollies' disadvantage.

On the regional classification
Firms are classified as EU- or US-based depending on the ultimate ownership of the company and not by the location of its activities. When EU young firms are taken over by US entities, the R&D, growth and jobs created by these companies are accredited to the US rather than the EU. Our search of the websites of sampled companies suggests however that this phenomenon is not too pervasive.

Most of the leading innovators in the scoreboard, old and new, are active beyond their region of ownership. An analysis based on location of a firm's activities rather than ownership could yield different results.

On the size of the sampled firms
The analysis only covers firms that have reached an R&D size sufficient to qualify them for entering the scoreboard of largest R&D spenders. The EU's lack of yollies could thus be explained by i). a lack of start-ups and/or ii). a lack of firms growing large enough to feature in the scoreboard. The scoreboard data does not allow these possible explanations to be disentangled, though the separate problems of firm entry and firm growth come with different policy implications.

On R&D performance
The analysis only looks at R&D performance, showing that EU yollies persistently lag their US counterparts in this respect. But should we care about their R&D performance? Perhaps young EU firms are doing well on world markets, basing their growth not on R&D but on other less R&D-intensive strategies. The analysis does indeed suggest that the sales growth performance gap between EU and US yollies is smaller than the R&D gap and that EU young firms are based more in non high-tech sectors compared to US young firms.

On 2007
The analysis is a snapshot of 2007 only. Perhaps the EU is a latecomer in many new sectors such as the internet sector. EU yollies in these sectors are perhaps only more recently starting to appear in the scoreboard. The EU might also be more successful in other new emerging sectors, such as green technologies, which are only recently becoming large enough to feature in the scoreboard. Analysis of future releases of the scoreboard data may validate these optimistic views.

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ANNEX 1: TABLES

Table A1: Contribution of yollies by sector					
	Yollies as % of firms	Yollies share of R&D	RDI yollies	RDI ollies	Sector's share of total R&D
Aerospace & defence	20.5	3.1	4.5	2.8	4.2
Automobiles & parts	14.5	3.7	4.2	3.8	17.5
Biotechnology	90.9	91.8	9.2	26.7	2.2
Chemicals	11	4.1	3.2	0.8	4.5
Commercial vehicles & trucks	4.5	1.8	2.9	2.3	1.7
Computer hardware	63.4	36.4	4.6	3.8	4.6
Computer services	64.3	12.6	5.5	4.6	1.8
Construction & materials	0	0	0.9		0.6
Electrical components & equipment	19.4	10.2	3.3	4.1	2.6
Electricity	6.7	1.7	1	0.3	0.6
Electronic equipt/office equipment	26.2	8.7	5.6	2.1	5.1
Fixed & mobile telecommunications	30	10.9	1.7	1	2.4
Food & drug retailers & general retailers	0	0	0.3		0.3
Food, beverages & tobacco	3.4	0.9	1.5	0.7	1.5
Gas, water & multiutilities	0	0	0.3		0.2
General industrials	8.6	3.7	2.2	1.3	2.2
Health care equipment & services	25.6	28.6	6	10.6	1.7
Household goods	10.5	3.5	2.2	4.3	1
Industrial machinery	5.9	5.1	2.4	7	1.3
Industrial metals	11.1	5.6	0.7	3.2	0.6
Internet	100	100		10.9	1
Leisure goods	26.9	9.6	6	13	3.8
Media	30	9.2	1.7	1.1	0.5
Oil equipment, services & distribution and oil & gas producers	6.7	7.7	0.4	0.6	2
Personal goods	6.7	4.4	2.1	2.9	0.6
Pharmaceuticals	28.2	3.4	15.5	15.1	17.2
Semiconductors	70.7	53.1	13.8	15.2	6.7
Software	85.9	88.2	13.8	15.3	4.6
Support services	30.8	15	2.2	2.1	0.3
Telecommunications equipment	64.1	34.4	12	13.5	6.6
Travel & leisure	50	48	9.9	1.6	0.3
TOTAL	33.7	18.9	3.2	6.4	100

Table A2: RTA indexes				
	EU	Japan	US	RoW
Aerospace & defence	1.7	0	1.1	0.3
Automobiles & parts	1.4	1.5	0.6	0.3
Biotechnology	0.2	0.1	2.2	0.5
Chemicals	1.3	1.4	0.6	0.7
Commercial vehicles & trucks	1.3	0.6	1	0.8
Computer hardware	0	2.4	1.2	0.6
Computer services	0.2	1.2	1.7	0.3
Construction & materials	1.3	2.2	0.2	0.6
Electrical components & equipment	1.6	1.4	0.2	1.6
Electricity	1.6	1.4	0	2.2
Electronic equipment and electronic office equipment	0.2	2.2	0.4	3.5
Fixed line & mobile telecommunications	1.7	1.1	0.2	1.7
Food & drug retailers & general retailers	2.1	0	0.9	0
Food, beverages & tobacco	1	0.9	0.7	2.1
Gas, water & multiutilities	2.4	1	0.2	0
General industrials	0.6	0.8	1.5	0.7
Health care equipment & services	0.7	0.1	1.8	0.3
Household goods	1	0.5	1.6	0
Industrial machinery	1.9	0.9	0.2	1.2
Industrial metals	1.1	2	0.3	1.6
Internet	0	0	2.5	0.2
Leisure goods	0.4	3.8	0.4	0.1
Media	2.2	1.1	0.2	0
Oil equipment, services & distribution & oil & gas producers	1	0.1	0.8	3.1
Personal goods	1.1	0.9	0.7	1.9
Pharmaceuticals	1	0.5	1.1	1.5
Semiconductors	0.5	0.3	1.7	1.1
Software	0.6	0	2	0.3
Support services	0.9	0.4	1.2	1.7
Telecommunications equipment	1.6	0	1.1	0.8
Travel & leisure	0	2.8	1.1	0.6

Note: RTA are calculated as the share of the region in total sectoral R&D relative to the share of the region in overall R&D. A RTA value higher than 1 reflects that the region is technology-specialised in this sector.

Table A3: R&D annual average growth (2004-07) of yollies and ollies by sector (%AAGR)

	Total sectoral R&D growth	Yollies' R&D growth	Ollies R&D growth	Yollies contribution to sectoral R&D growth	Sector contribution to total R&D growth
Aerospace & defence	11	13	11	4	5
Automobiles & parts	5	-4	5	-4	11
Biotechnology	14	16	1	98	4
Chemicals	3	10	3	10	2
Commercial vehicles & trucks	12	13	12	2	2
Computer hardware	7	13	5	58	4
Computer services	2	11	1	47	1
Construction & materials	4	0	4		0
Electrical components & equipment	-2	6	-3	-25	-1
Electricity	5	45	5	10	0
Electronic equipt/office equipment	7	17	6	19	4
Fixed/mobile telecommunications	12	3	13	3	3
Food/drug retailers/general retailers	18	0	18		0
Food, beverages & tobacco	3	33	3	8	1
Gas, water & multiutilities	-1	0	-1		0
General industrials	6	31	6	14	2
Health care equipment & services	12	18	11	37	2
Household goods	7	8	6	4	1
Industrial machinery	10	25	10	10	1
Industrial metals	8	26	7	15	1
Internet	37	37	0	100	3
Leisure goods	1	21	0	112	1
Media	11	19	10	9	1
Oil equipment, services & distribution & oil & gas producers	13	19	13	10	3
Personal goods	6	1	6	1	0
Pharmaceuticals	12	18	12	5	24
Semiconductors	9	12	7	61	7
Software	12	12	10	90	6
Support services	4	4	4	13	0
Telecommunications equipment	12	12	13	33	10
Travel & leisure	14	15	12	75	0
TOTAL	8	13	7	28	100

Table A4: R&D intensity and proportion of yollies by region and by sector (in %)

Sector	EU				US			
	RDI		Yollies as % of		RDI		Yollies as % of	
	Yollies	Ollies	Firms	R&D	Yollies	Ollies	Firms	R&D
Aerospace & defence	10.5	6.5	18.8	2	1.8	3.4	23.5	3.8
Automobiles & parts	3.6	4.7	7.7	0.6	4.2	3.8	35.3	14.5
Biotechnology	18.3	10.4	77.8	72.6	27	11.9	97.4	97.4
Chemicals	0.6	3.4	15	3.7	0.9	2.9	20.8	7.2
Commercial vehicles & trucks		3.6	0	0	2.3	2.7	11.1	4.4
Computer hardware		5.6	0	0	5.7	3.6	65.2	62.1
Computer services	3.5	4.5	80	80.1	6.1	5.7	25	4.7
Construction & materials		0.7	0	0		1.1	0	0
Electrical components & equipment	4.3	3.4	11.1	3.8	3.8	1.9	25	17
Electricity	0.3	1.1	20	3.4				
Electronic equipment & electronic office equipment	5.9	6.1	45.5	30.3	5.3	5.5	29.4	15
Fixed & mobile telecommunications	0.7	1.7	20	8.1		0.8	0	0
Food & drug retailers & general retailers		0.4	0	0		0.3	0	0
Food, beverages & tobacco		1.8	0	0		1.2	0	0
Gas, water & multiutilities		0.2	0	0		1.7	0	0
General industrials		2.9	0	0	1.3	2.5	16.7	1.8
Health care equipment & services	11.1	3.8	8.3	21.3	10.5	7.5	36.4	32.3
Household goods	9.9	2.3	16.7	6.5	2.4	2.5	12.5	2.5
Industrial machinery	8.1	2.8	8	6.1		1.7	0	0
Industrial metals		0.5	0	0	6.6	0.8	50	33.8
Internet					10.9		100	100
Leisure goods	11.8	5.9	25	3.5	19.9	4.6	44.4	53.7
Media	0.9	2.9	20	5	1.2	0.2	66.7	65.1
Oil & gas		0.3	0	0		0.4	0	0
Personal goods		1.6	0	0		1.7	0	0
Pharmaceuticals	25.1	15.5	13	2.3	14.3	15.3	48.3	5.2
Semiconductors	17.2	16.1	75	70.3	18.4	16	72.9	44.9
Software	17.3	14	85.7	49.2	14.9	13.1	86	97.5
Support services	2.6	2.1	40	23.5	1.8	4.2	40	18.4
Telecommunications equipment	18.4	13	28.6	1.2	14.2	10.7	73.9	62.5
Travel & leisure					7	9	60	80.6
TOTAL	4.4	2.9	20.1	7.1	10.2	3.5	51.7	35.1

ANNEX 2: DECOMPOSITION FORMULAS

Box 1:

$$RDI^{y} - RDI^{o} = \sum_i RDI_i \left(w_i^y - w_i^o\right) + \sum_i w_i \left(RDI_i^y - RDI_i^o\right)$$

where: RDI = R&D intensity defined as R&D investments divided by net sales

$$RDI^{y} = \sum_i w_i^y RDI_i^y$$

$$RDI^{o} = \sum_i w_i^o RDI_i^o$$

$$RDI_i = \left(RDI_i^y + RDI_i^o\right)/2$$

$$w_i = \left(w_i^y + w_i^o\right)/2$$

wiy = share of the sector in total number of young firms
wio = share of the sector in total number of old firms

Box 2:

$$RDI^{us} - RDI^{eu} = \sum_i \left(w_i^{*us,y} RDI_i^{us,y} + w_i^{*us,o} RDI_i^{us,o}\right) - \sum_i \left(w_i^{*eu,y} RDI_i^{eu,y} + w_i^{*eu,o} RDI_i^{eu,o}\right)$$

$$= \sum_i RDI_i^y \left(w_i^{*us,y} - w_i^{*eu,y}\right) + \sum_i RDI_i^o \left(w_i^{*us,o} - w_i^{*eu,o}\right) + \sum_i w_i^y \left(RDI_i^{us,y} - RDI_i^{eu,y}\right) + \sum_i w_i^o \left(RDI_i^{us,o} - RDI_i^{eu,o}\right)$$

structural young + structural old + intrinsic young + intrinsic old

where:

$$RDI_i^y = \left(RDI_i^{us,y} + RDI_i^{eu,y}\right)/2$$

$$RDI_i^o = \left(RDI_i^{us,o} + RDI_i^{eu,o}\right)/2$$

$$w_i^y = \left(w_i^{*us,y} + w_i^{*eu,y}\right)/2$$

$$w_i^o = \left(w_i^{*us,o} + w_i^{*eu,o}\right)/2$$

w*ius/eu,y/o = share of young/old firms in the us/eu sector total number of firms

Box 3:

$$RDI^{us,y} - RDI^{eu,y} = \sum_i RDI_i^y \left(w_i^{us,y} - w_i^{eu,y}\right) + \sum_i w_i^y \left(RDI_i^{us,y} - RDI_i^{eu,y}\right)$$