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# Boosts for the German Economy: Research-Based Industry and Exports to BRICS Countries

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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).

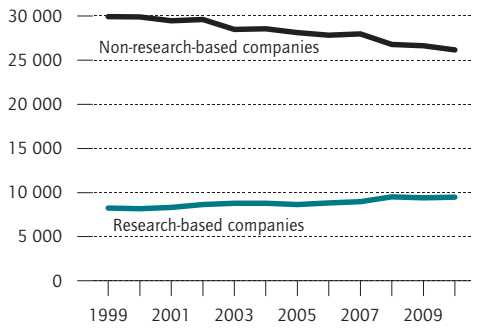
results of which are extrapolated. Comprising almost 18,000 enterprises in 2010, the total KSE sample captured 45 percent of all manufacturing companies. Among companies with up to 499 employees, a random sample is drawn, while companies with 500 or more employees are fully integrated into the survey. 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.

Figure 1

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




*Source: Federal Statistical Office, calculations by DIW Berlin.*



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-intensive[4] (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

**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).

**4** Definition according to H. Leger and R. Frietsch, Listen wissens- 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 wissens- 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.*



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.*



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]

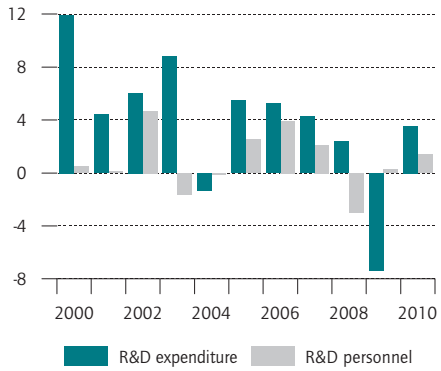
**6** Actual R&D expenditure in the manufacturing industry is even higher, as research-based companies with fewer than 20 employees are not covered by the KSE.

**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



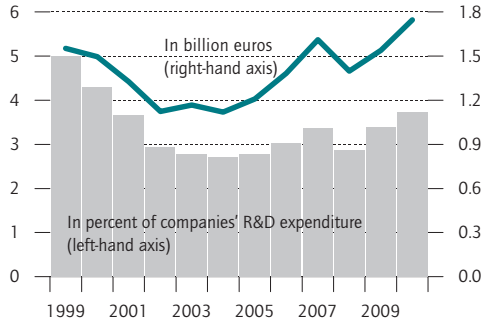

*Source: Federal Statistical Office, calculations by DIW Berlin.*



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

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.*



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

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 funding[9] 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 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 industry[14] (18.2 billion euros or 38.8 percent) along with electrical engineering,[15] mechanical engineering, and the chemical industry.[16] These

**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.

**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 to1999– 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 ceramics[6] | 3.1 | 2.7 | 2.4 | 2.3 | 2.2 | 2.3 | 2.4 | 2.4 | –2.30 |
| Metal production and processing, and manufacture 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.*



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 manufacturing 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.

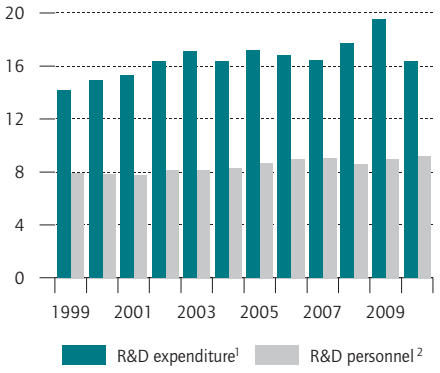
## Sharper Increase in R&D Expenditure Intensity ...

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

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.*



R&D intensity has increased.

**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.*



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.*



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.

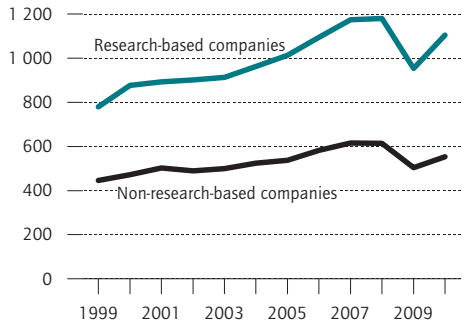
## Research-Based Companies Account for Growing Share of Output and Employment

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



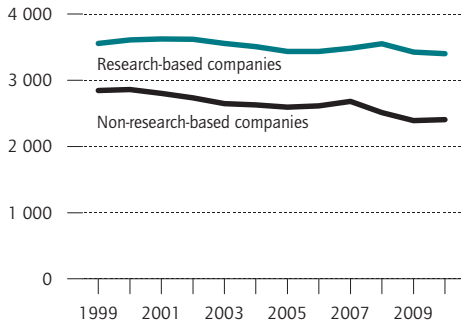

*Source: Federal Statistical Office, calculations by DIW Berlin.*



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.*



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

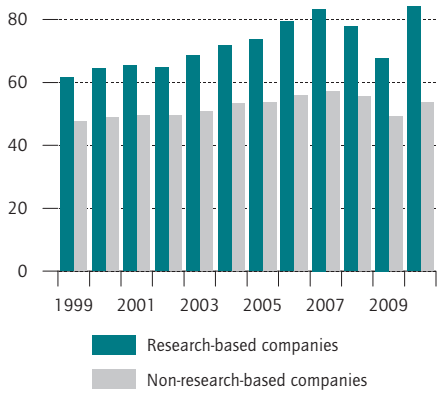
Some of the growth may be attributed to a statistical effect resulting from inclusion of the output of companies that began conducting research after 1999. This would result in an overestimate of the development of the output of research-based companies and an underestimate of that of non-research-based 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.*



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.*



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 employee[21]). 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 enterprises. 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.

Alexander Eickelpasch, Research Associate in the Innovation, Manufacturing, Service Department at DIW Berlin

SEVEN QUESTIONS TO ALEXANDER EICKELPASCH

# »Small and Medium-Sized Enterprises are Catching up«

1. Mr. Eickelpasch, the German economy is characterized by an innovative and research-intensive manufacturing industry. How has industrial research expenditure developed over the past few years? Research expenditure by industrial companies has increased over the past ten years. There are, of course, always cyclical fluctuations, but overall the research expenditure of industrial companies is following an upward trend.

2. How much money has been channeled into industrial research in Germany over the past few years? In 2008, the German federal government provided 1.4 billion euros to fund industrial research. The corresponding figure for 2009 was 1.5 billion and in 2010, the total amount rose to 1.7 billion euros. The manufacturing Industry itself invested 46.9 billion euros in research and development in 2010. Typically, this covers personnel costs, material costs, and investment in the companies' research institutes. If we look at this in relation to public funding, we can see that 3.7 percent of expenditure was co-financed by the federal government in 2010.

3. Which sectors and fields of technology have seen an increase in industrial research? We have major sectors which are very research-intensive: these include the automotive industry, mechanical engineering, chemical industry, and, of course, electrical engineering. These areas account for approximately 90 percent of industrial research expenditure in Germany. But it is interesting that other branches of industry, too, for instance, the plastics industry or metal production, have reported a considerable increase in research expenditure. A similar development has also been observed in small enterprises. Of course, these only account for a very minor share in industrial research expenditure but over the past decade, their expenditure has increased at a higher rate than for large companies.

4. Has there also been an increase in the number of research-based companies in Germany? There has been a slight increase in the number of research-based companies, while the number of non-research-based companies has decreased significantly.

5. Are research-based companies thusly performing better than non-research-based companies? Although this cannot be concluded directly from this development, it gives, however, a clear indication. We have attempted to illustrate this using key performance indicators and have examined the value added of companies with reference to their number of employees. We found that for the whole of the period studied, labor productivity for research-based companies was significantly higher than for non-research-based ones and that this gap continued to widen.

6. Has the number of jobs in industrial research increased? Yes, the number of industrial researchers is increasing. However, expenditure has risen more sharply than the number of researchers, indicating that research costs have increased in recent years.

7. What is the significance of research-based companies in general for Germany's industrial development? Not only do research-based companies perform better, but they also make an already significant but increasingly important contribution to manufacturing output and employment in industry. While 59 percent of those employed in industry were working for research-based companies in 2010, the corresponding figure for 1999 was 55 percent. What is interesting here is that the contribution to employment made by small and medium-sized enterprises has increased at a significantly higher rate than that of large companies.

Interview by Erich Wittenberg.

# Germany Profits from Growth in Brazil, Russia, India, China, and South Africa—But for How Much Longer?

by Georg Erber and Mechthild Schrooten

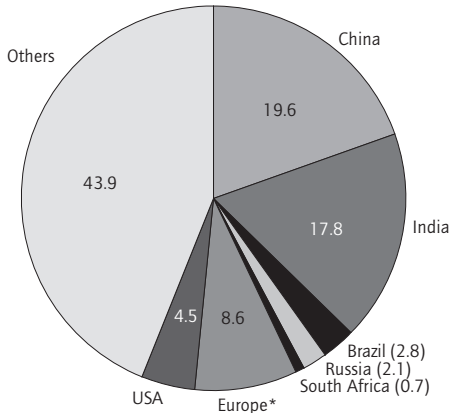
Brazil, Russia, India, China, and South Africa—the BRICS—show high overall economic growth rates by international standards. Even during the recent economic crisis, most BRICS countries still recorded above-average growth. This development has benefited German foreign trade in particular. This applies especially to automotive and mechanical engineering.

However, this geographical reorientation of German export trade in favor of the BRICS countries could soon reach its limits. The institutional and infrastructural conditions of the BRICS are increasingly proving to be bottlenecks for their economic catch-up processes. With the exception of Russia, rapid economic growth in these countries already slowed down in 2011. Further development will depend on the extent to which the governments of the BRICS countries are able to remove the obstacles to growth that have been identified.

The five BRICS countries are Brazil, Russia, India, China, and South Africa.[1] About 43 percent of the world's population (see Figure 1) live in the BRICS countries. Their share of global production has increased significantly in the last ten years, and in 2011 it was approximately 20 percent (see Figure 2). However, the contribution of the BRICS countries to global economic output is still well below their share of the world's population, despite strong growth in recent years.[2]

Figure 1

**Proportion of BRICS to World Population 2010**
In percent




** Excluding Russia, Europe includes the EU and other European economies.*
*Source: United Nations Population Division, online data.*



The BRICS have an overall share of about 43 percent of world population.

Average economic growth in the BRICS countries has been high in recent years. Even in the wake of the international financial crisis, the economies of these countries proved to be relatively stable; only Russia's growth took a real hit in 2009 (see Figure 3). Consequently, economic development in the BRICS countries has had a stabilizing effect on the global economy. Despite a partial decoupling from the global economic environment, individual BRICS countries are not yet able to assume the role of economic driver for the world's economy.[3] In 2011, overall economic dynamism slowed in all BRICS

1 The acronym BRICS was coined by the investment bank Goldman Sachs, attesting to these countries having disproportionately high development potential.

2 M. Schrooten, „Brasilien, Russland, Indien, China und Südafrika: Starkes Wirtschaftswachstum – große Herausforderungen, „Wochenbericht des DIW Berlin, no. 37/38 (2011).

3 C. Dreger and Y. Zhang, China, „Trotz hoher gesamtwirtschaftlicher Dynamik noch keine Lokomotive der Weltwirtschaft," Wochenbericht des DIW Berlin, no. 33 (2012).

countries except Russia. This may be due to government stimulus programs coming to an end. However, growth rates are still higher than those of the major industrial countries.

## Differences in International Integration

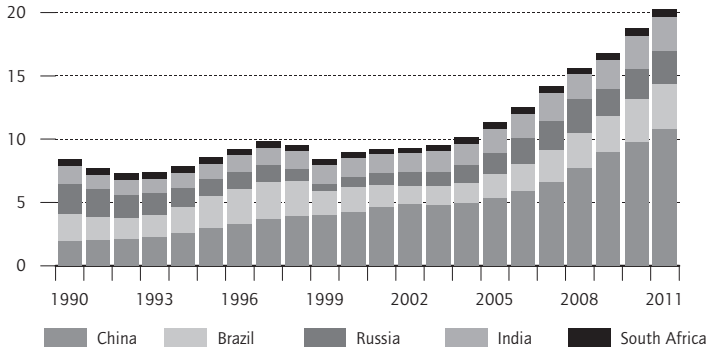
The BRICS countries rely on international economic integration; there is also growing interdependence. However, in view of its external economic integration, BRICS represent a highly heterogeneous group of countries. Russia and China have achieved years of trade surpluses compared to the rest of the world. However, in recent years, the current account balances of these countries relative to the gross domestic product have decreased significantly (see Figure 4). China's large current account surpluses have allowed China to become a major net creditor on the international capital market. China's overall savings rate is still more than 50 percent, and the rate of investment is high by international standards at more than 48 percent.[4] With such high rates of investment, however, there is a risk that unprofitable investment may also occur. This can affect long-term macroeconomic development. Domestic consumption, which increased in 2011 by more than nine percent, could be a strong pillar of China's economic development in future.

Russia, which formerly had massive debts on the international financial markets, also has now a current account surplus. This was 5.3 percent of gross domestic product in 2011. However, if exports of energy resources are excluded, it has a significant current account deficit of -13.1 percent of gross domestic product for 2011. This shows how strongly dependent Russia is on demand for and price development of energy resources in the international markets. In addition to exports of oil and gas, which accounted for 65 percent of all Russian exports in 2011, arms exports have become increasingly important in recent years.[5]

The situation in Brazil, India, and South Africa is quite different. These countries have moderate current account deficits, the causes of which, however, are very different. Brazil's current account deficit in 2011 was primarily attributable to the recovery of profits from international investors.[6] In contrast, the Brazilian trade balance shows a surplus, although regional demand for cars manufactured in Brazil fell. Its trade surplus is expected to continue to rise after the planned development of large offshore oil fields. India's current account deficit in 2011 was less than three percent of gross domestic product. What is striking is the positive balance of ser-

Figure 2

**BRICS' Share of Global Economic Output 1990 to 2011**
In percent



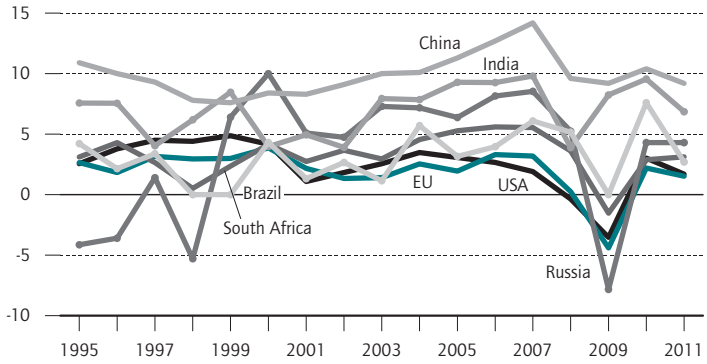

*Based on the current US dollar. China includes Hong Kong and Macau.*
*Sources: The World Bank, calculations by DIW Berlin.*



There has been a particularly sharp increase in China's share of global output.

Figure 3

**Growth of the BRICS Compared to the EU and the US from 1995 to 2011**
In percent




*Growth in real gross domestic product; preliminary figures for 2011.*
*EU = EU27.*

*Sources: International Monetary Fund, national statistics, calculations by DIW Berlin.*



Past growth in the BRICS countries was mostly above average.

4 International Monetary Fund, „People's Republic of China," IMF Country Report, no. 12/195 (July 2012).

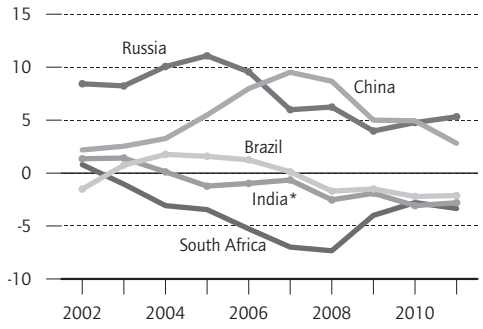
5 International Monetary Fund, „Russian Federation," IMF Country Report, no. 12/217 (August 2012).

6 International Monetary Fund, „Brazil," IMF Country Report no. 12/191 (July 2012).

Figure 4

**Current Account Balances of BRICS 2002 to 2011**

As percentage of gross domestic product




* *Fiscal year 2011/2012.*

*Sources: The World Bank, International Monetary Fund, calculations by DIW Berlin.*



In recent years, China and Russia have had large current account surpluses.

Table 1

**Human Development Index for BRICS and Germany 2011**

| | Rank | Human Development Index |
|---|---|---|
| Germany | 9 | 0.905 |
| Russia | 66 | 0.755 |
| Brazil | 84 | 0.718 |
| China* | 101 | 0.687 |
| South Africa | 123 | 0.619 |
| India | 134 | 0.547 |

* *China, excluding Hong Kong.*

*The HDI is, by definition, between 0 (worst) and 1 (best).*

*Source: United Nations Development Programme.*



As before, most BRICS have relatively low HDI values.

vices; software development plays a major role here.[7] In recent years, there has been a shift away from direct foreign investments to short-term portfolio investments in its capital account. South Africa has reduced its current account deficit significantly since 2008.[8] This resource-rich country has a near-even trade balance. Gold exports make up about ten percent of goods exports.

## Risks to Future Economic Development

The durability of the economic catch-up process also depends on the social, institutional, and infrastructural framework of an economy. These may pose risks to future macroeconomic dynamic growth in the BRICS countries. Indicators assessing overall framework conditions still point to a clear gap between BRICS and industrialized countries. The development gap between the individual BRICS countries is also evident from these indicators.

The Human Development Index (HDI), an international ranking regularly compiled by the United Nations, not only includes per capita GDP but also access to education and life expectancy.[9] It shows that the BRICS countries still have a lot of catching up to do (see Table 1). This is particularly clear in the case of India, 134th out of a total of 187 countries. India's structural weaknesses are also apparent when looking at the World Bank's Doing Business Indicator. This indicator compares how easy it is to do business in a particular country (see Table 2).[10] India ranks poorly here, too. It is worth noting the position of South Africa in this list which is significantly ahead of the other BRICS countries. Even partial indicators—for example for foreign trade or access to credit—show that the BRICS countries still have considerable potential for improving their framework conditions.

The Corruption Perceptions Index (CPI) compares the perceived corruption problems in various countries.[11] Here too, the BRICS countries are ranked far behind Germany and other industrialized countries (see Table

**7** International Monetary Fund, „India," IMF Country Report no. 12/96 (April 2012).

**8** International Monetary Fund, „South Africa," IMF Country Report no. 11/258 (July 2011)

**9** In 2011, the leader was Norway. In 187th and therefore last place was the Democratic Republic of Congo. United Nations Development Programme, Human Development Report 2011 (2011).

**10** In the current ranking, Singapore is in first place, Chad is in 183rd and therefore last place. The World Bank und International Finance Corporation, Doing Business 2012 (Washington, D. C.: 2012).

**11** The Corruption Perception Index CPI is compiled annually by the non-governmental organization, Transparency International. In 2011, New Zealand was in first place, North Korea and Somalia were last equal in 182nd place.

3). South Africa leads the ranking of BRICS countries, ahead of Brazil, China, and India; Russia brings up the rear. A perceived susceptibility to corruption can question, in particular, foreign investors' confidence in the legal security of the country in question. There is also a risk that existing economic potentials cannot be fully exploited because of corruption and, at the same time, the necessary investment in infrastructure lags behind the needs of the private sector and the general public.

## Infrastructural Barriers

The establishment and development of infrastructure in BRICS countries, particularly with regard to energy supply and transport (such as roads and ports), has not kept pace with economic growth. Consequently, access to electricity in most of the BRICS countries is still a major problem (see Table 2). Examples of this include the recent power outages in India. Even in China, there are power shortages, especially in the hot summer months, so factories need to reallocate production from the daytime to nighttime.[12] Thanks to the extremely rapid rise in the number of car owners in major cities such as Beijing, Shanghai, or Chong Ching in China, extensive traffic jams are common in these places.[13] The same also applies in similar megacities in the other BRICS countries. There are also bottlenecks in drinking water supply and sanitation. Furthermore—despite significant progress—there are still bottlenecks in information and communication infrastructures.[14] According to a comparison of infrastructure by the World Economic Forum, Brazil ranks only 104th out of 142 countries. Russia was ranked in 100th place, India in 86th, China in 69th, and South Africa in 62nd place.[15] Without massive investment, infrastructure in the BRICS countries could soon become a key obstacle to growth for these countries. Opportunities are opening up for the German export economy to offer appropriate technology and financing.

Table 2

### Doing Business Rankings for BRICS and Germany 2011

| | Overall ranking | Partial valuations | | |
|---|---|---|---|---|
| | | Cross-border trade | Access to credit | Access to electricity |
| Germany | 19 | 12 | 24 | 2 |
| South Africa | 35 | 144 | 1 | 124 |
| China* | 91 | 60 | 67 | 115 |
| Russia | 120 | 160 | 98 | 183 |
| Brazil | 126 | 121 | 98 | 51 |
| India | 132 | 109 | 40 | 98 |

**China, excluding Hong Kong.*

*Comparison of 183 countries. The lower the rank, the easier it is to do business in this country.*

*Sources: International Finance Corporation, the World Bank.*



It is comparatively difficult to do business in Russia, Brazil, and India.

Table 3

### Corruption Perception Index CPI for BRICS and Selected Industrialized Countries 2011

| Country | Rank | CPI |
|---|---|---|
| New Zealand | 1 | 9.5 |
| Germany | 14 | 8.0 |
| Japan | 14 | 8.0 |
| USA | 24 | 7.1 |
| South Africa | 64 | 4.1 |
| Brazil | 73 | 3.8 |
| China | 75 | 3.6 |
| India | 95 | 3.2 |
| Russia | 143 | 2.4 |

*The index can be a value between 1 (high corruption) and 10 (low corruption).*

*Source: Transparency International, Corruption Perceptions Index 2011.*



Most BRICS countries are still lagging a long way behind in the corruption index.

**12** Z. Yangpeng, „China's electricity shortages may worsen as summer looms," China Daily, February 24, 2012.

**13** Freeways are also struggling with congestion problems. H. Dan and W. Qian, „Monster traffic jam... again," China Daily, September 4, 2010.

**14** „Telecommunications in Brazil—The next big blackout?," The Economist, August 11, 2012.

**15** Table 5 in the World Economic Forum, The Global Competitiveness Report 2011-2012 (Geneva: 2011).

Box

## Germany's Foreign Trade in Cars by Country and Region

Table

### Exports of Automobiles from Germany to Importing Countries in 2010 and 2011

| | 2010 | | 2011 | | |
|---|---|---|---|---|---|
| | Quantities | Shares in percent | Quantities | Shares in percent | Rates of change 2010/2011 |
| **Total** | **4,238,759** | **100.0** | **4,518,973** | **100.0** | **6.6** |
| **Europe overall** | **2,634,866** | **62.2** | **2,729,928** | **60.4** | **3.6** |
| **GIIPS** | **659,012** | **15.5** | **607,959** | **13.5** | **–7.7** |
| Greece | 16,131 | 0.4 | 14,823 | 0.3 | –8.1 |
| Ireland | 25,615 | 0.6 | 26,597 | 0.6 | 3.8 |
| Italy | 372,457 | 8.8 | 349,240 | 7.7 | –6.2 |
| Portugal | 43,863 | 1.0 | 34,097 | 0.8 | –22.3 |
| Spain | 200,946 | 4.7 | 183,202 | 4.1 | –8.8 |
| **BRIC** | **596,245** | **14.1** | **774,457** | **17.1** | **29.9** |
| Russia | 93,088 | 2.2 | 150,227 | 3.3 | 61.4 |
| Brazil | 26,129 | 0.6 | 34,492 | 0.8 | 32.0 |
| China | 462,486 | 10.9 | 566,357 | 12.5 | 22.5 |
| India | 14,542 | 0.3 | 23,381 | 0.5 | 60.8 |
| **Africa** | **79,939** | **1.9** | **76,365** | **1.7** | **–4.5** |
| **USA** | **518,137** | **12.2** | **525,608** | **11.6** | **1.4** |

*No data available for South Africa.*
*Source: German Association of the Automotive Industry (Verband der Automobilindustrie, VDA).*



From 2010 to 2011, rising exports in BRICS countries have more than offset export losses to GIIPS countries.

With a share of 17.4 percent of German foreign trade, motor vehicles and motor vehicle parts was the most important branch of the export economy in 2011. Mechanical engineering is also prominent with a share of 15.2 percent.[1] In 2011, road transport equipment had an export rate of 77 percent. Certainly, development has varied widely in the individual regions and countries over the past two years.

Europe was still the most important market in 2011 with a share of around 60 percent of all automobile exports. That share in the eurozone was 47 percent. The GIIPS countries most affected by the euro crisis achieved a share of almost 14 percent. Compared to 2010, sales in these countries fell by eight percent, since automobiles, as durable goods, were particularly affected by the weak consumer demand in those countries. In absolute terms, the declines in Italy and Spain were the largest.

In contrast, during the same period, automobile sales boomed in the BRICS countries. They even exceeded exports to the GIIPS countries in 2011. Between 2010 and 2011, there was an increase in BRICS exports of almost 30 percent. Based on the absolute number of cars exported there, China is the clear frontrunner. There has been particularly strong growth in exports to Russia and India at more than 60 percent, although the level is still relatively low here. The South African market still has significant growth potential, too. However, the high growth rates of the past year will not continue permanently.

The growing importance of the BRICS countries for German automobile manufacturers can also be seen when compared to its traditional sales market, the US, whose share declined over the past year to less than twelve percent.

1 E. Triebskorn, "Der deutsche Außenhandel im Jahr 2011," Wirtschaft und Statistik (April 2012): 332–341.

## German Export Industry Benefits from BRICS

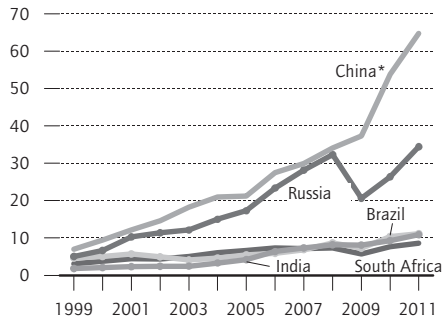
Due to their dynamic growth, the BRICS countries are gaining increasing importance as export markets for industrial countries. The German export industry has been able to benefit significantly from this development.[16] Since 1999, German exports, particularly to China and Russia, have increased dramatically (see Figure 5). In particular, automotive manufacturing and mechanical engineering played a major role (see box).

Compared to other trading partners, the importance of the BRICS countries for the German export market has increased significantly since 1999 (see Figure 6). In

16 G. Erber, „German-Chinese Economic Relations—Opportunities and Risks," Economic Bulletin, no. 3 (2012).

Figure 5

**German Exports to BRICS Countries from 1999 to 2011**
In billion euros at respective prices



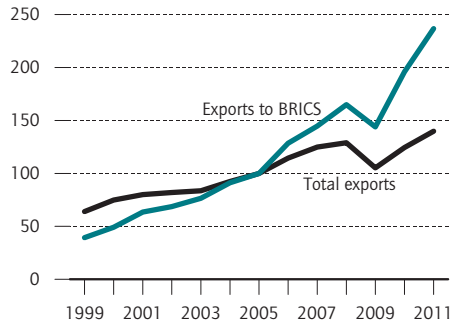

* Excluding Hong Kong and Macau.
Sources: Federal Statistical Office, calculations by DIW Berlin.



Exports to China and Russia since 1999 have increased dramatically.

Figure 6

**Development of German Goods Exports to the BRICS Countries and Overall 1999 to 2011**
Index 2005 = 100



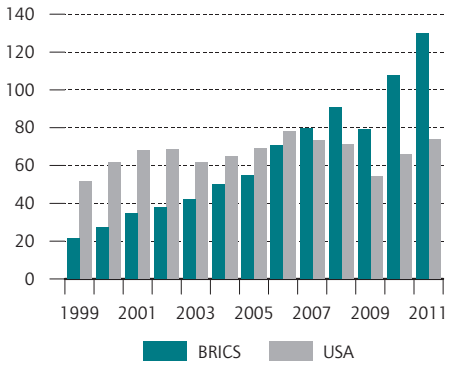

Sources: Federal Statistical Office, calculations by DIW Berlin.



Exports to BRICS countries have developed disproportionately well since 1999.

Figure 7

**German Exports to the USA and BRICS Countries from 1999 to 2011**
In billion euros at respective prices




Source: Federal Statistical Office, calculations by DIW Berlin.



Exports to BRICS countries have overtaken exports to the US.

1999, China only reached 16th place in the list of German export destinations (in terms of value of exported goods); in 2011, China has already risen up the ranks to 5th place. India improved its position in the same period from the 40th to 21st place, Russia, from 20th to 12th place, and South Africa rose from 30th to 24th place. Only the importance of Brazil for German exports remains virtually unchanged (from 21st to 20th place). Alongside European countries, the US, and Japan, the BRICS countries are already Germany's most important trading partners. In 2011, German exports to BRICS countries reached nearly 130 billion euros, almost double exports to the US at 74 billion euros (see Figure 7). In future, this ratio is likely to shift even more in favor of the BRICS countries due to the different growth dynamics.

A comparison with the current crisis countries in the eurozone, Greece, Ireland, Italy, Portugal, and Spain (GIIPS) shows that in 2011 German exports to BRICS countries (129.8 billion euros) clearly exceeded those to the GIIPS countries (113.5 billion euros). The remaining countries in the eurozone, with a total of 307.4 billion euros in 2011, are still of much greater importance to German foreign trade. Without a sustained increase in Europe's growth dynamic, the trend towards a shift in the importance of the BRICS countries for German foreign trade and away from Europe will continue. However, against the background of the above risks to the further economic development of BRICS countries, it is doubtful whether these countries can maintain their current growth paths.

## Conclusion

In recent years, Germany has benefited significantly from strong economic growth in the BRICS countries. This is especially true for the recent crisis years. The example of trade relations with the BRICS countries shows that the German export industry is flexible enough to adapt to changing growth poles in the global economy.

Meanwhile, there have been indications of a decrease in overall economic growth in the BRICS countries. This is not solely due to global economic conditions—in particular. the crisis in some industrialized countries. Rather, these are more likely also due to homemade obstacles to growth. Inadequate institutional and infrastructural framework conditions still represent a bottleneck factor for the further economic development of the BRICS countries. The onus is on national economic policies to ensure an improvement in framework conditions.

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**JEL**: F14, F15, F43
**Keywords**: BRICS, Germany, economic integration, development

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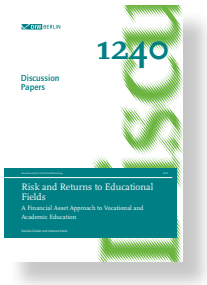
Discussion Papers Nr. 1241/2012
Daniela Glocker, Johanna Storck




## Risks and Returns to Educational Fields: A Financial Asset Approach to Vocational and Academic Education

Applying a financial assets approach, we analyze the returns and earnings risk of investments into different types of human capital. Even though the returns from investing in human capital are extensively studied, little is known about the properties of the returns to different types of human capital within a given educational path. Using information from the German Micro Census, we estimate the risk and returns to around 70 fields of education and differentiate between vocational and academic education. We identify fields of education that are efficient investment goods, i.e. high returns at a given level of risk, and fields that are chosen for other (non-monetary) reasons. Furthermore, we rank fields of education by their return per unit of risk and find that university education is not always superior to other educational paths.

JEL-Classification: I21, J24
Keywords: educational choice, human capital investment, returns to schooling, mean-variance analysis
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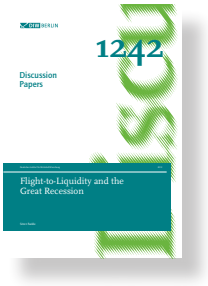
Discussion Papers Nr. 1242/2012
Sören Radde




## Flight-to-Liquidity and the Great Recession

This paper argues that counter-cyclical liquidity hoarding by financial intermediaries may strongly amplify business cycles. It develops a dynamic stochastic general equilibrium model in which banks operate subject to financial frictions and idiosyncratic funding liquidity risk in their intermediation activity. Importantly, the amount of liquidity reserves held in the financial sector is determined endogenously: Balance sheet constraints force banks to trade off insurance against funding outflows with loan scale. The model shows that an aggregate shock to the collateral value of bank assets triggers a flight to liquidity, which amplifies the initial shock and induces credit crunch dynamics sharing key features with the Great Recession. The paper thus develops a new balance sheet channel of shock transmission that works through the composition of banks' asset portfolios rather than fluctuations in borrower net worth as in the financial accelerator literature.

JEL-Classification: E22, E32, E44
Keywords: real business cycles, financial frictions, liquidity hoarding, bank capital channel, credit crunch
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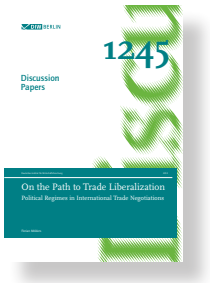
Discussion Papers Nr. 1245/2012
Florian Mölders




## On the Path to Trade Liberalization: Political Regimes in International Trade Negotiations

The number of free trade agreements has increased substantially since 1980 despite efforts to promote multilateral trade liberalization. While there is evidence on the determinants of FTA formation, still little is known on the processing of trade agreements, particularly regarding the pre-implementation duration. This paper fills the research gap by using event data on the proposal, the negotiation, the signing, and the implementation of trade agreements. Duration analysis is employed to examine the connection between regime types and the lengths of the negotiation and the ratification stages. The results support the claim that higher levels of democratization and political constraints are associated with delays in the implementation of an agreement. This is primarily observable in the ratification stage. Moreover, I detect significantly prolonged negotiation talks and ratifications if the European Union participates.

JEL-Classification: F13
Keywords: Free trade agreements, international cooperation, duration analysis
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SOEPpapers Nr. 490/2012
Torben Kuhlenkasper, Max Friedrich Steinhardt


## Who Leaves and When?: Selective Outmigration of Immigrants from Germany

IThe paper provides new evidence on the outmigration of foreign-born immigrants. We make use of data from the German Socio-Economic Panel and employ penalised spline smoothing in the context of a Poisson-type Generalised Additive Mixed Model (GAMM), which enables us to incorporate bivariate interaction effects. A unique feature is the use of data from dropout studies to identify outmigration. For Turkish immigrants, outmigration is characterized by positive skill selection intensifying the initial negative selection process. For Non-Turkish immigrants we instead find a u-shaped pattern between human capital and outmigration. Finally, we discover substantial variation in emigration behaviour during the life-cycle.

JEL-Classification: C14, C51, F22, J61
Keywords: Emigration, self-selection, German Socio-Economic Panel, generalised additive mixed models
www.diw.de/publikationen/soeppapers/soeppapers.html