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Cataloguing data can be found at the end of this publication.


doi 10.2777/88008

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Germany

The challenge of maintaining a high innovation capacity for an export oriented economy

Summary: Performance in research, innovation and competitiveness

The indicators in the table below present a synthesis of research, innovation and competitiveness in Germany. They relate knowledge investment and input to performance or economic output throughout the innovation cycle. They show thematic strengths in key technologies and also the high-tech and medium-tech contribution to the trade balance. The table includes a new index on excellence in science and technology which takes into consideration the quality of scientific production as well as technological development. The indicator on knowledge-intensity of the economy is an index on structural change that focuses on the sectoral composition and specialisation of the economy and shows the evolution of the weight of knowledge-intensive sectors and products and services.

<table>
<thead>
<tr>
<th>Research</th>
<th>Investment and Input</th>
<th>Performance/economic output</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D intensity</td>
<td>2011: 2.84% (EU: 2.03%; US: 2.75%) 2000-2011: +1.28% (EU: +0.8%; US: +0.2%)</td>
<td>Excellence in S&amp;T 2010:62.78 (EU: 47.86; US: 56.68)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2005-2010: +3.88% (EU: +3.09%; US: +0.53)</td>
</tr>
<tr>
<td>Index of economic impact of innovation</td>
<td>2010-2011: 0.813 (EU:0.612)</td>
<td>Knowledge-intensity of the economy 2010:44.94 (EU:48.75; US: 56.25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2000-2010: +1.04% (EU: +0.93%; US: +0.5%)</td>
</tr>
<tr>
<td>Hot-spots in key technologies</td>
<td>Automobiles, Environment, Energy, New production technologiesAAAAAAAAA</td>
<td>HT + MT contribution to the trade balance 2011: 8.54% (EU: 4.2%; US: 1.93%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2000-2011: -0.70% (EU: +4.99%; US: -10.75%)</td>
</tr>
</tbody>
</table>

Germany has expanded its research and innovation system over the last decade. Investment in R&D has grown substantially since 2000 to reach 2.84% of GDP in 2011, which is already close to the 3% national target for 2020. Public expenditure represents one third of investment in R&D. The government increased the public budget on research and innovation even during the 2009 economic crisis as part of a policy of prioritising spending on education and research. Business enterprise expenditure on R&D, which represents two thirds of investment in R&D, also grew as a % of GDP over the period 2000-2010.

The increase in public and private expenditure on research and development in Germany has helped to maintain a high innovation capacity and a strong export performance. The German economy is based to a considerable extent on medium-high technology sectors such as automobiles, electro-technical products, machinery, and chemical products. However, over the last decade Germany has lost its strong market position in pharmaceuticals and in optical industries. Germany has only produced a few successful new players in high-tech industries in the recent past. The development of biotechnology and advanced computer science remains below potential. There is also still underexploited growth potential as regards innovative and knowledge-intensive service economy sectors. Germany has come through the current economic crisis relatively well, partly as a result of a strong export sector. However, the German market position as regards medium-high-tech products may be challenged in the future by new players such as the BRIC countries. An ageing population and fewer young people represent further challenges for the German economy.

The German ministry for research (BMBF) has employed the so-called High-Tech Strategy to address several important challenges. However, further structural reforms of the education, research and innovation system are required. In view of the demographic situation a particular focus on the quality of human resources is necessary and further incentives for excellence and internationalisation are needed. There is room for more public-private cooperation and for implementing targeted supply-side and demand-side measures to foster innovation and fast-growing innovative firms in Germany. Such measures should in particular be targeted at high-tech sectors such as ICT, biotechnology and medical technologies.

1 In fact, Germany is planning to achieve its R&D intensity target of 3% in 2015.
Investing in knowledge

With an R&D intensity of 2.84% in 2011 Germany is above the EU average and is already close to the 3% national target. The gap of 0.16 percentage points currently corresponds to € 4 billion (German GDP amounted to about € 2.5 trillion in 2011). About one third of German R&D investment comes from public sources and two thirds from private sources - a distribution that has remained fairly stable over the last decade. Based on this distribution an additional € 1.5 billion of public expenditure on R&D will be needed (compared to 2011) to reach the R&D intensity target of 3.0%.

In the period 2000-2011 the federal public research budgets, which represent more than half of public spending on research, were expanded substantially. Federal spending on research and education increased by a further 7% in 2011 and by 12% in 2012. However, at Länder level, growth in R&D expenditure, including university expenditure on R&D was much lower. R&D intensities vary strongly between German Länder, ranging from 1.26% in Schleswig-Holstein and 1.27% in Saarland to 4.83% (2009) in Baden-Württemberg, the European region (NUTS II level) with the highest research intensity. Berlin (3.67%), Bayern (3.1%) and Hessen (3.05%) also have R&D intensities that are already above the German national target.

A recent survey of the Stifterverband für die Deutsche Wissenschaft revealed that internal R&D spending of the business sector is expected to amount to € 49.4 billion in 2011 (+5.1% in nominal terms compared to the year before) and € 49.9 billion in 2012 (+1.2%), implying a probable increase in real terms in 2011 of slightly below 3%, and if confirmed, a slight decrease in real terms in 2012. Research intensity is especially high in the automobile sector, which represents nearly one third of total German business R&D investment. A weak point of German R&D is the relatively low level of spending in high-tech areas such as pharmaceuticals and ICT.

Concerning EU funding Germany has allocated € 25.5 billion of ERDF Structural Funds to research, innovation and entrepreneurship with a 47.1% absorption rate. Germany counts 11 000 participants in the EU FP7 programme and receives the highest amount of FP7 funding in absolute terms (€ 4.3 billion). Its success rate of applications is above average (24% compared to an EU average of 20.4%), but FP7 funding as a % of GDP is below the EU average.
An effective research and innovation system building on the European Research Area

The graph below illustrates the strengths and weaknesses of the German R&I system. Reading clockwise, the graph provides information on human resources, scientific production, technology valorisation, and innovation. Average annual growth rates from 2000 to the latest available year are given in brackets.

In general Germany's research and innovation system performs very well. However, the international dimension is below the EU average, in particular in relation to foreign investment in business R&D and EU Framework Programme funding. Possible explanations relate to the country size effect, as well as to the high level of German domestic public and private expenditure on R&D. Despite the easy access to and relative abundance of national funding for research, Germany could better use the opportunities offered within the ERA and more specifically within the Framework Programme.

Germany has a particular strength in business R&D especially in innovative SMEs, many of which are world leaders in their particular small market segments. The high level of patenting is an indication of industrial leadership in several domains, most notably in medium-high-tech industries including engineering industries, automobiles and chemicals and also in environmental and energy technologies. Public-private co-operation in publications and in research is functioning well and is further supported by the federal government in the current new programme activities for innovation outlined in the "High Tech Strategy". While Germany performs well in terms of new doctoral graduates, its performance as regards new science and engineering graduates has only recently surpassed the EU average and there is the risk of slower growth in the long term as a result of the ageing of the population. The risk of a scarcity of qualified human resources could in the long term endanger the strong German export position in engineering and science based industries. In recent years there has been an increase in the number of students in science and engineering subjects (MINT), but efforts should be maintained to further reduce dropout rates and to increase the share of female professors, which in turn would attract more female students.
Germany's scientific and technological strengths

The maps below illustrate six key science and technology areas where German regions have real strengths in a European context. The maps are based on the number of scientific publications and patents produced by authors and inventors based in the regions.

Strengths in science and technology at European level

Scientific production  New production technologies  Technological production

Materials

Automobiles

Source: DG Research and Innovation – Economic Analysis unit
Data: Science Metrix using Scopus (Elsevier), 2010; European Patent Office, patent applications, 2001-2010
As illustrated by the maps above, there is a notable difference in performance between scientific production (publications) and technological production (patents) in Germany. Levels of scientific publication vary across German regions with only a few regions on the same level as their main competitors in Europe. This is even true for sectors such as production technologies, materials, and automobiles, where German companies are among the world leaders. An explanation of the relatively weak scientific publication activity in Germany may be a language bias.

Patenting activities in Germany are very high in the areas referred to above. Energy, environment and health are other areas where patenting is particularly strong. The big public research institutes such as the Max Planck Society, the Fraunhofer Society, the Helmholtz society, and also the Leibniz institutes are specialised in these areas, work closely with universities and are generally highly ranked in recognised international comparisons. The regions of the south and the south-west of Germany are most active in patenting. Saxony and southern Brandenburg (Potsdam) in the New Länder as well as Berlin also show relatively high levels of patenting.
Policies and reforms for research and innovation

The High-Tech Strategy 2020, launched in August 2006 and updated in July 2010, is seen as an instrument to improve cooperation between science and industry, and to improve the conditions for innovation with a view to enhancing the international competitiveness of technology-intensive manufacturing products in key sectors of the German economy. The 2010 update of the High-Tech Strategy prioritises the targeting by public-private partnerships of prospective markets related to important societal challenges in 10 so called forward-looking projects ("Zukunftsprojekte"). Strategic priorities of the High-Tech Strategy 2020 are health, nutrition, climate and energy security, and communication and mobility.

As regards fiscal policies Germany is one of the few countries that has not introduced R&D tax credits. The introduction of R&D tax credits is currently being considered at federal level as such credits tend to be requested by large international companies.

Germany is already quite close to achieving its national R&D intensity target of 3%. Only an extra 0.16 % of GDP or about € 4 billion are needed to reach the target. However, available data show an increasing disparity between R&D intensity in the northern Länder and the southern Länder. In fact R&D intensity is almost four times higher in Baden-Württemberg (the leading EU region) than in Mecklenburg-Vorpommern and Schleswig-Holstein. This disparity also applies to private investment in R&D.

The university system, which is the responsibility of the Länder, is considered to be underfinanced, given the recent strong increase in student numbers. In order to enable additional federal funding for universities, the Hochschulpakt (higher education pact), voluntary agreements between the federal and the Länder levels, has been set up. This pact was renewed in 2009 and additional resources were allocated in March 2011.

As regards human resources Germany has taken measures to remove restrictions on in-bound researcher mobility in view of a skills shortage in some science and technology domains. The federal government recently decided on a reform of the Immigration Act to facilitate the processing of residence permits, and on an action programme to ensure an adequate supply of labour, and on programmes for enhancing international mobility. The legal parameters for the employment of foreign graduates of German universities have been improved and the recognition of qualifications acquired abroad is being facilitated by new initiatives. This could help to increase the still relatively low share of foreign professors. Researcher salaries in Germany are above the EU average, but lag behind those in the United States and Switzerland. Recently the Constitutional Court issued a ruling on minimum wages for full professors in universities that could lead to increased salaries for those at the lower end of the wage scale.

A national pact to attract more women to science and engineering (‘Komm mach MINT-mehr Frauen in MINT-Berufen’) was set up on the initiative of the Research Ministry (BMBF) in June 2008 and a second phase of this pact was launched in December 2011.

As regards the knowledge triangle and the fostering of innovation activities the Research Ministry (BMBF) and the Ministry for Economic Affairs (BMWI) are making attempts to focus better their activities. The BMBF fosters public/private partnerships by activities such as the 'Leading-edge cluster competition', which aims at the formation of business and science clusters to boost Germany's innovative strengths in specific areas and more recently (August 2011) the 'Research Campus', a competitive funding scheme to strengthen cooperation between companies and research organisations. The BMWI uses the EXIST programme to stimulate an entrepreneurial environment at universities and research institutions. This programme is aimed at increasing the number of technology and knowledge-based business start-ups. The programme is part of the federal government’s 'High-tech Strategy' and comprises sub-programmes on improving start-up business culture, stipends and knowledge transfers.
Economic impact of innovation

The index below is a summary index of the economic impact of innovation composed of five of the Innovation Union Scoreboard's indicators.2

Source: DG Research and Innovation - Economic Analysis Unit (2013)
Data: Innovation Union Scoreboard 2013, Eurostat
Note: (1) Based on underlying data for 2009, 2010 and 2011.

Germany - Index of economic impact of innovation (1)

Germany has one of the highest economic impact of innovation in Europe. The German economy is more oriented towards knowledge-intensive sectors than the EU as a whole. This is reflected also in the composition of exports of goods and services and in the innovation activities of enterprises, including those of SMEs, which are clearly above the EU average. Innovative German enterprises have a good growth performance combined with a high level of technology development.

The distribution of business expenditure on R&D reflects the concentration of German industry in medium-high-tech sectors, with more than 30% of R&D spending carried out by the automobile sector alone. Other important medium-high-tech sectors in terms of R&D expenditure are machinery and equipment and chemicals excluding pharmaceuticals. These three sectors represent around 50% of business expenditure on R&D in Germany. Spending levels are relatively lower in high-tech areas with pharmaceuticals, radio, TV and communication equipment, and medical precision and optical instruments together accounting for only around 20% of business expenditure on R&D. Research is furthermore concentrated in big companies and research intensity is lower in the services sector than in manufacturing. To assist SMEs in enhancing research and innovation a Central Innovation Programme for SMEs (ZIM, 'Zentrales Innovationsprogramm Mittelstand') has been set up in 2008 and will run till 2014.

Framework conditions for entrepreneurship in Germany have improved as indicated by an improved ranking for Germany in the World Banks ease of doing business index. Germany has also made progress in reducing the administrative burden related to reporting obligations in the business sector. In 2011, The Bureaucracy Reduction and Better Regulation programme has been extended to cover other compliance costs. However, Germany remains at around the EU average regarding the administrative burden of the regulatory framework.

Labour productivity in Germany is high and access to bank lending for SMEs is above the EU average. The quality of the infrastructure is good and the legal and regulatory framework is perceived by business as being appropriate. Remaining weak points concern the availability of broadband and the usage of e-government services. Furthermore the availability of venture capital in Germany (0.17% of GDP in 2011) remains below the EU average (0.35%).

In the Global Competitiveness Report 2012-13 Germany is ranked highest among EU countries in capacity for innovation, second highest (after Finland) in company spending on R&D and 6th in the EU on university-industry collaboration on R&D.

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2 See Methodological note for the composition of this index.
**Upgrading the manufacturing sector through research and technologies**

The graph below illustrates the upgrading of knowledge in different manufacturing industries. The position on the horizontal axis illustrates the changing weight of each industry sector in value added over the period. The general trend of moving to the left-hand side reflects the decrease of manufacturing in the overall economy. The sectors above the x-axis are sectors whose research intensity has increased over time. The size of the bubble represents the share of the sector (in value added) in manufacturing (for all sectors presented in the graph). The red-coloured sectors are high-tech or medium-high-tech sectors.

![Graph illustrating the upgrading of knowledge in different manufacturing industries.](image)

**Source:** DG Research and Innovation - Economic Analysis unit

**Data:** OECD

**Notes:**
1. High-Tech and Medium-High-Tech sectors are shown in red. ‘Other transport equipment’ includes High-Tech, Medium-High-Tech and Medium-Low-Tech.
4. ‘Basic metals’, ‘Coke, refined petroleum and nuclear fuels’ and ‘Fabricated metal products’ are not visible on the graph.

The German economy is characterised by a relatively strong manufacturing industry. Nevertheless, as in many countries, the share of value added of manufacturing industries in total value added is tending to decrease (illustrated by a leftward shift in the graph above). This is linked to rationalisation and a relative decline in the price levels of manufactured goods, the expanding services sector and also to globalisation and competition from lower wage, emerging economies.

Compared to other EU Member States the German manufacturing industries present an above average dynamic of upgrading knowledge through R&D. Growth in business research intensity since 1995 was moderate, but still faster than the EU average. The motor vehicles industry, a key sector of the German economy, has expanded its high research intensity further and has also succeeded in increasing its share of value added. A second important medium-high-tech sector, machinery and equipment, has expanded its share of the economy even more strongly, despite a more moderate growth in research intensity. The same is true for the high-tech sector medical, precision and optical instruments. The medium-high-tech sector electrical machinery and apparatus, has lost research intensity over the last 15 years, but maintained its share of value added. Office, accounting and computing machinery is the only high-tech sector with a decreasing share of value added. In this sector there was also a decline in research intensity over the last 15 years. The insufficient pace of modernisation in these knowledge-intensive industries endangers their medium-term competitive advantage.
Competitiveness in global demand and markets

Investment in knowledge, technology-intensive clusters, innovation and the upgrading of the manufacturing sector are determinants of a country's competitiveness in global export markets. A positive contribution of high-tech and medium-tech products to the trade balance is an indication of specialisation and competitiveness in these products.

The German economy is strong and has high levels of exports of manufactured goods for an economy of its size. In fact, Germany is the third largest exporter worldwide\(^3\), after China and the United States. In 2010 Germany was the economy with the largest export surplus in absolute terms. As regards trade in services, in 2010 Germany ranked second, after the United States. In real terms, the German trade balance in high-tech and medium-tech products is positive and has more than doubled over the last decade.

The evolution of the contribution of high-tech and medium-tech products to the trade balance in the decade 2000-2011 shows a mixed picture for Germany, with few sectors expanding their contribution to the trade balance, most sectors not changing their contribution significantly and about one quarter of high-tech and medium-tech sectors decreasing their contribution. As regards the three largest German export industries, all classified as high-tech or medium-high-tech: machinery, in particular office machinery and power generating machinery has expanded its contribution to the trade balance, while road vehicles, today Germany's largest export industry, has also expanded its contribution, but to a lesser extent. The contribution of chemical products, Germany's third largest export industry, to the trade balance has shrunk over the same period.

Total factor productivity of the German economy increased since 2000 by 5% per annum. However, Germany has performed less well when it comes to up-skilling its labour force. The share of the population aged 30-34 who have successfully completed tertiary education has increased only moderately since 2000 and is now below the EU average\(^4\). Germany is also making progress towards the other Europe 2020 targets, backed up by a very high but decreasing level of patenting in areas of societal challenges, such as health-related and environment-related technologies.

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\(^3\) In the period 2003-2008 Germany was the largest exporter but has been overtaken in 2009 by China and in 2010 by the USA

\(^4\) If post-secondary non-tertiary education is included (ISCED 4), which Germany considers equivalent to higher education in its national target, Germany performs near the EU average, but growth in attainment still remains below average.
### Key indicators for Germany

#### ENABLERS

##### Investment in knowledge

- **New doctoral graduates (ISCED 6) per thousand population aged 25-34**
  - 2000: 2.12
  - 2001: 2.13
  - 2002: 2.14
  - 2003: 2.23
  - 2004: 2.59
  - 2005: 2.53
  - 2006: 2.52
  - 2007: 2.65
  - 2008: 2.64
  - 2009: 2.68
  - **Average annual growth (1)**: 2.4
  - **EU average (2)**: 1.69
  - **Rank within EU**: 3

- **Business enterprise expenditure on R&D (BERD) as % of GDP**
  - 2000: 1.74
  - 2001: 1.73
  - 2002: 1.77
  - 2003: 1.77
  - 2004: 1.74
  - 2005: 1.78
  - 2006: 1.77
  - 2007: 1.86
  - 2008: 1.91
  - 2009: 1.88
  - **Average annual growth (1)**: 0.8
  - **EU average (2)**: 1.26
  - **Rank within EU**: 4

- **Public expenditure on R&D (GOVERD + HERD) as % of GDP**
  - 2000: 0.73
  - 2001: 0.75
  - 2002: 0.77
  - 2003: 0.77
  - 2004: 0.77
  - 2005: 0.76
  - 2006: 0.76
  - 2007: 0.83
  - 2008: 0.92
  - 2009: 0.92
  - **Average annual growth (1)**: 2.3
  - **EU average (2)**: 0.74
  - **Rank within EU**: 5

- **Venture Capital (3) as % of GDP**
  - 2000: 0.19
  - 2001: 0.13
  - 2002: 0.06
  - 2003: 0.05
  - 2004: 0.06
  - 2005: 0.04
  - 2006: 0.34
  - 2007: 0.29
  - 2008: 0.10
  - 2009: 0.19
  - **Average annual growth (1)**: -1.2
  - **EU average (2)**: 0.35
  - **Rank within EU**: 10

- **S&T excellence and cooperation**
  - **Composite indicator of research excellence**
    - 2000: 105.9
    - 2001: 107.6
    - 2002: 107.6
    - 2003: 113.1
    - 2004: 115.6
    - **Average annual growth (1)**: 1.3
    - **EU average (2)**: 10.9
    - **Rank within EU**: 6

- **Science publications within the 10% most cited scientific publications worldwide as % of total scientific publications of the country**
  - 2000: 10.5
  - 2001: 10.7
  - 2002: 10.6
  - 2003: 11.7
  - **Average annual growth (1)**: 1.1
  - **EU average (2)**: 1.3
  - **Rank within EU**: 3

- **International scientific co-publications per million population**
  - 2000: 297
  - 2001: 273
  - 2002: 292
  - 2003: 413
  - 2004: 456
  - **Average annual growth (1)**: 0.20
  - **EU average (2)**: 0.26
  - **Rank within EU**: 13

- **Public-private scientific co-publications per million population**
  - 2000: 51.9
  - 2001: 62.8
  - **Average annual growth (1)**: 3.9
  - **EU average (2)**: 47.9
  - **Rank within EU**: 5

##### Innovation contributing to international competitiveness

- **PC1 patent applications per billion GDP in current PPS€**
  - 2000: 1.92
  - 2001: 1.99
  - 2002: 2.09
  - **Average annual growth (1)**: 0.3
  - **EU average (2)**: 3.9
  - **Rank within EU**: 3

- **Sales of new to market and new to firm innovations as % of turnover**
  - 2000: 17.6
  - 2001: 19.2
  - **Average annual growth (1)**: -2.1
  - **EU average (2)**: 14.4
  - **Rank within EU**: 4

- **SMEs introducing product or process innovations as % of total employment aged 15-64**
  - 2000: 14.9
  - 2001: 15.4
  - **Average annual growth (1)**: 0.3
  - **EU average (2)**: 13.8
  - **Rank within EU**: 9

- **Knowledge-intensive services exports as % of total services exports**
  - 2000: 48.8
  - 2001: 49.8
  - **Average annual growth (1)**: 2.5
  - **EU average (2)**: 45.1
  - **Rank within EU**: 5

- **Growth of total factor productivity (total economy) - 2000 = 100**
  - 2000: 100
  - 2001: 101
  - **Average annual growth (1)**: 0.3
  - **EU average (2)**: 103
  - **Rank within EU**: 15

##### Factors for structural change and addressing societal challenges

- **Composite indicator of structural change**
  - 2000: 40.5
  - 2001: 41.9
  - **Average annual growth (1)**: 1.0
  - **EU average (2)**: 48.7
  - **Rank within EU**: 14

- **Employment in knowledge-intensive activities (manufacturing and business services) as % of total employment aged 15-64**
  - 2000: 14.9
  - 2001: 15.4
  - **Average annual growth (1)**: 0.3
  - **EU average (2)**: 13.8
  - **Rank within EU**: 9

- **SMEs introducing product or process innovations as % of employment aged 25-34**
  - 2000: 53.4
  - 2001: 52.8
  - **Average annual growth (1)**: 2.5
  - **EU average (2)**: 38.4
  - **Rank within EU**: 1

- **Environment-related technologies - patent applications to the EPO per billion GDP in current PPS€**
  - 2000: 1.03
  - 2001: 0.98
  - **Average annual growth (1)**: -1.8
  - **EU average (2)**: 0.39
  - **Rank within EU**: 2

- **Health-related technologies - patent applications to the EPO per billion GDP in current PPS€**
  - 2000: 1.05
  - 2001: 1.12
  - **Average annual growth (1)**: -2.2
  - **EU average (2)**: 0.52
  - **Rank within EU**: 5

### EUROPE 2020 OBJECTIVES FOR GROWTH, JOBS AND SOCIETAL CHALLENGES

- **Growth of total factor productivity (total economy) - 2000 = 100**
  - 2000: 100
  - 2001: 101
  - **Average annual growth (1)**: 0.3
  - **EU average (2)**: 103
  - **Rank within EU**: 15

Source: DG Research and Innovation - Economic Analysis Unit

Date: Eurostat, DG JRC - ISPRA, DG ECFIN, OECD, Science Metrix / Scopus (Elsevier), Innovation Union Scoreboard

Notes:
1. Average annual growth refers to growth between the earliest available year and the latest available year for which compatible data are available over the period 2000-2012.
2. EU average for the latest available year.
3. Venture Capital includes early-stage, expansion and replacement for the period 2000-2006 and includes seed, start-up, later-stage, growth, replacement, rescue/turnaround and buyout for the period 2007-2011.
4. Venture Capital: EU does not include EE, CY, LV, LT, MT, SI, SK. These Member States were not included in the EU ranking.
5. EU is the weighted average of the values for the Member States.
6. The value is the difference between 2010 and 2000. A negative value means lower emissions.
8. The value is the difference between 2010 and 2000. A negative value means lower emissions.
9. The values for this indicator were ranked from lowest to highest.
10. Values in italics are estimated or provisional.
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Research and Innovation performance in Germany - Country profile

Luxembourg: Publications Office of the European Union

2013 — 10 pp. — 21 x 29,7 cm

doi 10.2777/88008