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## TRENDS IN RESEARCH AND DEVELOPMENT INVESTMENT OF TRANSNATIONAL CORPORATIONS BROKEN DOWN BY SECTOR<sup>2</sup>

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*The article aims to identify trends in R&D activities of transnational corporations in 25 sectors. The analysis covered the top 1000 TNCs in terms of R&D investment in 2003–2015. The investigation confirmed the existence of varying trends between sectors, despite the overall marked increase in R&D investment. The study also determined the characteristics of geographical locations of the top five sectors, strongly dominated by US TNCs. In addition, four groups of sectors were identified depending on the R&D trends observed in the period under analysis.*

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**Keywords:** multinationals, TNCs, R&D, industries, sectors, trends, research and development activities.

**JEL Classification Codes:** F23, M21, O30.

### Introduction

Transnational corporations (TNCs) are key players in global research and development (R&D), exerting enormous influence on the state of play and changes in the world's R&D (UNCTAD, 2005). For a long time, R&D activities of TNCs have been strongly concentrated in sectoral terms, owing to the existence of knowledge-intensive industries with traditions of very intensive R&D investment (Odrobina, 2016). It seems, however, that every corporation operating in the global environment should increase its

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research and development investment. On the other hand, it must be considered that specific characteristics of business activities in particular sectors affect the R&D investment of corporations operating the sector concerned.

This study aims to determine trends in the R&D investment of corporations operating in particular sectors and to identify changes in the locations of TNCs from five sectors characterised by the most intensive R&D investment. An additional objective is to classify the other sectors according to the level and trends of R&D investment.

Thus far, investigations have focussed on examining sectoral R&D in aggregate classifications based on several sectors (Karlsson, 2006; OECD, 2008; UNCTAD, 2011; European Commission, 2012a; De Prato, Nepelski, 2013; Booz&co., 2014; Poznańska, Kraj, 2015), on high-technology sectors only (Jaruzelski, Staack, Goehle, 2014; European Commission 2014a) or on case studies (Uppenberg, 2009; Hiratuka, 2011; Lu, Chen, 2012; Zimmermann, 2015).

In this article, the analysis by sector covers corporations included in the top 1000 TNCs with the highest R&D investment (hereinafter referred to as the Top 1000) in 2003–2015. On the basis of rankings published by the European Commission, 25 sectors were selected for examination, which allowed to capture more detail of and insights into trends and changes in the research and development investment of TNCs in individual sectors. The study is composed of three parts. The first part describes general trends in the R&D investment of TNCs. The second section focusses on dynamic analysis of the top five sectors in terms of R&D investment. Finally, the third part presents the results of the classification of the other sectors according to trends in R&D investment.

## **Dynamics of the R&D investment of corporations by sector**

It must be emphasised that in 2003–2015 R&D investment in the Top 1000 increased 2.1 times and a similar trend characterised the ten TNCs with the highest R&D investment (Top 10). The growth was slightly faster – by a factor of 2.3 – for the ranking champion (i.e., subsequently: Ford, Daimler, Ford, Pfizer, Microsoft, Toyota, Toyota, Roche, Toyota and, four times, Volkswagen). The least robust (1.9-fold) increase was noted in the Top 50 TNCs. At the same time, a significant rise by a factor of 2.5 was observed for the median and the third quartile, whereas the strongest growth characterised the first quartile (3.8 times). Therefore, it can be concluded that the 13 years covered saw the most intensive R&D investment in corporations ranked 750th to 1,000th. Nevertheless, very strong dominance of the top performers, i.e. the most powerful TNCs, is still clear (Table 1).

**Table 1. Description of R&D in the Top 1000 (EUR million)**

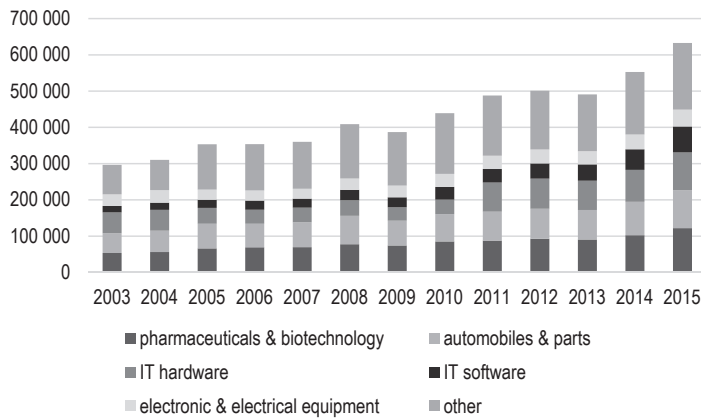
Attribute	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Champion	5 946	5 658	6 782	5 763	5 584	7 610	6 768	7 181	7 755	9 515	11 743	13 120	13 612
3 <sup>rd</sup> quartile	202	207	242	249	253	304	292	326	363	382	381	423	494
median	83	88	103	105	105	123	119	137	145	156	153	173	208
1 <sup>st</sup> quartile	32	50	60	60	61	72	70	80	88	94	95	104	122
Overall Top 10	48 559	49 323	55 108	52 251	52 595	58 591	54 539	62 763	68 809	71 789	75 412	89 168	101 700
Overall Top 50	147 838	150 926	160 711	165 798	166 978	183 988	172 640	193 708	214 884	218 272	214 658	242 513	278 937
Overall Top 1000	296 427	310 359	353 527	353 657	360 063	408 862	387 191	439 277	488 015	501 124	490 958	552 762	632 901

Source: own calculations based on European Commission (2004a; 2004b; 2005a; 2005b; 2006a; 2006b; 2007a; 2007b; 2008a; 2008b; 2009a; 2009b; 2010a; 2010b; 2011a; 2011b; 2012b; 2013; 2014b; 2015; 2016).

Undoubtedly, the analysis of sectors characterised by the highest R&D investment shows continuing strong dominance of five of them, namely: (1) pharmaceuticals and biotechnology, (2) automobiles and parts, (3) IT hardware, (4) IT software and (5) electronic and electrical equipment (Figure 1). In 2003–2004, TNCs from the five sectors accounted for ca. three-fourths of the R&D investment of the Top 1000 TNCs. Subsequently, in 2005–2010 the share of the five sectors declined from approx. 65% to ca. 62%, which meant increasing research and development activities of corporations operating in the other 20 sectors. However, starting from 2011, the proportion of the other sectors showed a steady decrease to a mere 29% in 2015, which indicates growing R&D concentration in the aforementioned five sectors.

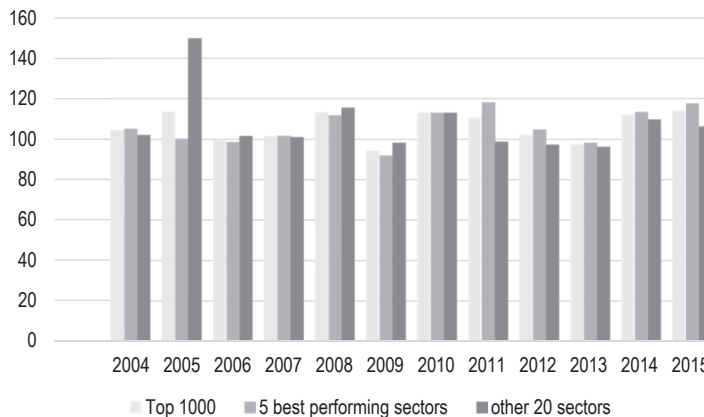
Overall, in 2003–2015, the R&D investment of the Top 1000 corporations totalled EUR 5,575.1 billion, of which pharmaceuticals & biotechnology represented EUR 1,047.5 billion, automobiles and parts – EUR 977.2 billion, IT hardware – EUR 794.9 billion, IT software – EUR 454.0 billion, electronic and electrical equipment – EUR 447.2 billion and the other 20 sectors – EUR 1,854.3 billion (Figure 1).

As already mentioned, the R&D investment of the Top 1000 TNCs under analysis more than doubled in 2003–2015; nevertheless, it is worth taking a closer look at the growth rate of R&D investment in specific years and between sectors (Figure 2). For the Top 1000, the most buoyant increases (by over 10%) on the previous year were noted in 2005, 2008, 2010, 2011, 2014 and 2015. The robust growth observed in 2010 and 2014 resulted from decreased investment in the previous years, as a consequence of the global financial crisis and the second wave thereof, which reflected considerable susceptibility of the research and development investment of TNCs to crisis developments.



**Figure 1. The Top 1000 by sector (EUR million)**

Source: as in Table 1.



**Figure 2. Growth rate of the R&D investment of the Top 1000 by sector (previous year=100)**

Source: as in Table 1.

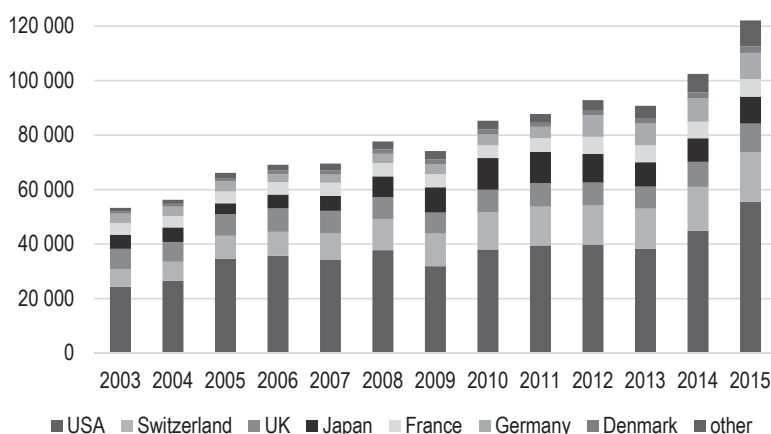
As regards the situation in 2005, it was caused by soaring R&D investment (up by 50.2%) in the other sectors accompanied by stagnation observed in the 5 best performing industries. As a matter of fact, the year 2005 witnessed spectacular and intensive R&D investment in five new sectors in comparison with 2004. Those were financial services (from EUR 175 million in 2004 to EUR 1,857 million in 2005), media and entertainment (from EUR 3,650 million to EUR 17,295 million), telecommunications (from EUR 6,363 million to EUR 29,741 million), travel and leisure (from EUR 368 million to EUR 607 million), transportation (from EUR 157 million to EUR 453 million). The high dynamics of 2011 and 2015 were directly attributable to greater intensity of R&D investment in the top five sectors; in 2011, the main driver was more than twofold growth in investment in IT hardware (from EUR 40 billion in 2010 to EUR 80.6 billion in 2011), whereas 2015

saw increased (against 2014) R&D investment in all the top five industries: IT software (by 27%), pharmaceuticals and biotechnology (by 19%), IT hardware (by 18%), automobiles and parts (by 14%), electronic and electrical equipment (by 14%).

## Analysis of the sectors characterised by the most intensive R&D investment

Further analysis focusses on identifying developments and trends in the five top performing sectors in geographical terms, in order to capture changes in the locations of TNCs involved in R&D.

The transnational corporations with the highest R&D investment in pharmaceuticals and biotechnology are based in the Triad countries, with a very strong dominance of US TNCs, accounting for nearly half of R&D in the whole sector (Figure 3). In addition, Swiss and German TNCs also had significant and strengthening positions, whereas from 2010 Japanese corporations gradually diminished in importance but still ranking fourth after UK TNCs. Over the years, increasing investment was observed in the case of German TNCs and TNCs from other countries, in particular TNCs headquartered in Ireland, Israel and India.

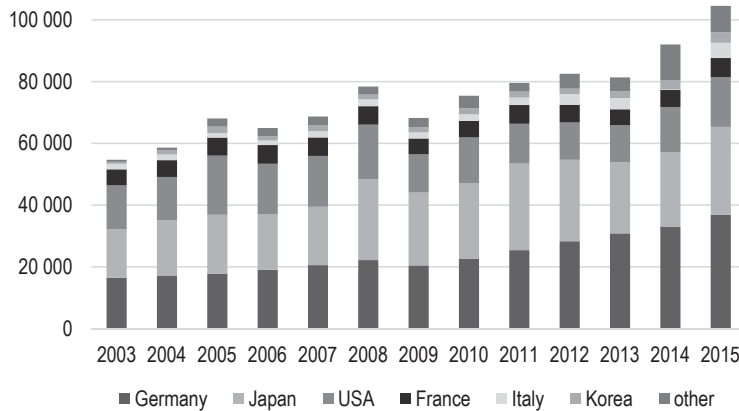


**Figure 3. R&D of the Top 1000 in pharmaceuticals and biotechnology (EUR million)**

Source: as in Table 1.

At the same time, R&D in automobiles and parts (Figure 4) is clearly dominated by German, Japanese and US TNCs, accounting for a combined share exceeding 81% of the R&D of the sector as a whole (against 85% in 2003), only from 2014 the proportion dropped to 78%. A stable position was maintained by French TNCs, whereas Korean automotive TNCs steadily gained in significance. Evidently, TNCs from other countries were relatively weak in the industry concerned, although it must be pointed out that

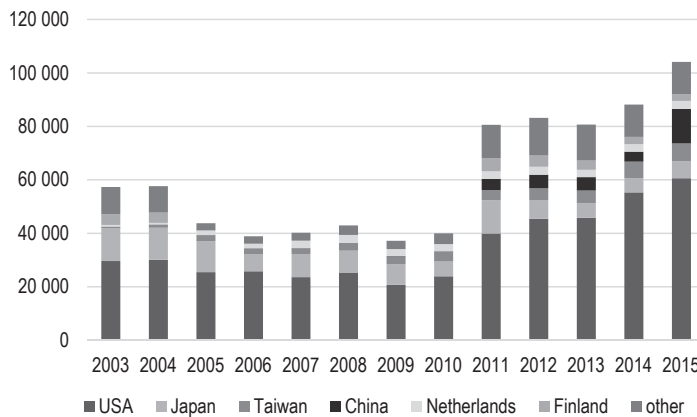
whereas in 2003 they represented a mere 1.3% of R&D investment in the sector, in 2015 the share jumped to 8.2% (and in 2014 to as much as 12%) and from the early 2010s the group also included Chinese, UK and Indian TNCs.



**Figure 4. R&D of the Top 1000 in automobiles and parts (EUR million)**

Source: as in Table 1.

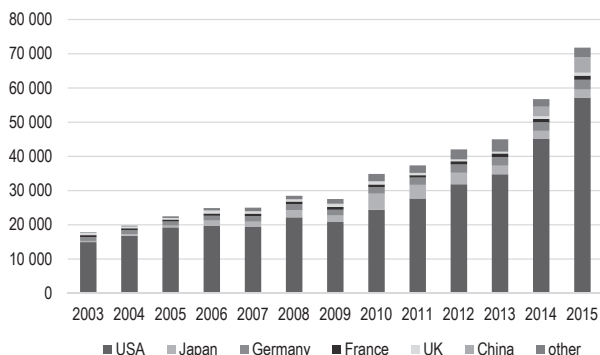
As regards transnational corporations active in IT hardware, after several years of decline and stagnation in R&D, from 2011 they evidently intensified their R&D investment, to exceed EUR 104 billion in 2015 (Figure 5). The sector in question is very strongly dominated by TNCs based in the USA, strengthening their share in the industry from 52% (2003) to 58% (2015). Japanese TNCs steadily lost ground to Taiwanese corporations and, from 2011, to TNCs from China which moved up to the second position in 2015. European TNCs are relatively weak in the sector under examination.



**Figure 5. R&D of the Top 1000 in IT hardware (EUR million)**

Source: as in Table 1.

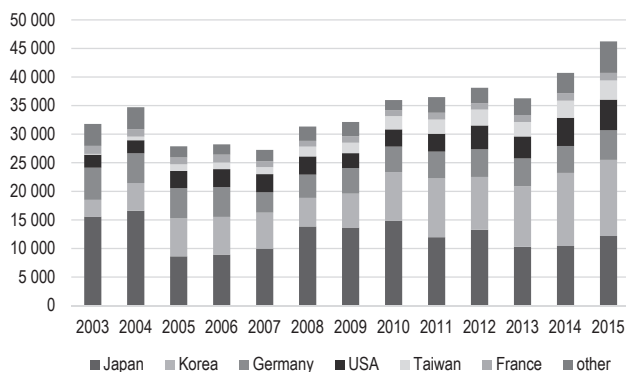
At the same time, the continuing upward trend of R&D investment in IT software was unquestionably led by US TNCs, accounting for ca. 80% throughout the period in question (Figure 6). Increasing R&D investment also characterised German TNCs, whereas Japanese TNCs diminished in importance. From 2014, new entrants in the sector were TNCs based in China, immediately ranking second behind the USA in terms of R&D investment.



**Figure 6. R&D of the Top 1000 in IT software (EUR million)**

Source: as in Table 1.

The sector of electronic and electrical equipment was led by Asian TNCs, accounting for ca. 65% of R&D investment (Figure 7). It must be noted that until 2010 the largest R&D investment characterised Japanese TNCs but starting from 2011 the position of Korean corporations gradually strengthened. Furthermore, TNCs from Taiwan steadily gained in importance, increasing their R&D investment more than 23 times in the period covered. Basically, stable R&D activities were carried out by German TNCs, whereas continuing growth was noted by US transnational corporations, from 2014 ranking third in terms of R&D investment (outperformed by Korean and Japanese TNCs), although the level was ca. 2.5 times lower that in the case of TNCs based in Korea.



**Figure 7. R&D of the Top 1000 in electronic and electrical equipment (EUR million)**

Source: as in Table 1.

## Trends in the R&D investment of transnational corporations in the other sectors

Apart from the five sectors performing best in R&D, the study also covered twenty other sectors in which the Top 1000 transnational corporations operate. Based on the analysis of R&D investment by sector in 2003–2015, those were broken down into the following four groups: (1) sectors with fast-growing R&D, (2) sectors characterised by stable growth in R&D, (3) stagnant sectors, (4) sectors relatively poorly engaged in R&D.

As already indicated, the research and development investment of TNCs more than doubled in the period under examination. However, it must be stressed that certain sectors showed spectacular growth, which mostly concerned industries previously not very significantly involved in R&D activities (Table 2). A record-high growth rate of R&D investment was noted in mining (90.1 times in the period covered), with a rapid rise in 2015. The second highest growth rate characterised financial services (70.9 times) but the breakthrough investment in that sector was recorded in 2005. The third best performer in this respect was travel and leisure (investment increasing 8.6 times) but in this case greater involvement in R&D was observed in 2005–2008. Growth by a factor of 4.9 characterised media and entertainment, which a breakthrough in 2005. At the same time, in construction a steady rise in R&D investment resulted in the overall R&D increasing 4.6 times. Other sectors with above-average growth were general retailers and support services (their R&D investment increasing 3.8 and 3.5 times respectively) but the former experienced a fall in R&D in 2015.

**Table 2. Sectors with the fastest-growing R&D investment in the Top 1000 (EUR million)**

sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
media & entertainment	3 198	3 650	17 295	16 317	15 240	18 496	15 462	17 132	18 707	15 888	13 171	13 978	15 613
financial services	176	174	1 858	2 789	3 082	3 691	5 660	7 396	8 172	8 207	9 332	15 343	12 499
mining	106	224	235	422	664	1 351	1 057	964	1 304	1 218	823	827	9 530
construction & materials	2 011	1 664	1 610	1 603	1 898	2 680	3 274	4 605	5 273	5 047	5 661	7 060	9 274
support services	1 296	1 418	1 235	1 212	1 031	1 086	1 255	1 412	2 397	2 418	2 330	2 272	4 548
general retailers	707	879	1 659	2 004	2 115	2 512	2 584	3 525	5 253	2 941	3 073	3 985	2 716
travel & leisure	241	368	607	912	798	1 251	1 258	1 435	1 585	1 623	1 667	2 008	2 075

Source: as in Table 1.



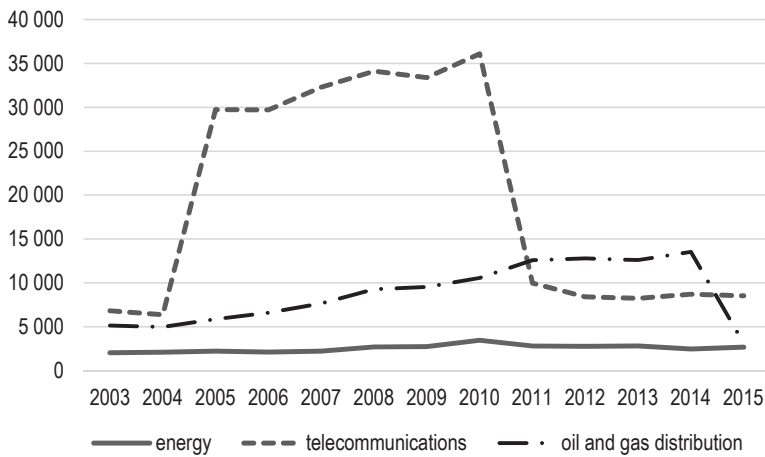
Table 3 presents eight sectors classified as industries characterised by stable growth in R&D. All the sectors in question were characterised by relatively significant R&D investment as early as 2003, with chemicals, aerospace and defence at the forefront. Furthermore, throughout the period covered the sectors concerned noted steady increases in R&D investment; the only exception was industrial engineering, experiencing a collapse in R&D in 2005–2010, but due to a marked recovery noted from 2011 the industry was classified in that group (investment having increased 2.3 times in 2015 against 2003).

**Table 3. Sectors characterised by stable growth in R&D investment in the Top 1000 (EUR million)**

sector	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
industrial engineering	9 477	9 168	3 879	4 001	4 342	5 045	5 206	6 509	17 209	20 640	19 071	19 638	22 127
chemicals	15 396	15 710	16 148	16 496	15 838	18 435	17 083	19 361	20 538	18 624	17 295	18 401	20 481
aerospace & defence	11 005	11 718	14 599	15 780	14 935	15 136	14 539	15 686	17 512	17 426	18 098	19 458	20 097
general industrials	5 776	5 925	8 833	8 539	7 861	11 606	11 262	13 340	13 839	15 658	14 934	15 430	17 400
health care	6 096	6 396	6 019	5 869	5 836	7 075	7 677	8 711	9 509	10 234	10 021	11 029	12 491
food & tobacco	4 439	4 626	4 729	5 013	5 132	6 219	7 000	8 073	8 704	7 555	7 534	8 031	8 610
household goods	5 571	5 653	5 568	5 495	5 563	6 042	5 878	6 011	7 233	6 816	6 713	7 009	8 293
metals	1 361	1 652	2 098	2 089	2 191	2 779	2 646	2 931	2 814	3 203	2 870	2 723	3 182

Source: as in Table 1.

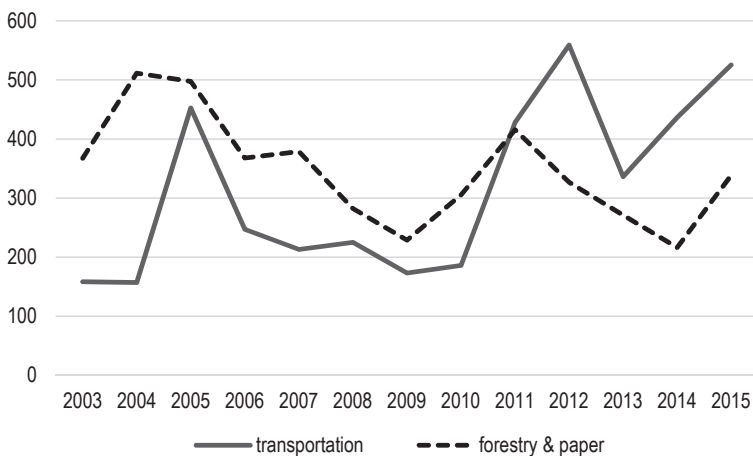
Three industries were classified as stagnant sectors (Figure 8). Interestingly, telecommunications made fast-growing R&D investment until 2010 but then experienced a collapse in 2011, followed by a steady downward trend. That development is attributable, at least in part, to a fall in the number of TNCs in the sector concerned as a result of their expanding operations and, consequently, re-classification of certain corporations to industrial engineering. In turn, after many years of rising R&D, in oil and gas distribution investment dropped more than four times in 2015 against 2014, below the 2003 level of R&D investment. At the same time, in the energy sector the involvement of TNCs in R&D remained almost unchanged.



**Figure 8. Sectors with stagnant R&D investment in the Top 1000 (EUR million)**

Source: as in Table 1.

TNCs operating in transportation as well as in the forestry and paper sector, even though included in the Top 1000, must be regarded as relatively poor R&D performers (Figure 9). Moreover, both sectors typically show significant fluctuations in R&D investment in the period under analysis, with an additional downward trend in the forestry and paper industry.



**Figure 9. Sectors relatively poorly engaged in R&D in the Top 1000 (EUR million)**

Source: as in Table 1.

## Conclusions

Despite the overall upward trend of the R&D investment of transnational corporations in 2003–2015, varying trends were observed in the R&D investment of corporations operating in particular sectors. It was demonstrated that R&D remained strongly dominated by TNCs from five sectors: pharmaceuticals and biotechnology, automobiles and parts, IT hardware, IT software (the fastest growers) as well as electronic and electrical equipment. It seems likely that in the coming years R&D growth in the five sectors concerned will continue to be more dynamic than in the other twenty industries.

The analysis of geographical locations in the top five sectors in terms of R&D investment indicated the strongest position of US transnational corporations, mostly operating in IT software and IT hardware. Asian TNCs (based in Korea, Japan and Taiwan) lead the way in electronic and electrical equipment. At the same time, the sector of automobiles and parts is dominated by corporations from Europe (Germany, France and Italy) and from Japan. With regard to pharmaceuticals and biotechnology, the top performers in R&D are primarily US and European TNCs, with those headquartered in Switzerland and the United Kingdom at the forefront. It is also worth pointing out that strong new entrants from China appeared in two sectors (IT software, IT hardware), although the five top performing industries tend to be dominated by TNCs from the Triad.

In addition, four groups of sectors were identified depending on the trends of R&D investment observed in 2003–2015. Eight sectors were classified as industries characterised by stable growth, with traditions of relatively strong involvement in R&D, i.e. industrial engineering, chemicals, aerospace and defence, general industrials, health care, food and tobacco producers, household goods and metals. Seven sectors were included in the group of the fastest growers (media and entertainment, financial services, mining, construction and materials, support services, travel and leisure, retailers), with a common characteristic of inclusion in more intensive R&D investment only during the period under examination. Three sectors were regarded as stagnant industries: telecommunications, the energy industry as well as oil and gas distribution, experiencing a downward trend. Finally, two sectors (transportation, the forestry and paper industry) were considered to be poorly engaged in R&D, on account of low R&D investment and significant fluctuations in the years covered.

By no means does this investigation exhaust the issues addressed but it will be the basis for more in-depth analyses of the R&D of transnational corporations operating in particular sectors, taking account of geographical and microeconomic aspects. It also seems justified to study the internationalisation of R&D by TNCs in order to determine the specific characteristics of the R&D of TNCs by sector.

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