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Article

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Research-Based Companies Perform Better

by Alexander Eickelpasch

The past ten years have seen an expansion in industrial research. There has been a significant increase in the number of research-based companies, as well as in employment in research and development, and in expenditure in this area. Growth has been observed predominantly in companies in less research-intensive sectors and in small and medium-sized enterprises. Consequently, over the last decade, industrial research in Germany has become more widespread.

There has been steady growth in the contribution made by research-based companies to total manufacturing output and to employment. Moreover, these companies are considerably more efficient than non-research-based companies—in terms of per capita productivity—and have increased their lead over the course of time. Political support may have also been a contributing factor to the expansion of research and development, particularly in medium-sized industrial enterprises.

Germany maintains its competitive edge in the international arena predominantly through its innovative and research-intensive manufacturing industry. The Donors' Association for the Promotion of the Sciences and Humanities in Germany (Stifterverband für die deutsche Wissenschaft), the Centre for European Economic Research (ZEW), and other institutions publish regular reports on research and development (R&D) and innovations in the Germany economy. These studies present a detailed picture of companies' research and innovation activities. However, they are frequently limited to just an overview of the activities of research-based companies. It would be more desirable to quantify the importance of R&D for the entire manufacturing industry. The present study makes a contribution to closing this gap by examining the following areas:

- the development of the research activities of manufacturing companies,
- the significance of research-based companies for the manufacturing industry, and
- the existence or absence of differences in productivity between research-based and non-research-based companies.

The analysis is based on data from the Cost Structure Survey for Enterprises in the Manufacturing Sector (KSE) conducted by the Federal Statistical Office. This annual survey, which has been carried out among manufacturing companies since 1999, gathers information on the number of persons employed in R&D (headcount) and also internal R&D expenditure (personnel and material costs as well as investment). The survey concept uses the internationally binding definitions and categories outlined in the OECD Frascati Manual.¹ The survey also provides data on economic output and turnover, costs and cost type, as well as on employment. The KSE is a representative random sample survey, the

¹ OECD, Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development (Paris: 2002).

results of which are extrapolated. Comprising almost 18,000 enterprises in 2010, the total KSE sample captured 45 percent of all manufacturing companies. Among companies with up to 499 employees, a random sample is drawn, while companies with 500 or more employees are fully integrated into the survey. The downside of the KSE is that it does not capture small manufacturing enterprises with fewer than 20 employees, nor contract research. A further shortcoming is that the survey only gathers information on the number of persons employed in R&D but not the number of working hours dedicated to R&D activities.

Based on the KSE, it is possible to make statements on the significance of R&D activities in research-based enterprises and also to draw comparisons between research-based and non-research-based companies with regard to economic performance.²

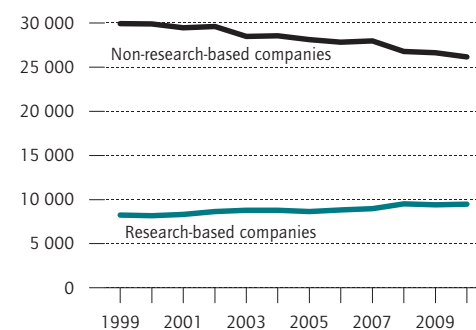
The following study is based on special analyses published by the Federal Statistical Office covering the years from 1999 to 2010. Based on these compilations, it is also possible to observe how the economy influences companies' research activities although the time series cannot be applied entirely universally. In 2008, the Federal Statistical Office adopted a new system for the classification of economic activities (WZ).³ As a result, since 2008, certain sectors have no longer been classified as part of the manufacturing industry and, also within the manufacturing sector, assignment to individual branches has been changed. However, the differences do not have a significant impact on the manufacturing industry as a whole.

² The R&D survey conducted by Wissenschaftsstatistik GmbH from the Donors' Association for the Promotion of Sciences and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft) provides detailed data on R&D. However, the survey does not allow a comparison with non-research-based companies. The KSE data are not entirely comparable with those of the Stifterverband due to, inter alia, differences in the definitions used for the reporting units and a different survey procedure, see H. Haug and C. Revermann, „Statistik für Forschung und experimentelle Entwicklung im Vergleich,“ *Wirtschaft und Statistik*, no. 12 (2003): 1130–1136, as well as U. Schasse et al., „Forschungs- und Entwicklungsaktivitäten der deutschen Wirtschaft,“ *Studien zum deutschen Innovationssystem*, no. 4 (Hanover and Essen: 2012). Furthermore, participation in the KSE is mandatory, whereas participation in the R&D survey conducted by Wissenschaftsstatistik GmbH is voluntary.

³ Federal Statistical Office, *Qualitätsbericht. Kostenstrukturerhebung im Verarbeitenden Gewerbe, im Bergbau sowie in der Gewinnung von Steinen und Erden. Kostenstrukturerhebung* (Wiesbaden: 2012), as well as Federal Statistical Office, *Kostenstruktur der Unternehmen des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden 2010, Fachserie 4, Reihe 4.3* (Wiesbaden: 2012).

Figure 1

Number of Research-Based and Non-Research-Based Companies in the Manufacturing Industry



Source: Federal Statistical Office, calculations by DIW Berlin.

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The number of non-research-based companies is declining dramatically.

Research Activity in Manufacturing: Significant Growth Observed

Research-Based Companies on the Increase...

According to the KSE, in 2010, almost 9,500 companies were conducting R&D compared to almost 8,300 in 1999 (see Figure 1). This corresponds to a 1.3 percent average annual increase in the number of research-based companies. The number of non-research-based companies, on the other hand, decreased by 1.2 percent, from almost 30,000 (1999) to just under 26,200 (in 2010). Almost 27 percent of manufacturing companies were conducting R&D in 2010, whereas the corresponding figure for 1999 was just 22 percent.

The number of research-based companies has increased in all sectors referred to in this study—both the research-intensive and the less research-intensive⁴ (see Table 1). In the less research-intensive sectors, however, average annual growth was, at over two percent, significantly above average. At the same time, the number of non-research-based companies has declined to a greater or lesser extent (with the exception of metal production and processing, and manufacture of metallic products). Consequently, the percentage of research-based

⁴ Definition according to H. Leger and R. Frietsch, *Listen wissenschafts- und technologieintensiver Güter und Wirtschaftszweige. Zwischenbericht zu den NIW/ISIZEW-Listen 2010/2011 für die WZ 2003*, and according to B. Gehrke et al., *Listen wissenschafts- und technologieintensiver Güter und Wirtschaftszweige. Zwischenbericht zu den NIW/ISIZEW-Listen 2010/2011 für die WZ 2008*.

Table 1

Number of Research-Based Companies in the Manufacturing Industry

	1999	2001	2003	2005	2007	2008	2009	2010	2010 compared to 1999	For information: Non-research-based companies in 2010 compared to 1999
	Annual average in percent									
Manufacturing overall	8,248	8,307	8,802	8,630	8,963	9,509	9,421	9,493	1.29	-1.22
Branch of industry										
R&D-intensive branches of industry	4,972	5,149	5,414	5,357	5,473	5,434	5,323	5,390	0.74	-2.69
Chemical and pharmaceutical products ¹	663	655	751	757	788	777	771	778	1.46	-0.09
Mechanical engineering ²	2,173	2,278	2,173	2,125	2,157	2,316	2,253	2,290	0.48	-2.43
Manufacture of motor vehicles ³	369	371	431	428	443	492	479	476	2.33	-0.14
Data processing equipment, electronic, optical and electrical products ⁴	1,767	1,845	2,059	2,047	2,085	1,849	1,820	1,847	0.40	-4.88
Other branches of industry	3,276	3,158	3,388	3,274	3,490	4,075	4,098	4,103	2.07	-0.75
Of which:										
Food industry ⁵	295	282	361	344	389	446	441	436	3.63	-0.25
Rubber and plastic products, glass and ceramics ⁶	900	863	1,015	974	1,053	1,037	1,067	1,065	1.55	-1.83
Metal production and processing, and manufacture of metallic products ⁷	1,103	1,049	1,097	1,051	1,123	1,255	1,254	1,249	1.13	0.43
Companies with... employees										
20 to 49	1,892	1,661	1,991	1,845	1,811	2,015	2,047	2,056	0.76	-1.26
50 to 99	1,752	1,850	1,980	1,950	2,020	2,227	2,214	2,259	2.34	-0.85
100 to 249	2,166	2,244	2,359	2,412	2,590	2,710	2,689	2,720	2.09	-1.35
250 to 499	1,193	1,277	1,253	1,246	1,338	1,323	1,301	1,309	0.85	-1.78
500 to 999	660	690	666	661	677	704	662	657	-0.05	-3.14
1,000 or more	585	586	554	516	526	531	509	492	-1.56	-2.21

Years under review: 1999 to 2008: WZ 1993 or WZ 2003 (WZ: classification of economic activities, years under review: 2008 to 2010: WZ 2008.

1 WZ 2003: 24, WZ 2008: 20, 21.

2 WZ 2003: 29, WZ 2008: 28.

3 WZ 2003: 34, 35, WZ 2008: 29, 30.

4 WZ 2003: 30 to 33, WZ 2008: 26, 27.

5 WZ 2003: 15, WZ 2008: 10, 11.

6 WZ 2003: 25, 26, WZ 2008: 22, 23.

7 WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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The number of small research-based companies has experienced a particularly dramatic increase.

companies as a share of the total number has increased in all sectors.

In the research-intensive sectors, the share of research-based companies is, by definition, high. However, what is surprising is that only just under half of all companies in this sector (48.4 percent in 2010) conduct research and development (see Table 2). Conversely, the share of research-based companies in the sectors classified as less research-intensive could be assumed to be universally low. However, in reality, in the rubber and plastic products, ceramics and glass sector, for example, the figure is actually as high as one-quarter.

There has also been a significant increase in the number of research-based small and medium-sized enterprises (SMEs).⁵ Companies with between 50 and 250 employees even experienced above-average growth of two percent. With regard to large companies (with 250 em-

⁵ The European Commission defines SMEs as companies with fewer than 250 employees and a turnover of up to 50 million euros or a balance sheet total of up to 43 million euros. The company must also be independent. The present report adheres to this definition and categorizes SMEs as companies with fewer than 250 employees. However, no information about the independence of the company is available. According to the classification used by the Institute for Research on Small and Medium-Sized Enterprises (IfM, Institut für Mittelstandsforschung) all independent companies with fewer than 500 employees and with a turnover of less than 50 million euros are classed as SMEs.

Table 2

Research-Based Enterprises as Percentage of All Companies

	1999	2001	2003	2005	2007	2008	2009	2010	1999 = 100
Manufacturing overall	21.6	22.0	23.6	23.5	24.3	26.2	26.1	26.6	123
Branch of industry									
R&D-intensive branches of industry	39.1	39.9	41.0	40.4	40.6	47.0	47.3	48.4	124
Chemical and pharmaceutical products ¹	51.7	51.1	55.1	54.8	55.8	55.5	55.1	55.9	108
Mechanical engineering ²	37.2	38.7	36.6	36.0	35.7	42.7	43.6	45.0	121
Manufacture of motor vehicles ³	31.4	30.1	33.3	32.7	33.6	38.6	37.7	37.4	119
Data processing equipment, electronic, optical and electrical products ⁴	40.1	41.0	44.8	44.0	44.4	53.4	53.3	54.8	137
Other branches of industry	12.9	12.7	14.1	13.9	14.9	16.5	16.5	16.7	130
Of which:									
Food industry ⁵	5.8	5.7	7.5	6.9	7.7	8.7	8.6	8.5	148
Rubber and plastic products, glass and ceramics ⁶	19.5	19.2	23.1	23.1	25.4	24.7	25.7	26.0	133
Metal production and processing, and manufacture of metallic products ⁷	15.9	14.8	15.7	15.1	15.7	17.1	16.8	16.9	107
Companies with... employees									
20 to 49	10.9	9.8	11.8	11.2	11.5	13.1	12.7	13.2	122
50 to 99	18.4	19.7	21.0	20.6	20.5	23.3	24.1	24.3	131
100 to 249	31.2	32.0	35.0	35.5	36.1	37.9	39.5	39.8	128
250 to 499	48.5	51.0	52.4	53.0	53.6	53.9	55.7	55.7	115
500 to 999	59.3	60.0	62.2	64.0	63.5	67.2	67.5	67.3	114
1,000 or more	77.0	76.4	77.9	78.4	78.2	79.2	79.5	78.3	102

Years under review: 1999 to 2008: WZ 1993 or WZ 2003 (WZ: classification of economic activities, years under review: 2008 to 2010: WZ 2008.

1 WZ 2003: 24, WZ 2008: 20, 21.

2 WZ 2003: 29, WZ 2008: 28.

3 WZ 2003: 34, 35, WZ 2008: 29, 30.

4 WZ 2003: 30 to 33, WZ 2008: 26, 27.

5 WZ 2003: 15, WZ 2008: 10, 11.

6 WZ 2003: 25, 26, WZ 2008: 22, 23.

7 WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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The share of research-based companies has increased across all sectors.

ployees or more), on the other hand, the number of research-based enterprises according to size category has barely increased or has in fact fallen (companies with 1,000 employees or more). However, this is not necessarily evidence of a decline in the research activity of larger companies as there was an equivalent or greater drop in the number of non-research-based companies. The end effect is that the share of large research-based companies (over 1,000 employees) increased from 77 percent to around 78 percent. Nevertheless, research-based companies in other size categories also experienced significant increases in their shares, with the highest being observed among companies with between 50 and 249 employees. Overall, developments demonstrate that industrial research today is much more widespread than it was a decade ago.

... as Well as Research and Development Expenditure...

According to KSE data, in 2010, R&D expenditure (personnel and material costs as well as investment) in the manufacturing industry amounted to 46.9 billion euros.⁶ This equates to almost 86 percent of the private economy's total R&D expenditure. Thus, manufacturing is—in terms of provision of research capacity—the most important sector of the economy.⁷

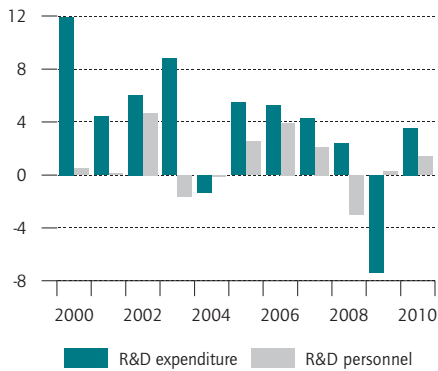
⁶ Actual R&D expenditure in the manufacturing industry is even higher, as research-based companies with fewer than 20 employees are not covered by the KSE.

⁷ A. Kladroba, „Forschung und Entwicklung im Wirtschaftssektor 2009 und 2010,“ FuE-Datenreport 2012. Analyse und Vergleiche (Essen: Stifterverband für die Deutsche Wissenschaft, 2012), 9.

Figure 2

R&D Expenditure and R&D Personnel in the Manufacturing Industry

Change in comparison with previous year in percent



Source: Federal Statistical Office, calculations by DIW Berlin.

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The development of R&D employment is less volatile than R&D expenditure.

R&D expenditure has increased by an annual average of 3.8 percent. However, annual rates of change indicate that this was not a sustained development (see Figure 2). Therefore, during the most recent economic crisis, R&D expenditure experienced a sharp decline (7.3 percent lower in 2009 than in 2008) followed by significant growth (3.5 percent higher in 2010 than in 2009). The temporary drop in overall research expenditure was probably predominantly a result of companies deferring research-related investments or making drastic cut-backs in material costs.⁸

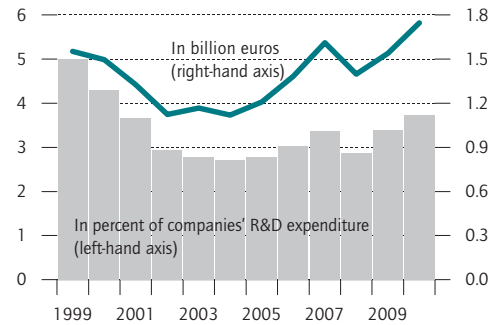
One reason for the growth in R&D expenditure between 2009 and 2010 may have been the increase in government subsidies. In fact, the amount of government funding⁹ and the share of these funds channeled into R&D increased dramatically from 2008 to 2010 (see Figure 3): from 1.4 billion euros in 2008 (2.9 percent of the manufacturing industry's R&D expenditure) to 1.9 billion

⁸ However, other expenditure incurred by companies to ensure that their innovative capability is maintained has dropped even more significantly than R&D expenditure. Thus, the ZEW's Mannheim Innovation Panel came to the conclusion that, in 2009, R&D expenditure experienced only a slight decline compared to 2008, whereas other innovation expenditure dropped by 18 percent. See C. Rammer, „Auswirkungen der Krise auf die Innovationstätigkeit der Unternehmen in Deutschland,“ in A. Kritikos and A. Konrad, „Der Forschungsstandort Deutschland nach der Krise,“ Vierteljahrshefte zur Wirtschaftsforschung 3 (DIW Berlin: 2011), 13-35.

⁹ Only federal government funding is considered here. See Federal Ministry of Education and Research (BMBF), Bundesbericht Forschung und Innovation, various years.

Figure 3

Federal Government Funding for R&D in Manufacturing Companies



Sources: Federal Statistical Office; Federal Ministry of Education and Research, calculations by DIW Berlin.

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The federal government recently significantly increased funding for R&D.

euros in 2010 (3.7 percent). As part of Germany's economic stimulus package, funding for manufacturing SMEs was topped up.¹⁰ Thus, in 2008, 573 million euros of government funding was channeled into SMEs, the corresponding sum for 2009 was 716 million, and for 2010, it was 905 million.¹¹ The government co-financing rate for SMEs, therefore, was approximately ten percent.¹² A further reason for the growth in R&D expenditure may have been the new regulation on short-time work which enabled companies to retain their research personnel.¹³

The most important sector according to research expenditure is the automotive industry¹⁴ (18.2 billion euros or 38.8 percent) along with electrical engineering,¹⁵ mechanical engineering, and the chemical industry.¹⁶ These

¹⁰ The Central Innovation Program for SMEs (ZIM) of the Federal Ministry of Economics and Technology (BMWi) plays a key role here.

¹¹ BMBF, Bundesbericht Forschung und Innovation (2012): 387.

¹² Here: companies with between 50 and 249 employees. G. Stenke, „Staatliche Förderung von FuE in der Wirtschaft,“ in Stifterverband für die Deutsche Wissenschaft, as above, 38. On government R&D funding for previous years see A. Eickelpasch and C. Grenzmann, „Extensive Research Does Not Imply Extensive Funding,“ Weekly Report, no. 33 (2009): 224-230.

¹³ H. Belitz et al., „Forschungsintensive Industrie gut aufgestellt,“ Wochenbericht des DIW Berlin, no. 17 (2001).

¹⁴ Manufacture of motor vehicles and motor vehicle parts as well as other vehicle construction.

¹⁵ Manufacture of data processing equipment, electronic and optical products, and electrical equipment.

¹⁶ Including the pharmaceutical industry.

Table 3

R&D Expenditure in the Manufacturing Industry

Structure in percent

	1999	2001	2003	2005	2007	2008	2009	2010	2010 compared to 1999— annual average in percent
Manufacturing industry overall in million euros	31,023	36,256	41,837	43,521	47,767	48,900	45,311	46,912	3.83
Branch of industry									
R&D-intensive branches of industry	92.6	93.1	93.5	93.2	93.4	91.0	90.6	90.4	-0.21
Chemical and pharmaceutical products ¹	19.8	18.0	15.2	15.5	14.4	14.0	15.1	15.4	-2.30
Mechanical engineering ²	10.6	10.5	13.1	10.8	11.6	16.5	16.9	17.0	4.46
Manufacture of motor vehicles ³	34.6	36.0	39.6	40.6	41.6	39.5	38.7	38.9	1.05
Data processing equipment, electronic, optical and electrical products ⁴	27.5	28.5	25.6	26.2	25.8	21.0	19.9	19.1	-3.25
Other branches of industry	7.4	6.9	6.5	6.8	6.6	9.0	9.4	9.6	2.31
Of which:									
Food industry ⁵	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.41
Rubber and plastic products, glass and cera- mics ⁶	3.1	2.7	2.4	2.3	2.2	2.3	2.4	2.4	-2.30
Metal production and processing, and manu- facture of metallic products ⁷	2.3	2.3	2.2	2.5	2.7	2.6	2.4	2.5	0.81
Companies with... employees									
20 to 49	0.7	0.6	0.8	0.8	0.7	0.7	0.8	0.8	0.57
50 to 99	1.4	1.2	1.4	1.5	1.5	1.5	1.6	1.8	2.57
100 to 249	3.7	3.3	3.8	4.2	4.1	4.7	4.8	5.0	2.79
250 to 499	4.8	5.2	4.9	5.5	5.5	5.1	5.4	5.7	1.48
500 to 999	7.0	7.4	6.7	7.0	7.3	7.5	7.2	6.9	-0.16
1,000 or more	82.4	82.3	82.4	81.1	80.9	80.6	80.2	79.9	-0.28

Years under review: 1999 to 2008: WZ 1993 or WZ 2003, years under review: 2008 to 2010: WZ 2008.

¹ WZ 2003: 24, WZ 2008: 20, 21.² WZ 2003: 29, WZ 2008: 28.³ WZ 2003: 34, 35, WZ 2008: 29, 30.⁴ WZ 2003: 30 to 33, WZ 2008: 26, 27.⁵ WZ 2003: 15, WZ 2008: 10, 11.⁶ WZ 2003: 25, 26, WZ 2008: 22, 23.⁷ WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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R&D is predominantly conducted by large companies in the capital goods industries.

four sectors, which constitute Germany's research-intensive industries, together account for over 90 percent of research expenditure in the manufacturing industry (see Table 3). However, the level of R&D expenditure in the research-intensive sectors was just as high in 2010 as in 1999. The less research-intensive sectors, on the other hand, actually experienced growth. Thus, there was a shift in weighting within the manufacturing industry in favor of less research-intensive sectors which accounted for 7.4 percent of R&D expenditure in 1999 and 9.6 percent in 2010.

Large companies with over 1,000 employees are the source of four-fifths of R&D expenditure in the manufactu-

ring industry, whereas "smaller" companies, with between 250 and 999 employees, account for a 12.6 percent share (5.6 billion euros). The high concentration of large companies is closely related to the sector concentration overall, as the research-intensive branches of industry are dominated by large companies. Among SMEs, it is medium-sized companies (between 100 and 249 employees) that provide the lion's share of research capacity (2.3 of the 3.5 billion euros from SMEs).

Admittedly, large companies still lead when it comes to maintaining research capacity, but the weighting has shifted in favor of SMEs, which accounted for 5.8 percent

of R&D expenditure in manufacturing in 1999. In 2010, this figure was already 7.6 percent.

... and Number of R&D Personnel

In 2010, almost 311,000 research-based company employees worked in R&D, a good 30,000 more than in 1999. The annual average growth here was just under one percent. As with R&D expenditure, growth in employment has also not been sustained. However, development here has been significantly less volatile (see Figure 2).

The distribution of R&D personnel by industry sector reflects the sectoral structure of R&D expenditure to a large extent. The most important sector is automotive engineering, which alone employs around 30 percent of industrial researchers (2010). This is followed by electrical engineering, mechanical engineering, and the chemical industry, which combined account for 86 percent of industrial researchers. In 2010, almost 68 percent of researchers were working in companies with 1,000 employees or more. If the “smaller” large-scale enterprises (companies with more than 250 but less than 1,000 employees) are included, the total share is just over 85 percent. Medium-sized enterprises with 100 to 249 employees account for over half of the research capacity of SMEs (26,521 of 45,906 SME researchers).

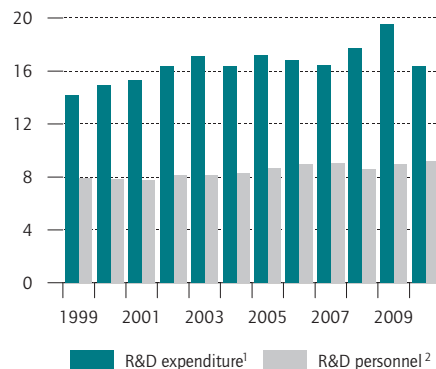
Parallels to the development of R&D expenditure can also be seen in the individual branches of industry and the size categories. In less research-intensive sectors, the number of researchers has increased by an annual average of 2.9 percent, while in the research-intensive branches it has virtually stagnated (−0.4 percent). What is also noteworthy is growth among SMEs—which was particularly strong in companies with 100 to 249 (+2.9 percent)—and among companies with 250 to 499 employees (+2.2 percent). Conversely, in large companies with 1,000 employees or more, the number of R&D personnel has dropped (−0.8 percent). The KSE data do not indicate to what extent this decrease is an aftereffect of the last economic downturn or due to organizational changes in large companies such as the establishment of legally independent research companies in place of intramural research activities, subcontracting, or replacing a company’s own researchers with temporary workers.

Sharper Increase in R&D Expenditure Intensity ...

In order to calculate the R&D expenditure intensity, the R&D expenditure of research-based companies is related

Figure 4

R&D Expenditure and R&D Personnel In percent



¹ Based on the value added in research-based companies.

² Based on the number of employees in research-based companies.

Source: Federal Statistical Office, calculations by DIW Berlin.

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R&D intensity has increased.

to the gross value added of these companies.¹⁷ Thus, it is possible to ascertain to what extent a company invests its generated revenue in research and development:¹⁸ In 2010, R&D expenditure amounted to 16.4 percent of the value added of research-based companies, while the corresponding figure for 1999 was 14.2 percent (see Figure 4). The high intensity for 2009 is a result of the sharp fall in value added due to the crisis and cannot be interpreted as an upward trend. The medium term development can, however, be seen as an overall increase in R&D expenditure intensity.

R&D intensity is, by definition, higher in research-intensive sectors (20 percent in 2010) than in less research-intensive sectors (6.1 percent). Here, too, automotive engineering occupies a leading position with 26.9 percent (see Table 4). While there has only been a slight increase in R&D expenditure intensity in research-intensive sectors (by 14 percent in 2010 compared with

¹⁷ The Wissenschaftsstatistik GmbH relates the R&D expenditure of the companies to the gross value added of the relevant sector, Kladroba, „Forschung und Entwicklung“; also the turnover of the research-based company is sometimes used as a reference point, Schasse et al., Forschungs- und Entwicklungsaktivitäten, 37. However, these reference points are only of limited suitability for ascertaining to what extent a company uses the value added it has generated to invest in R&D.

¹⁸ This calculation assumes that companies use their research output internally. Particularly for affiliated or group companies, this is not necessarily the case, however.

Table 4

R&D Expenditure in Percent of Total Value Added of Research-Based Companies

	1999	2001	2003	2005	2007	2008	2009	2010	1999 = 100
Manufacturing overall	14.2	15.3	17.1	17.2	16.4	17.7	19.5	16.4	116
Branch of industry									
R&D-intensive branches of industry	17.6	19.1	21.3	21.3	20.2	22.0	24.8	20.0	114
Chemical and pharmaceutical products ¹	20.2	19.2	18.9	18.8	17.2	17.3	18.9	17.0	84
Mechanical engineering ²	8.6	9.0	12.8	10.5	10.2	14.0	16.9	14.9	172
Manufacture of motor vehicles ³	20.3	21.8	26.2	27.9	26.8	32.8	39.6	26.9	132
Data processing equipment, electronic, optical and electrical products ⁴	20.3	25.5	24.3	24.8	23.3	22.2	22.7	18.7	92
Other branches of industry	4.1	4.2	4.5	4.7	4.6	5.9	6.4	6.1	146
Of which:									
Food industry ⁵	2.2	2.4	2.9	3.2	3.3	3.3	2.7	2.8	125
Rubber and plastic products, glass and ceramics ⁶	5.9	6.0	6.1	6.2	5.7	6.2	7.0	6.5	111
Metal production and processing, and manufacture of metallic products ⁷	3.6	4.0	4.0	4.3	4.4	4.4	5.1	4.8	134
Companies with... employees									
20 to 49	7.4	7.7	9.5	10.0	8.7	8.8	10.1	8.9	120
50 to 99	6.8	6.7	8.0	7.7	7.4	7.9	8.9	8.5	125
100 to 249	6.5	6.4	7.3	7.8	7.3	8.1	8.9	8.4	131
250 to 499	6.5	7.4	7.9	8.4	7.7	7.5	8.7	8.2	125
500 to 999	8.4	8.9	9.2	9.5	9.7	9.7	10.5	9.1	109
1,000 or more	17.8	19.4	22.3	22.4	21.5	24.0	26.5	21.2	119

Years under review: 1999 to 2008: WZ 1993 or WZ 2003, years under review: 2008 to 2010: WZ 2008.

1 WZ 2003: 24, WZ 2008: 20, 21.

2 WZ 2003: 29, WZ 2008: 28.

3 WZ 2003: 34, 35, WZ 2008: 29, 30.

4 WZ 2003: 30 to 33, WZ 2008: 26, 27.

5 WZ 2003: 15, WZ 2008: 10, 11.

6 WZ 2003: 25, 26, WZ 2008: 22, 23.

7 WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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Expansion of R&D intensity was particularly strong among SMEs.

1999), a strong upward trend can be observed in less research-intensive sectors (46 percent).

As expected, R&D expenditure intensity in SMEs (just under nine percent on average in 2010) is considerably lower than the industry average. It is striking, however, that “smaller” large-scale companies with 250 to 999 employees do not have a significantly higher expenditure intensity than SMEs (8.2 compared to 9.1 percent). Only large companies with 1,000 employees or more surpass all others with a value that is more than twice as high (21.2 percent).

A shift in favor of small enterprises can also be seen with R&D expenditure intensity. Growth was particularly pronounced among SMEs (between 20 and 31 percent) and companies with 250 to 499 employees (25 percent).

... than in R&D Personnel Intensity

The second indicator used for capturing R&D intensity is the number of R&D personnel as a share of all employees in research-based companies. Also measured according to this criterion, the R&D intensity of research-based companies has increased: it was 9.1 percent in 2010, compared to 7.9 percent in 1999 (see Figure 4).¹⁹

In the research-intensive branches of industry, R&D personnel intensity—like R&D expenditure intensity—

¹⁹ In addition, the number of R&D personnel can also be compared to the total number of employees in the manufacturing industry. This indicator can easily lead to misinterpretations, however, since changes in the R&D personnel intensity may also be a result of a change in the number of research-based companies and thus in the denominator. Therefore, this indicator is not suitable for measuring the research output of research-based companies themselves. The difference is not insignificant: the share of researchers in all employees in the manufacturing industry was 5.4 percent in 2010, and 9.1 percent in employees in the research-based companies.

Table 5

R&D Personnel as Percentage of Total Employees in Research-Based Companies

	1999	2001	2003	2005	2007	2008	2009	2010	1999 = 100
Manufacturing overall	7.9	7.8	8.1	8.6	9.0	8.6	8.9	9.1	116
Branch of industry									
R&D-intensive branches of industry	9.7	9.5	10.0	10.6	11.1	10.7	11.1	11.3	116
Chemical and pharmaceutical products ¹	11.0	11.0	10.7	11.3	12.1	11.5	11.8	12.0	109
Mechanical engineering ²	5.8	6.0	6.6	6.8	7.0	7.8	8.1	8.5	146
Manufacture of motor vehicles ³	10.3	10.1	10.6	11.7	12.1	12.0	12.6	12.9	125
Data processing equipment, electronic, optical and electrical products ⁴	12.2	11.5	12.5	12.8	13.8	12.1	12.7	12.4	102
Other branches of industry	2.9	3.0	3.1	3.3	3.6	3.8	4.0	4.2	143
Of which:									
Food industry ⁵	1.8	1.9	2.1	2.5	3.8	2.7	2.5	2.8	151
Rubber and plastic products, glass and ceramics ⁶	3.6	3.9	3.9	4.0	4.0	4.1	4.3	4.4	121
Metal production and processing, and manufacture of metallic products ⁷	2.6	2.7	2.9	2.9	3.2	3.3	3.2	3.4	134
Companies with... employees									
20 to 49	8.8	8.9	10.2	9.6	9.3	9.9	10.1	10.1	116
50 to 99	7.0	6.6	7.0	6.6	6.6	6.9	7.2	7.4	106
100 to 249	5.1	4.9	5.4	5.6	5.6	5.8	6.1	6.1	120
250 to 499	4.5	4.9	5.0	5.4	5.4	5.3	5.5	5.7	127
500 to 999	5.0	5.3	6.2	6.2	6.5	6.2	6.2	6.2	124
1,000 or more	9.6	9.4	9.8	10.6	11.5	10.7	11.2	11.6	120

Years under review: 1999 to 2008: WZ 1993 or WZ 2003, years under review: 2008 to 2010: WZ 2008.

1 WZ 2003: 24, WZ 2008: 20, 21.

2 WZ 2003: 29, WZ 2008: 28.

3 WZ 2003: 34, 35, WZ 2008: 29, 30.

4 WZ 2003: 30 to 33, WZ 2008: 26, 27.

5 WZ 2003: 15, WZ 2008: 10, 11.

6 WZ 2003: 25, 26, WZ 2008: 22, 23.

7 WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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R&D personnel intensity has increased across all sectors.

is significantly higher than in other branches. However, the differences here are not as pronounced as for R&D expenditure (in 2010, 11.3 percent compared to 4.2 percent).²⁰ The automotive industry is the forerunner here, too, but is followed closely by the other research-intensive branches (see Table 5). The differences between industries with regard to dynamics are similar to with expenditure intensity: personnel intensity has grown much faster in less research-intensive sectors (from 2.9 to 4.2 percent) than in research-intensive sectors (from 9.7 to 11.3 percent).

In large companies with 1,000 employees or more, research intensity is significantly above the industry average (11.6 percent in 2010). Even for small enterprises (20

to 49 employees), it is surprisingly higher than average (10.1 percent). One explanation for this might be that for these companies, the share of R&D personnel who only occasionally conduct R&D is higher than for other companies.

Research-Based Companies Account for Growing Share of Output and Employment

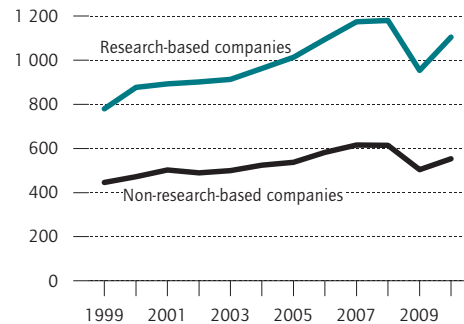
With 1.1 trillion euros, research-based companies generated around two-thirds of industrial output (gross output) in 2010. As shown in Figure 5, the output of research-based companies in the period studied is higher than that of non-research-based companies. However, research-based companies were more affected by the most recent crisis. The main reason for this was that research-based companies are particularly export-oriented and, therefore, experienced a slump.

²⁰ The fact that these sectors' lead for the indicator „R&D expenditure intensity“ is higher than for the indicator „R&D personnel intensity“ may also result from particularly high R&D investment (as a component of R&D expenditure).

Figure 5

Output in Research-Based and Non-Research-Based Companies

In billion euros



Source: Federal Statistical Office, calculations by DIW Berlin.

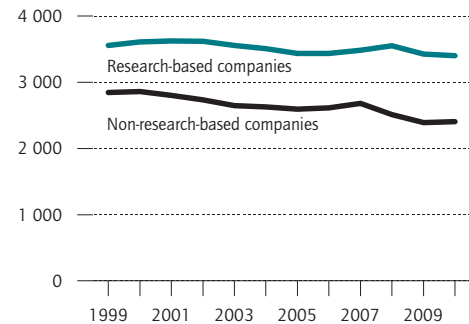
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The level of output of research-based companies relies heavily on export.

Figure 6

Employees in Research-Based and Non-Research-Based Companies

In 1,000 persons



Source: Federal Statistical Office, calculations by DIW Berlin.

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The contribution of research-based companies to employment in the manufacturing industry is steadily increasing.

Some of the growth may be attributed to a statistical effect resulting from inclusion of the output of companies that began conducting research after 1999. This would result in an overestimate of the development of the output of research-based companies and an underestimation of that of non-research-based companies. This shortcoming is not very likely to apply to the group of large companies, since these normally conduct research continuously. It is only possible to investigate exactly how great this effect actually is by using microdata, however. In any case, this shortcoming is irrelevant to an examination of shifts in shares between research-based and non-research-based companies.

The share of total industrial output contributed by research-based companies rose from 63.6 percent in 1999 to 66.6 percent in 2010. The 4.4 percentage point increase in the share accounted for by the less research-intensive sectors (up to 43.2 percent in 2010) was considerably higher than for research-intensive sectors (up 1.8 percentage points to 85.6 percent).

A clear picture also emerges when we distinguish between different company sizes: the share of total output accounted for by small businesses is lower than the contribution made by medium-sized enterprises, which is, in turn, still lower than that of larger companies. Thus, the share for small businesses (20 to 49 employees) is 17 percent, 28 percent for companies with 50 to 99 employees, 43 percent for medium-sized enterprises with

Figure 7

Labor Productivity in Research-Based and Non-Research-Based Companies in the Manufacturing Industry

In 1,000 euros



Source: Federal Statistical Office, calculations by DIW Berlin.

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The gap in productivity between research-based and non-research-based companies is constantly widening.

Table 6

Labor Productivity of Research-Based Companies

Labor productivity of non-research-based companies = 100

	1999	2001	2003	2005	2007	2008	2009	2010
Manufacturing overall	129	133	135	137	146	140	138	157
Branch of industry								
R&D-intensive branches of industry	129	128	132	132	137	124	123	141
Chemical and pharmaceutical products ¹	113	122	119	123	135	129	133	138
Mechanical engineering ²	116	117	122	121	127	124	125	136
Manufacture of motor vehicles ³	133	137	131	134	141	129	111	157
Data processing equipment, electronic, optical and electrical products ⁴	147	126	142	142	140	121	130	133
Other branches of industry	121	127	125	128	134	132	135	141
Of which:								
Food industry ⁵	149	153	148	155	152	164	167	173
Rubber and plastic products, glass and ceramics ⁶	116	121	120	120	124	124	119	126
Metal production and processing, and manufacture of metallic products ⁷	116	118	129	131	130	128	127	128
Companies with... employees								
20 to 49	112	111	118	123	126	126	119	125
50 to 99	114	115	120	124	129	122	122	129
100 to 249	110	111	115	116	116	119	115	120
250 to 499	110	110	110	111	115	116	113	121
500 to 999	105	108	110	106	113	116	119	121
1,000 or more	113	112	119	122	136	113	116	144

Years under review: 1999 to 2008: WZ 1993 or WZ 2003, years under review: 2008 to 2010: WZ 2008.

¹ WZ 2003: 24, WZ 2008: 20, 21.² WZ 2003: 29, WZ 2008: 28.³ WZ 2003: 34, 35, WZ 2008: 29, 30.⁴ WZ 2003: 30 to 33, WZ 2008: 26, 27.⁵ WZ 2003: 15, WZ 2008: 10, 11.⁶ WZ 2003: 25, 26, WZ 2008: 22, 23.⁷ WZ 2003: 27, 28, WZ 2008: 24, 25.

Source: Federal Statistical Office, calculations by DIW Berlin.

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Only slight differences in the lead of research-based companies are evident between the subgroups.

100 to 249 employees, and 86 percent for large companies (1,000 employees or more). The share in output of research-based companies contributed by small businesses has significantly increased, however, while remaining approximately the same for large companies. The strongest growth was reported for medium-sized enterprises with 100 to 249 employees (+11.5 percentage points) or 50 to 99 employees (+7.7 percentage points).

The share of total employment in the manufacturing industry accounted for by research-based companies reached almost 59 percent in 2010, compared to almost 55 percent in 1999 (see Figure 6). The 4.6-percentage-point increase in the share accounted for by the less research-intensive sectors was higher than that of the research-intensive sectors (+2.6 percentage points). When broken down according to size categories, it was highest for medium-sized enterprises at 9.2 percentage points,

while remaining virtually constant for large companies (1,000 employees or more) at 86.9 percent.

Productivity in Research-Based Companies Much Higher than in Non-Research-Based Ones

One indicator for the performance of research-based companies is labor productivity (gross value added to factor costs per employee²¹). This reached 84,100 euros in 2010, one-third more than in 1999

²¹ The gross value added to factor costs comprises remuneration of the factors of production used in the production process, including depreciation, indirect taxes, and subsidies. Labor productivity is normally measured in official statistics as a ratio of real value added per hour worked. Consequently, the ratio of nominal value added to the number of employees reported here is distorted.

(61,100 euros). With the exception of the crisis years of 2008 and 2009, there has been a steady increase in productivity (see Figure 7).

A comparison with the labor productivity of non-research-based companies is unambiguous: research-based companies are normally considerably more efficient than non-research-based ones:²² in 2010, the productivity of research-based companies surpassed that of non-research-based ones by 57 percent and research-based companies' lead increased in the period studied (29 percent in 1999).

Upon closer examination by sector, it becomes apparent that research-based companies' lead over non-research-based companies is just as high in research-intensive sectors as in non-research-intensive sectors (41 percent in both cases). This striking parallel can also be seen in recent years—with the exception of the crisis years of 2008 and 2009. A similar trend also emerges in an analysis of difference by size of company: in 2010, there was virtually no difference in terms of advantage in productivity. This was around one-fifth in all size categories. The same was observed in previous years. The only exception are large companies with 1,000 employees or more, where research-based companies had a significant lead over non-research-based in some years of observation. Since the group in question is small, these differences may be a result of the specific development of individual companies.²³

These results indicate that advantages in the productivity of research-based over non-research-based companies bear little relation to the sector or size of a company. Information about whether these or other factors (such as financing conditions or the development on the sales markets) are decisive can ultimately only be provided by a further study incorporating other potential influencing factors on the basis of individual data from the KSE.

Conclusion

The past ten years have seen a significant expansion in industrial research. There has been an increase in the number of research-based companies as well as in R&D employment and R&D expenditure. Growth has been seen primarily in companies in the less research-intensive sectors and in small and medium-sized enterpri-

ses. Consequently, even over the last decade, industrial research in Germany has become more widespread.

There has been an increase in the contribution made by research-based companies to total manufacturing output and to employment. Research-based companies are—in terms of per capita productivity—considerably more efficient than non-research-based companies and have increased their lead over the course of time. This is a further indication that research and development is a fundamental component of a productive industry. Political support has also been a contributing factor to growth in research and development, particularly in medium-sized industrial enterprises.

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²² On the positive correlation between productivity and R&D, see also T.J. Klette and S. Kortum, "Innovating Firms and Aggregate Innovation," *Journal of Political Economy*, vol. 112 (2004): 996–1018.

²³ In 2010, there were 492 research-based and only 137 non-research-based companies with 1,000 employees or more.

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