JRC SCIENCE FOR POLICY REPORT

From the complete publication:

RIO Country Report 2015: Germany

Chapter:

3. Public and private funding of R&I and expenditure

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2016

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JRC101181

Abstract

The 2015 series of RIO Country Reports analyse and assess the policy and the national research and innovation system developments in relation to national policy priorities and the EU policy agenda with special focus on ERA and Innovation Union. The executive summaries of these reports put forward the main challenges of the research and innovation systems.

3. Public and private funding of R&I and expenditure

3.1 Introduction

Total R&D expenditures in Germany have reached 2.88% of GDP in 2014 which is slightly higher compared with 2013 (2.83%) but significantly above the average of EU-28 of 2.03%. R&D expenditures in Germany have increased consistently over the last four years with total R&D appropriations (GBAORD) reaching €25.4b in 2014, an increase of 6.83% compared with 2011 (see Table 2 for details).

Private businesses consistently account for two-thirds of R&D spending in Germany. As a percentage of GDP, business R&D expenditures account for 1.95% of GDP in 2014 which is a slightly higher compared with 1.9% in 2013. The 2015 EU Industrial R&D Investment Scoreboard provides an overview on the distribution of the 2,500 firms with the largest R&D investments worldwide. 136 of these firms are headquartered in Germany. The German automotive firm Volkswagen is the worldwide number one of all firms with R&D investments reaching €13.1b or 6% of sales in 2014. Other large R&D investing firms headquartered in Germany among the top 50 worldwide include Daimler (14th spot), BMW (21), Robert Bosch (17), Siemens (24), Bayer (29), Boehringer Ingelheim (44) and SAP (50). In general, Germany benefits from a strong base of R&D investment from firms in medium high-tech manufacturing sectors, like automotive production, chemicals as well as machinery and equipment. In particular firms in the automotive sector in Germany play an important role. They account for three quarters of R&D investment in this sector in Europe and have increased their R&D investments by 9.7% in 2013 (European Commission, 2014c). In more general terms, firms on the R&D investment scoreboard headquartered in Germany have increased their R&D spending by 5.8% in 2013, compared with a worldwide increase of 4.9% and 2.5% of all EU headquartered firms.

A noteworthy pattern within these positive numbers of business R&D spending in Germany is identified by the Expert Commission on Research and Innovation (EFI) in its 2015 annual report (EFI, 2015). EFI finds that spending on innovation by small and medium sized firms ('Mittelstand') is decreasing. While the report asks for more research to identify drivers behind this observation, it deserves particular attention in the German context. Small and medium sized firms (SMEs) are particularly central to the German economy. SMEs are the most important source for employment and value added in Germany, more important than in any other European country and this importance has grown in recent years (European Commission, 2014a).

The Federal Government has provided €14.9b for R&D in 2015, an increase of €261m compared with 2014.[1] The budget plan for 2016 foresees another significant increase with a planned total budget for R&D of €16.4b (Deutscher Bundestag, 2015b). The Laender themselves are important funding bodies for research and education. They have invested €10.2b in R&D in 2012 which is an increase of 5.2% compared with 2010 levels (BMBF, 2014c). Laender investments in R&D are substantial and amount to roughly 75% of the investments of the Federal Government. Laender budgets for R&I are expected to be stable or grow slowly (BMBF, 2014c). There is a noticeable trend for the Federal Government to assume more financial responsibility for funding R&I in Germany. Examples include budget increases originating from the extension of the Pact for Research and Innovation and the decision of the Federal Government to take over funding for the student subsistence grants ('BAfoeG') from the Laender beginning 2015 (NRP, 2015). Laender are supposed to use the newly available budgets from the latter of €1.2b annually for funding higher education. Similarly, the programme allowance for indirect project costs ('DFG Programmpauschale') of grants from the German Research Foundation (DFG) as part of the Higher Education Pact 2020 will comprise 22% of

[1] https://www.bmbf.de/presse/rekordinvestitionen-in-innovationen-115.html (9/2015)

project grants starting in 2016. [2] The Laender will cover 2% while the Federal Government funds 20%.

Germany has received a total €4.02b for projects related to Research, Technology and Development (RTD) as part of the EU Structural Funds between 2007 and 2012 (RIO elaboration on DG Regio data)[3]. This is a strong increase compared to the total receipts of €2.2b for RTD in Germany between 2000 and 2006. It should be noted that data refer to allocated funds and not to the real execution.

Focussing on the participation in EU framework programmes, Germany received 4,388 projects from the FP6 programme with €3.02b in funding. That equals 19.2% of all EU funds allocated in FP6. By comparison, Germany received only 17.6% of EU funds from FP7, with 8,897 projects and €7.2b in funding. Success rates of applications from Germany are above average (24%) compared to the EU average of 20.4% (European Commission, 2014b). In absolute terms, Germany is the largest recipient of FP7 but as a percentage of GDP its share is below EU average. Characteristic for FP7 projects from Germany is that a high share of projects involves the private sector (33%) (BMBF, 2014a). Within Horizon 2020 Germany seems well positioned to increase its share of funding with a current funding level of 20.3% of total EU funds.

Table 1 Basic indicators for R&D investments

Indicator	**2011**	**2012**	**2013**	**2014**	**EU average (2014)**
GERD (as % of GDP)	2.79	2.87	2.88	2.84	2.03
GERD (Euro per capita)	923.5	966.6	972.1	1,038	560
GBAORD (€m)	23,743.525	24,070.224	25,370.994	25,363.5	93,629.532 (EU-28 total)
GERD funded by BES (% of GDP)	1.83	1.90	1.85	n.a.	1.12 (2013)
GERD funded by PNP (% of GDP)	0.01	0.01	0.01	n.a.	0.03 (2013)
GERD funded by GOV + HES (% of GDP)	0.83	0.84	0.82	n.a.	0.68 (2013)
GERD funded from abroad (% of GDP)	0.12	0.12	0.15	n.a.	0.20 (2013)
GERD performed by HEIs (% of GDP)	0.50	0.51	0.51	0.49	0.47
GERD performed by government sector (% of GDP)	0.41	0.41	0.42	0.43	0.25
R&D performed by business sector (% of GDP)	1.89	1.95	1.90	1.95	1.30

Note: Data for 2014 is based on estimates.

[2] https://www.bmbf.de/de/dfg-programmpauschale-513.html (1/2016)

[3] The data on structural funds (RIO elaboration of DG REGIO data) is low in comparison to data reported elsewhere such as last year's country report. One of the explanations for this difference is the definition adopted. The data presented here refers to Core RTD (See Annex for categories included), whereas the information provided elsewhere adopts a broader definition of RTDI and linked activities. In addition the data reported here refers to ERDF funding only and does not include cohesion funds.

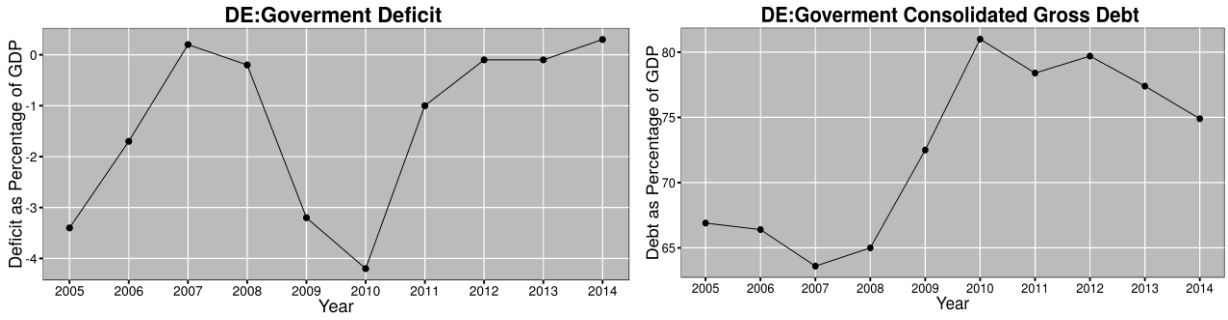
3.2 Smart fiscal consolidation

3.2.1 Economic growth, fiscal context[4] and public R&D

Real GDP in Germany rose by 1.6 in 2014 and 1.7% in 2015 and it was driven mainly by domestic demand. Since 2012 domestic demand has been the main contributor to GDP growth and is expected to remain so in the coming years. In 2014 its largest component was private consumption. The Commission expects further strengthening of the economic activity due to the strong labour market, favourable financing conditions, falling oil prices and improving external environment. Real GDP is expected to increase by 1.8% in both 2016 and 2017.

Before the crisis Germany had an improving budgetary balance. The deficit decreased gradually and turned into surplus by 2007 (Figure 2). The crisis had a negative impact on the German economy with an immediate consequence of widening budget deficit and increasing public debt between 2008 and 2010. Given that the impact of the crisis was not very strong (i.e. the GDP fell only in 2009 and only by ca. 5.5%, succeeded immediately by rather robust growth), public finances stayed under control both in terms of deficit and debt. Both the federal and the Laender governments have committed themselves to balanced budgets ('Schuldenbremse'). Laender differ in their progress towards balanced budgets but overall Germany had almost balanced budgets in 2012 and 2013 (-0.1% of GDP) and a surplus in 2014 (0.3% of GDP) and 2015 (0.5% of GDP). Equilibrated budgets are projected for 2016-17. The debt-to-GDP ratio is expected to fall steadily from the actual level of 74.9% to 66.8% by the end of 2017.

Figure 1: Government deficit and public debt



Data source: Eurostat

Total GERD in Germany was €79,730m in 2013. There are three main sources of R&D funding: the business sector (€52,176m), the government (€23,198m), and foreign funding (€4,110m). Direct funding from the government goes to R&D institutes in the business enterprises (€1,800m), the government (€9,864m) and the higher education sector (€11,534m).

Table 2: Key German Public R&D Indicators

	2007	2009	2013
GBAORD, % of gov. exp.	1.70	1.82	2.01
GERD, % of GDP	2.45	2.72	2.83
out of which GERD to public, % of GDP	0.73	0.88	0.93
Funding from GOV to, % of GDP			
Business	0.08	0.08	0.06
Public (GOV+HES)	0.60	0.73	0.76
Total	0.67	0.81	0.82
EU funding, % of GDP * **	n.a.	n.a.	0.05

Source: Eurostat

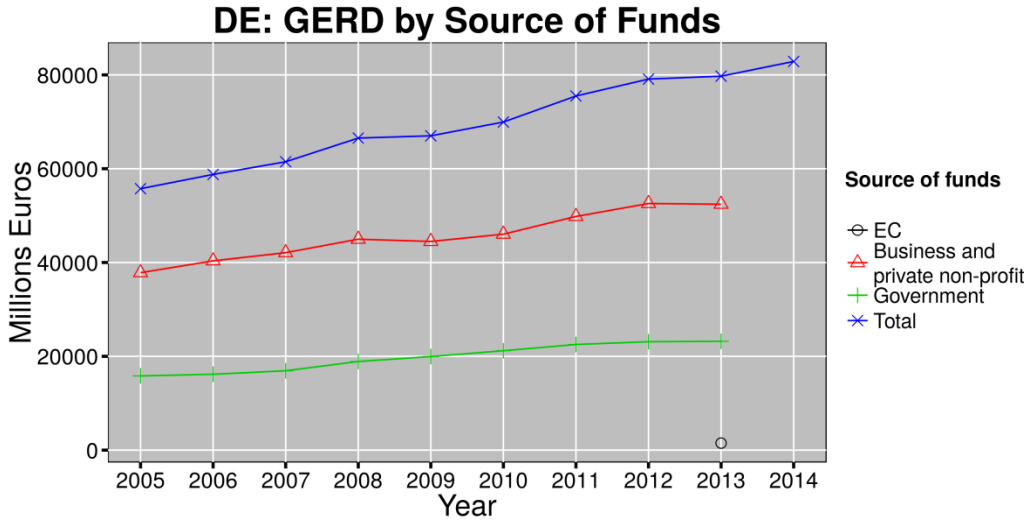
[4] Sources: DG ECFIN, http://ec.europa.eu/europe2020/pdf/csr2016/cr2016_germany_en.pdf

3.2.2 Direct funding of R&D activities[5]

Figure 3, below shows the historical evolution of GERD financing in current prices in Germany. The private sector plays a leading role in the financing of the GERD in Germany, which amounts to more than twice the contribution from the government. They both grow almost linearly in the period from 2005 to 2013 for which data are available (with the exception of a minor dip in the business contribution in 2009). From 2010 onward, the private sector shows greater vitality than the government in funding the German GERD as can be seen from the steeper increase in the contribution from the former.

Unfortunately, German official statistics provide quantitative data about the EC contribution to the financing of the GERD only for 2013 which corresponds to approx. 5% of the total GERD and 0.05% of GDP. Assuming that this share hasn't changed much over the years it is safe to conclude that EC contributions are small with respect to the contributions from the government and the private sector.

Figure 2: GERD by source of fund

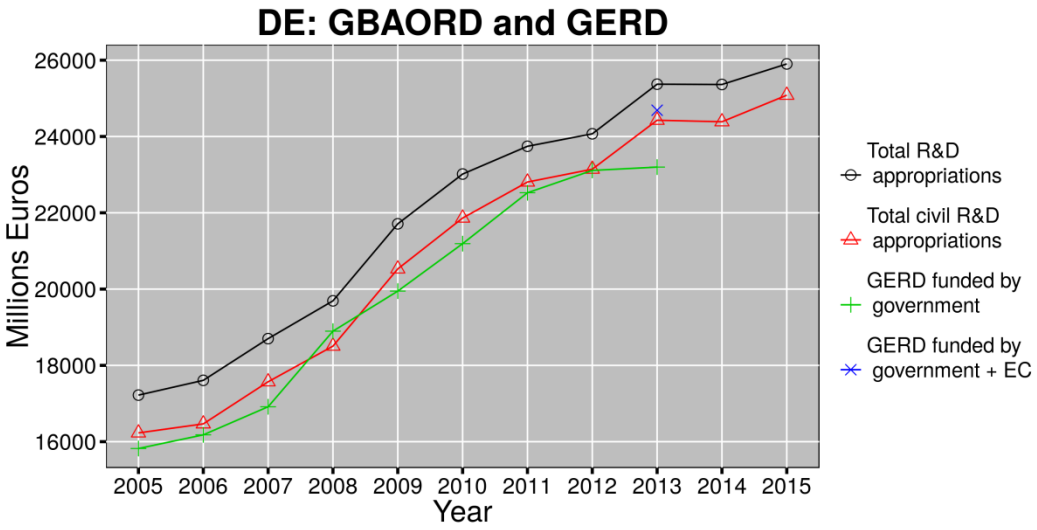


3.2.2.1 Direct public funding from the government

The total (civil) appropriations (GBAORD) have been following a growing trend from 2005 onwards. The difference between total and total civil appropriations measures the military R&D appropriations and is approximately constant in the period under scrutiny. The GERD funded by the government behaves similarly to the total civil appropriations. Until 2012 the civil appropriations and the government funded GERD are very close but in 2013 the GBAORD increases whereas the governemnt funded GERD remains at the level of 2012. However, when adding EC funding the total direct public support reaches (and even surpasses) the total civil R&D appropriations.

[5] The sources of R&D funding according to the Frascati manual are: Government sector (GOV), Higher education sector (HES), Private non-profit sector (PNP) and Abroad (including EC). In this analysis the public sector as source of funds is given by the GOV part of the total intramural R&D expenditure (GERD), whereas the public sector as a sector of performance is the aggregation of GOV and HES.

Figure 3: total (civil) appropriations and GERD funded by the government



3.2.2.2 Direct public funding from abroad

Unfortunately, little data is available about the public direct funding from abroad, as one can see in the table below:

Table 3: External public sources used for financing total German R&D

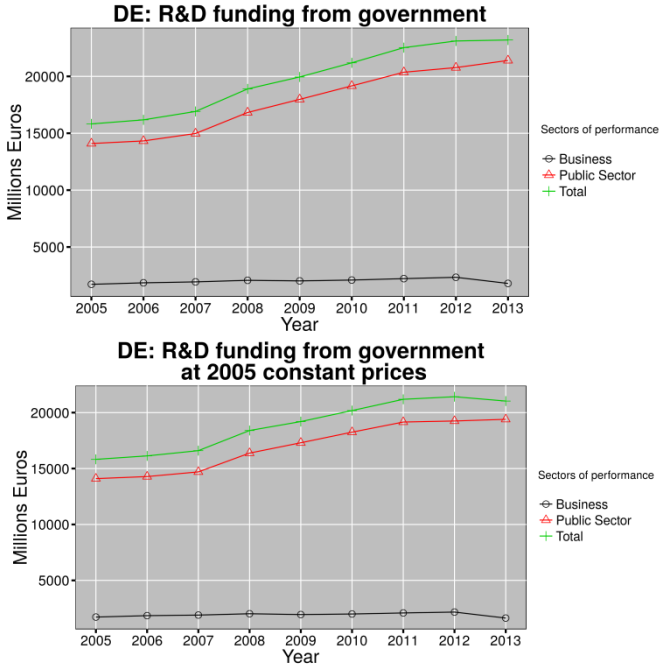
Source from abroad	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	2088.59	2246.10	2468.16	2669.72	2577.12	2716.46	3158.13	3420.33	4109.78
BES									2156.90
EC									1490.06
International Organizations									70.17
Total as % GERD	3.75	3.82	4.01	4.01	3.85	3.88	4.18	4.32	5.15
EC as % GOVERD									6.42

The funding from abroad, overall, has increased from less than 4% to above 5% of the total GERD the period 2005 – 2013. Based on 2013 data, R&D financing from Abroad corresponds to 5% of the total GERD of which about 52% comes from the foreign Business sector and about 36% comes from the EC through Structural Funds and Framework Programmes.

Distribution of public funding

Figure 5, below shows how the distribution of public funding to sectors of performance evolved over time:

Figure 4: Government intramural expenditure by sectors of performance



Data source: Eurostat

Unsurprisingly the public sector (GOV+HES) is the main recipient of the government funding. The funding received by the public sector increased almost linearly in the period 2007-2013. The trend is essentially the same also when measured at 2005 constant prices. Interestingly, in 2013 the direct public support to businesses, which is already low, decreases further whereas the support to the public sector keeps increasing (or remains unchanged when measured in constant prices).

3.2.3 Indirect funding – tax incentives and foregone tax revenues

Germany is the only big EU country whose R&I funding system does not include any tax credits. Instead, R&D funding in Germany takes the form of direct funding schemes on both federal and state levels (non-repayable cash grants, loans and participation programmes among which the Central Innovation Program for SMEsǁ (ZIM) may be the best known) (European Commission, 2014e).

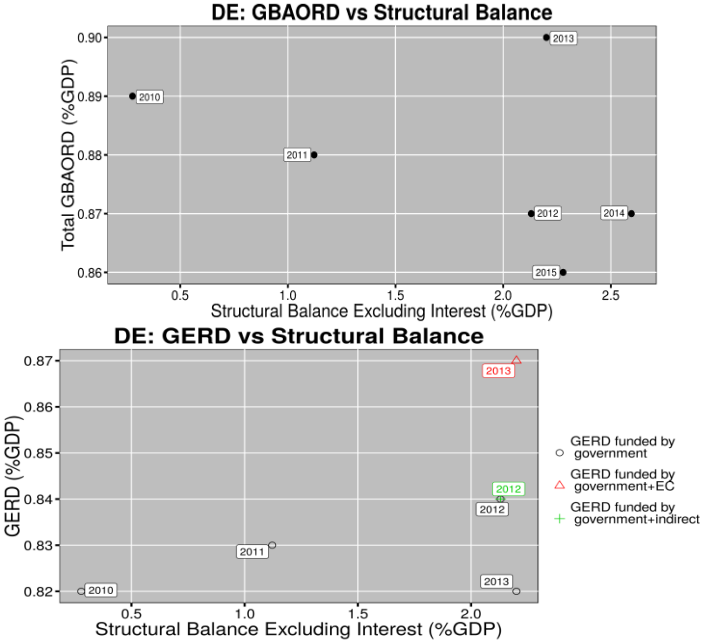
The introduction of R&D tax credits has on several occasions been recommended to the German government by the Expert Commission on Research and Innovation (EFI) and had also been enshrined in the last Federal Government's coalition agreement (2009 – 2013). However, under the current government political momentum for the introduction of tax credits has decreased and the item moved down on the political agenda of priorities. The potential fiscal costs of introducing preferential tax treatment for R&D in the Germany system have also been debated but there are only few concrete estimates. The Centre for European Economic Research (ZEW) estimates the fiscal costs of support in the form of a hypothetical tax credit on R&D expenses between €464m and €5,701m (European Commission, 2014e).

In spite of the lack of tax incentives, Germany has a R&D intensive industry and many internationalised companies that are often technology leaders in their sectors are headquartered in Germany. The same applies for countries like Finland and Switzerland which do not offer preferential tax treatment for R&D either.

3.2.4 Fiscal consolidation and R&D

Although the headline deficit of the country had to be diminished, in structural terms the German budget had a surplus throughout the whole post-crisis period. Figure 6, below shows the scatterplot of the structural balance and a relevant measure of the R&D (GBAORD as % GDP, first panel and GERD as % GDP, second panel)[6]:

Figure 5: Fiscal consolidation and R&D



Data source: AMECO, Eurostat

Based on the graphs, at first glance the picture is mixed: while GBAORD as % of GDP is decreasing, government GERD is increasing steadily during the same period, although neither of the two faced a nominal decrease. The reason behind is that the growth rate of government GERD was higher than that of the GDP, which in turn outpaced the slightly lower growth of GBAORD. However, in order of magnitude the post-crisis changes in GBAORD and government GERD in terms of GDP are very low (0.02% of GDP). Indeed, when measured as percentage of GDP, both the German GBAORD and the government funded GERD register fluctuations which are about an order of magnitude smaller than those experienced by the same indicators in France, Italy or the United Kingdom. Based on the above discussion it seems that the German post-crisis fiscal consolidation process has not come at the expense of public R&D expenditures.

The German economy consolidated in the years after the crises. In particular, the years 2010-2011 saw high growth rates of the GDP and public finance consolidation in the form of reduction of the government deficit and debt. During the consolidation phase, despite some minor fluctuations, the fraction of GDP devoted to the public funding of R&D in Germany has been essentially preserved.

The European Commission recommends in its response to the National Reform Programme (European Commission, 2015a) the use of the available fiscal potentials for increased investments in research and education (see also section 2.3 of this report).

[6] Structural balance data comes from the AMECO database the other indicators were taken from Eurostat.

3.3 Funding flows

3.3.1 Research funders

The legal basis for the allocation of public funds for R&D is the 'Freedom for Science'-Article 5(3) of the German constitution ('Grundgesetz,' GG). Further, rules for joint funding by federal and state governments are laid out in Article 91b GG of the constitution and in the Federal Budget Code ('Bundeshaushaltsordnung,' BHO). Article 91b GG of the constitution has been changed based on votes of both chambers of parliament in December 2014(Deutscher Bundestag, 2014). This change enables the Federal Government to be permanently involved in the funding of universities.

At the national level, the Federal Ministry of Education and Research (BMBF) covers most of the responsibilities for research policy. The Federal Ministry of Economics and Energy (BMWi) is also involved in some areas of innovation and technology policy. The Laender fund the universities in their state and co-fund Max Planck Society, Fraunhofer Society, Helmholtz Association, and Leibniz Association. The Laender also play a very active role in facilitating knowledge transfers between science and industry as well as other innovation programmes (see also section 1.2.2 of this report).

Apart from the main research organisations, there exist research institutes which provide ministries with specifically relevant scientific knowledge or assess quality or safety standards. ('Ressortforschungseinrichtungen'). Their budgets are comparatively smaller. R&D budgets of these institutes reached €965m or 7.2% of R&D funding of the Federal Government in 2013 (BMBF, 2014c). They are planned to reach €971m in 2014.

With regards to funding for basic research in Germany, the German Research Foundation ('Deutsche Forschungsgemeinschaft,' DFG) is crucial. It complements institutional funding with project funding. DFG selects the most promising research projects by scientists and academics at universities and non-university research institutions based on a competitive basis. Funding is typically the result of a bottom-up process of peer review. The review process is sophisticated and multi-layered:[7] The DFG head office appoints peer reviewers with relevant expertise (roughly 15,000 annually) while avoiding conflicts of interest. The reviewers evaluate academic excellence, relevance and originality of the proposals. The so-called review board, members of which are selected from the scientific community, evaluates and compares the reviews for selection of the most promising proposals (DFG, 2015a). The review process is international. Almost a third of all reviewers work outside Germany with the largest group working in the US (8.8%) (DFG, 2012).

R&D programmes put forward by ministries are administered and managed by various agencies with a clear coordination and implementation purpose ('Projektträger'). The latter are mostly located in large research centres.

Apart from these, several public and private foundations exist for financing research. The share of R&D financed by private, non-profit organisations is comparatively low at 0.01% of GDP in Germany in 2012. Examples for such foundations include the Volkswagen Stiftung, Fritz Thyssen Foundation, Alexander von Humboldt Foundation (AvH), or the Federal Foundation for the Environment. Additionally, R&D is also performed in the higher education sector through a combination of institutional funding and project funding (e.g. Initiative of Excellence, R&D thematic programmes by BMBF) and contract research conducted for industry. Aschhoff (2013) provides a detailed overview on German R&I system.

[7] http://www.dfg.de/foerderung/antragstellung_begutachtung_entscheidung/gutachtende/index.html (12/2014)

3.3.2 Funding sources and funding flows

The share of overall funding for R&D on government budgets has been stable at 3% from 2009 to 2012 (BMBF, 2015c). The Federal Government has increased funding for R&D from €9.0b in 2009 to €12.8b in 2010, €13.3b in 2011 and €13.5b in 2012 (BMBF, 2014c). This trend is supposed to continue. The budget plan for 2016 foresees another significant increase with a planned total budget for R&D of €16.4b (Deutscher Bundestag, 2015b). In contrast, the Laender have increased their funding for R&D continuously but with significantly lower growth rate from €9.3b in 2009, to €9.7b in 2010 and €10.2b in 2011 (BMBF, 2014c). Hence, in relative terms the Federal Government has become the most important funding source for R&D in Germany.

Funding for R&D from abroad is substantial but significantly lower. Total R&D funded from abroad account for 0.12% of GDP in Germany in both 2011 and 2012 (see section 3.1 Table 2 for details). BMBF (2014c) reports an average annual funding of €866m for R&D from the European Union between 2007 and 2013 because tranches of Seventh Framework Programme (FP7) projects are paid out sequentially. An individual annual number would therefore necessarily be unreliable. In total, Germany received funding of €7.2b for project within FP7 which as a significant increase compared with the €3.02b from the Sixth Framework Programme (FP6) (European Commission, 2014b).

In terms of EU structural funds related to Research, Technology and Development (RTD), Germany has received a total €4.02b between 2007 and 2012 (RIO elaboration on DG Regio data).[8] This is almost double the amount of €2.2b for RTD in Germany between 2000 and 2006. The Laender have used structural funds in various ways. Examples include (BMBF, 2014c):

- Lower Saxony initiated graduate schools which combine structural PhD training with labour market relevant competences. This is accompanied with an outreach initiative to regional business in order to facilitate hiring of highly qualified employees ('Wissenstransfer über Köpfe').
- Saxony has funded the construction and equipment of applied research institutes.
- Mecklenburg-Vorpommern has funded research collaborations in the fields of plasma physics and biotechnology.

Focussing on the absorption of funding by firms, the results of the Community Innovation Survey (CIS) provides firm level information (ZEW, 2014). 23.7% of all innovative firms[9] in Germany have received some kind of public support for their R&D or innovation activities between 2010 and 2012. This number is up from 19% in the timeframe 2006 to 2008 (CIS2008). 17.1% of innovative firms received funding from the Federal Government between 2010 and 2012. This share has more than doubled compared to the timeframe 2006 to 2008 (8%). EU funding has reached 5.2% of German innovative firms between 2010 and 2012, 3.7% benefitted from the 6th or 7th Framework Programme. Innovation support from the Laender and local authorities is still important with 7.4% of innovative firms receiving it but this share is down from 9% in the 2006 to 2008 period. In sum, there are many positive signals for R&I government funds reaching German companies and the trend is positive especially for funding from the Federal Government.

With regard to absorption rates of EU funding, there is no consensus on what an optimal rate would be. The success rate of grant applications from Germany in FP7 (24%) is

[8] The data on structural funds (RIO elaboration of DG REGIO data) is low in comparison to data reported elsewhere such as last year's country report. One of the explanations for this difference is the definition adopted. The data presented here refers to Core RTD (See Annex for categories included), whereas the information provided elsewhere adopts a broader definition of RTDI and linked activities. In addition the data reported here refers to ERDF funding only and does not include cohesion funds.

[9] Information from the survey is limited to firms with technological activities, i.e. firms which invested into some form of R&D or innovation activities.

higher than EU-average (20.4%) (European Commission, 2014b). FP7 project applications from Germany are also more likely to involve the private sector (33%) (BMBF, 2014a). Then again, compared to its share of GDP, Germany receives less FP7 funds than EU average. There is no precise estimate for the absorption capacity of Germany, i.e. the extent to which a country is capable of effectively and efficiently spending its Structural Funds allocation. Nevertheless, there are no obvious indications that Germany has reached the limits of its absorption capacity.

The importance of R&D expenditures from foreign controlled firms has increased in Germany between 1997and 2007 but is at a moderate level with 26.2% of business R&D expenditures stemming from foreign-controlled affiliates (OECD, 2010). This level is significantly lower compared with Ireland (72.4%), Israel (61.8%) or Belgium (59.4%) but above countries such as Finland (17%), Switzerland (14.4%), the US (14.3%) or Japan (4.7%).

3.4 Public funding for public R&I

3.4.1 Project vs. institutional allocation of public funding

Public funding for R&D has two primary components in Germany: institutional (block) funding and project funding. Long-term institutional funding covers essential financial demands (basic facilities) of universities (Laender) and non-university research organisations (Federal Government and Laender governments). In contrast, project funding is directed at a particular goal with typically short to medium-term time horizons (Sofka, 2015). The German funding system is rather complex and precise shares of project vs. institutional funding of R&D are difficult to state reliably. EUROSTAT data shows that 37.2% of R&D funding is competitively allocated while 63.7% stem from institutional funding. These shares are hardly changing compared with 2011 and 2012. Then again, the "Joint and Open Research Programs in Germany" report (JOREP, 2011) suggests that funding schemes have shifted from institutional to project funding.

Public R&I in Germany is conducted in universities and the main non-university research organisations Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL). 1,125 employees of the research organisations had co-appointments as university professors in 2014 (2010: 745) (GWK, 2015).

Universities receive institutional funds ('laufende Grundmittel') for both teaching and research. These funds are largely provided by the Laender. These institutional funds amounted to €17.5b in 2012 or 43.4% of university income (DFG, 2015a). 16.8% (€6.8b) stem from competitive project funding ('Drittmittel') and 39.8% (€16b) from other income such as student payments or university hospitals (DFG, 2015a). Universities have comparatively higher shares of competitive project funding (17.9%) compared with universities of applied sciences (9.7%) or pedagogical, theological, art or music universities (5.5%). The ratio of competitively (performance based) to non-competitively (block funding) allocated funds has reached 28% in 2013 compared with 19% in 2003 (GWK, 2015). Hence, the importance of competitive funds is increasing over time.

The German Research Foundation DFG and the other main non-university research organisations are funded jointly by the Federal Government and the Laender governments. Those institutions had a total budget of €12.1b in 2014 with €7.9b stemming from institutional funds (65%) and €4.2b (35%) originating from competitive funding ('Drittmittel') (DFG is a funding organisation in itself) (GWK, 2015). Total budgets have increased by 6.7% compared with 2013 with institutional funds increasing by 6.1% and competitive funds by 7.9% following a similar pattern in the increases between 2012 and 2013 (GWK, 2015). These trends provide additional evidence that the importance of competitive funds for public R&I in Germany has been increasing.

3.4.2 Institutional funding[10]

The funding of education and research at universities is devolved to a large extent to the sixteen states (Laender) which are highly autonomous in matters of education policy. In summary, the Laender's public funding typically consist of three possible procedures one of which is an incremental/discretionary/non-competitive part which is mainly based on the previous' year funding and corrected for inflation. During the past years, this approach to funding has gradually become less important. In order to achieve goals of the state government, like internationalisation and gender equality, the state government can financially award well-performing institutions. This type of funding is generally non-competitive (Van Daalen et al, 2014 as quoted in Jonkers & Zacharewicz, 2015.).

During the past decade, many Laender have introduced an indicator-based formula to determine the amount of public funding. Van Dalen et al. (2014) provide an overview of how formula based funding developed in 9 Laender over time. They observe an increase over time in the number of Laender that integrate an indicator-based formula into their funding program. Moreover, the individual shares increased as well for most Laender. This indicator-based part of the annual budget consists of both a teaching and a research component. Typically, the research component carries more weight for (research) universities than for universities of applied sciences (Fachhochschulen), but the exact ratio varies by Laender (e.g. Berlin applies a 50/50 ratio for universities and a 80/20 ratio for Fachhochschulen). The teaching component often consists of the number of students and graduations, whereas the research component is often distributed on the amount of external funding and the number of PhD graduations (Van Daalen et al, 2014 as quoted in Jonkers & Zacharewicz, 2015.)..

During the past years, the funding of higher education has increasingly turned towards indicator-based funding. On top of this, Laender started to implement state-wide pacts and individual target-agreements as a complementary steering instrument. An important thing to note about these target-agreements is that they are not directly linked to financial rewards and/or penalties (Van Daalen, 2014 as quoted in Jonkers & Zacharewicz, 2015; see also De Boer et al (2015) for further description of the German situation)..

The Pact for Research and Innovation ('Pakt fuer Forschung und Innovation') has been a major driver for non-university institutional funding for public R&I in Germany in recent years. The initial agreement between the Federal Government and the Laender governments encompassed the years 2005 to 2010 and was extended in 2009 for the years 2011-2015 ('Pakt II'). The Pact for Research and Innovation increased the institutional funds annually by 5% for the German Research Foundation DFG and the main non-university research organisations Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL). Accordingly, institutional funding for these institutions (including funds for implementing the Initiative for Excellence through DFG) is 92% higher in 2015 compared with 2005 (GWK, 2015). R&I stakeholders in Germany, such as the Expert Commission on Research and Innovation (EFI) have welcomed the pact not just for the increase in funds but for secure planning coordinates which facilitate strategic decision making (EFI, 2014). The Federal Government and the Laender governments have agreed in December 2014 to extend the Pact for Research and Innovation until 2020 with annual budget increases of 3%[11]. The Pact is being accompanied by mutually agreed research policy goals. In addition to early and systematic identification of cutting-edge research fields, promotion of junior scientists, improvement of the representation of women, inter-organisational networking and internationalisation, the main goals of the Pact include transfer of knowledge and technology and formation of sustainable partnerships with commercial partners.

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[10] This section is based on Jonkers & Zacharewicz, 2015.

[11] http://www.gwk-bonn.de/fileadmin/Papers/PFI-III-2016-2020.pdf (8/2015)

Part of the pact agreement is the commitment of DFG and the main non-university research organisations to report annually to the Joint Science Conference ('Gemeinsame Wissenschaftskonferenz', GWK) of the Federal Government and the Laender governments. These reports culminate in a monitoring report which documents developments and practices (GWK, 2015). An initial stage in the allocation of institutional funding is the allocation across the main non-university research organisations which have distinct R&I profiles and organize the allocation of funds among their member institutes internally. Besides, DFG and the main non-university research organisations differ in the degree to which they are dependent on institutional funds, how they allocate resources between their institutes as well as how they adjust their research profiles (GWK, 2015):

- Max Planck Society (MPG)
  MPG encompasses 83 institutes which conduct basic research in natural sciences, life sciences, social sciences, and the humanities. MPG had a total budget of €1.8b in 2014, 86% of which originate from institutional funds. MPG ties the review of existing departments or institutes to the retirement of their academic leadership. A process is initiated which can lead to changes in topics, extensions, closures or new foundations of departments or whole institutes. Between 2006 and 2014 10 MPG institutes experienced a change in research focus with new leadership, 5 institutes were newly founded and one institute was split up. MPG has a system of ex-ante, ex-post and extended evaluations through academic committees with strong international participation[12].
  With regard to new research opportunities or requirements, the sections of MPG have perspective commissions which routinely evaluate medium and long-term opportunities. Besides, MPG has established a strategic innovation fund ('Strategischer Innovationsfond') to foster innovative topics and support excellent talents.

- Fraunhofer Society (FhG)
  FhG consists of 67 institutes and research units which focus on the application of research and technology. FhG had a total budget of €2b in 2014, 31% of which originate from institutional funds. FhG distributes 60% of its institutional funds among its institutes based on an allocation rational which rewards in particular institutes with strong records for attracting competitive project funds ('Drittmittel') from the private sector. The rest is allocated through direct, internal competition based on evaluation processes. A central strategy fund exists for the support of new, strategic investments which are selected in a competitive process.
  FhG identifies new research topics in multi-year cycles based on internal participation and technology foresight instruments. Anticipated demand by business and society are central drivers of portfolio development.

- Helmholtz Association (HGF)
  HGF consists of 18 scientific-technical and biological-medical research centres which deal with long-term research questions. HGF had a total budget of €4b in 2014, 71% of which originate from institutional funds. HGF allocates institutional funds across programmes in six strategic research areas which span multiple research areas. The goal is to support interdisciplinary collaboration across research centres. The research programmes are evaluated by peer groups with the criteria of scientific quality and strategic relevance.
  HGL evaluates its portfolio of research topics every five years. A competitive process exists for funding large, new strategic extension investments (>€15m) and temporary funding for supporting internal network and impulse activities.

[12] https://www.mpg.de/9704077/Evaluation2015.pdf (1/2016)

- Leibniz Association (WGL)
  WGL encompasses 89 research institutions focussing on societal, ecological and economic research questions. WGL had a total budget of €1.4b in 2014, 75% of which originate from institutional funds. Since 2011, each institute of WGL has a core budget ('Kernhaushalt') depending on their activity which increases annually according to the Pact for Research and Innovation. €30m are allocated annually in an internal competition and an additional €2m strategy fund exists through which the presidency of WGL can set strategic impulses across institutes. The identification of new topics is decentralized in WGL institutes which are supposed to form partnerships ('Forschungsverbuende') for working jointly on emerging scientific and societal research questions.
- German Research Foundation (DFG)
  DFG had a total budget of €2.9b in 2014, 65 % of which originate from institutional funds. The rest stems from implementation of the Initiative for Excellence, programme allowance for indirect project costs and large research infrastructure. DFG evaluates its support instruments continuously with regard to changing demands from the community in different fields. In 2014 it enacted a review on structural effects and funding success across fields (see also section 3.4.3 of this report).
  DFG supports the identification of new topics in a response-mode, i.e. it encourages self-directed research identification from applicants and creates research initiatives for particularly strategic topics or fields.

3.4.3 Project funding

Project funding for R&I in Germany (outside the portfolio of the German Research Foundation DFG) is organised in programmes and can be applied for by individuals, individual institutions or consortia of institutions ('Verbundprojekte'). The overriding goal is to fund projects which allow research to reach or sustain internationally competitive quality in a particular field (BMBF, 2014c). Indirect project funding exists (see also section 3.5 of this report) to support collaboration between public research institutes and the commercial sector, e.g. through the provision of research infrastructures, facilitation of networks, personnel exchange or other forms of collaboration. Apart from project research funding, contract research ('Auftragsforschung') exists in which ministries define research needs and appropriate the intellectual property of research outcomes (see also section 3.4.4 of this report on 'Ressortforschung') (BMBF, 2014c).

Universities in Germany received a total of €6.8b of competitive project grants in 2012 (DFG, 2015a). The largest share (roughly a third) originates from the German Research Foundation (DFG), followed by the Federal Government (25%), the private sector (20%) and the EU (10%). The biggest changes over time stem from an increasing importance of the Federal Government (2006: 19%) and EU sources (2006: 6%) and a reduction of importance of private sector funding (2005: 28%) (DFG, 2015a).

Among the largest recent initiative for public R&I is the Initiative for Excellence ('Exzellenzinitiative'). The original Initiative for Excellence was enacted in 2005 as a joint programme of the Federal Government (75% of funding) and the Laender governments (25% of funding). Total funding for this first round of the initiative was €1.9b (BMBF, 2014c). The Initiative for Excellence was renewed in 2009 until 2017 with a total budget of €2.7b. The Joint Science Conference (GWK) has commissioned an international expert commission with conducting the evaluation of the Initiative for Excellence.[13] The commission reported final results in January 2016. The report concludes that the Initiative for Excellence had positive effects for R&I in many areas and recommends its extension with some adjustments (IEKE, 2016). . The Federal Government and the

[13] http://www.ieke.info/ieke (10/2015)

Laender governments have agreed in principle to extend the Initiative for Excellence beyond 2017.[14]

The goal of the Initiative for Excellence is to support internationally excellent research at universities in Germany and make it visible. The initiative contains three programme lines and five years of funding (BMBF, 2009):

- Establishment of graduate schools for strengthening the training of junior researchers
  45 graduate schools have been established since 2012 receiving 14.9% of initiative funds (DFG, 2015b)
- Excellence clusters for creating networks of excellent research
  43 excellence clusters have been funded since 2012 receiving 56.6% of initiative funds (DFG, 2015b)
- Future concepts for particularly promising research projects
  11 future concepts have been funded since 2012 receiving 28.5% of initiative funds (DFG, 2015b)

Funding criteria are exclusively scientific in nature, encompassing excellence in research and training of junior researchers, interdisciplinary research and the creation of international networks as well as collaborations across and beyond universities (BMBF, 2009). The application evaluation commissions consisted exclusively of scientists (14 for graduate schools and excellence clusters, 12 for future concepts). The scientific commissions had the majority of the votes in the final grant commission which also included representatives of the Federal Government and the Laender governments.[15]

Another major competitive project funding initiative as part of the new High-Tech Strategy of the Federal Government is the Leading-Edge Cluster Competition ('Spitzencluster-Wettbewerb') of BMBF.[16] The programme targets regional initiatives connecting scientific research with the private sector. The last round of selection occurred in 2012 and the programme will conclude in 2017 (BMBF, 2014c). 15 clusters in total were eventually selected to receive funding of up to €40m over 5 years. Applicants could choose topics freely. Applications were evaluated by an independent commission. The programme was evaluated in 2015 (Rothgang et al., 2015). The evaluation process is described by the Expert Commission on Innovation (EFI) as a model for future policy evaluations in Germany (EFI, 2015). The evaluation of the Leading-Edge Cluster Competition is generally positive. EFI (2015) expresses doubts that the competition should be repeated, given that expected returns are about to decline. In addition to the Leading-Edge Cluster Competition a funding measure for the Internationalisation of Leading-Edge Clusters, Future Projects, and comparable networks ("Internationalisierung von Spitzenclustern, Zukunftsprojekten und vergleichbaren Netzwerken") was initiated by BMBF in 2015. In the first of three rounds eleven selected projects will receive up to four million euros over a period of up to five years on the German side starting in 2016.[17]

The German Research Foundation DFG provides project funding of three major types (excluding the Initiative for Excellence which it implements jointly with German Science Council, 'Wissenschaftsrat', on behalf of the Federal Government and the Laender governments) (DFG, 2015a):

- Individual grant programmes (€2.6b granted between 2011 and 2013):
  These can be applied for by researchers (typically holding a PhD and working for universities or research institutes in Germany) for financing individual research

[14] http://www.gwk-bonn.de/fileadmin/Papers/PFI-III-2016-2020.pdf (8/2015)
[15] https://www.bmbf.de/files/Auswahl_und_Begutachtungsverfahren_Exzellenzinitiative.pdf (10/2015)
[16] https://www.bmbf.de/de/der-spitzencluster-wettbewerb-537.html (10/2015)
[17] https://www.bmbf.de/en/internationalisation-of-leading-edge-clusters-forward-looking-projects-and-comparable-1416.html (4/2016)

projects, scientific networks or positions. Examples include Clinical Trials, Emmy Noether Programme or Reinhart Koselleck Projects (see also Annex 2 of this report for a list).[18]

- Coordinated programmes (€3.4b granted between 2011 and 2013)
  These programmes target universities and promote national and international collaboration. Grants can fund research groups or units (see also Annex 2 of this report for a list).[19]
- Funding of research infrastructure (€459m granted between 2011 and 2013)
  These grants can fund large research equipment, scientific literature- or information systems (see also Annex 2 of this report for a list).

Apart from these project funding lines, DFG also funds a number of prizes which together with grants for other recipient groups accounted for €155m between 2011 and 2013. Individual grant programmes account for roughly three quarters of the budgets for coordinated programmes. While there is no optimal ratio between the two funding components, there is no obvious indication that this ratio may create disadvantages for public R&I in Germany.

Funding is typically the result of a bottom-up process of peer review. The review process is sophisticated and multi-layered:[20] The DFG head office appoints peer reviewers with relevant expertise (roughly 15,000 annually) while avoiding conflicts of interest. The reviewers evaluate academic excellence, relevance and originality of the proposals. The so-called review board, the members of which are selected from the scientific community, evaluates and compares the reviews for selection of the most promising proposals (DFG, 2015a). The review process is international. Almost a third of all reviewers work outside Germany with the largest group working in the US (8.8%) (DFG, 2012).In 2014 34% of all new individual grant applications were successful; for coordinated programmes no overall comparable number exists, for graduate colleges the success rate was 30% (DFG, 2015b).

DFG has high, international standards of programme evaluations, encompassing all programmes, independent evaluators, quantitative assessments and considerations of both effectiveness and efficiency of resources.[21] Evaluations within the last three years included:

- Evaluation of International Research Training Groups 2015[22]
- Statistical Information on the Development of the Heisenberg Programme (2015)[23]
- Interdisciplinary: Reviewing Across Discipline Boundaries (2013)[24]
- Evaluation in Research and Research Funding Organisations: European Practices (2012)[25]

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[18] http://www.dfg.de/en/research_funding/programmes/individual/index.html (10/2015)
[19] http://www.dfg.de/en/research_funding/programmes/coordinated_programmes/index.html (10/2015)
[20] http://www.dfg.de/foerderung/antragstellung_begutachtung_entscheidung/gutachtende/index.html (12/2014)
[21] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/evaluation_standards/index.html (10/2015)
[22] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/study_international_rtg/index.html (10/2015)
[23] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/report_heisenberg/index.html (10/2015)
[24] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/report_interdisciplinarity/index.html (10/2015)
[25] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/report_interdisciplinarity/index.html

- Evaluation of Transfer Projects in Collaborative Research Centres (2012)[26]
- Gender Effects in Research Funding (2012)[27]

Evaluations have been generally used for documenting the progress or success of programmes or across programmes. Accordingly, evaluations have provided inputs for decisions of steering or review commissions by highlighting potentials for improvements or extensions.

Other initiatives have been put in place at the Laender level. The state of Baden-Wuerttemberg emphasizes for example research at technology colleges which have a high potential to create fruitful knowledge flows between science and business (NRP, 2014). Another example is Hesse which structures interactions between science, business and politics through a "House of" strategy for central state themes: finance, IT as well as logistics and mobility (NRP, 2014).

3.4.4 Other allocation mechanisms

A relatively new instrument of R&I funding in Germany is the programme allowance for indirect project costs ('DFG Programmpauschale') of grants from the German Research Foundation (DFG) and most project funded directly through BMBF, which accounted for 20% of grants. As part of the Higher Education Pact 2020 it will increase to 22% of project grants starting in 2016.[28] The Laender will cover 2% while the Federal Government will fund 20%. The Expert Commission for Innovation (EFI) had stressed the necessity and benefits of an increase in such budgets for covering project-related costs at universities in the past (EFI, 2014).

A particular feature of the German R&I system are service providers for project management ('Projekttraeger'). These project management agencies are typically part of larger research institutes and provide a variety of services related to the funding programmes of ministries of the Federal Government. Their services encompass activities such as communicating programme calls, informing and consulting potential applicants, preparation of decision making, dissemination of results, coordination of partners and activities as well as project controlling (BMBF, 2014c). Some ministries have developed selection criteria and procedures which allow the project management service providers ('Projekttraeger') not just to prepare grant decisions but to conduct them.

Besides, there exist Federal research institutes which provide ministries with specifically relevant scientific knowledge for political consulting, transfer to legislation and standardization and legal tasks like type approval, quality assessment or safety standards ('Ressortforschungseinrichtungen'). R&D budgets of these institutes reached €965m or 7.2% of R&D funding of the Federal Government (BMBF, 2014c). They are planned to reach €971m in 2014. Examples of these institutes include the National Metrology Institute of Germany ('Physikalisch-Technische Bundesanstalt', PTB) under the authority of BMWi, responsible for precise, reliable and internationally acknowledged measurements or the Robert Koch Institute (RKI) working in the field of biomedicine, e.g. for the identification and surveillance of diseases. All institutes of this category have been evaluated by the German Council of Science and Humanities ('Wissenschaftsrat') between 2004 and 2010 with the goal of securing and extending academic excellence (BMBF, 2014c). A new round of evaluations is ongoing.

(10/2015)

[26] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/study_tfp_crc/index.html (10/2015)

[27] http://www.dfg.de/en/dfg_profile/facts_figures/evaluation_studies_monitoring/studies/study_gender_effects/index.html (10/2015)

[28] https://www.bmbf.de/de/dfg-programmpauschale-513.html (8/2015)

Finally, BMWi provides support for the commercialisation of research results from science in Germany. Technology Alliance ('TechnologieAllianz')[29] provides an online platform for the commercialisation of knowledge from universities and research organisations (for more information see chapter 5.6).

3.5 Public funding for private R&I

3.5.1 Direct funding for private R&I

Funding for private R&I in Germany occurs in multiple forms. The Federal Government has undertaken efforts to re-structure the funding system in particular for SMEs with the goal of increased transparency (Deutscher Bundestag, 2015a). The system is now built around four central pillars: entrepreneurship, competence creation, pre-competitive research and technology transfer as well as application of R&D for commercialisation.

The Federal Government provides a range of support initiatives to facilitate entrepreneurship from science by addressing various needs (see also section 5.2 of this report) (BMBF, 2014c):

- EXIST – Existenzgruendung aus der Wissenschaft[30]:
  The programme of BMWi was initiated in 1998 and is co-financed by the European Social Fund (ESF). It provides a range of instruments to entrepreneurs from academia. As part of the broader programme, EXIST wants to foster an entrepreneurial culture in universities through the competition "EXIST-Gruendungskultur." 120 universities have developed and submitted concepts, from which 22 universities with the most promising concepts have been chosen and receive support for the implementation of their concepts. "EXIST-Gruenderstipendium" provides yearlong scholarships for potential entrepreneurs from universities and research organisations. The scholarship is supposed to facilitate the pre-entrepreneurship stage in which potential founders develop business plans. Roughly 150 scholarships are granted annually. "EXIST-Forschungstransfer" provides bridge funding for the development of technologically advanced research projects into commercial applications. It has resulted in 90 new firms since 2007. EXIST has been reformed in December 2014 with increases in available funds[31]. Scholarships (EXIST-Gruenderstipendium) increase by 25% and the included funds for investments can now reach €30,000 instead of €17,000. Within EXIST-Forschungstransfer available investments in high tech projects increase from €70,000 to €250,000.
- High-tech Start-Up Fund ('High-Tech Gründerfonds', HTGF)[32]:
  HTGF was initiated in 2005 in collaboration of BMWi, government controlled banking group KfW and industrial partners with an investment endowment of €272m. The purpose of HTGF is to address particular funding needs of new firms for which it can be extremely difficult to attract lender or private equity investors. HTGF provides equity financing of up to €500,000 for newly founded technology firms. HTGF provides also access to a network of certified coaches and venture capital investors for future investment rounds. HGTF has 330 investments in its portfolio (March 2014) and has provided support for investments of third parties of roughly €600m.

[29] http://www.technologieallianz.de/angebote.php (10/2015)
[30] http://www.exist.de/DE/Home/inhalt.html (10/2015)
[31] http://www.bmwi.de/DE/Presse/pressemitteilungen,did=674028.html (10/2015)
[32] http://high-tech-gruenderfonds.de/en/ (10/2015)

- ERP-Startfonds[33]:
  ERP-Startfonds provides equity financing for small technology-intensive firms during the early stages of their development. Financing is supposed to enable these firms to invest into R&D as well as commercialisation. ERP-Startfonds has financed roughly 500 technology-intensive firms since its creation. The fund works on the principle of co-financing with a lead investor (e.g. venture capital fund). The fund matches the investment of the lead investor if the latter provides management support to the focal firm. The fund can invest up to €5m in a particular firm.
- INVEST – Zuschuss Wagniskapital[34]:
  INVEST provides incentives to private investors such as Business Angels who can receive 20% of their investment (maximum €250,000) into a young, innovative firm back from the Federal Government if they hold their initial equity investment (minimum €10,000) for three years. INVEST started in 2013 and has received 1,000 investor applications between May 2013 and December 2014 (EFI, 2015). Grants for a total of €11.7m were approved during this period corresponding to a total investment sum of €58.6m.
- IKT Innovativ[35]:
  IKT Innovativ is an entrepreneurship competition for newly founded firms with IT products or services at their core. Potential entrepreneurs compete with start-up plans which are evaluated by experts. The potential founders also receive coaching, feedback and access to professional networks. The winners receive start up grants of up to €30,000.

Research organisations also provide initiatives for science-based entrepreneurship which are typically financed by BMBF. Examples include the Life Science Incubator of the cancer research centre in Bonn or Helmholtz Enterprise. The latter can for example provide funding for up to three years for researchers from the Helmholtz society for developing business plans and commercialisation strategies[36].

With regard to competence creation and technology transfer, many policy instruments aim at creating interaction, knowledge spillovers and technology transfer between scientific research and firm R&D. Some programmes emphasize geographical proximity which can foster the efficiency of knowledge flows between science and industry because of direct interaction between scientists and the establishment of channels based on social networks. Among those are the Leading-Edge Cluster Competition ('Spitzencluster-Wettbewerb') (see also section 3.4.3 of this report) from BMBF in which the Federal Government has invested €360m since 2008 up to the end of 2014[37] and the initiative 'Unternehmen Region' of BMBF[38]. The initiative 'Zwanzig20 –Partnerschaft für Innovation' of BMBF follows a similar approach. It creates a competition between interdisciplinary consortia including firms to develop joint innovation strategies. The initiative provides €500m until 2019 for developing joint innovation strategies based on a competitive assessment[39].

Apart from these cluster initiatives, the German Federation of Industrial Research Associations (AiF) „Otto von Guericke" plays a crucial role in connecting research and innovation. Its primary purpose is to bridge basic research and industrial application of innovation. It manages a network of 100 research associations for applied research

[33] https://www.kfw.de/inlandsfoerderung/Unternehmen/Gr%C3%BCnden-Erweitern/Finanzierungsangebote/ERP-Startfonds-%28136%29/ (10/2015)
[34] http://www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/invest.html (10/2015)
[35] http://www.gruenderwettbewerb.de/ (10/2015)
[36] http://www.helmholtz.de/en/research/technologietransfer/foerderinstrumente/helmholtz_enterprise/ (10/2015)
[37] http://www.bmbf.de/pub/WEDO_SCW_Broschuere_2014_barrierefrei_NEU.PDF (10/2015)
[38] http://www.unternehmen-region.de/ (10/2015)
[39] https://www.bmbf.de/presse/foerderprogramm-zwanzig20-partnerschaft-fuer-innovation-startet-639.html (10/2015)

across business sectors and including research organisations and universities. It has roughly 50,000 members from business and has provided public funding of €490m in 2013 mostly on behalf of BMWi as part of IGF and ZIM.[40] AiF is also representing the interests of the industrial research associations vis a vis policymakers. This decentralized structure allows AiF to react flexibly to changing research demands and opportunities, e.g. from Industry 4.0.[41]

Given the importance of SMEs for the German economy, virtually every major R&I policy initiative involving business refers to the challenges and opportunities of SMEs. This includes the High-Tech Strategy as well as the Digital Agenda 2014-2017 (see section 2.1 of this report). Several innovation policy instruments are particularly directed at SMEs. Among the most important ones are (BMBF, 2014c):

- Central Innovation Programme for SMEs ('Zentrales Innovationsprogramm Mittelstand' ZIM)[42]:
  ZIM is an initiative of BMWi to strengthen innovativeness and competitiveness of SMEs in Germany. ZIM is not limited to a particular industry or technology field. Criteria for financial support through ZIM are the innovation content and commercialisation potential of a project. Otherwise, SMEs have a high degree of flexibility within ZIM. They can choose topics, conduct project R&I in-house or collaborate with a university or research institute. ZIM also supports the creation of innovation networks across firm boundaries. ZIM has approved 29,000 projects since its start in 2008.[43] The Federal Government budgets €513m for ZIM in 2014 which has provided a total of €3,9b in grants since 2008. A recent ZIM monitoring report from September 2014 highlights the flexibility of ZIM grant applications as a major advantage from the perspective of firms as well as its positive effects on private R&D investment and employment[44]:
- ERP-Innovation Programme ('ERP-Innovationsprogramm')[45]:
  The programme targets the needs of SMEs to finance innovation activities which do typically not provide significant collateral for bank lending or only at high interest rates. Two combinable financing options are available: a regular loan with usually below-market interest rates and/or a subordinated credit tranche for which no collateral has to be provided. ERP-Innovation Programme is administered by government owned promotional bank KfW. The programme is designed to provide loans for applied R&D in SMEs. Repayment plans are designed to incorporate the time for commercialisation of the underlying innovation. Loans in the amount of €1.329m for 629 applications have been provided in 2014.
- KMU-innovativ[46]:
  KMU-innovativ is an initiative by BMBF targeting excellent research and innovation with high commercialisation potential of SMEs within nine technology fields: biotech, medical devices, ICT, nanotech (from 2016 extended to materials in general), production technology, technology for resource and energy efficiency, photonics, electronic systems and e-mobility as well as research for civil security. KMU-innovativ provides a special piloting service to potential applicants and a fast application process which is also attractive to small SMEs. The programme

[40] http://www.aif.de/en/about-aif.html (10/2015)
[41] http://www.aif.de/home/detailansicht/news/fir-gewinnt-als-teil-des-nrw-konsortiums-im-wettbewerb-des-bundeswirtschaftsministeriums.html (10/2015)
[42] http://www.zim-bmwi.de/ (10/2015)
[43] http://www.zim-bmwi.de/aktuelles/staatssekretaerin-gleicke-uebergibt-20.000.-zim-zuwendungsbescheid (10/2015)
[44] http://www.zim-bmwi.de/download/studien-berichte-expertisen/rkw-studie-09-2014 (10/2015)
[45] https://www.kfw.de/inlandsfoerderung/Unternehmen/Innovation/Finanzierungsangebote/ERP-Innovationsprogramm-%28180-185-190-195%29/ (10/2015)
[46] http://www.bmbf.de/de/20635.php (10/2015)

provided €100m in grants in 2012 to SMEs directly (60%) and their research partners.

- Innovation vouchers (‚BMWi-Innovationsgutscheinen', go-Inno)[47]:
  Within this programme BMWi provides up to 50% of financing for professional consulting through accredited consulting firms for SMEs through a voucher system. Consulting can target product innovations ('go-innovativ') or process innovations ('go-effizient'). Voucher recipients report that 80% started an R&D-project or had substantial cost reductions (€200,000 annually) (BMBF, 2014c).
- Apart from these programmes there are also initiatives with a regional or topical focus such as for Innovation Competence in East Germany ('Innovationskompetenz INNO-KOM-Ost') or climate change ('Nationale Klimaschutzinitiative') (BMBF, 2014c).

Additionally, the Federal Government has enacted a new law for the reduction of bureaucratic burden particularly for SMEs ('Bürokratieentlastungsgesetz') based on lower requirements for reporting and tax accounting.[48] Parliament has approved the law in July 2015 (Deutscher Bundesrat, 2015) and the Federal Government has accompanied it with a commitment to offset new bureaucratic burdens on firms with the reduction of existing ones ('Bürokratiebremse').[49] However, the impact assessment which accompanies the new law could not identify an expected effect on firm innovation (Kienbaum, 2015).

Focusing on support for commercialisation, the programme "Protection of Ideas for Commercial Use" ('Schutz von Ideen für die Gewerbliche Nutzung', SIGNO)[50] of BMWi has been targeting universities, companies and inventors since 2008. The goals of the program are to provide information and promote strategic thinking about commercial use of inventions. The monitoring report of SIGNO from June 2014 shows that SIGNO has led to 542 patent applications, 530 patent sales and 375 licensing agreements among other outcomes since 2008[51]. The report concludes that the programme has performed well in creating awareness and momentum for commercialisation strategies but requires adaptations to the needs of various stakeholder groups (Kulicke, 2014).

Funding instruments undergo regular evaluations following international standards. Examples include the evaluation of the Central Innovation Programme for SMEs (ZIM) (Kulicke, 2014), the evaluation of EXIST[52] or KMU-innovativ.[53] The Expert Commission for Innovation (EFI) emphasizes the need for more systematic and professionalized evaluations in general (EFI, 2014) and recommends the evaluation of the Leading-Edge Cluster Competition ('Spitzencluster-Wettbewerb') as a template (EFI, 2015).

The Federal Government promotes active participation in Horizon 2020 through a dedicated website and a national contact point[54]. Further, it provides support for the internationalisation of Leading-Edge Clusters, Future Projects, and comparablenetworks ('Internationalisierung von Spitzenclustern, Zukunftsprojekten und vergleichbaren Netzwerken') which is now a BMBF programme with three yearly funding rounds between 2015 and 2017 (see 3.4.3). In each round cluster or network managements can apply for funding for the development of internationalisation concepts (up to two years) and implementation (up to three years)[55].

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[47] http://www.innovation-beratung-foerderung.de/INNO/Navigation/DE/go-Inno/go-inno.html;jsessionid=41D0A72EF834602311550032AFBE2E0C (10/2015)
[48] http://www.bmwi.de/DE/Themen/Mittelstand/buerokratieabbau,did=508704.html (10/2015)
[49] http://www.bmwi.de/DE/Presse/pressemitteilungen,did=719462.html (10/2015)
[50] http://www.signo-deutschland.de/ (10/2015)
[51] http://www.signo-deutschland.de/e5072/e13035/SIGNO_Erfolgskontrolle_Endbericht_FraunhoferISI.pdf (12/2014)
[52] http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/EXIST/exist-0311,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf (10/2015)
[53] http://ftp.zew.de/pub/zew-docs/gutachten/KMU-innovativ2012.pdf (10/2015)
[54] http://www.horizont2020.de/beratung-nks.htm (10/2015)
[55] http://www.bmbf.de/de/25370.php (10/2015)

In sum, the government funding for private R&I covers the stages from research to commercialisation comprehensively. They include both accesses to financing as well as knowledge. Particular attention is paid to the needs and opportunities of SMEs ('Mittelstand') and many programmes aim at leveraging interaction between scientific research and firm R&D. In particular the German Federation of Industrial Research Associations (AiF) „Otto von Guericke" can react flexibly to changing demands and opportunities because of its decentralized structure and integration with firms. Central Innovation Programme for SMEs (ZIM) is the dedicated policy instrument targeting SMEs. Innovative approaches include vouchers for professional consulting of SMEs without dedicated innovation management or controlling functions.

In terms of lead market initiatives, the new high-tech strategy (BMBF, 2014d) of the Federal Government identifies six future challenges with major opportunities for economic growth and prosperity: Digital economy and society, sustainable economy and energy, innovative employment, healthy living, intelligent mobility as well as civil security. These can be consistently be seen reflected in other policy initiatives such as the Leading-Edge Cluster Competition or the Digital Agenda 2014-2017 (BMWi, 2014a).

3.5.2 Public Procurement of Innovative solutions

Due to the lack of standardised statistics, estimates for the total value of public procurement in Germany vary between €200b and €496b per year which corresponds to 12%-13% of GDP (Kienbaum, 2014). Municipalities account for the lion's share of public procurement and federal and state governments for the remainder. A study carried out in 2009 showed that innovation-relevant procurement made up about 10% of total procurement and that IT, telecommunications, energy, the environment, R&D, facility management and construction services are the sectors of German economy with most potential for public procurement of innovative products and services (OECD, 2011).

Legal Public Procurement framework

Germany transposed the two 2004 Directives on public procurement (2004/17/CE and 2004/18/CE) into national law in 2006. The changes adopted in the EU Directives have been incorporated into several different already existing German legal acts. The above guidelines have been codified by law in the Act against Restraints of Competition ('Gesetz gegen Wettbewerbsbeschränkungen', GWB), the Regulation on the Award of Public Contracts ('Vergabeverordnung', VgV), the Sector Regulation ('Sektorenverordnung', SektVO), the German Construction Contract Procedures ('Vergabe- und Vertragsordnung für Bauleistungen', VOB (public works)), the Procurement and Contract Procedures for Supplies and Services ('Vergabe- und Vetragsordnung für Leistungen', VOL) and the Procurement and Contract Procedures for Freelance Services ('Vergabeordnung für freiberufliche Dienstleistungen', VOF).

Article 16 of Directive 2004/18/CE and Article 24 of Directive 2004/17/CE including exemptions for R&D services were also transposed into national law and the corresponding provisions can be found in Article 100, paragraph 2, letter n of the Act against Restraints on Competition (GWB)[56].

Recent public procurement Directives 2014/24/EU (replacing Directive 2004/18/EC), 2014/25/EU (replacing 2004/17/EC) and 2014/23/EU have to be transposed into German law until April 2016. Responsible authority for the implementation is the Federal Ministry for Economic Affairs and Energy (BMWi). According to the Federal Government, the implementation of the new EU public procurement directives should make procurement procedures in Germany more flexible and user-friendly while increasing legal certainty for companies and public procurers.

The PCP/PPI landscape in Germany

[56] http://www.bmwi.de/BMWi/Redaktion/PDF/Gesetz/achte-novelle-gwb,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

The concept of innovation-oriented public procurement has been included as a goal in several of the most important strategic documents of innovation policy at federal level, such as the Digital Agenda 2014 – 2017.

The Federal Government has made further steps towards innovative public procurement in 2015. It has proposed a reform of procurement law ('Vergaberechtsmodernisierungsgesetz – VergRModG') as part of a bureaucracy reduction initiative. The law would establish innovation as part of procurement decision making. The law is currently being debated in parliament. Furthermore, the Act against Restraints on Competition (GWB) was modified in 2009 in such a way that public procurers can also require innovative aspects in addition to social and environmental aspects in the service specifications[57].

In 2010 (updated in 2014), the German Ministry for Economic Affairs and Energy (BMWi) published a first version of practical guide on PPI with recommendations and best practice cases to help public sector organisations incorporate innovation procurement into their purchasing practices[58].

Particular emphasis has been put on resource efficient and sustainable procurement. In 2008, the Federal Cabinet adopted "General administrative provisions for procurement of energy efficient products and services" and corresponding guidelines which are binding for all departments at federal level[59]. In 2010, the Alliance for Sustainable Procurement ('Allianz für nachhaltige Beschaffung') was formed under the chairmanship of Federal Government which has become the central portal for public sustainable procurement on all levels of public administration (Federal Government, Laender and municipalities). The Alliance for Sustainable Procurement issued guidelines for public actors on "resource efficient procurement" in 2014 and "procurement of electro and hybrid vehicles" in 2013 which were updated in February 2015[60]. However, the Alliance prioritises environmental and social criteria rather than innovative aspects of procurement.

PCP/PPI initiatives

In 2012, the BMWi set aside a budget of €2.8m to start providing financial incentives to German public procurers to pilot PCP in Germany[61]. The dedicated budget for 2013 added up to €3.8m with most of it earmarked for the creation of the KOINNO Competence Centre for Innovative Public Procurement, which was set up in 2013 under the auspices of BMWi[62]. The Centre is managed by German Association Materials Management, Purchasing and Logistics (BME). It is advising procurers at federal, state and municipal level and aims to raise awareness about innovation-relevant public procurement at all levels of public administration. In addition, KOINNO is planning the launch of three pilot projects for PCP and runs a database with best practice examples for innovative public procurement.

Funding for pre-commercial procurement has also been integrated in some of the already existing federal grant schemes for innovation, such as "KMU innovativ" and the Central Innovation Programme SME[63].

Moreover, the BMWi has been awarding a prize for best practice in public procurement of innovations "Innovation creates a lead" (Innovation schafft Vorsprung) since 2006.[64]

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[57] http://www.gesetze-im-internet.de/gwb/__97.html
[58] http://de.koinno-bmwi.de/system/publications/files/000/000/201/original/BMWi_Leitfaden_KOINNO_web.pdf?1400241968
[59] http://www.bmwi.de/BMWi/Redaktion/PDF/A/aav-zur-beschaffung-energieeffizienter-produkte,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf
[60] http://www.nachhaltige-beschaffung.info/SharedDocs/Kurzmeldungen/DE/2014/140213_AnB_2014.html
[61] http://cordis.europa.eu/fp7/ict/pcp/docs/pcp-germany-v1.pdf

[63] http://www.koinno-bmwi.de/information/forderprogramme
[64] http://www.koinno-bmwi.de/innovation/innovationspreis

Among the best documented pilot schemes for increasing demand for innovative products through public procurement is the support for electric mobility in city and traffic planning ('Elektromobilität in der Stadt- und Verkehrsplanung'). The Federal Ministry for traffic and digital infrastructure ('Bundesministeriums für Verkehr und digitale Infrastruktur', BMVI) has provided financial support of €850m between 2006 and 2015 for the scheme although detailed budget for procurement are not available. Since 2009 fleets and charging infrastructure have been put in place in several model regions. Examples are the "LivingLab BWe mobil" in Baden-Württemberg, the "Internationales Schaufenster Elektromobilität" in Berlin-Brandenburg, "Unsere Pferdestärken werden elektrisch" in Lower Saxony and the project "Elektromobilität verbindet" in Bavaria and Saxony. Altogether, 90 common projects are being realised in these four model regions between 2012 and 2016. One concrete example for such a project is an EU-wide tendering process initiated by the state of Berlin for the expansion of its e-car charging facilities from about 220 to 1600 charging points[65].

On European level, Germany is participating in several EU funded projects that include pre-commercial procurement such as THALEA, IMAILE and HBP. In the framework of THALEA[66], a group of procurers (learning institutions such as schools and universities) from several EU countries are preparing a joint PCP under German law in the field of telemedicine for Intensive Care Unit patients at increased risk. IMAILE[67] is the first project on a European level which addresses the area of ICT in the field of Education and e-learning from both the demand and the supply side. The HBP (Human Brain Project) [68], focusing on simulation of the human brain using supercomputers, is conducting pre-commercial procurement under German law of interactive super computers that will be used to replicate and study the human brain. The procurement is now in its final phase.

However, binding strategies or concrete national targets across all public bodies for PCP or PPI do not exist. The EFI Expert Commission which is advising the Federal Government on research and innovation matters concluded in its 2013 report that Germany is not sufficiently exploiting the potential of innovation-oriented procurement yet. An important step in this process is overcoming the fragmentation of public procurement in Germany. An estimated 30,000 different government procurement offices at federal, Laender and municipality levels exist (EFI, 2013). Current policies focus on dealing with fragmentation before setting input or output goals.

Much potential also still seems to exist at the level of municipalities in Germany. A study carried out by KPMG in 2013 covering 56 German municipalities revealed that still only a minority of municipalities considers procurement as a driver for innovation that could help achieve strategic objectives of the municipality[69].

On the other hand, recent analyses for Germany show that public procurement is as important for firm innovation performance as industry-science linkages (Aschhoff and Sofka, 2009). What is more, the effect is particularly strong for firms in Germany which may otherwise not participate in government R&I policies, i.e. small firms, firms in service sectors and firms in economically less developed East Germany.

3.5.3 Indirect financial support for private R&I

R&I funding in Germany does not include R&D tax credits. The introduction of R&D tax credits has been on the political agenda for some time. However, the current government seems less inclined to introduce them compared with the previous one (EFI, 2014). While there is no explicit R&D tax credit, expenditures for R&D reduce a firm's taxable income if they constitute costs. According to German income tax law, all current

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[65] http://schaufenster-elektromobilitaet.org/de/content/ueber_das_programm/programmuebersicht.html
[66] http://www.thalea-pcp.eu/
[67] http://www.imaile.eu/
[68] https://www.humanbrainproject.eu/
[69] http://www.publicgovernance.de/docs/Studie_Kommunale_Beschaffung_im_Umbruch.pdf, p.16

R&D expenditures are fully deductible from taxable income. Capital assets of a company and acquired know-how can be subject to depreciation or a reduction in value.

3.6 Business R&D

3.6.1 The development in business R&D intensity

As one can see from Figure 7, the German BERD has been following a growing trend since 2005 and in the years 2010-2012 it is close to an intensity of 2%. The service and manufacture sectors amount together to more than 95% of the German BERD. In particular, manufacturing is extremely important and strongly correlated to the total BERD. The business sector (Figure 8) is by far the main funder of the German BERD. The contributions from abroad and from the government are of a comparable intensity, in both cases much lower than those of the business sector and only play a minor role.

As for the impact on the economic crisis on business R&D spending, business R&D expenditures contracted in 2009 (-1.7%), but much less so than nominal GDP which left business R&D intensity unscathed.

During the years following the crisis positive trends in BERD growth could be observed. This dynamic was broken in 2013 when BERD slightly contracted, However, in 2014 BERD grew again moderately. Under this relatively calm surface, some further changes are observable. Recent data by Germany's Stifterverband show that expenditures by German businesses for extramural performed R&D have strongly been increasing in 2013, in particular in chemical and pharmaceutical industries (+17% and +19% respectively) while intramural expenditures have been slightly declining. A major part of the additional extramural expenditure is spent in small specialised service oriented SMEs. Consequently, intermural R&D expenditures of independent scientific and technological service providers have increased by 13.3% between 2012 and 2013 (Nace-Code "M"). This is an indication for more open corporate innovation strategies characterised by increased usage of external knowledge and competence. The coming years will have to show whether this trend is solidifying. Generally, it can be noted that over the past 20 years intramural business R&D expenditures doubled while extramural expenditures quadrupled (Stifterverband, 2015d).

Figure 6: BERD intensity broken down by most important macro sectors (C= manufacture, G_N=services)

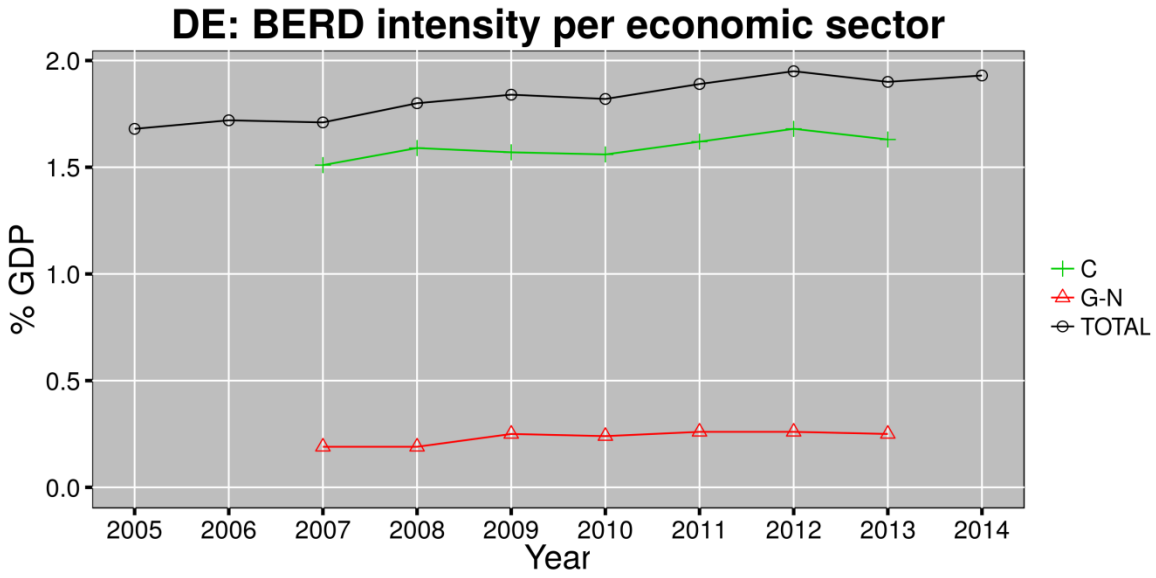
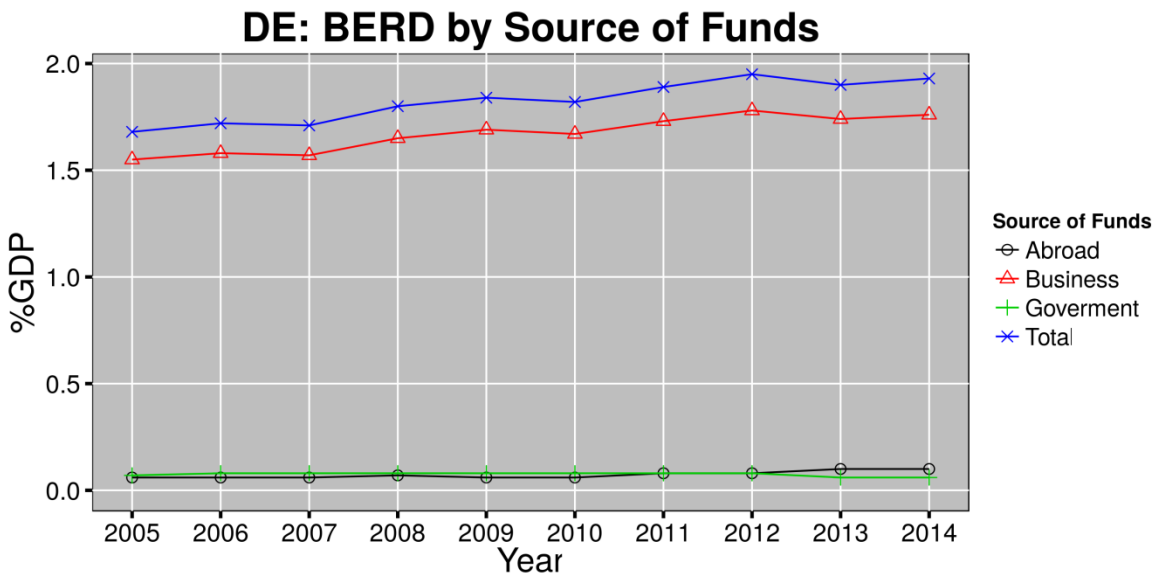


Figure 7: BERD by source of funds



3.6.2 The development in business R&D intensity by sector

Manufacturing increased its R&D intensity by 7.9% between 2007 and 2013, from an already high level of 1.51% to 1.63%. Over the same period R&D intensity in services increased by 31.6%, from 0.19% to 0.25%.

The automotive sector is the leading sector of the German manufacture (see Figure 9), followed at distance by the manufacture of computer, electronic and optical products and by the manufacture of other machinery and equipment. For the three sectors mentioned above, and in particular for the automotive sector, one can observe a growing trend after the dip in 2009. Other important sectors include pharmaceutical and chemical industries. The automotive sector in Germany is a particularly important contributor to R&D. It accounts for three quarters of all R&D investment in this sector in Europe and has increased R&D investments by 9.7% in 2013. In more general terms, firms on the R&D investment scoreboard headquartered in Germany have increased their R&D spending by 5.8% in 2013, compared with a worldwide increase of 4.9% and 2.5% of all EU headquartered firms. Volkswagen is the worldwide number one of all firms with R&D investments reaching €13.1b or 6% of sales in 2014.

As for the impact on the economic crisis on business R&D spending, it was observed that business R&D expenditures contracted in 2009 (-1.7%), but much less so than nominal GDP. On closer examination, it becomes obvious that manufacturing was hit the strongest with R&D expenditures dropping by 5% in 2009. In the automotive industry, R&D expenditures plummeted by about 10% and in electronic engineering by more than 10%. It is due to very positive developments in ICT services and professional, scientific and technical service activities (Figure 10) that business R&D contracted only very moderately during the crisis. This positive trend in services had started already a little earlier but continued unabatedly over 2009 and 2010. In important sectors like automotive and electronics, it took until 2011 for R&D expenditures to reach pre crisis levels (Stifterverband, 2012) (see also Figure 9).

Figure 8: top sectors in manufacturing
(C26=manufacture of computer, electronic and optical products; C28=manufacture of machinery and equipment n.e.c.; C29=manufacture of motor vehicles, trailers and semi-trailers).

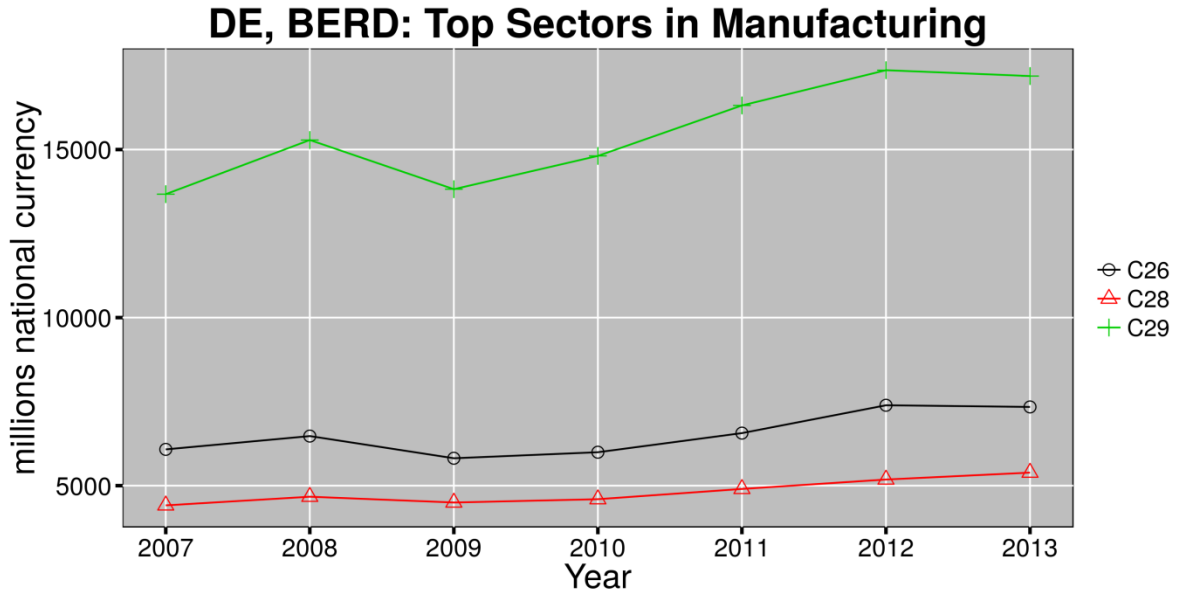
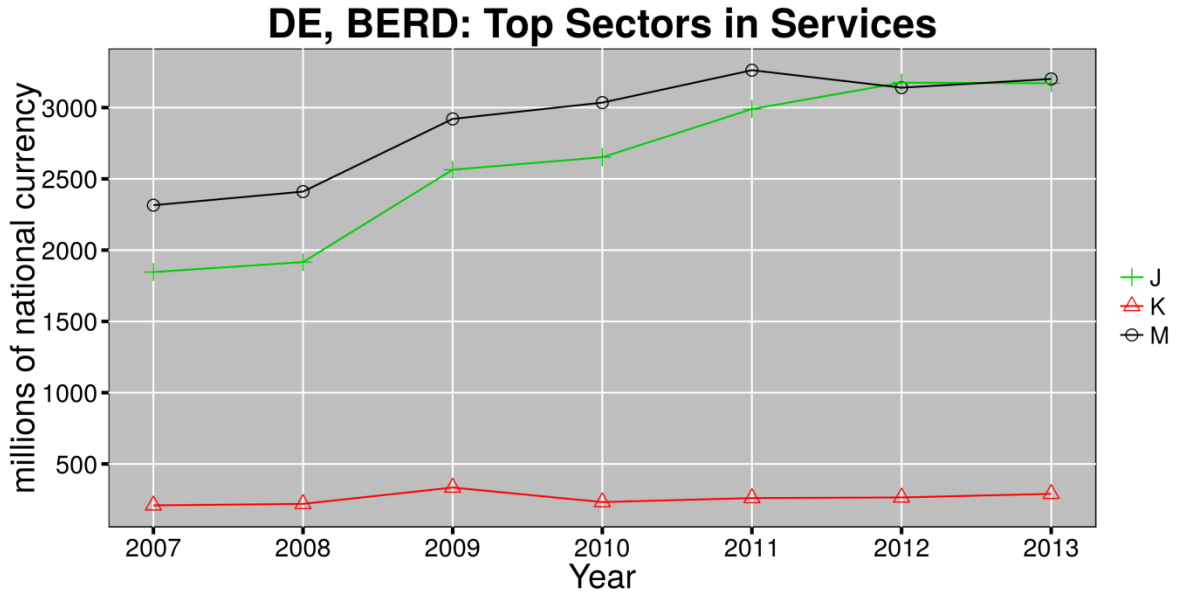


Figure 9: top service sectors
(J=information and communication, K=financial and insurance activities, M=professional, scientific and technical activities).



As mentioned above, the importance of the ICT and scientific/technical services which have been on the rise since 2008 stands out. In 2012, they are practically at the same nominal levels slightly above €3,000m. Enterprises in the ICT service sector are mostly smaller but they carry out above average amounts of R&D and they have come to dominate the ICT sector, in terms of turnover and value added as well as in terms of numbers of enterprises and employees.

3.6.3 The development in business R&D intensity and value added

Unsurprisingly, due to its importance in the German BERD, manufacturing is the biggest contributor to Gross Value Added (GVA) in Germany in 2012 (Figure 11). A top service sector in terms of BERD, namely the professional, scientific and technical activities also appears as one of the most importance sectors in terms of GVA, in particular when

putting it into relation to GVA in manufacturing broken down by most important sub sectors (Figure13). Finally, some services (like the real estate activities and the activities related to human health) are important in terms of their GVA, whereas they play a more modest role in the BERD.

Figure 10: economic sectors as percentage of the total GVA.
Top 6 sectors in decreasing order: 1) manufacture, 2) real estate activities, 3) wholesale and retail trade (repair of vehicles and motorcycles), 4) human health and social work activities, 5) professional, scientific and technical activities, 6) administrative and support service activities.

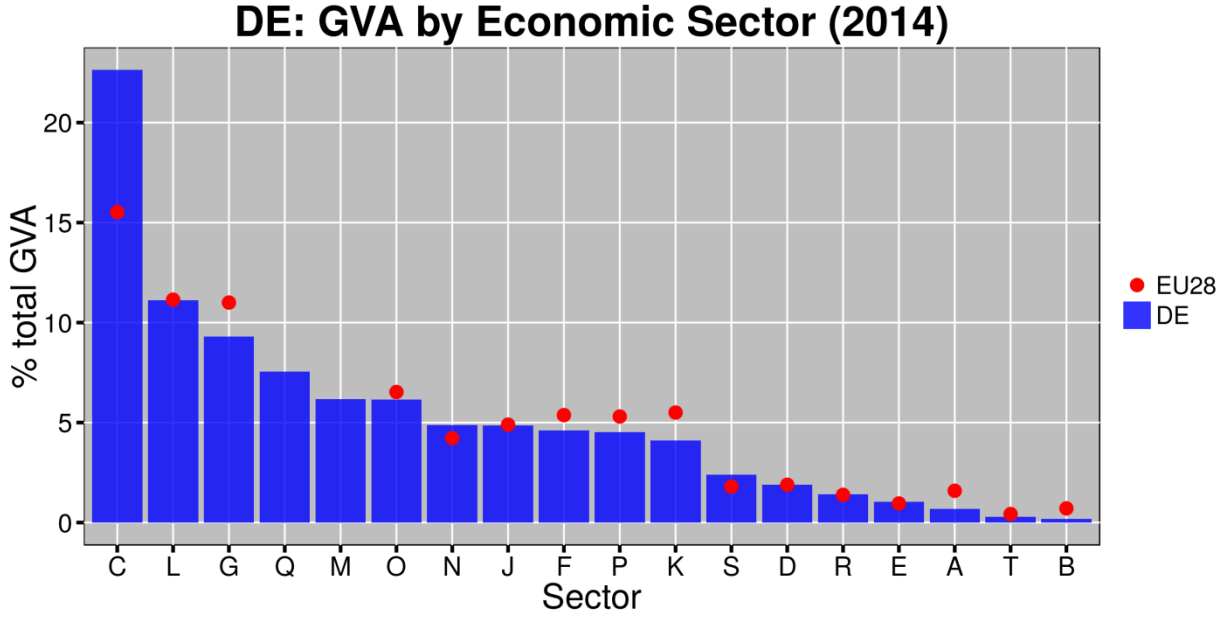
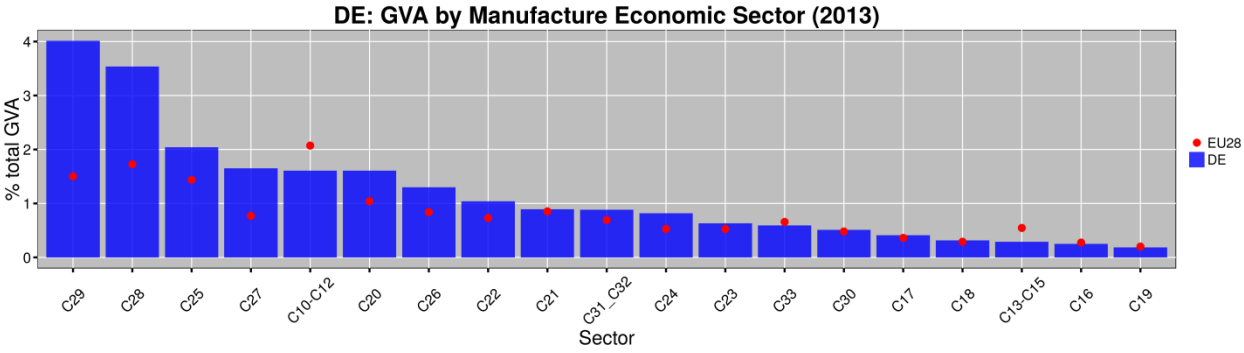


Figure 11: GVA in manufacturing.
Top 6 manufacturing sectors: 1) manufacture of machinery and equipment n.e.c., 2) manufacture of motor vehicles, trailers and semi-trailers, 3) manufacture of fabricated metal products except machinery and equipment, 4) manufacture of electrical equipment, 5) manufacture of food products, beverage and tobacco products, 6) manufacture of chemicals and chemical products.

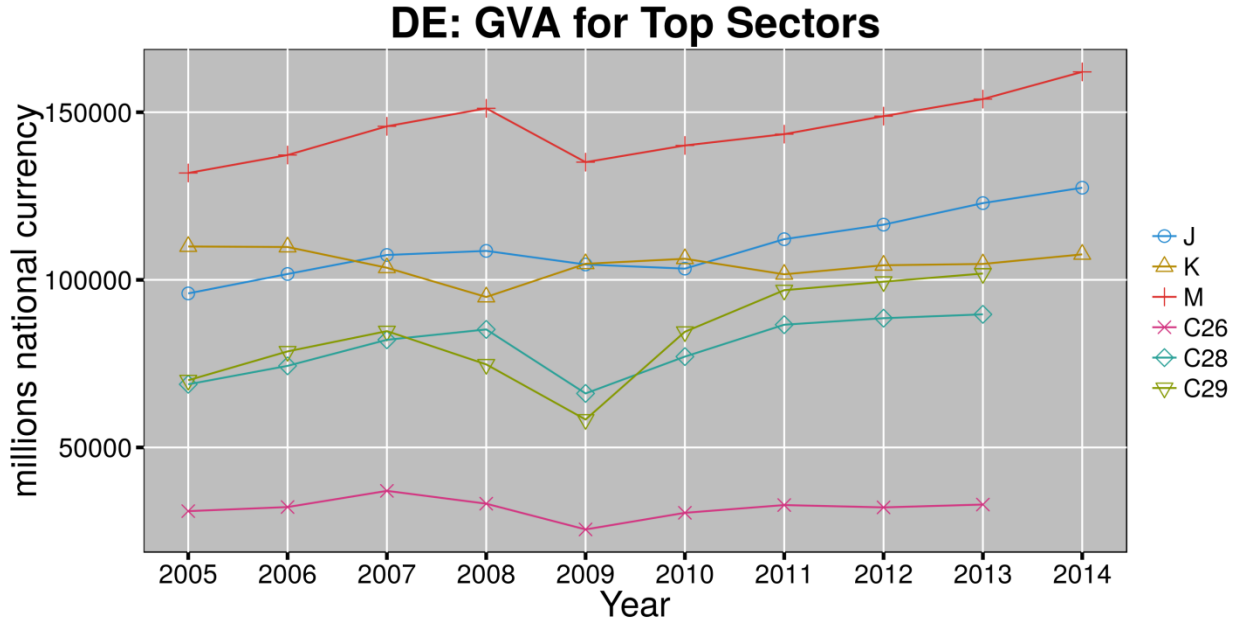


Consistently with the aforementioned importance of the automotive industry in the German economy, the manufacture of motor vehicles and machinery are the two leading sectors also in terms of GVA for the German manufacture. The food industry and the chemical industry also make important contributions to GVA (Figure 12).

One should also note the importance of SMEs for value added in Germany. The success of German SMEs throughout the crisis period of 2008-2014 is unique in the EU. The number of SMEs soared from 1.87 million in 2008 to almost 2.2 million in 2014. The number of people employed in German SMEs is estimated to have increased by some 2.8 million to a total of almost 16.85 million in 2014. The surge in total value added was estimated at 16 % across almost all sectors. This success story is set to continue at least for the near future. The number of SMEs is forecast to expand by 100 000 new firms in

2015 and 2016, creating an additional 820 000 jobs in the process. SMEs of all size classes are expected to create more jobs, most notably medium-sized ones with an expected increase of 3.1% a year[70].

Figure 12: Value added for the leading manufacture and service sectors in Figures 9 and 10.



3.7 Assessment

The system of R&I funding in Germany reflects the size and complexity of the economy as well as a federal tradition with important responsibilities of the Laender. Focussing on funding for public R&I in particular the Initiative for Excellence and the Pact for Research and Innovation have had positive effects. The former has been a major departure from the federal tradition of university funding in Germany. However, it has created positive dynamic of ambitious new research initiatives and doctoral training with scientific excellence in mind. The Pact for Research and Innovation has increased the planning horizon of the main research organisations and provided them with new funding. While their institutional funding is granted as a block, competitive mechanisms are in place within each organisation to allocate fund competitively among member institutes. Besides, the system of institutional funding for research organisations guarantees a general balance between basic and applied research. There are no indications that the German Research Foundation DFG is not functioning properly in organizing competitive allocations of funds for individual researchers as well as research units, institutes or universities.

[70] European Commission, DG GROW, Small Business Act (SBA) fact sheet Germany, http://ec.europa.eu/growth/smes/business-friendly-environment/performance-review/index_en.htm

Focusing on funding for private R&I, many efforts are undertaken to connect academic discovery in universities and research institutes with commercial application in firm R&D. The funding system is particularly geared towards the needs of SMEs. This is appropriate given the importance of this group of firms for the German economy and R&I system. Then again, current trends indicate that investment in innovation of German SMEs is slowing down (EFI, 2015) and their rate of success with innovative products has declined albeit from a high level (European Commission, 2015c). This trend requires further insights into cause and effect relationships.