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An international comparison of R&D:* Germany benefits from industrial research strength

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In developed countries, investments in R&D are the key driver for growth. The fact that Germany has stepped up its R&D efforts since 2007 is therefore very encouraging. This has occurred both in industry and the public sector. Germany now ranks fifth among comparable OECD countries, which means it even beats the USA and is far ahead of France and Great Britain.

The strength of Germany's (private-sector) industry in terms of R&D is primarily due to R&D-intensive sectors within manufacturing: 55 % of R&D activity is concentrated in the vehicle manufacturing, computing / electronics and mechanical engineering sectors. In a country comparison, Germany's strength in R&D is due to its favourable sector composition and has less to do with how much effort the respective sectors put into R&D.

Germany is on the right track but it must not let up in its efforts to further increase R&D investment. For a country that to a large degree owes its prosperity to R&D-intensive industry and knowledge-intensive services associated with production, R&D investment continues to be a key requirement for future growth.

In developed economies, research and development (R&D) and the innovations it brings are crucial determinants of a country's ability to compete on an international level, of productivity trends and economic growth. On behalf of the KfW Banking Group, DIW Berlin carried out a study of R&D's effect on growth and Germany's position relative to 14 major competing countries, covering the period from 1995 to 2012.[1]

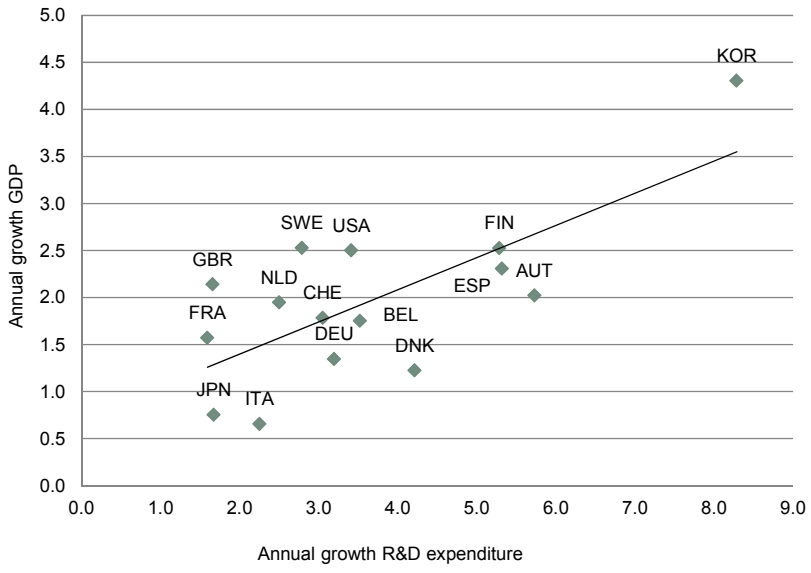
R&D as a driver of growth

It is immediately clear from Figure 1 that there is a strong correlation between the amount of effort a country puts into R&D and its economic growth: Countries that have substantially expanded their R&D activities often achieve high GDP growth, as is the case for South Korea, Finland, Spain and Austria. In contrast, the Japanese and Italian economies grew by the smallest amount, and both of these are countries that had only limited success in increasing R&D expenditure.

This is confirmed by econometric analyses: An increase of one percentage point in the rate of R&D growth leads to a rise in GDP growth of around 0.05 to 0.15 percentage points in the subsequent year (depending on the regression method and model specifications). The value for Germany determined by this analysis is at the upper margin of this range.[2] Based on the econometric analyses, for Germany this means: a EUR 1bn increase in R&D spending already results in between EUR 470m and 1bn of GDP growth the following year. Investments in R&D raise the know-how in an economy – technically speaking they increase the R&D capital stock. As this knowledge is permanently available, investments in R&D not only have an effect in the short term but also lead to long-term increases in productivity and

Figure 1: Correlation between R&D and economic growth, 1995–2012

(in per cent)

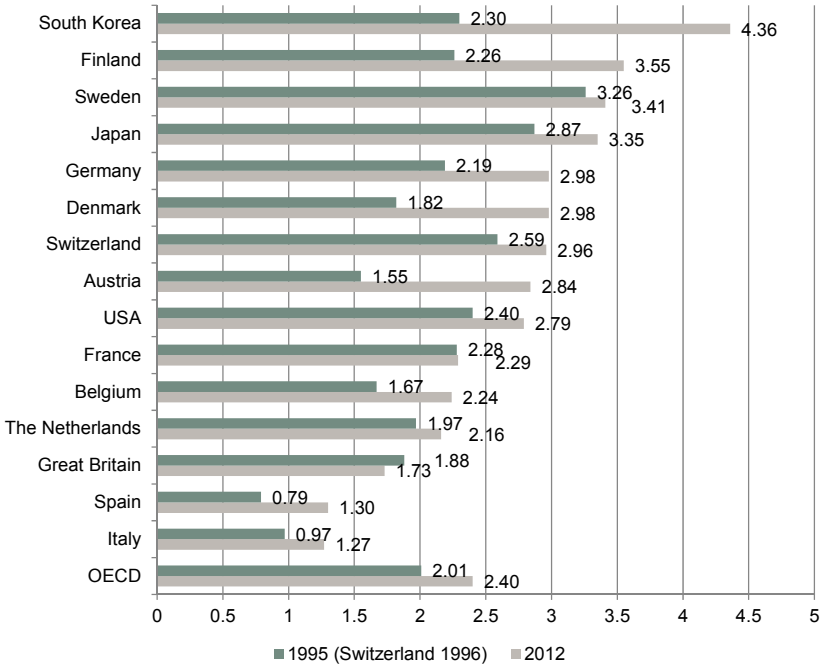


Source: OECD, calculations by DIW Berlin

* The study draws on the OECD's MSTI, ANBERD and STAN databases. Data as at June 2014. The changeover to ESA 2010 GDP calculations had not yet taken place at this point.

Figure 2: R&D intensity (ratio of R&D expenditure to GDP) in 1995 and 2012

(in per cent)



Source: OECD, calculations by DIW Berlin

economic growth.

Investment in R&D: Germany ranks highly ...

In view of this, it is encouraging to note that in relation to its economic power, Germany's investment in research and development is substantially higher than average compared with the other countries studied. With an R&D intensity (ratio of R&D expenditure to GDP) of 2.98 %, Germany comes fifth among the countries studied (average score: 2.40 %). This means Germany even beats the USA and is far ahead of France and Great Britain (Figure 2). Among the major economies, only South Korea and Japan's R&D intensity is higher than in Germany. This means that in 2012 Germany also came close to achieving the target score of 3 % set out under the Lisbon Strategy.[3]

... thanks to a considerable increase in R&D intensity since 1995

But Germany did not always fare this well. While in the 80s the Federal Republic of Germany had been one of the leading countries in terms of R&D, by 1995 the reunified Germany had dropped to eighth place among the countries studied. However, between 1995 and 2012, Germany managed to substantially increase its levels of R&D again and overtake countries such as Switzerland, the USA and France in terms of R&D intensity.

Rapid growth in the R&D budget ...

The improvement in R&D intensity is the result of sharp rises in real R&D spending over recent years. Having stood at only 2.6 % p.a. at the start of the period under consideration, between 2005 and 2012 R&D growth in Germany accelerated to well over 4 %. After 2005, only South Korea outpaced Germany in terms of R&D growth (Figure 3).

... in industry and the public sector

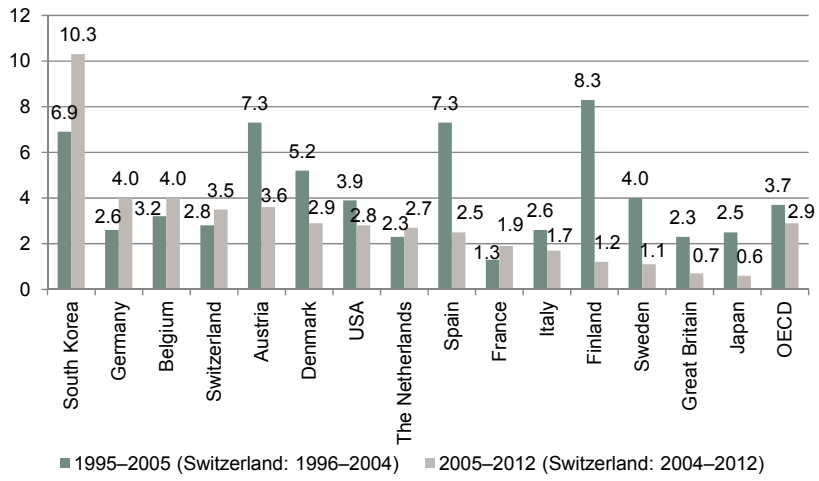
This occurred both in industry and the public sector. With an average rise of 4.8 % a year, public-sector investment in R&D increased particularly strongly after 2005, primarily in universities and research institutions. Among the 15 countries considered here, Germany even managed to achieve second place in the public-sector growth rankings between 2005 and 2012, having come only 12th in the period before that (public-sector R&D growth rate 1995–2005: 1.6 %). This reflects a change in policy from 2007 onwards, which now places greater emphasis on public-sector research. In industry, investment in R&D rose from 3.1 to 3.7 % p.a. In terms of R&D intensity, Germany's private sector came in sixth in 2012, placing it in the top part of the second third of the table.

Figure 4 shows how Germany intensified its focus on R&D. During the second half of the 90s, R&D expenditure in industry increased more dynamically than GDP growth. R&D spending in the public sector, however, only rose in line with GDP between 1995 and 2007.

It was not until after 2007 that R&D investment began to grow more quickly in both sectors, although real R&D ex-

Figure 3: Annual growth in R&D spending in industry and the public sector, 1995–2012

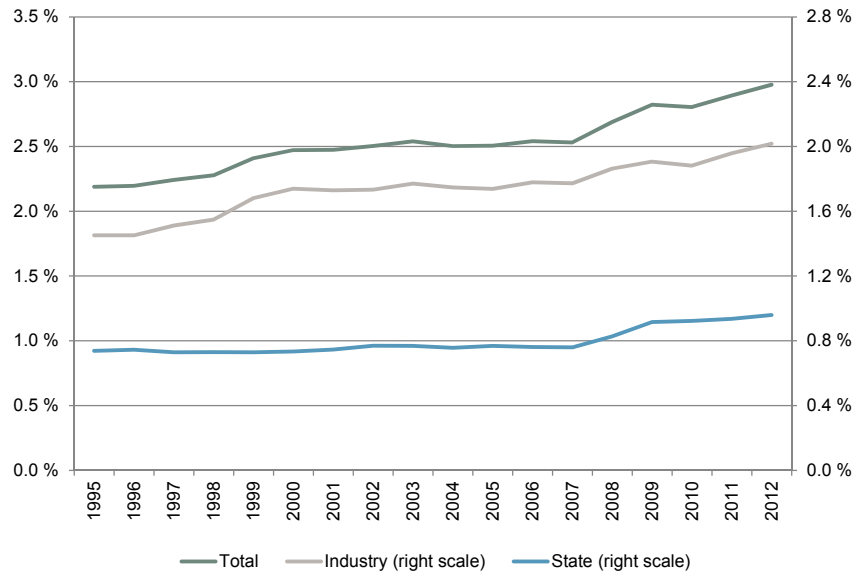
(in per cent)



Source: OECD, calculations by DIW Berlin

Figure 4: R&D intensity in Germany – industry and public sector, 1995–2012

(in per cent)



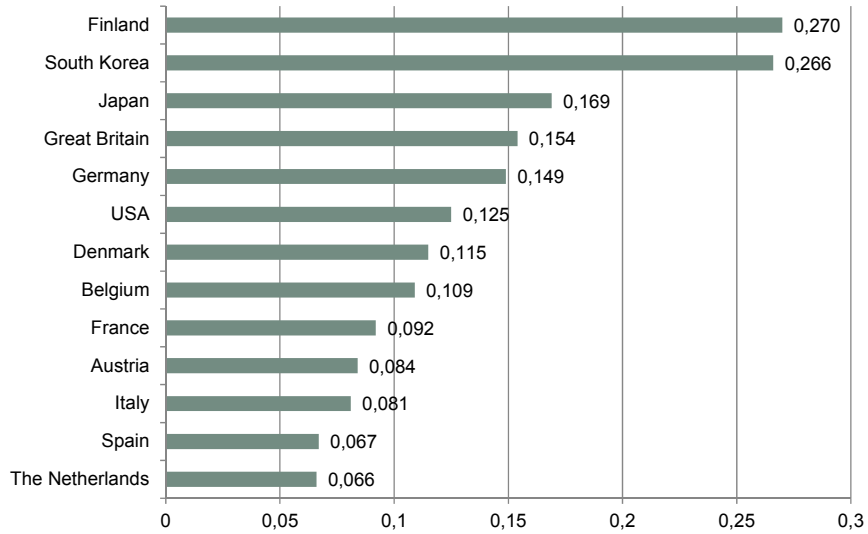
Source: OECD, calculations by DIW Berlin

penditure in industry suffered a setback in 2009/2010 as a result of the financial crisis. In the public sector, R&D spending rose particularly strongly in 2008 and 2009. Not only did this help to alleviate the effects of the financial crisis, it also contributed to a further rise in overall R&D intensity.

Germany maintains R&D share despite falling trend

Thanks to the substantial rise in R&D spending, Germany managed to slightly increase its share of total R&D expenditure among the comparative countries relative to 1995. In contrast, other large countries such as the USA, Japan, France and Great Britain were forced to accept reductions. The proportion of overall R&D spending attributable to Germany (9.2 %) puts it in third place, behind the USA (41 %) and Japan (13.7 %).[4]

Figure 5: Sector concentration in R&D expenditure 2011



Note: Sector concentration is measured using the Herfindahl-Hirschman index.

Source: OECD, calculations by DIW Berlin

R&D profile in German industry: industrial research strong

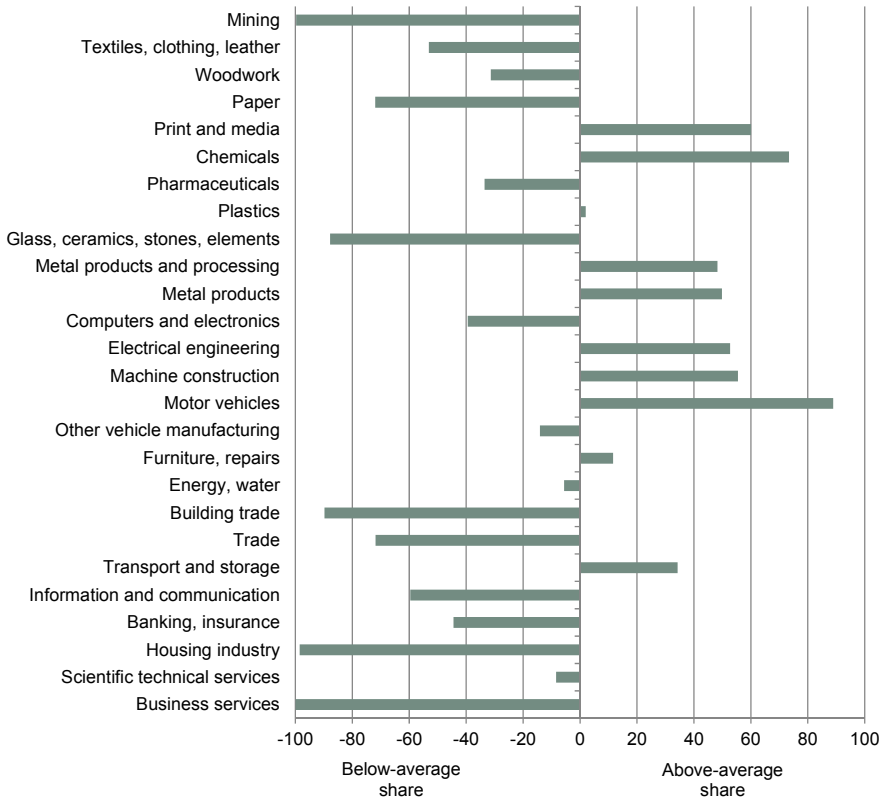
In Germany, as in Japan and South Korea, more than 85 % of R&D carried out in the private sector relates to manufacturing industries. The figure in the USA is less than 70 %; in France it is just under 50 % and in Great Britain only 37 %. R&D investment within German industry is also concentrated relatively highly within certain sectors. Vehicle manufacturing, computing / electronics and mechanical engineering account for 55 % of Germany's R&D, with vehicle manufacturing alone making up 31 %.[5] The scientific Commission of Experts for Research and Innovation (Expertenkommission Forschung und Innovation – EFI), is one group that sees this as cause for concern.[6] Germany has the fifth highest sector concentration in R&D among the countries studied (Figure 5).[7]

Contrary to what might be expected, R&D concentration within a country is not directly correlated with its size. Concentrations are higher in Japan and South Korea, both large countries, as well as in Finland, which is relatively small. In contrast, R&D is less concentrated within individual sectors in Denmark, Belgium and the Netherlands – all small countries – than it is in Germany.

German research focused on vehicles, chemistry, machinery and the electrical sector

In comparison with other countries, there is also a strong specialisation in Germany on R&D-intensive economic sectors. The main sectors concerned are vehicle manufacturing, chemistry, mechanical engineering and electrical engineering (Figure 6).[8] Printing and media, manufacturing of metal products and metal production are also major areas for R&D in Germany. In contrast, relatively little research is carried out in Germany in the R&D-intensive sectors of pharma and computing & electronics compared with other countries. Other countries also focus more of their R&D on most of the service sectors, infrastructure, mining and construction than Germany. One ar-

Figure 6: Relative share of R&D investment (RSR) by economic sector in Germany, 2011



Source: OECD, calculations by DIW Berlin

ea within the service sector is an exception to this – transport and storage.

Favourable economic structure or high level of commitment at sector level?

Differences between countries' private-sector R&D intensity can arise both as a result of divergent economic structures and because of variations in investment patterns within sectors. The differences between Germany and the comparative countries were therefore broken down into behavioural and structural components.[9] For example, Germany's R&D intensity is 1.51 percentage points lower than South Korea's. Of this amount, a difference of -1.77 percentage points is attributable to variations in economic structure (structural effect). The behavioural effect in Germany's favour (0.27 percentage points) has the opposite effect (Figure 7).

The behavioural effect for Germany is negative for almost all comparative countries (grey bar). This means that there is often less investment in R&D within a sector in Germany than in the comparative countries. In contrast, the structural effect is generally positive for Germany (green bar). Hence Germany's economic structure is beneficial to R&D, and the R&D-intensive sectors of industry have a particularly large impact.

Conclusion

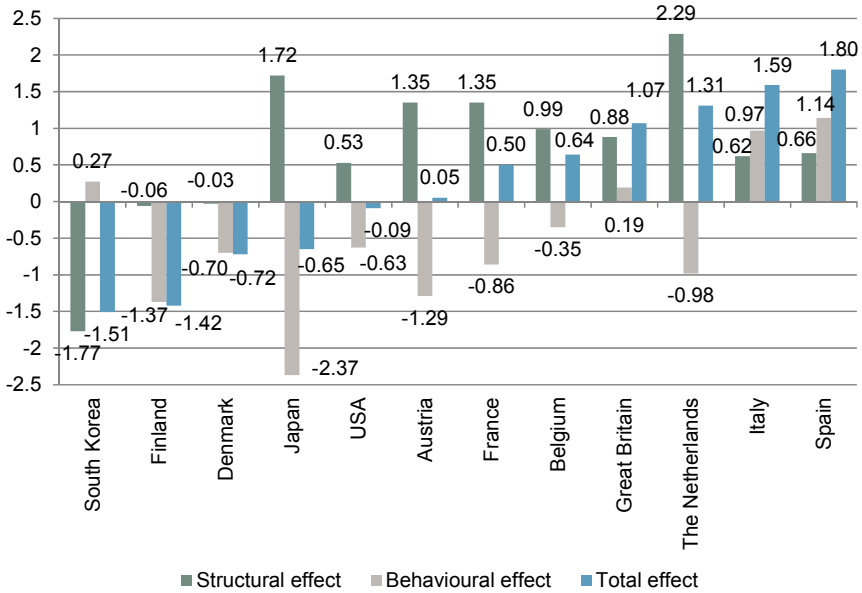
Investment in R&D can increase Germany's GDP – if the R&D growth rate rises by one percentage point, GDP growth already goes up by around 0.05 to 0.15 percentage points in the subsequent year.

Hence it is very encouraging that Germany came close to reaching the goal of investing 3 % of gross domestic product (GDP) in R&D in 2012. Germany is therefore above the average for comparable OECD countries, even beating the USA and far ahead of France and Great Britain.

Above all, from 2007 onwards R&D spending in Germany grew faster than GDP, both in industry and the public sector, meaning that growth in Germany's R&D spending was also particularly robust in comparison with other countries.

Figure 7: Behavioural and structural effects as an explanation of differences in R&D intensity in the private sector, 2011

(in per cent)



Illustrative example: The fact that Germany's private-sector R&D intensity is 1.51 percentage points lower than South Korea's is primarily driven by structural differences. The differences in intensity in Germany's favour within certain sectors (behavioural effect) are low.

Note: France and Spain: 2009; South Korea, Denmark, USA and Italy: 2010

Source: OECD, calculations by DIW Berlin

Compared with the position in 1995, Germany was able to overtake countries such as Switzerland, the USA and France in terms of R&D intensity.

Germany's robust R&D investment in industry is mainly based on manufacturing and less on services than in other countries. Within manufacturing, R&D is highly concentrated in a small number of research-intensive sectors. This could certainly be seen as cause for concern. It is also discouraging that, compared with other countries, the German economy benefits more strongly from its favourable sector composition than it does from efforts to push ahead with R&D within the economic sectors concerned.

The econometric analyses carried out show that R&D investment in industrialised countries is a key driver of growth. In order for R&D to be transformed into growth, research findings must quickly be translated into marketable products and services and efficient production processes must be implemented.

Germany is on the right track, but it must not let up in its efforts to increase R&D investment further. Even though the Commission of Experts for Research and Innovation's goal of increasing R&D investment to 3.5 % of GDP by 2020 is ambitious, this still holds true.[10] For a country that to a large degree owes its prosperity to R&D-intensive industry and knowledge-intensive services associated with production, R&D investment continues to be a key requirement for future growth. ■

[1] See Belitz, H., Junker, S., Schiersch, A. and M. Podstawski (2015): *Wirkung von Forschung und Wachstum auf das Wirtschaftswachstum* (only available in German). Report carried out by DIW on behalf of the KfW Banking Group.

[2] The effect of R&D on GDP growth was studied in two ways: firstly by looking at a panel of 19 countries, secondly using time series techniques to look specifically at the effects of R&D expenditure in Germany. Both approaches come to the same conclusion, namely that investment in R&D promotes growth within a given country, as measured by GDP. Thus the results of the panel analysis indicate that, among the OECD countries considered, a one percentage point increase in the growth of a country's overall spending on research quickly leads GDP growth to rise by an average of 0.05 percentage points. In the time series models for Germany the effect is even stronger; with the preferred specification it is almost three times as large.

[3] Germany's R&D intensity was 2.85 % in 2013. Because of changes to the way the figure is calculated and corrections to the reported numbers, this value is not directly comparable with the figure published here for the previous year.

[4] Measured at purchasing-power parity.

[5] 2013 figures. See Schasse, U. (2015): *Forschung und Entwicklung in Staat und Wirtschaft – Kurzstudie* (only available in German). *Studien zum deutschen Innovationssystem* (Studies on the German innovation system), issue 3-2015.

[6] The EFI has repeatedly highlighted the fact that German R&D is strongly concentrated in a small number of high-tech sectors, while at the same time R&D is weak in cutting-edge technological sectors (including pharma, computing and electronics). For examples, see Commission of Experts for Research and Innovation (2010, 2013, 2014), Report on Research, Innovation and Technological Performance in Germany. Berlin.

[7] The degree of concentration is measured using the Herfindahl-Hirschmann index (HHI). The HHI is a measure of concentration and in this instance it is calculated taking the proportion of overall R&D expenditure in a country's economy represented by each of 27 economic sectors, squaring each of these proportions and adding together the resulting numbers. The HHI can be between 1/27=0.037 (all sectors represent the same proportion) and 1 (maximum concentration).

[8] The relative share of R&D investment (RSR) that a country makes within a given sector is calculated in a similar way to the relative share of world trade – a calculation familiar to anyone studying foreign trade. This measure compares the share of private-sector R&D expenditure within a sector with each corresponding share in the rest of the world (here, 13 OECD countries that are strong in research): $RSR_{ij}=\text{tanhyp } 100 \ln [(a_{ij}/\Sigma_j a_{ij})/(\Sigma_i a_{ij}/\Sigma_{ij} a_{ij})]$.

[9] A non-parametric variant of the Oaxaca-Blinder decomposition (shift-share analysis) is used to determine this. The decomposition is indebted to the work of Ronald Oaxaca and Alan Blinder on wage differentials. Oaxaca, R. (1973): Male-female wage differentials in urban labour markets. International Economic Review, 14(3): 693–709. Blinder, A. (1973): Wage Discrimination: Reduced Form and Structural Estimates. Journal of Human Resources, VII(4):436–455.

[10] See Commission of Experts for Research and Innovation (2015), Report on Research, Innovation and Technological Performance in Germany. Berlin.