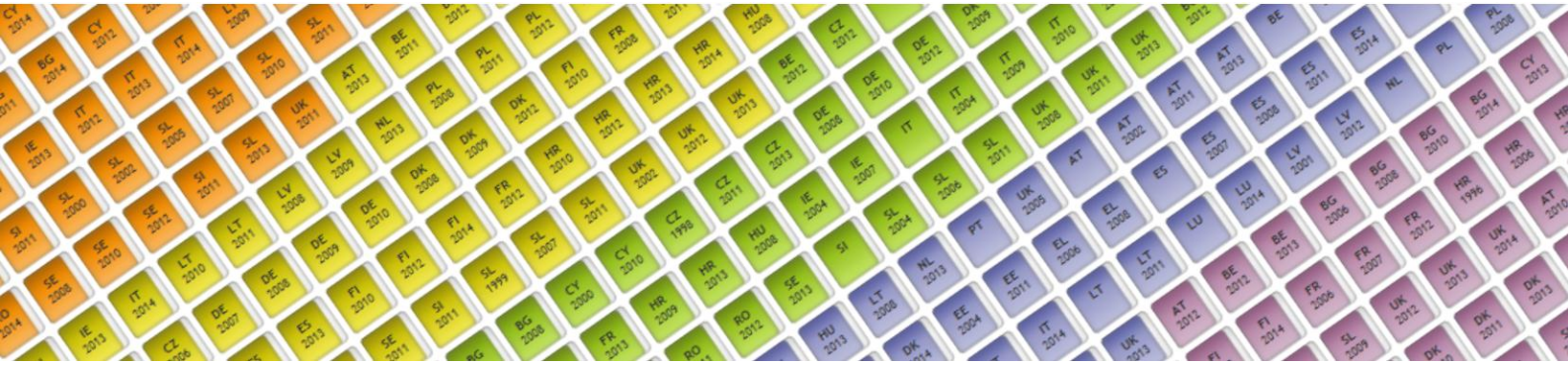
European Commission

JRC SCIENCE AND POLICY REPORT

RIO Country Report Germany 2014

Wolfgang Sofka

2015



Report EUR 27309 EN

Joint Research Centre

European Commission
Joint Research Centre
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JRC Science Hub
https://ec.europa.eu/jrc

JRC 96485

EUR 27309 EN

ISBN 978-92-79-48969-3 (PDF)

ISSN 1831-9424 (online)

doi:10.2791/80342

Luxembourg: Publications Office of the European Union, 2015

Abstract

The report offers an analysis of the R&I system in Germany for 2014, including relevant policies and funding, with particular focus on topics critical for two EU policies: the European Research Area and the Innovation Union. The report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc. The report identifies the structural challenges of the German research and innovation system and assesses the match between the national priorities and those challenges, highlighting the latest policy developments, their dynamics and impact in the overall national context.

Acknowledgments

The report draft has benefited from comments and suggestions of Lutz Gros from the Germany Federal Ministry of Education and Research and of Maren Sprutacz from JRC-IPTS. The contributions and comments from DG RTD and JRC-IPTS are also gratefully acknowledged.

Executive summary

Germany has the largest Research and Innovation (R&I) system in Europe. Gross R&D expenditures (GERD) have reached €79.1b in 2012 which implies that Germany accounts for 29.3% of all R&D expenditures in EU-28. The German R&I system showed a strong performance in 2014. The EU Innovation Union Scoreboard 2014 classifies Germany as an innovation leader member state together with Sweden, Denmark and Finland. Research and innovation are among the top priorities at all levels of decision making, for the federal government, state governments (so called 'Laender') and the business sector. All of these actors have increased their investments in R&I significantly over the last years. Accordingly, R&D investments in Germany have reached 2.85% of GDP in 2013 which puts Germany within reach of its 3% goal. Two thirds of these investments are made by the business sector. This report was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites, etc. The quantitative and qualitative data is, whenever possible, comparable across all EU Member State reports.

2014 has been characterized politically by a new federal government taking up its work. The new governing coalition has been formed in December 2013 by the Christian Democratic Parties (CDU/CSU) and the Social Democratic Party (SPD). The government is led by Chancellor Angela Merkel for the third consecutive legislation period. The new federal government has been consistent with its commitment to R&I policies overall as well as with R&I strategies from the previous government. Three strategy documents stand out in particular:

The government has renewed its High Tech Strategy which defines priority fields and sectors for innovation in Germany as well as strategic guidelines for how the economic and societal potentials can be achieved.

Similarly, the federal government has provided a "Digital Agenda 2014-2017" which highlights areas and strategies in which government can maximize the benefits from an increasingly digital and interconnected economy and society.

The federal government has also formulated a comprehensive strategy and an action plan for increasing Germany's role within an increased international collaboration and mobility in research especially within the European Research Area (ERA).

A major legislative achievement of the new federal government is the change of the constitution in December 2014. Article 91b of the German constitution had previously put important limitations on the role of the federal government for funding education and research in universities. The latter was so far the prerogative of the Laender. With the change in the constitutional law, the federal government will have a permanent and strategic role in financing universities. Experts had called for this change for several years but the necessary majorities in both chambers of parliament (with the 'Bundesrat' representing the Laender) appeared difficult to mobilize. In this regard, the current federal government has the advantage that it is formed by parties of which at least one is also part of every Laender government.

The change in the constitution shows a broader consensus between federal and Laender governments for continued emphasis on R&I in Germany. Federal and Laender governments had previously collaborated on three central policy packages (often times

referred to as “pacts”) which were all due to expire in the current legislation period. Against the backdrop of the change in the constitution, federal and Laender governments have agreed to continue the Pact for Research and Innovation (‘Pakt für Forschung und Innovation,’ directed at research organizations) as well as the Higher Education Pact (‘Hochschulpakt,’ directed at funding education and research at universities) until 2020. Both parties have also signalled their intention to extend the Initiative for Excellence (‘Exzellenzinitiative,’ directed at promoting excellent research in Germany) beyond 2017. These are important decisions because signals for excellent research in German universities, such as record number of starting grants from the European Research Council (ERC) for researchers in Germany in 2014, begin to emerge.

Further advantages of the German R&I system stem from the capabilities of firms for turning research in economically successful innovations. Firms in Germany are not just successful with new products and processes but also through novel forms of organization and marketing. They also draw from a broad portfolio of instruments for appropriating economic returns of innovations including patents, copyrights and design protection. Structurally, innovation in German businesses has two particular features. First, Germany has large and successful firms in medium high-tech manufacturing sectors such as automotive or chemical production. Second, Germany has a large base of highly specialized, innovative and exporting SMEs. Many, R&I policy initiatives reflect the particular opportunities of this structure, e.g. through more interconnected modes of production (‘Industrie 4.0’).

In terms of challenges to the German R&I system, three particular issues deserve most attention. First, Germany tends to lose more skilled researchers to universities and research institutes abroad then it can attract to move to Germany. What is more, the most research and publication active researchers leave. A related field of international competition is the location of firm R&D activities. Germany finds itself in intense competition for the location of firm R&D centres especially in high-tech fields. Emerging economies become increasingly attractive locations for R&D centres in medium high-tech sectors. Excellent research environments and particularly well trained students, such as envisioned in the Initiative for Excellence, can provide important competitive advantages when Germany wants to attract more skilled researchers and firm R&D.

Second, two factors influence the human capital underlying the German R&I system. The first trend is rooted in demographics and an overall aging society in Germany. This affects the availability of scientists and engineers. The second trend stems from a shift in the career choices of secondary school students. Germany has traditionally benefited from a mix of academically educated students and individuals with professional qualifications based on apprenticeships and on the job learning (‘Facharbeiter’). The latter career path becomes increasingly less attractive to secondary school students. Academic training will hardly be able to replace the professional and often times tacit experience acquired in day to day interaction with processes, procedures and clients.

Third, Germany has a strong base of innovative firms in medium high-tech sectors. However, opportunities from increasingly knowledge-based societies emerge especially in high-tech manufacturing and knowledge-intensive service. Successful firms in such sectors are more likely to emerge through entrepreneurship. Germany has a deficit in this area compared with other countries. On the one hand, Germany provides good career opportunities in existing firms. On the other hand, the entrepreneurial high-tech firms find

it difficult to secure financing and the market for venture capital in Germany is comparatively small.

The R&I policy mix in Germany shows that policy makers are responsive to these challenges which roots are complex and often times interrelated. For example the renewed High Tech Strategy, Digital Agenda 2014-2017 or a newly introduced instrument for incentivising venture capital investment ('INVEST – Zuschuss Wagniskapital') demonstrate that policies are being developed and refined to turn the challenges into opportunities.

In sum, the German R&I system performs well and continues to benefit from positive dynamics. Especially the extension of the "pact" policy programmes will provide new opportunities for excellence in the German R&I system. At the same time, it will lead to more differentiation between universities which will require strategic management skills. On the innovation side, Germany benefits from an array of established knowledge transfer mechanisms. Several recent policy initiatives, such as "Leading Edge Clusters," encourage geographical and topical clusters in which innovation emerges from a shared strategic understanding of knowledge producers and users. New R&I policy potentials emerge especially from demand-side instruments, e.g. through public procurement which seems currently too fragmented.

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1. Overview of the R&I system

1.1 Germany in the European RDI landscape

Germany is the largest country within the European Union in terms of population and gross domestic product (GDP). The country has 80.8 million inhabitants in 2014 and a GDP of €2,737.6b in 2013 (EUROSTAT).[1] In relative terms, 16% of the population of EU-28 live in Germany and 21% of EU-28 GDP is produced in Germany. GDP per capita is almost 30% higher in Germany than EU-28 average.

Germany was severely affected by the financial and economic crisis. In 2009 GDP decreased by 5.1%. However, the German economy recovered quickly with strong growth rates of 4% in 2010 and 3.3% in 2011. Growth rates have been lower since then. In 2012 the German economy grew by 0.7% in 2012 and by 0.4% in 2013. These growth rates still surpassed EU-28 average growth (0.1% in 2013). The Federal Ministry for Economic Affairs and Energy ('Bundesministerium fuer Wirtschaft und Energie', BMWi) had predicted significantly stronger GDP growth for 2014 and 2015 in its Annual Economic Report 2014 ('Jahreswirtschaftsbericht', BMWi, 2014a) but had to reduce the projection in its fall prognosis 2014 to 1.2% in 2014 and 1.3% in 2015 <link (12/2014)>.

Gross R&D expenditures (GERD) in Germany have reached €79.1b in 2012 or 2.88% of GDP.[2] GERD in Germany amounts to 29.3% of all R&D expenditures in EU-28. GERD has grown by 19.6% between 2009 and 2013. This growth has been equally fuelled by government and private sector sources. Government budget appropriations or outlays for research and development (GBAORD) amount to €25.4b in 2013 which is 16.9% higher than in 2009. Business expenditures on R&D have reached 1.9% of GDP in 2012 (latest available year). The relationship between government and private R&D investment in Germany is very stable over the years with two thirds (66.9% in 2013) being provided by the private sector. The persistent investments in R&D by both government and private sector in Germany are remarkable given that they have increased in times of severe economic stress from financial and economic crises.

In terms of innovation outcomes, firms in Germany generated 15.5% of their sales from innovative products and services in 2010 (latest available year). This number is higher than the EU-27 average (13.4%). The European Commission classifies Germany in its Innovation Scoreboard 2014 (European Commission, 2014b) as an innovation leader. The leader position indicates that country innovation performance is at least 20% above EU-28 average. Germany is overall ranked third within Europe and shares the innovation leader status with Sweden, Denmark and Finland.

[1] If not referenced otherwise, all quantitative indicators are based on EUROSTAT data.

[2] EUROSTAT started publishing GDP data according to the ES 2010 standard in September 2014. Following the new calculation standard GDP in Germany is slightly higher which implies that R&D as a share of GDP is slightly lower. According to the previous standard, R&D as a share of GDP in Germany would have reached 2.98%. Several reports used for this report are based on the previous calculation standard and they are cited accordingly.

1.2 Main features of the R&I system

Germany has an R&I system of multiple layers and institutional pillars. The German R&I infrastructure is broadly developed encompassing virtually all disciplines, a large number of research facilities and skilled personnel. The German R&I system has two primary features which add to its complexity. First, R&I responsibilities are shared by the federal government as well as by the governments of the 16 German states ('Bundeslaender' or 'Laender' for short). Second, and overlapping with the first factor, research is not just conducted in universities and companies but also at non-university institutes and universities of applied sciences. There exist more than 800 publicly funded research institutions in Germany and numerous R&D centres of companies. Many of these institutions collaborate in topical networks or regional clusters (for a complete overview follow <link (12/2014)>).

Much of publicly funded research is conducted in a well-established university system and in non-university public research institutes. The latter are mostly organized in the large research organizations: Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL). R&I in the private sector is especially strong in medium high-tech industries, like automotive production, machinery and equipment and chemicals. R&D and its commercial exploitation in successful innovation is a major component of the strategy of many German firms as evidenced by the Innovation Union Scoreboard 2014 (European Commission, 2014b).

Finally, the German R&I system also includes specialized service providers which consult, support and manage R&D and innovation in various ways. Such services include technology transfer, IPR consulting or innovation marketing. Such services are available throughout the country and add to the dynamic of research and innovation in Germany (<link (12/2014)>).

1.3 Structure of the national research and innovation system and its governance

The federal structure of Germany is also reflected in political decision making on Germany's R&I system. The federal government has far reaching but not exclusive authority on several fields of R&I policy. 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. A number of other ministries have own research institutes ('Ressortforschungseinrichtungen'). These institutes provide ministries with specifically relevant scientific knowledge or assess quality or safety standards.

In contrast, education policy is the responsibility of the Laender governments with few exceptions. 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.

Federal and Laender governments coordinate joint initiatives through the Joint Science Conference ('Gemeinsame Wissenschaftskonferenz', GWK). It encompasses the ministers and senators of the federal government and the Laender responsible for science and research as well as for finance. Especially in recent years, federal and Laender

governments have collaborated on ambitious, multi-year policy programmes affecting many aspects of research, education and innovation and Germany. The three largest and most prominent programmes are the Initiative for Excellence ('Exzellenzinitiative'), Pact for Research and Innovation ('Pakt für Forschung und Innovation') as well as the Higher Education Pact ('Hochschulpakt'). All of these policy packages will expire during the current legislation period. GWK has agreed in October 2014 to continue Pact for Research and Innovation ('Pakt für Forschung und Innovation') as well as the Higher Education Pact ('Hochschulpakt') until 2020 and signalled to extend the Initiative for Excellence ('Exzellenzinitiative') beyond 2017 (<link (2/2015)>; <link (2/2015)>, <link (2/2015)>). The GWK agreement requires the approval by the federal and Laender governments. German constitution (Art. 91b GG 'Grundgesetz') has until now been strict in limiting the authority of the federal government for funding research and education at universities. The political and legislative process is under way to reform the constitution and enable the federal government to have a broader and more permanent funding role (<link (2/2015)>). The federal parliament has approved the change of the constitution; the other chamber of parliament representing the Laender ('Bundesrat') has approved the change in December 2014 (<link (12/2014)>).

The German Science Foundation (DFG) is the self-governing organisation for science and research in Germany. DFG is mostly in charge of conducting a competitive process through which the best fundamental research projects from scientists of universities and research institutions receive funding. It covers both natural sciences and humanities. The promotion of applied R&D for small and medium-sized enterprises (SMEs) in some sectors is the responsibility of the German Federation of Industrial Research Associations "Otto von Guericke" (AiF) and of the Central Innovation Programme for SMEs ('Zentrales Innovationsprogramm Mittelstand' ZIM; see section 4.5 of this report for details).

The research organizations Max Planck Society, Fraunhofer Society, Helmholtz Association, and Leibniz Association are a unique feature of the German R&I system. Their institutes cover a broad spectrum from basic to applied research and act as providers of research services. A particularity of the German R&I system is also the presence of funding agencies ('Projekttraeger', PRO) which are typically located at larger research institutes. Their role is to administer and manage the R&D programmes funded by ministries. Universities and research institutes can be interlinked. Many directors of research institutes are also chaired university professors.

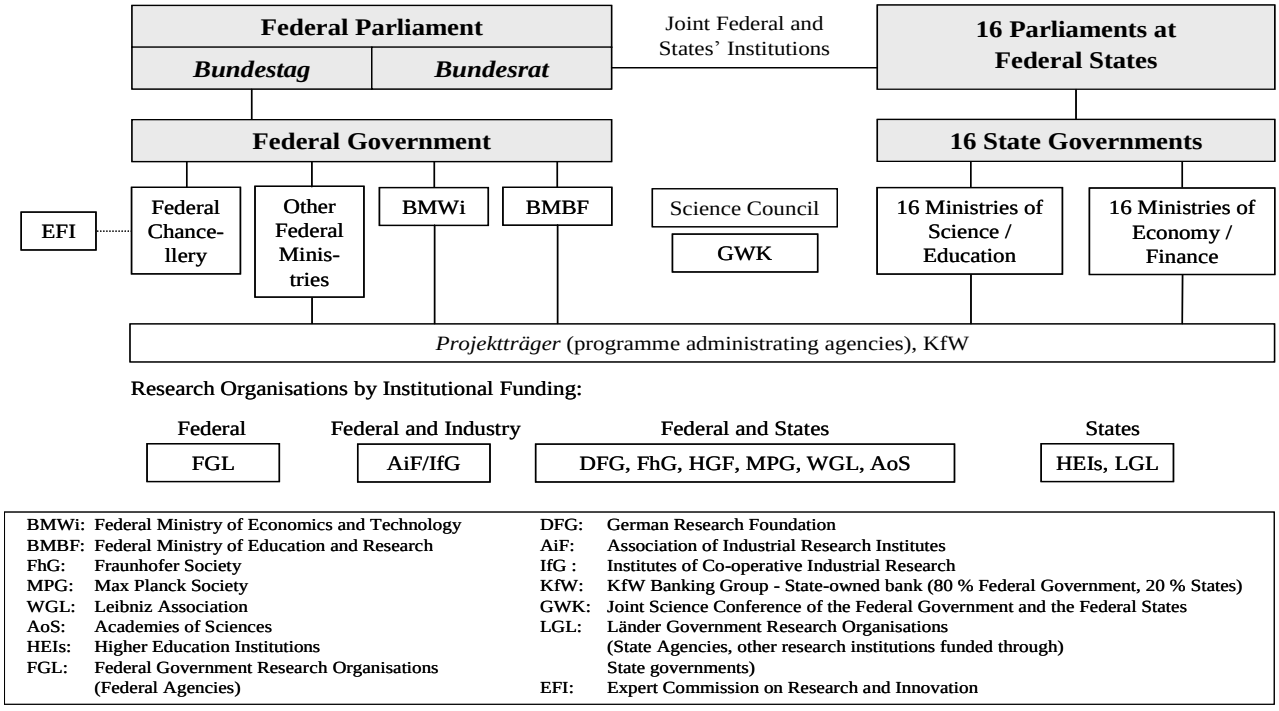
Evaluation of the German R&I system as a whole is conducted most comprehensively by the Expert Commission on Research and Innovation (EFI). Besides, the German Council of Science and Humanities (Wissenschaftsrat) conducts evaluations and provides counselling for federal and Laender governments. A more detailed description of the evaluation process can be found in chapter 2.7 of this report.

The Community Innovation Survey (CIS) provides information on the composition of innovation within the business sector (ZEW, 2014). Most recent data is available for 2012. CIS provides information on innovation expenditures which go beyond R&D and also include expenditures for the acquisition of equipment, licenses or for market introduction. Based on the CIS definitions and industry coverage, 61,902 firms in Germany invested innovation in 2012. 92% of these innovative firms had more than 10 but fewer than 250 employees. The sectors with the overall largest innovation expenditures in Germany are the manufacturing of motor vehicles, followed by the manufacturing of machinery and equipment as well as the manufacturing of computer, electronic and optical products. In

terms of innovation intensity, i.e. innovation expenditures as a share of sales, the manufacturing of pharmaceuticals is the more innovation intensive sector in Germany (12%), followed by the manufacturing of computer, electronic and optical products (9%) and the manufacturing of motor vehicles (8.8%).

The structure of the German R&I system has been fairly stable in recent years. However, major efforts have been undertaken to connect institutions and sectors more effectively. This is especially relevant since two-thirds of all R&D is undertaken by private firms in Germany. Figure 1 summarizes the structure of the German research system.

Figure 1 Germany's RDI governance system



BMWi:	Federal Ministry of Economics and Technology	DFG:	German Research Foundation
BMBF:	Federal Ministry of Education and Research	AiF:	Association of Industrial Research Institutes
FhG:	Fraunhofer Society	IfG :	Institutes of Co-operative Industrial Research
MPG:	Max Planck Society	KfW:	KfW Banking Group - State-owned bank (80 % Federal Government, 20 % States)
WGL:	Leibniz Association	GWK:	Joint Science Conference of the Federal Government and the Federal States
AoS:	Academies of Sciences	LGL:	Länder Government Research Organisations
HEIs:	Higher Education Institutions		(State Agencies, other research institutions funded through)
FGL:	Federal Government Research Organisations		State governments)
	(Federal Agencies)	EFI:	Expert Commission on Research and Innovation

Finally, R&I policy making follows a stable path in Germany. Many successful programs have been adapted and extended (see list of major changes below). Given the long-term character of R&I policies and their consequences, several of the policies enacted in previous years are still important for this report.

Main changes in 2014
New federal government collation begins work *Agreement on extension of the pacts and change in constitution by federal and Laender governments* *Renewal of the High Tech Strategy of the federal government*
Main Changes in 2013
Election of federal parliament *Establishment of the competence centre for public procurement* *National research infrastructure roadmap (i.e. for instance large scale research infrastructures of national / European importance, comprehensive experiments, etc.).*
Main changes in 2012
Freedom for Science law ('Wissenschaftsfreiheitsgesetz') goes into effect *Funding from third round of Initiative for Excellence begins* *Foreign Skills Recognition law goes into effect*
Main changes in 2011
Decision on new energy policy excluding nuclear power *Introduction of "High-tech Start-up Fund II"* *Introduction of "blue card" for simplified work permission for foreigners in Germany*
Main Changes in 2010
Launch of initial High Tech Strategy 2020 *Continuation of "Higher Education Pact 2020" (275,000 additional university places 2011 and 2015)* *Continuation of the Pact for Research and Innovation*

2. Recent Developments in Research and Innovation Policy and systems

Innovation and the capacities to innovate are now widely considered as prerequisites for economic growth and for solving a multitude of societal challenges. This consensus holds for Germany and the EU alike. This section emphasizes developments within the last 12 months. However, it is important to note that R&I systems evolve over time. Many changes require more time to bear fruit and R&I systems take time to go through co-evolutionary processes with broader changes in economy and society. Hence, for a broader and deeper understanding of Germany's R&I system it is advisable to consult previous ERAWATCH Country Reports on Germany.

2.1 National economic and political context

The most important political event in Germany was the election of the federal parliament on 22 September 2013. The result of the election was that Christian Democratic Parties (CDU/CSU) and the Social Democratic Party (SPD) have formed a coalition government led by Chancellor Angela Merkel who will lead the government for the third consecutive legislation period. The governing coalition has changed because the previous coalition partner of CDU/CSU did not receive enough votes to cross the mandatory 5%-barrier for seats in parliament. The current coalition holds a broad majority of 504 of the 631 seats in parliament. At least one of the coalition parties of the federal government is also part of the Laender governments in all 16 states. This implies that the potential for policy making which requires majorities in both chambers of parliament (the 'Bundesrat' represents the Laender) as well as changes to the constitution is high.

While there has been a change in the governing coalition of the federal government, the political priorities with regard to education, research and innovation are largely aligned with the previous government. The coalition has laid out a coalition agreement detailing its vision for governing until the end of the legislation period in 2017 in its 'Koalitionsvertrag' (<link (12/2014)>). Significant parts of this contract are devoted to central components of the R&I system, such as increasing quality and quantity of university research and education, providing support for start-ups, international collaboration in research and innovation as well as fostering growth in digital and high-tech industries. A priority activity is the increase of R&D investment by €3b during the electoral term. Major policy initiatives of the past such as the 'Exzellenzinitiative' or the 'Pakt für Forschung und Innovation' are explicitly mentioned for extension or further development. Hence, there is strong evidence that R&I policies in Germany under the new government are stable, predictable and a significant political priority.

The prioritization of R&I policies in Germany can also be seen in the Annual Economic Report 2014 of the federal government (<link (12/2014)>) which embeds it in a broader economic strategy of continuing economic growth and employment balanced with social cohesion and fiscal sustainability. This approach is very much aligned with the Europe 2020 strategy for smart, sustainable and inclusive growth. Germany's National Reform Programme (NRP) for 2014 lists four strategic economic policy goals accordingly:

- Creating a more targeted investment and innovation policy
- Improving the possibilities for participation and enhancing the fairness of participation
- Ensuring the success of reforms for more energy production from renewable sources ('Energiewende')
- Stabilising and deepening the economic and monetary union of Europe.

These goals are largely in line with the Country-Specific Recommendations issued by the Council of the European Union on 8 July 2014.[3]

In line with these priorities the budget for the Federal Ministry of Education and Research (BMBF) will amount to €14b in 2014 (<link (12/2014)>). The budget is largely a continuation of the 2013 budget which had increased by roughly €1b (BMBF, 2014a). There are promising signals from companies in Germany. 65% of firms in a survey of the Stifterverband report that they will spend more on R&D in 2014 compared with the previous year (<link (11/2014)>). It is the first year since 2011 that this early indicator for firm R&D spending in Germany has turned more positive.

The subsequent sections will provide more detailed information but most of the data points in the direction that Germany is among the leading R&I systems in Europe.

2.2 National R&I strategies and policies

R&I strategies and policies in Germany follow stable and predictable pathways. The federal government has formulated the so-called 'Hightech-Strategie' as a comprehensive, resort-spanning strategy in 2006 for all major components of R&I in Germany, encompassing relevant research, education, innovation and technology transfer topics. This strategy has triggered investments by the federal government of up to €27b between 2006 and 2013 (BMBF, 2014a). The strategy has been replaced in September 2014 (<link (12/2014)>). The resulting new high-tech strategy ('Neue Hightech-Strategy', BMBF, 2014f) describes five central themes which are supposed to be accomplished as a concerted effort across almost all ministries. The five themes are:

- Priority for 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.
- Improved transfer of knowledge between science and business, nationally and internationally.
- Increased innovation dynamic especially in new as well as SMEs.
- Improved framework conditions for satisfying the demand for skilled scientists and engineers.
- Intensified dialogue with society.

The budget for the new high-tech strategy is €11b in 2014 (<link (12/2014)>). An explicit element of the strategy implementation is the involvement of important stakeholders. For this purpose a new expert group was created with members of science, business and

[3] Official Journal of the European Union, published on 29 July 2014 2014/C 247/05.

society. The purpose of this expert group is to develop proposals for the further development and implementation of the new high-tech strategy (BMBF, 2014f).

Major R&I policies are about to expire in the current legislation period. The Expert Commission on Research and Innovation (EFI) sees the extension or development of these programs as a central priority for the R&I system in Germany (EFI, 2014). The policy initiatives are (BMBF, 2014a):

- Initiative for Excellence ('Exzellenzinitiative'): Policy package to foster elite research in universities funded by both the federal government (75%) and the states 'Laender' (25%) (Budget 2012-2017: €2.7b, <link (12/2014)>, <link (02/2015)>);
- Higher Education Pact ('Hochschulpakt'): Policies to increase (a) quantity as wells as quality of university education and (b) the international competitiveness of university research (Budget 2011-2015: €7b of the federal government with a similar commitment of the Laender, <link (12/2014)>, <link (12/2014)>);
- Pact for Research and Innovation ('Pakt für Forschung und Innovation'): Stabilize and increase funding for research organizations (Fraunhofer-Gesellschaft, Helmholtz-Gemeinschaft, Max-Planck-Gesellschaft und Leibniz-Gemeinschaft, Deutsche Forschungsgemeinschaft) with 5% annual funding increases (Total institutional funding 2012: €7b, <link (12/2014)>, <link (12/2014)>). The funding will increase by 3% annually starting in 2016.

Federal and Laender governments have agreed in October 2014 to continue the Pact for Research and Innovation ('Pakt für Forschung und Innovation') as well as the Higher Education Pact ('Hochschulpakt') until 2020 and signalled to extend the Initiative for Excellence ('Exzellenzinitiative') beyond 2017 (<link (12/2014)>). This is now more easily to be implemented with thechange in constitution which both chambers of parliament have approved in December 2014 (<link (12/2014)>). The German Science Council ('Wissenschaftsrat') emphasizes the importance of the continuation of these policy bundles (<link (12/2014)>). The council highlights the positive developments in the German R&I system as a result of the three central initiatives. The positive effects stem not just from increased investments but also from a renewed strive for excellence and the unlocking of synergy potentials. As a consequence, the German Science Council urges policy makers to renew and refine the expiring programs.

Overall R&I strategies and policies in Germany are progressing. Some recent policy developments are briefly outlined below which highlight activities in particular areas or topics:

- Budgets for R&I are stable after increases in the past (BMBF, 2014a). The federal government has increased its funding for R&D expenditures by roughly €1b in 2013 to €14.5b. The budget proposal for 2014 is €14.4b. R&I expenditures of the Laender which are responsible for most of the funding of university education have slightly increased.

- BMBF has enacted a plan for increasing international collaboration ('Aktionsplan Internationale Kooperation') (BMBF, 2014b). The latter is designed to bundle existing as well as new measures like those to increase the international mobility of students and scientists. Policy support is supposed to become more effective and

efficient. The plan is explicitly designed to leverage opportunities originating from the European Research Area (ERA). It also aims at extending collaborations with developing countries (see chapter 3 of this report for an extended discussion).

- The federal government has laid out its strategy and roadmap for the European Research Area (BMBF, 2014c). Within this framework the government develops priorities for the realization of ERA. The details will be discussed in chapter 3 of this report.
- The federal government will increase the subsistence support of students ('BAföG') by 7% (beginning in 2016) and will take over the financing share of the Laender (<link (2/2015)>). The initiative is designed to attract more students and reduce the financial burden on the Laender. Resulting financial availabilities of the Laender are supposed to benefit university funding.
- BMBF will support the internationalization of leading edge clusters and similar networks ('Internationalisierung von Spitzenclustern, Zukunftsprojekten und vergleichbaren Netzwerken'). The plan consists or three yearly funding rounds between 2015 and 2017. In each round cluster or network managements can apply for funding for the development of internationalization concepts (up to two years) and implementation (up to three years) (<link (2/2015)>.
- BMBF has announced a new initiative directed at removing barriers for the industrial implementation of new technologies for reduced resource consumption in August 2014 ("r+Impuls - Innovative Technologien für Ressourceneffizienz - Impulse für industrielle Ressourceneffizienz"). The program provides targeted R&D subsidies. The initiative is part of the framework programme 'Forschung für nachhaltige Entwicklungen (FONA)' (<link (12/2014)>).
- German Academic Exchange Service (DAAD) has launched a new international mobility initiative for post-doctoral researchers (P.R.I.M.E. - Postdoctoral Researchers International Mobility Experience). The initiative enables post-doc researchers to conduct research abroad for one year and return to a guaranteed position at a German university. The initiative is co-funded by BMBF and EU-Marie-Curie facility COFUND (<link (12/2014)>).
- BMBF and BMWi will provide €150m for research in the future of the electrical grid ('Zukunftsfähige Stromnetze'). Projects begin August 2014 (<link (12/2014)>).
- Also the Laender have strengthened their R&I systems with several policy initiatives (NRP, 2014). Hesse is for example structuring interactions between science, business and politics through a "House of" strategy for central state themes: finance, IT as well as logistics and mobility. Other examples include Bavaria extending its 'Bayern Patent' initiative to support the commercialization of university research or Baden-Wuerttemberg investing into promoting research at universities of applied sciences.

In sum, R&I strategies and policies are coherent and reflect EU priorities. The parts of current R&I policies which require renewal are especially targeted towards excellent and frontier science at universities and dedicated research institutes. The extension of these instruments is a highly positive signal. It is noteworthy that many newly announced policy initiatives aim at formulating a comprehensive German strategy towards realizing ERA.

With regard to funding themes, Table 1 shows the distribution of public funding for R&D among thematic fields of research and within the main scientific disciplines. Such shares of funding can be interpreted as priorities. Industrial production and technology receives the highest share of R&D funding. This is fairly in line with the distribution of economic activity in Germany. Focusing on societal challenges, Germany has increased R&D funding for energy and health themes but not for environment themes. This tendency suggests that R&D funding themes in Germany are at least partially aligning with EU priorities.

Table 1 R&D funding by thematic field of research as percent of GBAORD.

	2006	2007	2008	2009	2010	2011	2012	2013
Exploration and exploitation of the earth	1,8	1,7	1,9	1,8	1,7	1,8	1,7	1,8
Environment	3,1	3,2	3,0	2,9	2,8	2,7	2,9	2,9
Exploration and exploitation of the space	4,9	4,8	4,9	4,9	4,7	4,6	4,8	4,7
Transportation, telecom and other infrastructure	1,8	1,8	1,7	1,7	1,6	1,4	1,5	1,5
Energy	2,9	3,5	3,7	4,0	3,8	3,8	4,5	5,2
Industrial production and technology	12,6	12,1	11,8	12,7	14,5	15,3	12,6	12,8
Health	4,5	4,7	4,4	4,6	4,3	4,6	5,3	5,1
Agriculture	2,3	2,6	2,8	3,1	3,4	3,1	2,9	2,9
Education	3,5	1,0	0,9	0,9	1,0	0,8	0,9	0,9
Culture, recreation, region and mass media	:	1,1	1,1	1,2	1,4	1,3	1,3	1,1
Political & social systems, structures & processes	:	1,7	1,8	1,8	1,8	1,6	1,7	1,8
Defense	6,5	6,1	6,0	5,4	5,0	4,0	3,9	3,8
General advancement of knowledge*	56,8	56,3	56,5	55,5	54,7	55,7	56,9	56,5
R&D related to natural sciences*	:	25,3	24,7	23,8	23,9	24,2	25,2	25,3
R&D related to Engineering Sciences*	:	7,5	6,6	7,0	7,0	7,3	7,4	7,3
R&D related to Medical Sciences*	:	11,5	12,3	12,2	11,3	11,8	11,7	11,3
R&D related to Agricultural Sciences*	:	1,5	1,3	1,4	1,4	1,2	1,2	1,2
R&D related to Social Sciences*	:	4,9	5,8	5,4	5,3	5,2	5,3	5,3
R&D related to Humanities*	:	5,6	5,9	5,8	5,8	6,0	6,2	6,1

* Sum of R&D financed from General University Funds (GUF) and sources other than GUF
Definitions differ, 2013 values provisional
Source: EUROSTAT (table code: gba_nabsfin07)

The distribution of funding across disciplines (lower part of Table 1) does hardly change over time. The stable numbers point towards a reliable allocation of funding. If there are shifts in priorities of R&D funding they occur within disciplines not between them.

2.3 National Reform Programmes 2013 and 2014

The federal government in Germany has changed between 2013 and 2014. However, the National Reform Programmes (NRP) from 2013 and 2014 show continuity when it comes to R&I policies. Fiscal stability is a major theme of both NRPs. Then again, both NRPs emphasize the need to increase investment in research, innovation and education. These investments are largely on the way.

Major components of NRP 2014 are:

- Increase investment on education and research
- Continue the three central R&I policy initiatives: 'Exzellenzinitiative', 'Hoschschulpakt' and 'Pakt für Forschung und Innovation'
- Develop new key areas for innovation support: Big data, health care and sustainable mobility
- Strengthen technology transfer between academia and business
- Reduce funding constraints for start-up and young firms
- Enact a digital agenda involving broadband internet, ICT technology and security
- Intensify ERA and develop it actively.

Germany has made important progress especially moving towards the investment goals in research and education. Available R&I budges have steadily increased from the federal government and through the three major agreements 'Exzellenzinitiative', 'Hoschschulpakt' and 'Pakt für Forschung und Innovation' (BMBF, 2014a). Recipients have been universities but also non-university research organizations. Hence, many goals have been met or are very much within reach:

- Germany is likely to reach the goal of R&D expenditures totalling 3% of GDP with two-thirds stemming from business sectors based on latest available data for 2013 (BMBF, 2014a)
- Germany is close to its goal of 10% of its GDP being spent on research and education by 2015 with 9.3% in 2011 (NPR, 2014)
- Germany has surpassed the goal of 40% of 30-34 year olds with tertiary education (43.5% in 2012; NPR, 2014)

Given these developments on the investments into R&I it is not worrying that the budget proposal for R&D funding by the federal government for 2014 is at the level of 2013. The outlook for future R&I budgets is positive. The federal government plans to increase the budget of the ministry for education and research by €1.2b to €15.3b in 2015 with a target outlook of €17b (<link (12/2014)>). The political commitment for the extension and development of 'Exzellenzinitiative', 'Hochschulpakt' and 'Pakt für Forschung und Innovation' is an important signal. Both the Expert Commission on Research and Innovation (EFI, 2014) and the German Science Council ('Wissenschaftsrat') have given it high priority in their annual reports and public announcements (<link (12/2014)>). Increases in university funding seem warranted because the leadership of universities in Germany is sceptical about the funding outlook for their institutions in a survey ('Hochschul-Barometer 2013', <link (12/2014)>) of the business association Stifterverband (Stifterverband, 2013).

There are several instruments in place to support technology transfer between academia and business such as the initiative 'Clusterplattform Deutschland' which maps and highlights geographical clusters of technological excellence (<link (12/2014)>) or 'Forschungscampus' (public-private partnerships for innovation) (<link (12/2014)>). See chapter 4 of this report for more detailed information.

In general, the level of research interaction between academia and business in Germany is quite high already. The NPR 2014 plan for increasing technology transfer does therefore seem like an extension of an already successful R&I system.

Similarly, Germany has several policy initiatives in place to provide young firms with access to funding. Recent ones include EXIST (<link (12/2014)>) and 'High-Tech Gründerfonds' targeting entrepreneurs and start-ups (<link (12/2014)>) (see section 4.2 and 4.6 of this report for details). Germany has renewed its on ICT strategy of the federal government 'Digital Germany 2015' developed by BMWi (BMWi, 2010) which included particular measures for growth and innovation in start-up and young ICT firms. Details of the new "Digital Agenda 2014-2017" (BMWi, 2014b) are presented in section 3.3 of this report.

Finally, the federal government has clarified its ERA strategy (BMBF, 2014c) and accumulated an action plan for increasing international collaboration ('Aktionsplan Internationale Kooperation', BMBF, 2014b) (see section 3 of this report for details).

In sum, Germany's NRP 2014 builds on its R&I strengths. The items of the plan are reflected in existing and new R&I policy initiatives. The plan is geared towards consolidating and fostering existing initiatives which gives it a high likelihood to succeed. Then again, Germany could be in a position to set and achieve even more demanding goals.

2.4 Policy developments related to Council Country Specific Recommendations

The European Council Recommendations for 2013[4] and 2014[5] refer to R&I policies in Germany to the degree that they encourage sustained investments in research and education as well as more ambitious goals. As the Council Recommendation 2014 puts it (paragraph 10):

"Germany has made limited progress in increasing spending on education and some progress concerning higher research spending. Further efforts appear necessary at all levels of government to meet the target for total public and private expenditure on education and research of 10 % of GDP by 2015, and even more ambitious follow-up targets should be aimed for in order to catch up with the most innovative economies."

Correspondingly the Council Recommendations for both 2013 and 2014 suggest for Germany to use available budgets to increase investments in research and innovation.

With regard to investments in research Germany has largely followed up on the recommendations of the European Council. Overall R&D expenditures in Germany have consistently increased in recent years (see Table 2 below). They have reached 2.88% of GDP in 2013 and are therefore very close to the 3%-goal. Both the federal government and the Laender have continuously increased expenditures for R&D reaching a total of €13.5b (up from €12.8b in 2010) and €10.2b respectively in 2012 (up from €9.7b in 2010) (BMBF, 2014a). While Germany has not reached its goal of 10% of GDP being spent on research and education by 2015 yet, it comes fairly close with 9.3% in 2011 (NPR, 2014).

The federal government plans with a budget for research of €14.4b in 2013 and 2014. Increases are foreseen for 2015. The federal government plans to raise the budget of BMBF by €1.2b to €15.3b in 2015 with a target outlook of €17b (<link (12/2014)>). With

[4] Official Journal of the European Union, published on 30 July 2013 2013/C 217/09.
[5] Official Journal of the European Union, published on 29 July 2014 2014/C 247/05.

regard to education, Germany has experienced more students entering the university system since 2006. This is partly due to an increased demand for higher education and partly due to changes in the school system (BMBF, 2014d). Shorter time in high school has implied that for a transition period two generations of school students enter universities simultaneously. Not all Laender have adopted those changes in the school system at the same time and in the same fashion. Hence, the overall effect for Germany was spread out over time. While demand for higher education is still expected to be strong, the particular effects from the transition in the school system are largely coming to an end after 2013 (BMBF, 2014d). The Expert Commission on Research and Innovation (EFI) recommends using resulting budgets for increasing the quality of research at universities (EFI, 2014).

Focusing on more ambitious targets, the annual report on research and innovation of the German federal government (BMBF, 2014a) benchmarks Germany's R&I performance within Europe and internationally. R&D expenditures in Germany as a share of GDP have reached 2.94% in 2014 which is significantly above EU-28 average (2.02%) Within Europe Germany is among the most R&D intensive countries together with Finland (3.32%), Sweden (3.21%) and Denmark (3.05%). Interestingly, Germany is the only country out of this group of R&D intensive EU member states with a consistent upward trend since 2009. Outside of EU, the German government considers a group of benchmark countries with higher shares of R&D spending on GDP in its annual report on research and innovation (BMBF, 2014a): Israel (4.20 %), South Korea (4.36 %) and Japan (3.34 %). While these countries are mentioned, no concrete targets are developed for catching up with them. Then again, it is not obvious which country or group of countries should serve as a relevant benchmark.

Finally, Germany has started an ambitious reform program in the energy sector to increase the share of renewable energy ('Energiewende'). The European Council Recommendations for 2013 and 2014 suggests that these reforms should be conducted with a priority on cost-effectiveness. It is noteworthy that the Expert Commission on Research and Innovation (EFI) was not able to identify a positive innovation effect from the changes in energy policies (EFI, 2014), even if this statement lead to a discussion about the methodological basis of the findings.

2.5 Funding trends

2.5.1 Funding flows

Germany has set two primary targets for R&D investment. First, R&D expenditures should reach 3% of GDP with a contribution of two thirds from the private sector. Second, Germany wants to reach a total investment of 10% of GDP for research and education by 2015 (NPR, 2014). Both goals are well within reach. Table 2 provides an overview for the latest available data. R&D spending in Germany has increased steadily since 2009 in absolute terms but also as a percentage of GDP. In 2013 Germany almost reached the 3%-target with 2.85% of GDP being spent on R&D. Between 2009 and 2012 the share of private sector R&D on total expenditures has been almost unchanged around 66%. Hence, both private and public R&D investments have increased in similar proportions and stronger than GDP growth overall. The European Commission's monitoring report on the Innovation Union (European Commission, 2014a) predicts that this trend will continue.

Accordingly, Germany is likely to reach the 3% target as well as the target for private sector participation of two thirds.

With regard to the second goal of 10% of GDP invested in research and education by 2015, Germany has not reached this goal yet but comes close. Total expenditures for research and education reached 9.3% of GDP in 2011 (NRP, 2014). While this number is close to the target it seems to be plateauing at this level with shares of 9.5% in 2009 and 2010 (NPR, 2013). Hence, more investments in education are necessary to reach the goal of 10% in 2015. The German Science Council (Wissenschaftsrat) suggests that the timing for investments is promising right now because policy initiatives for strengthening excellence in university such as the 'Exzellenzinitiative' have provided a fresh dynamic (<link (12/2014)>). Similarly, the Expert Commission on Research and Innovation recommends investing into the basic funding for universities to increase research competitiveness (EFI, 2014).

Table 2 Basic indicators for R&D investments

	2009	**2010**	**2011**	**2012**	**2013**	**EU-28 (2013)***
GDP growth rate	-5.1%	4.0%	3.3%	0.7%	0.4%	0.1%
GERD (% of GDP)	2.73%	2.72%	2.80%	2.88%	2.85%	2.01%
GERD (euro per capita)	817.2	855.1	923.5	966.6	977.4	536
GBAORD - Total R&D appropriations (€ million)	21,710.	23,015. 6	23,743. 5	24,070. 2	25,371	92,094. 2
R&D funded by Business Enterprise Sector (% of GDP)	1.80%	1.78%	1.84%	1.90%		1.10% (2012)
R&D funded by Private non-profit (% of GDP)	0.01%	0.01%	0.01%	0.01%		0.03% (2012)
R&D funded from abroad (% of GDP)	0.10%	0.11%	0.12%	0.12%		0.19% (2012)
R&D related FDI (€ million)			11,292. 5			
R&D performed by HEIs (% of GERD)	17.6%	18.1%	17.8%	17.7%	17.6%	23.4%
R&D performed by Government Sector (% of GERD)	14.8%	14.8%	14.5%	14.3%	15.1%	12.3%
R&D performed by Business Enterprise Sector (% of GERD)	67.6%	67.1%	67.7%	68.0%	66.9%	63.5%
Share of project vs. institutional public funding for R&D			37.3% vs. 63.4%	35.9% vs. 64.8%	36.9% vs. 64.1%	N/A
Venture Capital as % of GDP (Eurostat table code tin00141)	0.03%	0.03%	0.03%	0.02%	0.02%	N/A
Employment in high- and medium-high-technology manufacturing sectors as share of total employment	10.0%	9.9%	9.7%	9.7%	9.6%	5.6%
Employment in knowledge-intensive service sectors as share of total employment	39.5%	40.0%	40.2%	40.3%	39.4%	39.2%
Turnover from Innovation as % of total turnover (Eurostat table code tsdec340)	17.4% (2008)	15.5%		13.0%		11.9% (2012)

Source: EUROSTAT if not indicated differently

* Source: European Commission (2014a), Innovation Union progress at country level 2014

Focusing on funding trends, the federal government plans to raise the budget of BMBF by €1.2b to €15.3b in 2015 with a target outlook of €17b (<link (12/2014)>). Federal and Laender governments have agreed to continue the Higher Education Pact ('Hochschulpakt') as well as the Pact for Research and Innovation ('Pakt fuer Forschung und Innovation') in October 2014 (<link (12/2014)>). This extension implies additional funding of €25.3b until 2020.

The Laender themselves are important funding bodies for research but especially education. They have invested €10.2b in R&D in 2012 which is an increase of 5.2% compared with 2010 levels (BMBF, 214a). 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, 2014a). Overall R&D expenditures as a share of GDP vary strongly between the Laender (European Commission, 2014a): The state of Baden-Wuerttemberg is the EU region with the highest R&D intensity in 2011 (5.1% of GDP) and other Laender such as Berlin (3.6%) and Bayern (3.2%) have also already surpassed the national goal of 3%. Schleswig-Holstein (1.4%), Saarland (1.5%) and Sachsen-Anhalt (1.5%) have the lowest R&D intensities among the Laender and below EU-28 average (2.02% in 2013). Given that Germany is implementing a law for balancing government budgets at the Laender level ('Schuldenbremse'), growth potentials in Laender investments in research and education are limited. These growth potentials are largely dependent on whether the federal government takes over funding responsibilities to free up Laender budgets. Some of these changes are under way. For example, subsistence support of students ('BAFOEG') will be funded completely by the federal government by 2015 (<link (2/2015)>).

A recent survey among the leadership of universities in Germany by 'Stifterverband' finds that universities are sceptical about their financial budgets for research in the future (Stifterverband, 2014). In the same survey universities acknowledge that their competitiveness in research and education has improved compared with 2011. While the survey does not allow causal inferences, the increase in quality may also force universities to provide competitive career opportunities for retaining excellent personnel. The Expert Commission on Research and Innovation (EFI) recommends that available funds from lower student entry numbers at universities should be used to increase the quality of research. The agreement between the federal and Laender governments to continue the Pact for Research and Innovation ('Pakt für Forschung und Innovation') as well as the Higher Education Pact ('Hochschulpakt') until 2020 and signalled to extend the Initiative for Excellence ('Exzellenzinitiative') beyond 2017 is therefore a positive sign (<link (12/2014)>).

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).[6] This is a strong increase compared to the total receipts of €2.2b for RTD in Germany between 2000 and 2006. A similar trend can be seen when comparing funding for Germany from the Sixth (FP6) with the Seventh EU Framework Programme (FP7). Germany received 4,388 projects from the FP6 programme with €3.02b

[6] 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.

in funding compared with 8,892 projects from FP7 with €7.2b in funding. Success rates of applications from Germany are above average (24%) compared to the EU average of 20.4% (European Commission, 2014a). 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). In sum, Germany benefits significantly from EU support for R&I. Nevertheless, there is potential for investing in application frequency and quality to increase success rates.

Finally, R&D investment from the private sector is central for R&I in Germany. The EU innovation Union Scoreboard 2014 sees Germany in a leading position when it comes to firm investment in R&D only surpassed by Sweden (European Commission, 2014b). Hence, it is a highly promising sign that private R&D investment is expected to grow further in Germany. The 'Stifterverband' publishes a recent survey in which 65% of firms indicate that they will spend more on R&D in 2014 compared with the previous year (<link (2/2015)>). This early indicator for firm R&D spending in Germany has not been more positive since 2011. Trends on the R&D spending of private firms in Germany can also be deducted from the 130 companies headquartered in Germany which are covered by the 2013 EU Industrial R&D Scoreboard (<link (12/2014)>). The scoreboard covers the 2,000 leading firms worldwide with regards to their R&D spending. German firm Volkswagen tops the list in 2013. The average growth rate of R&D at an annual basis for the 130 German companies on the list is 13.2% for 2010 to 2012 and 14.2% in 2012 itself. For comparison the average R&D growth rates for the 2,000 most R&D investing firms in the world are 6.2% and 6.4% respectively. It should be kept in mind that the 130 companies of EU Industrial R&D Scoreboard are headquartered in Germany while they typically have R&D centres in multiple, international locations. An increase in R&D spending of any particular company does therefore not automatically imply that R&D investment in the country of the headquarters will increase. Nevertheless, there exists important evidence that private R&D investment by German firms has been growing strongly and there is some indication that the growth is even accelerating.

2.5.2 Project vs. institutional allocation of public funding

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 (<link (12/2014)>). This change enables the federal government to be permanently involved in the funding of universities.

Public funding for R&D has two primary components in Germany: institutional (block) funding and project funding (i.e. competitive allocation of funding). Institutional funding covers essential financial demands e.g. of universities as well as for R&D investments in topics or fields for which third-party funding is hardly available, especially fundamental research. In contrast, project funding is directed at a particular goal with typically short to medium-term time horizons (see BMBF, 2012: pp. 53ff for details on 'how R&D funding in Germany works').

With regards to funding for basic research in Germany, the German Research Foundation ('Deutsche Forschungsgemeinschaft,' DFG) is crucial. It complements institutional funding for basic research with project funding. DFG selects the most promising research projects by scientists and academics at universities and research institutions based on a competitive basis which leads to the financing of these projects. Funding is typically the result of a bottom up process of peer review. The review process is sophisticated and multi-layered (<link (12/2014)>): DFG appoints reviewers with relevant expertise (roughly 10,000 annually) while avoiding conflicts of interest. The reviewers evaluate academic excellence, relevance and originality of the proposals. A topical board of elected area scientists evaluates and compares the reviews for selection of the most promising proposals. The review process is international. Almost a third of all reviewers works 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. Again, such programmes provide project funding on a competitive basis. Apart from these, several public and private foundations exist for financing research. Examples for the latter 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.

The German funding system is rather complex and precise shares of project vs. institutional funding of R&D are difficult to predict 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.

DFG and the main non-university research organizations Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL) had a total budget of €11.3b in 2013 which has increased by 6.2% compared to 2012 (GWK, 2014). 66% of these budgets stem from institutional funding; the rest is project funding ('Drittmittel'). DFG budgets originated to 65% from institutional funding in 2013 (GWK, 2014). The main non-university research organizations differ in the degree to which their budgets are composed of institutional funding in 2013 (GWK, 2014): Fraunhofer Society 31%, Helmholtz Association 74%, Leibniz Association 74% and Max Planck Society 83%.

Apart from the main research organizations, 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 (BMBF, 2014a). They are planned to reach €971m in 2014.

In sum, the trend towards emphasizing project funding instead of institutional funding has a positive effect on research effectiveness. However, there may be limits to this approach originating from the theme and type of research. As a result, the balanced approach combining project and institutional funding in Germany seems to fit the complexities of its R&I system.

2.5.3 R&I funding

Germany has a well-developed system for funding fundamental research as well as innovation activities with closer ties to economic exploitation on markets. In this regard, German R&I strategy is very much aligned with the provisions set out in Horizon 2020. Many policy initiatives cover both research and innovation aspects. Funding streams are therefore difficult to disentangle. A good example because of it significant size and ambition is the Pact for Research and Innovation ('Pakt für Forschung und Innovation'). In this pact the funding for non-university research organizations is increased by 5% annually between 2011 and 2015. The goal of this initiative is to increase the degree to which these organizations can plan for the future. The agreement is an investment in both research and innovation because it encompasses institutes with a clear focus on basic research (e.g. Max Planck Society) but also with a pronounced innovation focus (e.g. Fraunhofer Society). Besides, many R&I policy schemes are targeted at particularly promising fields, important industries or business segments. Prominent examples include the renewed High Tech Strategy ('Neue Hightech-Strategy', BMBF, 2014f; see section 2.2 of this report for details), the Leading-Edge Clusters initiative ('Spitzencluster'; see section 4.4 of this report for details) or the Central Innovation Programme for SMEs ('Zentrales Innovationsprogramm Mittelstand' ZIM; see section 4.5 of this report for details).

The German R&I system ranks very high in Europe with regards to how innovations are protected and exploited. The EU Innovation Scoreboard 2014 ranks Germany first with regard to the share of firms becoming successful innovators, third in the degree to which firms can protect their intellectual assets and second in the degree to which innovations result in economic performance (European Commission, 2014b). Hence, the German R&I system performs very well in turning knowledge production through R&D into economic success of resulting innovation. One key factor to this success can be the holistic approach to commercial exploitation in which firms can protect their knowledge from imitation which allows them to establish competitive advantages and economic performance which in turn enables them to invest in more R&D.

The federal government has spent €2.3bn in 2012 in support for R&D in private firms which is slightly down from €2.6bn in 2010 (BMBF, 2014a). R&D expenditures of the Laender are not available in such detailed breakdowns. Total R&D expenditures of the Laender in both public (e.g. universities) and private institutions amounted to €10.2bn in 2011 with the majority being provided by Nordrhein-Westfalen (19.8% of Laender total), Bavaria (16.7%) and Baden-Wuerttemberg (14.4%) (BMBF, 2014a). R&D expenditures of the Laender have increased compared with 2009 from €9.4bn (BMBF, 2014a). The results of the Community Innovation Survey (CIS) show that government funding reaches innovative firms (ZEW, 2014). 23.7% of all innovative firms[7] 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

[7] 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.

positive signals for R&I government funds reaching German companies and the trend is positive especially for funding from the federal government.

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 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 .Apart from tax incentives, the federal government is increasing its initiatives for creating demand for innovative products and services based on public procurement. Such demand side measures can trigger R&D and innovation in private firms because firms can foresee future sales potentials. These public procurement incentives for innovation have been found in a recent publication to be equally important for firm innovation performance in Germany as collaborations with universities (Aschhoff and Sofka, 2009). Interestingly, the same study finds that the effect of public procurement on innovation performance is especially strong for smaller firms in service sectors and in economically less developed East Germany. Hence, the potential of this policy instrument seems to be especially strong for reaching firms which have lower participation rates in other R&I funding schemes. Efforts for introducing innovation elements to public procurement processes across ministries, states and municipalities are therefore promising. The federal government is making progress in this direction by establishing a competence centre for innovation oriented procurement ('Kompetenzzentrum Innovationsorientierte Beschaffung') (BMBF, 2014a). It serves as an information and consultation centre for innovation procurement in a large range of public institutions (see also section 4.7 of this report).

What is more, Germany has several policy initiatives which emphasize the geographical component of knowledge transfers between disciplines as well as R&D and innovation. They follow mostly the principle that colocation can provide conduits for knowledge flows based on social interaction, visibility and networks. Examples for such initiatives include 'Unternehmen Region' initiated by BMBF which encourages the identification of core competences in regional clusters as well as their commercial exploitation <link (12/2014)>. Similarly, with the initiative 'Zwanzig20 –Partnerschaft für Innovation' BMBF supports interdisciplinary consortia including firms with €500m until 2019 for developing joint innovation strategies based on a competitive assessment <link (12/2014)>. The goal of these programmes is to facilitate a shared vision of knowledge creation and exploitation in a region and area. This can make existing R&D investments of firms more effective and efficient or trigger additional investments.

Other policy initiatives aim at spanning the complete spectrum of value creation from research to innovation. The 'EXIST – Existenzgründungen aus der Wissenschaft' scheme is for example particularly designed to enable university researchers creating start-up firms <link (12/2014)>. Hence, it is designed to exploit scientific research and discovery through the creation of new firms (see also section 4.2 of this report for details). EXIST has been reformed in December 2014 with significant increases in the levels of financial support that founders and start-ups can receive (<link (2/2015)>.

In sum, R&I funding in Germany is well-developed and covers all aspects of the research and innovation process. It uses many policy instruments which provide inputs into firm R&D activities, an innovation friendly environment as well as demand side mechanisms. R&D

tax credits are not part of this policy configuration and the political momentum for introducing them has slowed down (EFI, 2014).

2.6 Smart Specialisation (RIS3)

Smart specialization builds on the concept of regional innovation systems (RIS) in which innovation performance is not exclusively determined by individual actors such as firms or universities in isolation but also by their interactions. The smart specialization concept takes into account that not a single best practice for such RIS exists but that regions can develop individual strategies tailored to their needs and opportunities.

Smart specialization is part of the agreement between Germany and the European Commission on the implementation of the European Structure and Investment fund (<link (2/1015)>) and at least implicitly part of its High Tech Strategy 2020 (<link (12/2014)>). In this regard, Germany has several policy initiatives to leverage geographical clusters such as the Leading-Edge Cluster Competition ('Spitzencluster') of BMBF with a budget of €200m for up to five leading edge clusters in each round of funding. However, there is currently no policy document which explicitly outlines a smart specialization strategy at the federal level. This is largely due to the federal structure of Germany in which the Laender have important authority over R&I. There is some indication that the federal government prioritizes strengthening the international connectedness of the leading-edge clusters. Examples include the successful application for two Knowledge and Innovation Communities (KIC) ("Raw materials" and "Healthy living and active aging") in a European-wide competition of the European Institute of Technology which will be coordinated in Germany (<link (12/2014)>) Support for the internationalization of leading edge clusters and similar networks ('Internationalisierung von Spitzenclustern, Zukunftsprojekten und vergleichbaren Netzwerken') is now a BMBF programme with three yearly funding rounds between 2015 and 2017. In each round cluster or network managements can apply for funding for the development of internationalization concepts (up to two years) and implementation (up to three years) (<link (2/2015)>.

The Laender are currently going through the processes of developing smart specialization strategies. They have been in charge of developing Regional Development Programmes as a prerequisite for applying for funds from the European Regional Development Fund (ERDF) (<link (12/2014)>). These programmes are supposed to be replaced by RIS3 strategies. Saxony has a smart specialization strategy approved by state government, other Laender are developing and discussing them. Thuringia, for example, has formulated a draft RIS3 strategy (<link (12/2014)>). Other Laender have not made their RIS3 strategies public so far. The ones that are public, such as from Thuringia, incorporate the need for funding at the Laender level into a broader framework of funding from the federal and European levels. Thuringia's draft strategy does develop a monitoring and evaluation scheme with detailed output indicators.

2.7 Evaluations, consultations, foresight exercises

Evaluations are part of all major R&I policy schemes in Germany. Evaluations occur regularly, at all levels and through qualified bodies of experts. Many of these evaluation and monitoring reports provide important inputs and insights for this report. Evaluations

have significant influence on how programmes change and develop. For example, the BMWi programme 'EXIST' was created in 1998 with the goal of fostering entrepreneurship from scientists and researchers. It has since undergone important changes with regard to funding recipients, instruments and approaches as a reflection of continuous monitoring and impact evaluations (Kulicke, 2014).

The most comprehensive evaluation at the system level of R&I in Germany is carried out by the Expert Commission on Research and Innovation (EFI). The Commission consists of six Professors who cover a broad field of expertise of R&I-related topics. It is noteworthy that two of the current members work for Swiss universities and can therefore bring independence and immediate international comparisons to the evaluation. The EFI commission publishes a comprehensive, annual report (available in German and English language versions). In its 2014 report EFI emphasizes particularly the following issues:

- Further investments into research and education as part of the extension/development of the important policy programmes 'Exzellenzinitiative', 'Hoschschulpakt' and 'Pakt für Forschung und Innovation' which are about to expire in the current legislation period. Particular emphasis is put on overcoming the constitutional barriers for funding from the federal government.
- Consistent programme evaluation through establishment of a central data center and a dedicated budget for evaluation in each project.
- Strengthening tertiary and vocational education with an emphasis on flexible and individual education careers as well as quality based funding.
- Investment into fostering the knowledge economy in Germany through entrepreneurship, innovation and growth financing, as well as R&D tax credits.
- Retention and recovery of German talent in international competition for R&D.
- Developing stronger ties between electro mobility and an overall ICT agenda.
- Finally, the commission evaluates the effect of the Renewable Energy Sources Act (EEG) on innovation in Germany and questions its innovation effect.

Apart from EFI, the German Council of Science and Humanities ('Wissenschaftsrat') conducts evaluations and provides counselling for federal and state governments. The council provides comprehensive reviews incorporating all system relevant aspect. Examples include its recent "Science-driven Evaluation of Large Research Infrastructure Projects for the National Roadmap" <link (12/2014)> or its recommendations on the development of medical education in Germany based on a review model of medical degree programmes <link (12/2014)>.

Since 2007 the ministers and senators of the federal government and the Laender responsible for science and research as well as for finance form the Joint Science Conference ('Gemeinsame Wissenschaftskonferenz,' GWK). It provides annual monitoring reports and identifies room for improvement in projects such as annual monitoring of the policy initiative for improved funding of non-university research organizations ('Pakt für Forschung und Innovation') <link (12/2014)>. GWK has also started in September 2014 to evaluate the 'Exzellenzinitiative' which was designed to strengthen excellent university research in Germany <link (12/2014)>.

With the German Centre for Research on Higher Education and Science Studies ('Deutsches Zentrum für Hochschul- und Wissenschaftsforschung,' DZHW) a dedicated research

institute was founded in 2013 to provide data and analyses on higher education and science studies in Germany (<link (12/2014)>). Hence, an infrastructure is in place to conduct evaluations. The Institute for Research Information and Quality Assurance ('Institut für Forschungsinformation und Qualitätssicherung iFQ') will join DZHW in January 2016 (<link (12/2014)>). The combined institute will then provide data and analysis for both education and research activities of higher education in Germany.

Non-university research organizations have evaluation systems of their own institutes in place. The Max-Planck society has for example a detailed system of ex-post and ex-ante evaluations <link (12/2014)>.

With regard to how the evaluation system in Germany can be further developed the Expert Commission on Research and Innovation (EFI) advocates a professionalization of approaches and procedures. EFI recommends the establishment of an independent Chief Evaluation Office for all ministries with significant budgets for R&I as well as a standardized share of programme budgets (0.5%) dedicated to evaluation (EFI, 2014). The EFI report presents the evaluation pilot initiative 'Aufbaukreis Foerdercontrolling/Evaluation' of BMWi as a promising example which should be systematically developed across ministries.

Finally, the most comprehensive foresight initiative is conducted by BMBF <link (12/2014)>. The actual foresight project is conducted in a biannual cycle with a time horizon of 15 years into the future. The goal is to provide inputs and ideas about necessary needs of the German R&I system in the future as well as providing an early warning system for challenges. The current cycle (started in 2012) builds on the assumption that both technological opportunities and demand in society create innovations. The methodological approach has therefore been to investigate both streams (technology push and demand pull) separately before connecting them in a third stage. The final report was published in the end of 2014. The interim report capturing the societal demand aspect was published in August 2014 <link (12/2014)>. This interim report (BMBF, 2014e) titled "Societal Challenges 2030" ('Gesellschaftliche Herausforderungen 2030') lists seven fields ranging from citizen involvement in R&I to frictions between digital data transfers and privacy protection concerns. The final report titled "Stories from the future" ('Geschichten aus der Zukunft', <link (4/2015)>) describes nine narratives which are supposed to start and inspire new discussions about the future. The topics of the nine narratives are:

- Germany Selfmade ('Deutschland Selbermachen')
- Selfassessment and Wellbeing Competence ('Selbstbeobachtung und Wohlergehens-Kompetenz')
- Colleague Computer ('Arbeitskollege Computer')
- Education for Everybody and Everything ('Bildung für alle(s)')
- Act Locally – Collaborate Globally ('Lokal handeln – global kooperieren')
- Data intensive Government ('Datenintensive Governance')
- Experiment collaboratively for Future Solutions ('Gemeinsam experimentieren für Zukunftslösungen')
- Collaboration Economy ('Kollaborativ-Wirtschaft')
- Changing Privacy ('Privatsphäre im Wandel')

3. National progress towards realisation of ERA

Germany has participated in all initiatives towards increased R&I collaboration in Europe and internationally. The commitment towards further strengthening and developing ERA is explicitly part of the coalition agreement of the new federal government coalition in which it lays out its policy priorities until 2017 (<link (12/2014)>). Accordingly, the federal government has formulated a strategy ('Strategie der Bundesregierung zum Europäischen Forschungsraum,' BMBF, 2014c) and an action plan for international collaboration ('Aktionsplan Internationale Kooperation,' BMBF, 2014b) in 2014.

3.1 ERA priority 2: Optimal transnational co-operation and competition

The commitment of Germany to strengthening co-operation within ERA has steadily increased. BMBF's project funding for international projects with EU partners has reached €109m in 2013, an increase of 47% compared with 2009 (BMBF, 2014b). However, project funding for international projects with non-EU partners has almost doubled during the same time period (96%) and has reached €235m in 2013 (BMBF, 2014b). BMBF contributions for international research programmes and R&D infrastructures have reached €402m in 2013 (2009: €373m) (BMBF, 2014b). The federal government has set a goal for a 20% share of partners from abroad in BMBF funded projects in its internationalisation strategy (BMBF, 2008). This goal has already been reached (BMBF, 2014b).

The federal government formulates a vision for Germany's role within transnational co-operation and competition of ERA in its ERA strategy (BMBF, 2014c). This strategy envisions science in Germany as part of an intensified, visible European and international network but with independence in decision making. The strategy encompasses the following instruments for co-operation:

Strengthening the structural effects of Joint Programming Initiatives (JPIs) especially with a far reaching intent to incorporate European components in the planning of BMBF funding programmes reflecting the content of jointly agreed JPI research agendas.

Continuation and increased use of other border-spanning initiatives and platforms of ERA such as European Innovation Partnerships (EIPs). The strategy document highlights the EUREKA and COST initiatives because of their bottom up approaches, flexibility and lean administration.

Use and extension of public-public-partnerships (P2Ps) such as EUROSTARS for research funding of SMEs (<link (12/2014)>) and public-private-partnerships (PPPs) such as BBI the initiative for bio based industries (<link (12/2014)>).

Increase the visibility and documentation of the European and international networks of German science through new indicators. Additionaly, BMBF has established an association for research marketing ('Aktionsbuendnis Forschungsmarketing') as a dialogue between science, business and politics which is supposed to analyse and design a framework for research marketing of Germany abroad (BMBF, 2014b).

Continue, extend and support transnational co-operation through the research organizations such as DFG. Successful examples of mechanisms for transnational research support include the "Lead Agency" approach in Germany, Austria and Switzerland (D-A-CH)

by which grant proposals can be submitted in one country and national research organization coordinate among themselves.

The action plan for international collaboration of the federal government reflects this strategy (BMBF, 2014b). It emphasizes the joint programme planning based on JPI. Germany participates currently in 8 of the 10 JPIs (BMBF, 2014c). The action plan emphasizes topical choices for future programme planning which overlap with the key technological fields outlined in Germany's High Tech Strategy as well as the increasing importance of topics relevant to other countries, especially emerging economies. A notable initiative among the public research organizations for increasing international co-operation is the opening of two newly founded Max-Planck institutes outside of Germany (BMBF, 2014b)

The action plan also demonstrates the awareness for monitoring. For this purpose BMBF will publish a biannual report on the internationalization of the German research and science environment ('Bericht zur Internationalisierung in der deutschen Forschungs- und Wissenschaftslandschaft'). In terms of visibility of German science abroad, BMBF has established an association for research marketing ('Aktionsbuendnis Forschungsmarketing') as a dialogue between science, business and politics which is supposed to analyse and design a framework for research marketing of Germany. The framework concept is expected in Spring 2015 (BMBF, 2014b).

3.2 ERA priority 3: An open labour market for researchers. Facilitating mobility, supporting training and ensuring attractive careers

3.2.1 Introduction

Germany has been classified as a country with regulated labour markets for researchers (JRC, 2013). This implies that national legislation or collective agreements determine processes related to hiring and promotions. Germany shares this institutional feature with Belgium, Cyprus, Greece, Spain, France, Italy, Malta and Portugal (JRC, 2013). The dominant form of employment for researchers in Germany is as civil servants ('Beamte') or public sector employees ('Angestellte').

The official education report of the federal government of 2014 (BMBF, 2014d) provides insights into the employment numbers at universities: Universities employed roughly 640,000 employees in 2012 which is an increase of 28% compared with 2006. Scientific personnel accounted for the larger share of this increase (+40%). 84% of the scientific personnel have fixed-term contracts. This includes PhD students because they do not have student status in the German system. Roughly 60% of PhD students do not stay in research after finishing their PhD. Roughly 40% of the scientific personnel is financed by competitively acquired funds ('Drittmittel'). This share has increased over recent years.

Roughly 2.47m employees worked in scientific professions in 2010 in Germany. Roughly 135,000 of those employees were immigrants (EFI, 2014). The share of foreigners in scientific professions is therefore significantly smaller (5.5%) than in non-scientific professions (10.8%). Among researchers with scientific publications 19,521 researchers have newly moved to Germany between 1996 und 2011 compared with 23,460 who have left Germany (EFI, 2014).

3.2.2 Open, transparent and merit-based recruitment of researchers

The principle of transparent, open and merit-based (TOM) recruiting is established in constitutional law, through the higher education laws of the Laender and a general Anti-Discrimination Act of 2006.

The hiring procedures at German universities for teachers and professors are traditionally competitive in nature. The Laender set the rules for hiring in higher education in Germany. They are increasingly transferring the appointment rights for new staff to the universities or public research organizations. Laender higher education laws guarantee the openness of recruiting procedures including advertising. As a rule, openings are announced through public advertising nationally and internationally. The latter can be mandatory or contingent on the importance of the respective position.

The evaluation process of applications typically includes external experts in committees which compare applications. It is unlikely in the German system that universities would hire their own PhD students after they have received their doctorate. This rule is supposed to ensure the openness and transparency of hiring decisions. The Laender have changed legislation to introduce a tenure track system in which junior faculty can enter as "Junior Professor" on a fixed term contract which can be transferred into a permanent university professor position. The tenure track model is supposed to make academic careers faster and more transparent. It is fairly similar to the Assistant Professor tenure track system for junior faculty positions in many other countries.

The federal government has enacted the Academic Freedom Act in 2012 which gives higher education institutions more autonomy in their recruiting decisions including the use of third-party funds for hiring top researchers. Public research organizations have also significant autonomy in their hiring decisions. Taking also into account that the individual Laender enact legislation on higher education implies that the recruiting landscape cannot be fully homogeneous throughout Germany.

In conclusion, there are no obstacles to open, transparent and merit based recruitment of international researchers in Germany. Barriers can emerge from differences in language or the institutional backgrounds of researchers from abroad (BMBF, 2014b). The action plan of the federal government includes elements to lower such barriers. It envisions a "welcome culture" ('Willkommenskultur) which provides information, e.g. in welcome centres or online through EURAXESS, the European information portal. Other measures include Alexander von Humboldt-Professorships which provide German universities and research organization with additional funds (up to €5m) to hire excellent researchers from abroad (BMBF, 2014b).

3.2.3 Access to and portability of grants

Access to grants and scholarships depends on the programme. Scholarships are generally advertised internationally and many programmes target international recipients, e.g. through the German Academic Exchange Service (DAAD), the German Research Foundation (DFG) or the Alexander von Humboldt Foundation (AvH). Practical consideration can limit access to certain scholarships such as when they require language skills, e.g. especially in German, or the recognition of professional skills or diplomas. The latter has become easier since 2012 with the enactment of a law for simplifying such recognition procedures ('Gesetz über die Feststellung der Gleichwertigkeit von Berufsqualifikationen,

Berufsqualifikationsfeststellungsgesetz - BQFG', <link (2/2015)>). Roughly 16,700 recognition applications were processed in 2013 with a positive recognition rate of almost 80% (<link (12/2014)>). Improving international recognition procedures even further is also part of the action plan of the federal government for the future (BMBF, 2014b).

Access to apply for grants for researchers affiliated in foreign institutions follows different rules. DFG defines as a general rule that every researcher in Germany or affiliated with a German research institute abroad can apply (if her/his scientific education ends with a PhD) (<link (12/2014)>). Researcher from outside Germany can be funded in collaborative research projects (Money follows Cooperation line) (DFG, 2009). Further exceptions exist for cross-border access for researchers from Germany, Austria and Switzerland (D-A-CH). Researchers from research institutions in these countries can apply for funding for border crossing projects in one country only (Lead Agency Principle) (<link (12/2014)>).

DFG has agreed to the principle of "Money Follows Researcher" within D-A-CH in 2003 and within EUROHORCs (European Heads of Research Councils) in 2004 (DFG, 2009). This implies that grants for research can be transferred to other countries with few conditions.

3.2.4 EURAXESS

EURAXESS Germany acts as a portal to facilitate the matching of internationally mobile researchers with vacancies in German universities or research institutes. The portal allows registered organizations and institutes to post job advertisements and cv's respectively. Interested applicants can also find a multitude of relevant information about research, working and living in Germany online. EURAXESS Germany is a national coordination point operated by the Alexander von Humboldt Foundation (AvH) and by BMBF. EURAXESS has 79 EURAXESS Service Centres in 2014 spread throughout Germany and typically located at large universities or research institutes (<link (12/2014)>).

The combination of more standardized but easily accessible information online and local service centres with specific knowledge and opportunities for personal questions allows for a large degree of responsiveness to the needs of individual researchers. Out of the total of 3,045 jobs for researchers advertised on EURAXESS in December 2014, 312 are located in Germany (<link (12/2014)>). This 10% share makes Germany the third largest destination within EURAXESS behind the UK (19%) and only very slightly behind the Netherlands (10%).

3.2.5 Doctoral training

The German higher education system graduated 2.8 new doctorate students per 1,000 25-34 year olds in the population in 2011 (European Commission, 2014b). This ratio has slightly increased in recent years (2008: 2.6) and is significantly above the average of EU-28 (1.7). Germany ranks significantly below EU-28 averages when it comes to attracting non-EU doctoral students. Only 11.2% of doctoral students in Germany come from outside of the EU compared to 24.2% in EU-28 in 2011 (European Commission, 2014b).

The system of doctoral training in Germany is heterogeneous. First, the Laender are responsible for setting rules in education as a principle established in the German constitution. Second, within Laender laws universities and sometimes even individual faculties have agency in deciding about structures, rules and procedures for acquiring a

PhD ('Prüfungsordnung, Promotionsordnung'). Structural training is not automatically required for earning a PhD in Germany. Students can receive a doctoral degree at a chair ('Lehrstuhl').

The role of the federal government is limited. However, it has in recent past expressed its interest in reforming doctoral training in Germany by increasing the number of structured PhD training programmes and improving supervision <link (12/2014)>. The most important policies pointing in this direction stem from funding schemes for structured doctoral training programmes provided by the DFG (since 1990) and as part of the joint Initiative for Excellence of federal government and Laender (since 2006). The resulting doctoral programmes are typically referred to as graduate schools or research training schools ('Graduiertenschulen/Graduiertenkollege). DFG has provided €384.1m for the establishment of these PhD schools between 2008 and 2010 as well as an additional €138.2m through the Initiative for Excellence in the same time period (DFG, 2014). This funding has resulted in 237 PhD schools through the former and 39 through the latter (DFG, 2012). In addition, Max Planck society has introduced International Max Planck Research Schools (IMPRS) in 2000 as structured doctoral programmes. There are currently 61 IMPRS.

The PhD schools receiving funding through DFG or the Initiative for Excellence do not follow a fully standardized model. Concepts are individually developed by universities and subsequently evaluated through DFG and the Science Council ('Wissenschaftsrat'). The evaluation is based on four criteria: Quality of the proposed research programme (relevance, novelty, appropriateness, coherence, etc.), quality of the participating researchers (credentials and experience with training), quality of the qualification and supervision strategy (e.g. supervision structures) as well as the fit with the environment (<link (2/2015)>).The best concepts receive funding.

The competition for funding of PhD schools through the Initiative for Excellence has been a major driver for innovative PhD training schemes. The innovativeness of the proposed PhD school was an evaluation criteria. At the same time, the diversity of proposals left room for creative proposals which fit the context of the topic and location.

The Expert Commission on Research and Innovation (EFI) sees attractive PhD schools for top international students as a major instrument for Germany to increase its benefits from international knowledge flows (EFI, 2014).

3.2.6 HR strategy for researchers incorporating the Charter and Code

The federal government supports Charter & Code (C&C) but highlights the need for flexible implementation in the national context (<link (12/2014)>). Most of the C&C principles are implemented and applied in Germany, such as through the Research-Oriented Standards on Gender Equality by DFG, quality assurance measures and awards like "family-friendly university" (<link (12/2014)>) or the total e-quality award (<link (12/2014)>). The Conference of German University Rectors ('Hochschulrektorenkonferenz,' HRK) representing the German Higher Education Institutions signed the C&C in 2005 and invites its members to adopt the principles of C&C. It is optional for research organizations to adopt C&C. The German subscribers of Charta & Code are, for instance, the German Rector's Conference (HRK), the Alexander von Humboldt-Foundation (AvH), the German Academic Exchange Service (DAAD) and the Fraunhofer Society (FhG) as well as the Universities of Freiburg and Erlangen-Nuremberg.

BMBF provides an outline for how C&C principles will be further incorporated in human resource strategies for researchers in earlier reports (<link (12/2014)> and <link (12/2014)>) as well as in the strategy for ERA of the federal government (BMBF, 2014c). Major elements include improvements in social security and pension schemes to reflect the increased mobility of scientists.

Other plans are targeting to improve the attractiveness of careers in research in general through performance-related payment, better career prospects for junior researchers, fewer administrative limitations and more flexibility as well as promoting women and dual-career couples. Especially initiatives that benefit women are holding significant potential for Germany based on the analysis of the Expert Commission on Research and Innovation (EFI, 2014).

In conclusion, the attractiveness of the academic labour market in Germany is increasing for both domestic and foreign researchers. Major improvements have been triggered especially through the Initiative for Excellence. Nevertheless, Germany finds itself in competition with other countries for the best researchers and scientists. The heads of German universities acknowledge that their competitiveness has increased but are worried about their budgets for recruiting personnel in the future (Stifterverband, 2014). Similarly, the most productive researchers leave Germany and return rates are lower compared with other countries (EFI, 2014). Investments in excellent research conditions combined with more flexible administrative environments could certainly help to keep excellent researchers in Germany, attract international talent and encourage returns of German researchers from abroad. The agreement between federal and Laender governments to continue the Initiative for Excellence is a good signal in this direction.

3.2.7 Education and training systems

In general, Germany is challenged to improve the inflows of skilled students into higher education because of the demographic structure through which many skilled scientists and researchers will retire in coming years. Politics has recognized these challenges. Improvements to the education and training system have received significant priority in the coalition agreement of the new federal government which lays out its policy guidelines until 2017 <link (12/2014)>. Among the relevant policy priorities for education and training are:

- Reducing barriers for entering universities especially for individuals with professional qualifications
- Increasing the number of foreign students in Germany by a third to 350,000 annually and increasing the share of university graduates with foreign experience to 50%
- Increase the awareness for the attractiveness of mathematics, information sciences, natural sciences, and technology (MINT) already in childcare by reaching out to 80% of child care centres in Germany
- Increase the recognition of vocational and professional training as well as government funding for it by reforming the law for the “Promotion of Advancement through Training” (‘Aufstiegsfortbildungsförderungsgesetz,’ AFBG).

The education system has improved its performance by increasing the number of secondary education graduates qualifying for university education ('Allgemeine Hochschulreife'). 42.3% of students in the relevant age group were qualified in 2012 compared with 29.6% in 2006 (BMBF, 2014d). The total number of students enrolled in German universities reached a record high in the winter semester of 2014 with almost 2.7m (<link (12/2014)>). New enrolments have been 1.9% lower compared with previous years. This reflects two exceptions in the German education system in recent past. First, with the abolishment of the mandatory military service more students have entered universities. Second, the length of secondary education for obtaining the qualification to enrol at a university was shortened by one year. Hence, two generations of secondary school graduates entered universities at the same time. Not all Laender have agreed and implemented this change at the same time and the effect on student numbers has therefore been prolonged. However, the exceptional effects are about to expire. A side effect of these changes is that the average student reaching the end of secondary education is now younger (19.4 years) (BMBF, 2014d). The German Centre for Research on Higher Education and Science Studies ('Deutsches Zentrum fuer Hochschul- und Wissenschaftsforschung,' DZHW) finds the percentage of university students quitting their studies was 28% in 2012 which is largely unchanged from previous years (DZHW, 2014). Rates in mathematics, information sciences, natural sciences, and technology (MINT) are higher. 39% of university students in maths and natural sciences do not finish their studies, 36% in engineering. The latter has been reduced significantly compared with previous student generations.

The German constitution requires that federal and Laender governments collaborate in the evaluation of the education system and in conducting international comparisons. For this purpose the German Institute for International Educational Research ('Deutsches Instituts für Internationale Pädagogische Forschung,' DIPF) assembles biannually a group of independent experts who collect indicators and analyse specific topics for the national education report ('Bundesbildungsbericht', BMBF, 2014d) since 2006. Germany has also participated in the following international evaluation studies (BMBF, 2014a):

- PIRLS (Progress in International Reading Literacy Study) under the heading of IGLU ('Internationale Grundschul-Lese-Untersuchung') in Germany for primary schools
- TIMSS (Trends in International Mathematics and Science Study) for fourth grade students
- PISA (Programme for International Student Assessment) for 15 year old students
- ICILS (International Computer and Information Literacy Study) of school students
- PIAAC (Programme for the International Assessment of Adult Competencies) for adults

Federal and Laender governments have founded the Centre for International Student Assessment ('Zentrum für internationale Bildungsvergleichsstudien,' ZIB) in 2010 for conducting large scale assessments. BMBF also funds the initiative Research Data Education ('Forschungsdaten Bildung,' <link (12/2014)>) which collects data in various forms on school education to enable and increase the empirical research on education (<link (12/2014)>).

In terms of quality of incoming university students, the German school system ranks mid-field in comparative studies such as PISA. Especially the PISA and IGLU comparative studies have triggered reforms in the German school systems. Excellence in education is

often times triggered by comparison and competition among the Laender because education falls under Laender responsibility. There are some indications that changes to secondary schools show success. Reading and math skills of 15 year olds or fourth grade students are improving over time (BMBF, 2014d). It is noteworthy that improvements originate especially from students with the lowest initial competences and with migration backgrounds. The computer and information literacy competences are about EU average and only slightly above OECD average. This reveals the recent International Computer and Information Literacy Study of the International Association for the Evaluation of Educational Achievement (IEA) among 8th grade students (Bos et al., 2014). The study finds that a particular shortcoming in Germany does not stem from the availability of digital equipment in schools but its usage in education. BMBF has announced to provide funding of €500m over the next ten years for quality improvements in teacher training ('Qualitätsoffensive Lehrerbildung') in cooperation with the Laender (<link (12/2014)>).

Focusing on vocational training, the German training system of apprenticeships ('Berufsausbildung') is long established and provides dual part time training in vocational schools and part time work at firms. 497,427 students entered the dual system in 2013 which equals 51.4% of students entering vocational training (BMBF, 2014d). The level and share of students has been rather stable over time. The dual system is accompanied by fulltime vocational schools (21.9%) and transitory support systems (26.6%) for students to find jobs. There are significant concerns in Germany that the current system of dual training will not provide enough skilled employees for the future ('Fachkraeftmangel'). Among professions for which apprenticeship supply does not meet demand are several with relevance for R&I in Germany as evidenced by the supply to demand ratios: Technicians (-10%), electrical technician (-10%) and IT (-11%) (BMBF, 2014d).

A central issue of political discussion is the opening of university education to individuals with professional training but no formal school degree to enter a university ('Hochschulreife'). The Standing Conference of the Ministers of Education and Cultural Affairs of the Laender ('Kultusministerkonferenz,' KMK) has agreed in 2009 to provide this opportunity for individuals with certain degrees of vocational trainings, e.g. master craftsmen ('Handwerksmeister') (<link (12/2014)>). The implementation of this agreement is due to the Laender and they have found varying solutions and requirement (for an overview see <link (12/2014)>). The acceptance of this opportunity for university education is growing slowly. In 2012 2.6% of new university students used the opportunity (BMBF, 2014d). Often times these students choose universities for applied sciences or distance study universities.

Technical colleges ('Fachhochschule') and universities of applied sciences ('Berufakademie') provide opportunities to connect university education with direct application in business. They allow students to enrol themselves into higher education with a more clearly defined focus on application skills. 37.4% of students opted for starting their studies at a technical college in the winter semester of 2012 (BMBF, 2014d). Individual Laender have started initiatives to increase the role of universities of applied sciences to connect higher education with business needs. Particularly Baden-Wuerttemberg is investing into promoting research at technical colleges. There is currently little information on the availability of entrepreneurship education in Germany.

3.3 ERA priority 5: Optimal circulation and access to scientific knowledge

3.3.1 e-Infrastructures and researchers electronic identity

The federal government has announced its Digital Agenda 2014-2017 in 2014 (BMWi, 2014b). In the agenda the federal government highlights its objectives and priorities:

- Digital networks as drivers for economic growth and employment, with a particular focus on manufacturing and logistics as well as on small and medium sized companies.
- Access and participation, especially through broadband networks and childhood education.
- Confident and secure usage, particularly through secure communications and infrastructures.

The agenda covers a broader set of initiatives, e.g. innovative public administration, but the most relevant aspect for this report is under the heading of "Education, science, research, culture and media:" There are six priorities defined within this subject:

- Accelerating the digital transformation in science:
  Within this area the development of a digital transformation strategy is planned which facilitates the flow of information between archives, libraries, research and publication. The federal government also wants to support strategic projects which connect research databases, repositories and virtual research environments. The process is accompanied by the establishment of a Council for Information Infrastructure ('Rat fuer Informationsinfrastrukturen') as an advisory committee and for the development of recommendations. This council has been established in November 2014 as a shared initiative of federal and Laender governments. It consists of eight representatives of scientific users, eight representatives of organizations such as libraries and archives, four representatives of public life and four representatives of federal and Laender governments (<link (12/2014)>).
- Safeguarding access to knowledge as a basis for innovation:
  The federal government plans a comprehensive open access strategy and an increase in the ease with which funded research publications and data can be accessed. Further, the introduction of a copyright limitation for education and science is planned.
- Education campaign for the digital knowledge society:
  The federal government will develop a digital learning strategy together with the Laender which are responsible for decisions on education. Further, the federal government wants to identify and implement training needs for initial training, further training and continuing education. This is supported at the vocational school level through the programme Digital Media in Vocational Education and Training" ('Digitale Medien in der beruflichen Bildung,' <link (12/2014)>) as well as at the university level through the Digitisation University Forum ('Hochschulforum Digitalisierung,' <link (12/2014)>).
- Exploiting digitisation's potential for innovation:
  In this area the federal government wants to integrate the opportunities of its broader High Tech Strategy with the areas of IT security research, microelectronics and service research. Special priority is also given to opportunities originating from

big data with the establishment of two centres of excellence for big data in Berlin and Dresden. They are supposed to provide innovation support in business, science and health services. The federal government also wants to establish Germany as a leader in high-performance computing and strengthen research on digitization in medicine.

- Understanding the digital transformation through research:
  The federal government wants to increase research into privacy protection and the right to privacy as well as self-determination and transparency. For this purpose it envisions interdisciplinary studies which focus on topics such as the coevolution of technology, work, society and skills. There are plans for a publicly funded research institute which will investigate ethical, legal, economic and participatory aspects of the internet and digitization.
- Culture and media:
  The federal government plans a German Digital Library. In a broader sense it wants to increase the digitization of cultural assets and their diffusion while addressing needs for legal frameworks and copyright legislation.

It is also noteworthy that Germany's Digital Agenda 2014-2017 incorporates explicitly European and international dimensions (BMWi, 2014b). The integration of German and European digital agendas are especially prioritized in governance and legal frameworks as well as in the involvement of Germany in European decision making committees.

The Digital Agenda process is accompanied by monitoring reports. The latest monitoring report ('Monitoring-Report Digitale Wirtschaft 2014,' <link (12/2014)>) was published in December 2014 (BMWi, 2014c). The monitoring report takes a broader perspective on the state of the digital economy in Germany as a whole not just R&I related topics. The report places Germany in fifth spot in an international comparison on the overall performance, significantly behind the United States as the leading digital economy. The German digital performance is close to several other European countries, e.g. Denmark or Finland, as well as China, and behind but within reach of South Korea, the UK and Japan. With regard to R&I topics the monitoring report identifies also potential for improvement (BMWi, 2014c):

- The penetration of optical fibre cable in the broadband network infrastructure should be improved in Germany. Germany ranks currently last in Europe with a penetration rate of 1%. There are ongoing political discussions that the federal government could increase its investment into the digital network as part of an additional spending bill directed at infrastructure improvements (digital or physical).
- Innovation should be encouraged which facilitates the digital integration of supply chains such as between suppliers, manufacturers and customers. The performance, efficiency and flexibility potentials of such integrations are sometimes referred to as "Industry 4.0". Such innovations are often times improvements of business processes and have a large performance potential especially for SMEs in Germany ('Mittelstand').
- The potentials of the previous point are best reached if education and training systems become more interdisciplinary in nature. Skillsets which will be in high demand are not just better along the dimensions of technology and mathematics but will require also management skills as well as international expertise.
- Regulatory steps, e.g. on data protection, should be unified across Europe and embedded in global regulatory systems.

With regard to existing instruments in place for identity validation and personal data use, Germany has an electronic ID card. This card allows electronic authentication and electronic signature. Hence, it enables secure identification via the internet. The card contains biometric features which limit the risk of identity theft. The card is intended to facilitate secure and trusted business transactions online for e-government and e-business. Technological boundaries and security concerns prevent a broader use of electronic IDs. Digital Author IDs are for example currently only in a discussion stage, similarly to a unified European ID card in projects such as BIOP@SS project (<link (12/2014)>).

3.3.2 Open Access to publications and data

Open access to publications and data is an explicit priority of the Digital Agenda 2014-2017 of the federal government (BMWi, 2014b). Most Open Access initiatives in Germany are traced back to the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities ('Berliner Erklärung über den offenen Zugang zu wissenschaftlichem Wissen,' <link (12/2014)>) of 2003. The declaration was introduced by the Max Planck Society but signed by currently 480 institutions which commit themselves to Open Access. The Alliance of Science Organisations in Germany[8] is actively promoting Open Access through its Priority Initiative "Digital Information" (<link (12/2014)>). The alliance has recently reiterated its support for the use of Open Access to scientific publications as well as open licenses for data or software use (<link (12/2014)>). German research organizations are also active as members of Science Europe which has recently announced its Principles for the transition to Open Access for research publications (<link (12/2014)>)

The most recent discussion on Open Access in Germany follows legal changes of copyright law in 2013. The new law introduces a Secondary Exploitation Right ('Zweitverwertungsrecht') for authors (<link (2/2015)>). The essence of the law is that scientific authors will have the right to publish their research again one year after they have initially published it in scientific journals and presumably transferred all exploitation rights to a publishing house. Hence, the transfer of copyrights in an author contract becomes irrelevant after one year. While the law is generally in line with the goal of Open Access, it has been criticized especially from research organization for its exceptions (<link (2/2015)>). Most of the criticism stems from the condition that the law will only apply to results of teaching or research with at least half of its funding from public project funding or at an institutionally funded extramural research institution. This share can be hardly determined in practice and excludes university research unless it is financed by public third-party funding ('Drittmittel').

Open Access has been typically classified in three types: Gold, green and hybrid.[9] Archambault et al. (2014) present a set of indicators for the diffusion of Open Access in

[8] The members of the alliance are Alexander von Humboldt Foundation, the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), the Fraunhofer-Gesellschaft, the German Academic Exchange Service, the German Council of Science and Humanities (Wissenschaftsrat), the German National Academy of Sciences Leopoldina, the German Rectors' Conference, the Helmholtz Association of German Research Centres, the Leibniz Association, and the Max Planck Society (<link>)

[9] Gold open access (open access publishing): payment of publication costs is shifted from readers (via subscriptions) to authors. These costs are usually borne by the university or research institute to which the researcher is affiliated, or by the funding agency supporting the research.
Green open access (self-archiving): the published article or the final peer-reviewed manuscript is archived by the researcher in an online repository before, after or alongside its publication. Access to this article is often delayed ('embargo period') at the request of the publisher so that subscribers retain an added benefit. The

various countries. This study provides indicators for the share and type of Open Access publications between 2008 and 2013. Out of 66,268 scientific papers sampled for Germany, 50.9% were available through Open Access between 2008 and 2013. This share is almost equal to the average EU-28 (51.3%). 7.6% of articles in Germany were available through Gold Open Access which is slightly below EU-28 average (8.6%). 11.4% of articles in Germany were available in Green Open Access formats and 33.2% in other Open Access formats. This share is above EU-28 average of 9.4% for Green Open Access and slightly below 34.9% for other Open Access formats. In sum, Open Access patterns in Germany are well aligned with the rest of Europe.

A more recent variant of Open Access is the ID/OA mandate (i.e. Immediate deposit/Optional Access)[10] or also called the "Liege Model." There is no information available on the usage of this model in Germany.

green access model allows for certain variations: the length of the embargo period and the version that may be archived at different moments in time vary, e.g. depending on the agreements between publishers and authors.

Hybrid open access refers to a publishing model in which subscription-based journals allow authors to make individual articles open access on payment of an article publication fee.

[10] The model implies that upon acceptance for publication authors are required to upload the publication to the repository of their institution. The access decision (closed or open) is left to the authors but they are strongly encouraged to make the full text available in an open format quickly (<link>).

4. Innovation Union

4.1 Framework conditions

Framework conditions for innovation in Germany are generally comprehensively developed and applied. They include both supply and demand-side instruments for stimulating innovation. All major R&I policy strategies, such as the renewed High Tech Strategy (BMBF, 2014f) or the Digital Agenda 2014-2017 (BMWi, 2014b), contain elements for increases in the availability of excellent knowledge and technologies (supply-side) as well as by strengthening demand for innovative products, process and services. There is a fundamental understanding that the public and private sector interact in a systematic way for innovation. What is more, major policy initiatives such as Central Innovation Programme for SMEs ZIM ('Zentrales Innovationsprogramm Mittelstand') or the German Federation of Industrial Research Associations AiF ('Arbeitsgemeinschaft industrieller Forschungsvereinigungen') „Otto von Guericke", demonstrate sensitivity in the policy making process for the need to transfer and develop scientific discoveries into innovations.

The German R&I system is complex and policy initiatives influencing framework conditions for innovation are discussed throughout this report. A few especially influential supply and demand-side initiatives should be highlighted because of their current importance:

- Federal and Laender governments have signalled that they would like to extend the Initiative for Excellence ('Exzellenzinitiative') beyond 2017 (<link (12/2014)>). The initiative has created an important stimulus for dynamic and creativity in the German higher education sector (<link (12/2014)>). The initiative sets incentives for universities to develop tailored concepts for excellent research in their universities and be rewarded through competitive allocation of funds. Universities report that competitiveness of their research has been increasing (Stifterverband, 2014). Hence, the continuation of the initiative is an important signal.
- On the demand-side of innovation policy, the renewed High Tech Strategy (BMBF, 2014f) of the federal government stands out as one of the most important R&I strategy documents in Germany. The demand-side element of the strategy stems especially from the identification of priority topics from which demand for innovation will flow in the future with crucial implications for Germany: Digital economy and society, sustainable economy and energy, innovative work environments, healthy living, intelligent mobility as well as civil society.
- A unique element of the German R&I system are the non-university research organizations. They span a range from basic research (e.g. in the Max Planck Society) to the application of innovative technologies (e.g. in the Fraunhofer Society). The budgets of these research organizations have benefited significantly from the Pact for Research and Innovation ('Pakt für Forschung und Innovation'). These improvements stem from increases in total funds but also more predictability in the development of financing in the future. Hence, the pact has facilitated strategic planning. Federal and Laender governments have agreed in October 2014 to extend the pact which is a positive signal for innovation in Germany (<link (12/2014)>).

All of the mentioned framework conditions are continuations of existing programmes. While this speaks to the predictability of framework conditions in the German R&I system,

it may understate the responsiveness of the system. Examples for the responsiveness of policy making for addressing deficits in the framework conditions in Germany include:

- Federal and Laender government accomplished a change in the constitution in December 2014 which overcomes the strict limits which the constitution placed on the involvement of the federal government (<link (12/2014)>). This is an important step for the German R&I system which was debated for years (e.g. EFI, 2014) and provides many new opportunities. The legislative demands for changing the constitution are high and the fact that the new federal government as well as the Laender governments managed to meet them reflects positively on the responsiveness of the political system. What may have been helpful in this regard is that the new federal government is formed by the two largest political parties in Germany which are also part of all Laender government coalitions.
- The federal government has formulated a strategy consensus in 2014 on the European Research Area (ERA) (BMBF, 2014c) and complimented it with an action plan for international collaboration (BMBF, 2014b) (see also section 3.2 of this report). Hence, a comprehensive strategy for the internationalization of R&I could be established.
- Similarly, a consistent shortcoming of the German R&I system is the availability of venture capital. The federal government has responded with a new initiative which provides direct incentives to private investors ('INVEST – Zuschuss Wagniskapital,' see section 4.6 of this report).

In other areas, such as on R&D tax credits which are currently absent in the German system, the momentum appears to have slowed (EFI, 2014). However, on balance supply and demand-side framework conditions for innovation in Germany are comprehensive, versatile and positively evolving.

4.2 Science-based entrepreneurship

The creation of new firms for the exploitation of scientific discoveries is an important channel through which new technologies, materials and processes lead to economic growth and job creation. This vision is largely shared by federal and Laender governments in Germany as evidenced in the national report on research and innovation ('Bundesbericht Forschung und Innovation', BMBF, 2014a). The overall entrepreneurship environment in Germany has improved in 2013 with 868,000 newly founded firms; a plus of 12% compared to 2012 (KfW, 2014). The KfW Start-up Monitor ('KfW Gruendungsmonitor') also reveals that more entrepreneurs in Germany start their firms based on an innovative product (11% in 2013 compared with 4% in 2009).

The federal government provides a range of support initiatives to facilitate entrepreneurship from science and by addressing various needs (BMBF, 2014a):

- EXIST – Existenzgruendung aus der Wissenschaft (<link (12/2014)>)
  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 organizations. 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 (<link (2/2105)>). Scholarships (EXIST-Gruenderstipendium) increase by 25% and the included funds for investments cannot 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) (<link (12/2014)>):
  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 particularly 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.
- ERP-Startfonds (<link (12/2014)>):
  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 commercialization. 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 (<link (12/2014)>):
  INVEST differs from other policy instruments targeting at the funding needs of young, technology intensive firms by providing incentive to private investors such as Business Angels. Within INVEST a private investor can receive 20% of its investment into a young, innovative firm back from the federal government if it holds the initial equity investment for three years.[11] The measure is intended to make the expertise of equity investors available to more young firms by lowering the risk of their investment. INVEST started in 2013 and has so far approved 350 cases (April 2014).
- IKT Innovativ (<link (12/2014)>):
  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.

[11] The government commitment is caped at €1m equity shares per invested firm annually.

Research organizations 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 commercialization strategies (<link (12/2014)>). Entrepreneurship is also part but not the exclusive goal of the target portfolio of several other R&I policy programmes. These include the Leading-Edge Cluster Competition ('Spitzencluster-Wettbewerb,' <link (12/2014)>) or the Central Innovation Programme for SMEs (ZIM).

Given that the Laender are responsible for university education, many initiatives related to encouraging science based entrepreneurship in Germany are due to their initiatives. These initiatives are often times in the form of incubators, entrepreneurship advisers or consultants. Examples include (BMBF, 2014a): Humboldt-Innovation GmbH of Humboldt-University in Berlin which provides entrepreneurship consulting and services which have since 2005 resulted in more than 50 new firms; business plan competitions in the project "Spin off" of the research association of Mecklenburg-Vorpommern or the "Startercenter" of the University of Saarland which has hosted 255 newly founded firms since 1995.

Entrepreneurship propensity in Germany is comparatively low in an international context. This is often times explained with the promising career opportunities in existing firms and hurdles for obtaining early stage funding (BMBF, 2014a). Then again, most recently the latter obstacle is declining in the perception of entrepreneurs (KfW, 2014). At least the policy portfolio in Germany is well geared towards addressing all stages of the entrepreneurship process from science with the fostering of an entrepreneurship culture (EXIST), idea generation (various competitions), counselling and advice (university incubators and entrepreneurship offices), early stage funding (HTGF), creation of professional networks and advice (INVEST) as well as funding for business development (ERP-Startfonds).

4.3 Knowledge markets

Markets for knowledge (also referred to as markets for technology or ideas) have important potentials for the efficiency of knowledge creation and exploitation in a country. They enable an efficient division of labour. Entrepreneurial firms with novel technologies, materials or processes often times lack the complementary assets to exploit them, e.g. manufacturing capacities, sales networks, brands. It would be a costly and lengthy process for them to find financing for the development of complementary assets. In the presence of an efficient market for technology, such firms can sell their technology, often times through licensing, to incumbent firms which already possess the complementary assets. Conversely, established firms with significant capacities for manufacturing, sales or servicing are likely better off by acquiring new knowledge or technologies on markets instead of going through the uncertain process of developing new technologies themselves. As a result the presence of efficient markets for technology benefits both entrepreneurial and incumbent firms.

The efficiency of markets for technology depends crucially on whether the market is thick (with sufficient buyers and suppliers), safe and uncongested (Gans and Stern, 2010). These factors are interconnected and relate to the underlying intellectual property rights regime (IPR). The institutional environment in Germany ranks high with regard to IPR protection based on the coverage of IPR protection and its enforceability (Park, 2008). A more recent

survey among business executives of the World Economic Forum ranks IPR protection in Germany 21st out of 144 economies as part of the Global Competitiveness Report 2014-2015 (<link (12/2014)>). IPR protection is fairly skewed in this indicator, i.e. Germany achieves a rating of 5.4 (out of a maximum of 7) which puts it not far from the leading economy Finland (6.2) and very close to Sweden (5.5), Denmark (5.3) and the US (5.4).

German inventors are very active in applying for patents which enables them to engage in licensing agreements. The EU Innovation Scoreboard of 2014 shows that they apply for 2.74 patents as part of the Patent Cooperation Treaty (PCT) and 1.2 patents at the European Patent Office (EPO) per billion GDP (European Commission, 2014b). EU-28 averages are 1.98 patent applications for the former and 0.92 patent applications for the latter. Germany is also significantly above EU-28 averages in the usage of community trademarks and community design protection. These protection instruments do not protect a particular technology but can allow a firm to develop a unique brand based on words, slogans or designs which cannot be copied by competitors. Germany had 7.9 community trademarks per billion GDP in 2012 (EU-28: 5.91) and 7.42 protected community designs (EU-28: 4.75) (European Commission, 2014b).

Focusing on the demand side for external knowledge, 12.1% of all firms in Germany (CIS industry selection) have acquired external knowledge (e.g. through licensing) and spent a total of €2.14b in 2012 (ZEW, 2014). The size of expenditures is significantly smaller than for external R&D which is largely not traded on markets because it requires a contractual agreement between partners (2012: €12.3b). Both numbers are significantly smaller compared with what firms invest into machinery and equipment for their innovation activities (2012: €37.8b). Machinery and equipment can embody novel knowledge in itself and its functions.

Compared with 2008 both the share of firms acquiring external knowledge in Germany (2008: 18%) and their expenditures (2008: €3.4b) have decreased significantly (ZEW, 2014). A possible explanation can be the increase in innovation collaborations (see section 4.4 of this report below). License and patent revenues from abroad (0.64% of GDP) are also below EU average (0.77% of GDP) but have been increasing slightly (3.3%) in 2013 (European Commission, 2014b).

Major policy initiatives in Germany have been directed at increasing supply and demand on markets for technology (see also section 4.4 of this report). On the supply side the programme "Protection of Ideas for Commercial Use" ('Schutz von Ideen für die Gewerbliche Nutzung SIGNO, <link (12/2014)>) of BMWi targets 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 (<link (12/2014)>) shows that SIGNO has led to 542 patent applications, 530 patent sales and 375 licensing agreements among other outcomes since 2008. The report concludes that the programme has performed well in creating awareness and momentum for commercialization strategies but requires adaptations to the needs of various stakeholder groups (Kulicke et al., 2014).

On the demand side, Technology Alliance ('TechnologieAllianz,' <link (12/2014)>) of BMWi provides an online platform for the commercialization of knowledge from universities and research organizations. TechnologieAllianz bundles technologies on offer in one online location, secures IPR rights and offers assistance from trained consultants with industry/technology expertise. TechnologieAllianz also offers technologies from external partners for which it provides quality assurance. TechnologieAllianz has currently 28

members. Among those are individual universities, research organizations (e.g. Fraunhofer patenting and licensing) as well as patent organizations for Laender universities (e.g. for 28 univesities in Bavaria "Bayerische Patentallianz"). TechnologieAllianz is member of the international Alliance of Technology Transfer Professionals (ATTP) <link (12/2014)>. Otherwise there is little information available about the coordination of market platforms for technology internationally.

4.4 Knowledge transfer and open innovation

The creation of innovations in most modern firms is increasingly a networked activity with external partners. This is in contrast with traditional models of innovation in which all relevant knowledge leading to innovation has been produced by a firm's own R&D department. This paradigm of 'closed' innovation is increasingly replaced by more open approaches to innovation. Within these open innovation models firms increase their innovation performance by combining their own knowledge with the knowledge of external partners such as universities or suppliers. The advantages of this open approach stem from the ability to draw from richer pools of knowledge which combine competences from various fields. Typically, this enables the creation of much more novel innovations and/or reduces the time and investments needed for doing so. However, this also requires that firms find available knowledge efficiently and that they can transfer it safely. Especially the latter requires an effective and efficient system of intellectual property rights (IPR).

Institutionally, Germany is well prepared for benefiting from the open innovation trend. Its IPR system is well developed. Park (2008) provides an internationally comparable index for how well a country's patent system performs along a comprehensive list of dimensions: the coverage of what can be patented, the length of the protection, the breadth of protection rights and their enforceability as well as how well the system performs within international patent treaties. Germany reaches an index value of 4.66 out of a maximum of five in the last available year 2005 (for comparison US 4.88). Universities, companies and inventors can receive government support for protecting their intellectual property to make it safe to exchange with other partners in programs such as SIGNO from BMWi (<link (12/2014)>). SIGNO ties into the 'TechnologieAllianz' platform which offers intellectual property from public research for sale to private businesses (<link (12/2014)>). However, the most recent EU Innovation Scoreboard sees Germany only in seventh spot in Europe when it comes to linkages and entrepreneurship (European Commission, 2014b). However the Scoreboard also shows that Germany's R&I system performs significantly above EU-average with regard to collaborations of innovative SMEs and scientific co-publications between science and private firms. Both indicators have also increased in the last year by 7.2% and 1.1% respectively.

The German Federation of Industrial Research Associations (AiF) „Otto von Guericke" plays a crucial role in connecting research and innovation. It manages a network of 100 research associations for applied research across business sectors and including research organizations and universities. It has roughly 50,000 members from business and has provided public funding of €490m in 2013 mostly on behalf of BMWi (<link (12/2014)>). Recent policy initiatives have emphasized closer linkages between science and industry in Germany. Among those are the Leading-Edge Clusters initiative ('Spitzencluster') from BMBF in which the federal government has invested €360m since 2008 (<link (12/2014)>) and the initiative 'Unternehmen Region' of BMBF <link (12/2014)>. They encourage firms

and universities in regional clusters to identify core competencies as well as their commercial exploitation. The geographical proximity 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. 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 <link (12/2014)>. Other policy initiatives are directed at creating unified innovation strategies for particular topics such as electric mobility ('Nationalen Plattform Elektromobilität', BMUB, 2012 <link (12/2014)>) or encouraging collaboration with and among particular organizations especially medium sized firms, e.g. 'Zentrales Innovationsprogramm Mittelstand (ZIM)' (<link (12/2014)>).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).

Focusing on Open Innovation performance indicators at the firm level, the results of the Community Innovation Survey for Germany provide more detailed insights into the collaboration behaviour of German firms (ZEW, 2014). Latest survey data is available for the time frame 2010-2012 (CIS2012). 23.7% of all innovative firms in Germany had an innovation-related collaboration during this timeframe. Universities are the most commonly chosen partner for such collaborations. 14.3% of all innovative firms had innovation collaborations with a university compared with 11% in EU-27 (EUROSTAT). Almost half of the firms in Germany (7%) found the collaboration also as the most valuable one for their own innovation activities. Hence, there is evidence for both participation and value in innovation collaboration between firms and universities in Germany. This link is even stronger for collaborations with government owned or public research institutions. The participation rate is lower. Only 2% of innovative firms had such a collaboration but almost all of them rate them as their most valuable collaboration. Part of the explanation for this successful partnership can be that Germany has non-university research organizations which are dedicated to application oriented research, especially the Fraunhofer society (<link (12/2014)>). In terms of historical comparisons, the participation of private firms in innovation collaborations is up. In the timeframe 2006-2008 (CIS2008) 21% of innovative firms had a collaboration and 11% with universities. This implies an increase from CIS2012 of 2.7% for the former and 3.3% for the latter.

German universities, too, show an increased interest in collaborations with private firms. In a recent survey of the business association Stifterverband among the leadership of universities in Germany ('Hochschul-Barometer 2013', <link (12/2014)>) 93% of universities would like to increase their collaborations with firms. Universities see such collaborations mostly as opportunities to increase their financing. Among the challenges for more university-business collaborations the report finds differences in time and risk perspectives (85% of respondents), project cost coverage (82%) and costs for finding fitting partners (74%) as the most important ones (Stifterverband, 2014). Universities can also have the commercial potential of their research results evaluated as part of the VIP project of BMBF (<link (12/2014)>). The large research organizations have initiatives with a similar purpose such as the Helmholtz Validation Fund (<link (12/2014)>) or Max-Planck-Innovation (<link (12/2014)>). Additionally, BMBF funds research in technology colleges ('Fachhochschulen') with €40.7m in 2012 (<link (12/2014)>). Research in such universities is especially geared application and the needs of business.

Focusing on innovation collaborations within the private sector, in the period 2010 till 2012 9.8% of innovative firms had innovation collaborations with suppliers, 8.7% with clients, 4.7% with competitors or firms in their own industry and 9.9% with consultants or commercial labs. The comparable numbers from the period 2006-2008 are 7% of innovative firms had collaborations with suppliers, 11% with clients, 5% with competitors and 6% with consultants and commercial labs.

In sum, the shift towards open innovation in Germany has mostly worked through increased collaborations with universities, suppliers and consultants or commercial labs.

4.5 Innovation framework for SMEs

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, 2014d). At the same time many of these SMEs (often time referred to as 'Mittelstand') are highly specialized, innovative and active on export markets. German SMEs are substantially more likely to perform in-house R&D and engage in collaborations than the average SME in EU-28 (European Commission 2014b). This is also reflected in innovation outputs. SMEs in Germany are almost 50% more likely than EU-28 average to introduce products and processes but also more marketing and organizational innovations (European Commission 2014b).

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 (see also section 2.2 of this report), Digital Agenda 2014-2017 (see section 3.3 of this report) and SIGNO (see section 4.3 of this report). Several innovation policy instruments are particularly directed at SMEs. Among the most important ones are (BMBF, 2014a):

- Central Innovation Programme for SMEs ('Zentrales Innovationsprogramm Mittelstand' ZIM, <link (12/2014)>):
  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 commercialization 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 (<link (12/2014)>). 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 (<link (12/2014)>).
- ERP-Innovation Programme ('ERP-Innovationsprogramm,' <link (12/2014)>):
  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 commercialization of the underlying innovation. Loans in the amount of €1.329m for 629 applications have been provided in 2014.

- KMU-innovativ (<link (12/2014)>):
  KMU-innovativ is an initiative by BMBF targeting excellent innovation with high commercialization potential of SMEs within the technology fields of biotech, medical devices, ICT, nanotech, production technology, technology for resource and energy efficiency. KMU-innovativ provides counselling to potential applicants and a fast application process which is also attractive to small SMEs. The programme provided €100m in grants in 2012 either to SMEs directly (60%) or their research partners.
- German Federation of Industrial Research Associations ('Arbeitsgemeinschaft industrieller Forschungsvereinigungen' AiF) „Otto von Guericke" (<link (12/2014)>):
  AiF was founded in to 1954. Its primary purpose is to bridge basic research and industrial application of innovation. AiF manages a network of 100 research associations for applied research across business sectors including research organizations and universities. It has roughly 50,000 firm members (mostly SMEs) and has provided public funding of €490m in 2013 mostly on behalf of BMWi.

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, 2014a). Besides, Germany has a dedicated national contact point for SMEs (<link (12/2014)>) which provides information as well as coaching and mentoring also for application for Horizon 2020.

In sum, the innovation framework for SMEs in Germany is broad and versatile. Many policy initiatives stress simplicity and flexibility to account for resource constraints and heterogeneity which are characteristic for SMEs.

The Global Entrepreneurship Monitor compares the risk of failure perception in multiple countries. Risk of failure is defined in this report as "Percentage of 18-64 population with positive perceived opportunities who indicate that fear of failure would prevent them from setting up a business" (<link (2/2015)>). This risk of failure perception among potential entrepreneurs is at 40% in 2014 and only slightly down from 2011 (42%) (<link (2/2015)>). At this level the perception in Germany is almost identical to EU-28 average (40.7%), close to Denmark (41%) but higher than in Sweden (36.5%) and Finland (36.8%), among the other innovation leader member states as defined by the EU Innovation Scoreboard 2014 (Global Entrepreneurship Monitor, 2015). For comparison, the value for the United States is 29.7%. Focusing on opportunities for the reorganization of companies, German insolvency law ('Insolvenzordnung,' InsO, <link (12/2014)>) stems from 1999. The law provides the opportunity to find flexible and economical solutions between creditors and debtors to preserve the company. Both parties can take the initiate to file for insolvency in court. In Germany, more than 80% of filings originate from the indebted firm (Egeln et al., 2010). The court appoints an insolvency administrator ('Insolvenzverwalter') to organize the insolvency process. The insolvency law provides the opportunity to design an insolvency plan ('Insolvenzplan') which lays out the current state of the firm but also what

steps would be necessary to preserve it (<link (12/2014)>). All parties need to agree on the plan.

In principle the insolvency plan should make it more likely to preserve the firm. A recent study of BMWi from 2010 (<link (12/2014)>) finds, however, that the option of an insolvency plan is rarely used or ineffective especially for young firms. The study cites three primary reasons (Egeln et al., 2010): insolvent companies are not aware of the opportunities from an insolvency plan, insolvency administrators have little incentive to invest time into developing an insolvency plan and judges have little economic expertise to evaluate it.

4.6 Venture capital markets

Young and especially knowledge-intensive companies struggle with securing external financing. Large parts of R&D investments are required for the wages of engineers and scientists as well as for highly specialized equipment, e.g. labs. Hence, such investments generate very little collateral for traditional bank financing. Young and high-tech firms are therefore often times limited to their own cash flows and equity financing to fund R&D. The availability of venture capital investors is therefore critical.

Such investors have expertise in selecting and monitoring particularly promising firms. They can also advice the often times inexperienced management of young firms professionally, e.g. on commercialization and staffing strategies, or provide access to professional networks.

Within the European Union Innovation Scoreboard of 2014 Germany is generally classified as an innovation leader but its venture capital market is significantly smaller than the average of EU-28 and of other innovation leaders. What is more, the share of its venture capital market as a percentage of GDP is declining (European Commission, 2014b): In 2012 the venture capital market in Germany was 0.05% of GDP, compared with 0.06% in 2009 and 0.08% as the average of all EU-28 countries. Other innovation leader EU member states, such as Denmark (0.09%), Finland (0.1%) and Sweden (0.08%) have significantly larger venture capital markets.

The European Private Equity & Venture Capital Association (EVCA) compiles an annual yearbook which provides insights into the structure of venture capital funding (EVCA, 2014). Venture capital financing can be classified into three primary stages. Seed financing is provided for the development and evaluation of a business concept before the firm is established. Start-up financing covers the stage at which the firm is established and later stage financing would be typically provided once the firm is already in existence for multiple years. 174 concepts have received seed financing in 2013 in Germany (€43.6m), 494 firms secured start-up financing (€355.4m) and 174 firms received later stage financing (€257.6m). Comparing these numbers to the averages of all European countries covered by EVCA in the same year provides some interesting similarities and differences. The bulk of venture capital investments (roughly 60% of firms and amounts) goes to start up financing in both Germany and Europe. Comparatively more firms in Germany receive seed financing (21% of venture capital financed firms and 7% of venture capital provided) compared with Europe (13% of venture capital financed firms and 3% of venture capital provided). Conversely, later stage venture capital financing is less pronounced in Germany (21% of venture capital financed firms and 39% of venture capital provided) when

compared with Europe as a whole (29% of venture capital financed firms and 43% of venture capital provided). In sum, the Germany venture capital market is geared towards seed investment.

Crowdfunding (or crowd investing) is growing in Germany and is estimated to reach €22m in 2014 or 3% of venture capital investment in 2013 (EFNW, 2014). BMWi considers a reliably and moderately structured regulatory framework for crowd investments to be of crucial importance .In its draft for a new law on investor protection the federal government has therefore proposed exceptions for small, crowd investments from regulatory burdens (i.e. mandatory reporting to investors and related liabilities) under certain conditions . The legislative procedure is expected to be finished in June 2015.

In terms of policy initiatives to foster the venture capital market in Germany, both active approaches in which government acts as a venture capital investor and passive approaches in which the government incentivizes private investors are present. Many of the policies target entrepreneurship in high-tech sectors and therefore overlap with science-based entrepreneurship (see section 4.2 of this report). Among the most important policy initiatives are (BMBF, 2014a):

- High-tech Start-Up Fund ('High-Tech Gründerfonds', HTGF):
  HTGF is an investment fund for technology start-ups of BMWi, government owned development bank KfW as well as industrial partners. Its initial investment endowment in 2005 was €272m. Investments are limited to €500,000 and the fund provides access to coaches as well as venture capital investors for future investment rounds. The HGTF portfolio encompasses 330 investments (March 2014).
- ERP-Startfonds:
  ERP-Startfonds provides early stage equity financing for R&D intensive firms. The fund can invest up to €5m in a particular firm and always acts as a co-investor, i.e. firms have to have a private lead investor whose investment is matched by ERP-Startfonds. ERP-Startfonds has financed roughly 500 technology-intensive firms since its creation.
- INVEST – Zuschuss Wagniskapital:
  INVEST provides incentives to private investors such as Business Angels who can receive 20% of their investment into a young, innovative firm back from the federal government if they hold their initial equity investment for three years. INVEST started in 2013 and has so far approved 350 cases (April 2014).

4.7 Innovative public procurement

Public procurement has substantial potential to trigger innovation in private firms. Recent analyses for Germany show that public procurement is equally 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. The Expert Commission on Research and Innovation (EFI) recommends in its evaluation report of 2013 to increase public procurement for innovation (EFI, 2013). 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.

A central step in this direction is the creation of a competence centre for innovation oriented procurement ('Kompetenzzentrum Innovationsorientierte Beschaffung,' KOINNO, <link (12/2014)>) (BMBF, 2014a). KOINNO is a collaboration of BMWi with the Association Materials Management, Purchasing and Logistics ('Bundesverband Materialwirtschaft, Einkauf und Logistik e.V.,' BME). The latter represents roughly 9,000 member firms from materials management, purchasing and logistics. KOINNO serves as an information and consultation centre for innovation procurement in a large range of public institutions. KOINNO provides for example guidelines such as for the procurement of innovative products, process or services in the R&D relevant pre-competitive stage (<link (12/2014)>).

Other initiatives to overcome fragmentation in public procurement and establish innovative principles in the process include the Alliance for Sustainable Procurement ('Allianz für nachhaltige Beschaffung') of BMWi. Experts provide intelligence and advice on public procurement within the alliance. A comprehensive public procurement process is for example outlined for electric mobility as part of the alliance in a report of 2013 (<link (12/2014)>).

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 ('Elektromobilitaet in der Stadt- und Verkehrsplanung', <link (2/2015)>). 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 (<link (2/2015)>).[12]

In terms of available data, European Public Sector Innovation Scoreboard 2013 (EPSIS) uses three indicators to compare government procurement practices and their effect on firm innovation (European Commission, 2013):

- Government procurement as a driver of business innovation
- Government procurement of advanced technology products
- Importance of innovation in procurement

Germany ranks slightly above EU averages in the first two dimensions but significantly below EU average on the dimension of the importance of innovation a procurement. Results of an interim report from a survey on public procurement of KOINNO (<link (12/2014)>) point in a similar direction with cost considerations as primary procurement principles.

In sum, fragmentation of procurement initiatives is still a major challenge for public procurement for innovation in Germany. Progress towards the collection of data on procurement approaches and effects as recommended by the 2013 report of the Expert Commission on Research and Innovation (EFI, 2013) is currently not observable.

[12] Projects include: „Modellregionen Elektromobilität", „Schaufenster Elektromobilität", „Nationales Innovationsproramm Wasserstoff- und Brennstoffzellentechnologie".

5. Performance of the National Research and Innovation System

5.1 Performance of the National Research and Innovation system

The EU Innovation Union Scoreboard 2014 classifies Germany as an innovation leader, i.e. Germany's innovation performance has been significantly above EU-28 averages (European Commission, 2014b). Table 3 below provides selected indicators. Germany is ranked third overall behind Sweden as well as Denmark and ahead of Finland. Those countries are the other innovation leader member states. Germany has traded places with Denmark compared to their performance in the EU Innovation Union Scoreboard 2013.

The EU Innovation Union Scoreboard 2014 allows also a more detailed examination of the innovation process in Germany, i.e. inputs and outputs (European Commission, 2014b). Focusing on inputs into the innovation process, Germany has increased its performance with regard to educating and training human resources. Germany continues to produce significantly more new doctoral graduates (2.8 per 1000 population aged 25 – 34) compared to EU-28 average (1.7). The share of population with tertiary education is still below EU-28 averages (31.9% compared with 35.8%) but has improved by 2.9% compared with the EU Innovation Union Scoreboard 2013.[13]

The research system in Germany is performing extremely well in terms of the number of international scientific co-publications (more than double compared with the EU-28 average). Measured through citations, the quality of scientific publications is only slightly above EU-28 average. Interestingly enough, the biggest deficit of Germany within the EU Innovation Union Scoreboard 2014 originates from the ability to attract doctoral students from outside the EU. In this indicator Germany reaches hardly half of the average performance of EU-28 and the value is virtually unchanged compared with the 2013 scoreboard (European Commission, 2014b).

Similarly the availability of financing for R&I is mixed. R&D expenditures of the public sector are significantly above EU-28 average and continue to grow annually (+3.4% compared to the 2013 scoreboard). Business sector investments in R&D are almost 50% higher compared with the average of EU-28 and have grown, too (+1.6%). Firms in Germany are also significantly more likely than the average firm in EU-28 to conduct research together with universities or research institutes as evidenced by the number of joint scientific publications. The amount of venture capital funding, though, is only at 80% of EU-28 average and declining (-1.6%).

The EU Innovation Union Scoreboard 2014 also documents strong R&I performance of Germany in terms of innovation outputs. Germany outperforms EU-28 averages in patent applications (PCT and EPO) in general and also in particular technology fields addressing societal challenges (climate change mitigation; health). While statistics on applications to national patent office are not always comparable across countries, they can provide some indication of technological development activities that are not captured by EPO/PCT data. In Germany 234,521 patent applications were made at the EPO in the period 2000-2010. 177,632 patent applicants took the PCT route.

[13] Education Benchmark 2020 on tertiary education attainment includes post-secondary education for Germany (ISCED 4). Including ISCED 4, the 2012 rate for Germany is 43.3%.

The National Patent Office received 615,170 applications in this period (these three figures are based on fractional counting).[14] The strong output performance is also reflected in the technological sophistication of exports. The share of medium and high-tech export goods and knowledge intensive services on total goods or service exports exceeds EU-28 averages.

An exception to this positive output performance is the indicator on the revenues from abroad originating from licenses and patents. In this category, Germany is clearly below EU-28 average, however it has improved compared with the previous report (+3.3%).

On average in 2012, Germany produced 16.93 publications per 10,000 inhabitants, well above the EU-28 average (13.8). These publications are also internationally orientated with 46.3% of publications internationally co-published. In 2012, Germany had about 783.6 international scientific co-publications per million population. This number is significantly lower than in the other innovation leader member states identified by the EU Innovation Scoreboard 2014 Sweden (1,791.1), Denmark (1,915.8) and Finland (1,489.8). In the period 2002-2012, almost 13% of the German scientific publications were in the top 10% most cited publications worldwide in comparison with 11% of top scientific publications produced in the EU28 (Science Metrix, 2014).[15] The share of public-private co-publications in Germany is 3.1% in the period 2008-2013 against 2.8% for the EU28.[16]

Within the group of innovation leader member states of Sweden, Denmark and Finland (as defined by the EU Innovation Union Scoreboard 2014), Germany has consistent advantages based on the innovativeness of its SMEs both in terms of the likelihood of engaging in innovation activities and achieving innovation outcomes (new products/processes as well as marketing/organizational innovations). German firms invest also more in non-R&D innovation activities, e.g. for market introduction, and use more community trademarks. Both indicators suggest that innovation in Germany is less technology and hence patent-intensive than in the other innovation leader member states. German firms also generate larger shares of sales from innovations (especially compared with Sweden).

Focusing on consistent deficits of the German R&I system compared to the other three innovation leaders, Sweden, Denmark and Finland have all significantly higher shares of population with tertiary education. Their research systems are also more internationalized in terms of international co-publications and they receive more license and patent revenues from abroad. These differences may be partly explained through differences in country size compared with Germany. Public and business R&D expenditures are lower in Germany compared with the other innovation leaders. The three other innovation leaders have also larger venture capital markets. Interestingly, innovation seems to be more collaborative in the other innovation leader member states. Germany has comparatively lower rates for SMEs engaged in collaborations and public-private co-publications.

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[14] Data is derived from INCENTIM KU Leuven, Universita Commerciale Luigi Bocconi, KITeS and Technopolis Consulting Group, 2014, Measurement and analysis of knowledge and R&D exploitation flows, assessed by patent and licensing data.

[15] These publication data are based on Elsevier's Scopus database. ScienceMetrix, Analysis and Regular Update of Bibliometric Indicators, study conducted for DG RTD. They represent an update of the data displayed in the table below. See also http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=other-studies

[16] Scival 2014, Scopus based publication indicators derived from Elsevier's SciVal platform, www.scival.com last accessed December 2014.

Table 3 Assessment of the Performance of the National Research and Innovation System

1. ENABLERS	Year	DE	EU
Human resources			
New doctorate graduates (ISCED 6) per 1000 population aged 25-34	2011	2.80	1.70
Percentage population aged 30-34 having completed tertiary education	2012	31.90	35.80
Open, excellent and attractive research systems			
International scientific co-publications per million population	2012	745.70	343.15
Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	2009	11.64	10.95
Finance and support			
R&D expenditure in the public sector as % of GDP	2012	0.96	0.75
Venture capital as % of GDP	2012	0.05	0.08
2. FIRM ACTIVITIES			
R&D expenditure in the business sector as % of GDP	2012	1.95	1.31
Linkages and entrepreneurship			
Public-private co-publications per million population	2011	75.50	52.84
Intellectual assets			
PCT patent applications per billion GDP (in PPS€)	2010	7.51	3.92
PCT patent applications in societal challenges per billion GDP (in PPS€) (climate change mitigation; health)	2010	1.49	0.85
3. OUTPUTS			
Economic effects			
Contribution of medium and high-tech product exports to trade balance	2012	9.24	1.27
Knowledge-intensive services exports as % total service exports	2011	55.59	45.26
License and patent revenues from abroad as % of GDP	2012	0.40	0.59

Source: European Commission, IUS Database (2014).

5.2 Structural challenges of the national R&I system

The EU Innovation Union Scoreboard 2014 indicates that the German R&I system performs well within Europe. Germany differs significantly from the other innovation leader member states because of its size and federal structure as well as the industry composition of the economy. The particular situation of the German R&I system provides many opportunities which may turn into challenges if they are not addressed. Based on this report and the report of the Expert Commission on Research and Innovation (EFI, 2014) the following major opportunities and challenges can be identified:

- Coordination of federal and Laender governments in the funding of universities and non-university research organizations:
  The German R&I system has benefited significantly from the joint initiatives of federal and Laender governments for research and education often times summarized as "pacts" (Pact for Research and Innovation 'Pakt für Forschung und Innovation,' Higher Education Pact 'Hochschulpakt,' Initiative for Excellence 'Exzellenzinitiative'). Some of the positive effects are an increase in international competitiveness of research, more and attractive PhD schools ('Graduiertenkolleg'), thematic focus on leading edge clusters, budget expansion and security for non-university research organizations as well as an expansion of student capacities.

Agreements between federal and Laender governments have been reached to extend the pacts and the legislative process has been concluded to allow the permanent involvement of the federal government in funding higher education (<link (12/2014)>).
This development is positive and will strengthen the competitiveness of the German R&I system as a whole. It will also increase the degree of differentiation between universities. Success of the extended pacts will depend on the quality of implementation. Universities should be able to develop and compete based on individually developed concepts. Concept development and enhancement can be facilitated by increases in the basic funding. Top universities with attractive research environments can attract international talent and increase the visibility of R&I in Germany as a whole. They will also require flexibility in providing attractive teaching conditions given that the average teaching load for German professors is comparatively high.

- Effective evaluation and improvement of innovation policies:
  The effectiveness of the German R&I system can be improved through further steps towards effective evaluation which can unlock performance potentials. In this regard, evaluation procedures should be institutionalized and performed before, during and after policies are implemented (there is very little ex ante evaluation in Germany, most evaluation is ex post). Institutionalization can imply that an overarching competence centre, e.g. a chief evaluation office, is created which sets standards for meaningful evaluation processes as well as their refinement and development. Such processes also imply that valid data is collected, stored and reliably analysed.
- Mix of academic and professional skills for R&I:
  The German R&I system has traditionally benefitted from a labour force in which innovation is not exclusively the task of university trained scientists and engineers. Instead, a broad group of employees with human capital acquired through apprenticeships, on the job training and professional experience ('Facharbeiter') has complemented scientific research and discovery in crucial ways. However, in recent years preferences of school students have shifted towards academic skill development in universities. This shift can lead to shortage of crucial human capital in the German R&I system which cannot be taught at universities but require continues involvement and the accumulation of tacit knowledge when interacting with processes, customers etc.
  Hence, the attractiveness of vocational training and apprenticeships should be strengthened through more flexible career paths between professional experience and university education, e.g. through dual education, further vocational training or the recognition of professional experience for university acceptance.
- Business opportunities from the knowledge society:
  The German R&I system benefits especially from the strengths of its medium high-tech sectors such as automotive production, chemicals and machinery/equipment. However, innovative business opportunities within a knowledge society emerge increasingly in high-tech manufacturing and knowledge intensive services, e.g. finance or health. Germany finds itself in intense international competition for developing these sectors from developed as well as emerging economies. Hence, the German R&I system will need to support more entrepreneurship in high-tech manufacturing and knowledge intensive service sectors. This is a challenge given the relative shortage of venture capital in Germany. Then again, positive leverage

effects can emerge from identifying business opportunities from network effects with the highly innovative SMEs in Germany ('Mittelstand') as well as leading firms in medium high-tech manufacturing.

- Internationalization of R&I:
  The German R&I system competes for the best researchers in both public research and business R&D. With regard to the public research, Germany loses more researchers to universities abroad than it can attract from abroad. What is more, it loses many highly research productive and therefore publishing researchers. There are opportunities especially for German researchers abroad to return based on family ties but they will require internationally competitive research and teaching conditions. With regard to the location of R&D centres of businesses, Germany is in intense international competition. Many German firms conduct R&D especially in high-tech sectors outside of Germany. Hence, the German R&I system will need to increase its competitiveness as an international R&D location based on the availability of specialized expertise as well as market opportunities.

The challenges are summarized in Table 4.

Table 4 Policy measures addressing structural challenges in Germany

Challenge	**Policy measures / actions addressing the challenge**	**Assessment in terms of appropriateness, efficiency and effectiveness**
Coordination of federal and Laender governments in the funding of universities and non-university research organizations	Change in constitution for allowing permanent role of federal government in university funding Extension of pacts	Strong political momentum with many new opportunities for the collaboration between federal and Laender governments. Requires planning and management expertise to achieve excellence for the system as a whole.
Effective evaluation and improvement of innovation policies	Establishment of promising pilot projects: BMWi ('Aufbaukreis Foerdercontrolling/Evaluation') Establishment of effective data infrastructure to evaluate university research and teaching through combined institutes	Positive developments with potential for further improvement and broader application.
Mix of academic and professional skills for R&I	Removal of barriers for skilled workers to enter universities	Difficult challenge which will require more government attention.
Business opportunities from the knowledge society	Digital Agenda 2014-2017 Industry 4.0 ZIM, EXIST, etc.	Strong political support for appropriate measures.
Internationalization of R&I	ERA strategy of federal government Action plan international collaboration Internationalization of leading edge clusters DAAD, Humboldt society, etc.	Active political strategy. Success remains to be seen in highly competitive, international environment.

5.3 Meeting structural challenges

The main issues for the German R&I system laid out in the previous section are complex in nature and require integrated, long term policy solutions. The current mix of R&I policies in Germany outlined in this report shows that policy makers are aware of the issues. The challenges are reflected to varying degrees.

With regard to the coordination of R&I policy between federal and Laender governments, R&I policy in Germany has made important progress of changing the constitution for an expanded and permanent role of the federal government in financing higher education. The strict separation of responsibilities has been a limiting factor in R&I policies for some time. The federal parliament has approved the change of the constitution; the other chamber of parliament representing the Laender ('Bundesrat') has approved the change in December 2014 (<link (12/2014)>). The change in constitution facilitates also the implementation of the extension of the pacts to which federal and Laender governments have agreed in October 2014 (<link (12/2014)>). The agreement as well as the change in the constitution signals also that governments are responsive to evaluation bodies such as Expert Commission on Research and Innovation (EFI, 2014) or German Science Council ('Wissenschaftsrat') (<link (12/2014)>).

There are several indicators that the pacts (especially the Initiative for Excellence) have improved the excellence of research in Germany, such as the record number of starting grants from the European Research Council (ERC) for researchers in Germany in 2014 (<link (12/2014)>) or the self-assessment of the heads of German universities (Stifterverband, 2014). However, the same survey ('Hochschul-Barometer 2013') reveals that the concerns for sufficient personnel budgets in German universities increases. A more competitive German research sector may also find it harder to retain excellent researchers and recruit new ones. Visible top talent in Germany is likely to attract job opportunities from abroad with comparatively higher earnings potential and more flexibility in the design of positions (teaching loads, administrative burden). A critical mass of excellent researchers and increased flexibility can create an environment that attracts or retain talents because of the opportunities for development and cross-fertilization. The extension of the pacts is a promising sign but the increased financial involvement of the federal government coincides with strict budget controls of Laender governments ('Schuldenbremse'). The dynamic induced by the pacts will further increase the differentiation among universities but it is currently hard to foresee what the vision for an optimal level of differentiation is.

Focusing on an institutionalization of evaluation processes and procedures, there are promising signals. These include the establishment of a pilot initiative for a dedicated evaluation office at BMWi ('Aufbaukreis Foerdercontrolling/Evaluation') (EFI, 2014) or the planned merger of the German Centre for Research on Higher Education and Science Studies ('Deutsche Zentrum für Hochschul- und Wissenschaftsforschung, DZHW)' with the Institute for Research Information and Quality Assurance ('Institut für Forschungsinformation und Qualitätssicherung iFQ') in January 2016 (<link (12/2014)>). The latter will provide unified source of data for evaluations of both research and education of universities. In other areas, such as public procurement for innovation, it is difficult to identify ex-post or ex-ante evaluation processes which makes it difficult to quantify goals and potentials.

The political will for an optimized mix of academically and professionally developed human capital for R&I is clearly reflected in the coalition agreement of the new federal government (<link(12/2014)>). Then again, the attractiveness of dual, professional education through apprenticeships is decreasing while the share of young population in Germany opting for university education increases (BMBF, 2014d). The share of dual university careers (combining work with university education) is still small but increasing (BMBF, 2014d). Nevertheless, university education is the preferred career strategy for most school students and their parents. Given the substantial number of students not finishing their university studies (28% in 2012; DZHW, 2014) a professional education with the option of entering university later in the career may be a preferable solution. However, there is little indication that existing policies have had an influence on the general preference for university education. The plan of the federal government to reform the law for the "Promotion of Advancement through Training" ('Aufstiegsfortbildungsförderungsgesetz,' AFBG) is a positive signal.

With regard to business opportunities emerging from the knowledge economy in high-tech and knowledge-intensive services, the current policy mix heavily emphasizes such fields. This follows the renewed High Tech Strategy identifying key technological areas in these sectors. The focus on these areas is consistently reflected in programmes such as leading edge clusters or the Digital Agenda 2014-2017. There are also significant initiatives in place to benefit from more interconnected forms of production under the headings of Industry 4.0 or Smart Services which should hold particular performance potentials for highly innovative SMEs in Germany ('Mittelstand'). Science and technology based entrepreneurship receives support from programmes such as EXIST programme in various forms (see chapter 4.2 of this report). Recent evaluations on the dynamic of the ICT sector (BMWi, 2014c) or electric mobility (BMUB, 2012) show progress. However, the important determinant of the availability of venture capital for entrepreneurs is comparatively small in Germany and declining. The government has increased its involvement in the area for example through the High-tech Start-Up Fund ('High-Tech Gründerfonds', HTGF). The most recent initiative for incentivizing private equity investors "INVEST – Zuschuss Wagniskapital" is too early in its implementation to assess effectiveness.

The issue of internationalization of R&I is deeply connected with the structural challenges. A more excellent research environment will attract top researchers to German universities and research institutes. The availability of promising research environments and excellent teams can provide leverage to attract research talents from abroad even if earnings potentials are comparatively lower or teaching loads higher. This should result in more advanced research outputs and excellent students which will in turn be attractive for firm R&D centres. Similarly, vibrant markets for high-tech products and knowledge intensive services as well as cluster of excellence are attractive locations for international R&D centres. The statistics used by EFI suggest that Germany is losing highly productive researchers to universities abroad and firm R&D activities in high-tech sectors to foreign locations (EFI, 2014). However, the policy mix described in this report (e.g. the extension of pacts) suggests that Germany is structurally geared towards increasing its international attractiveness for R&I.

In sum, the mix of R&I policies in Germany shows awareness for structural challenges and opportunities. Federal and Laender governments demonstrate willingness to invest into improved policies and adapt the policy mix dynamically. These developments provide confidence in the future of the German R&I system.

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Annex 2 - Abbreviations

AiF	Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von “Guericke” (German Federation of Industrial Research Associations)
AvH	Alexander von Humboldt Foundation
BERD	Business Expenditures for Research and Development
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMWI	Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)
BMI	Bundesministerium des Inneren
BMU	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit
BMVBS	Bundesministerium für Verkehr, Bau und Stadtentwicklung
BMVg	Bundesministerium der Verteidigung
CDU	'Christlich Demokraische Union'
CHE	Centre for Higher Education
CEWS	Center of Excellence Women and Science
C&C	Charter & Code
ERA	European Research Area
DAAD	Deutscher Akademischer Austausch Dienst (German Academic Exchange Service)
D-A-CH	Deutschland – Austria – Switzerland
DG	Directorate General (of the European Commission)
DESY	Deutsches Elektronen Synchrotron (German electron synchrotron)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DWIH	Deutsche Wissenschafts- und Innovationshäuser
EC	European Commission
ECB	European Central Bank
EFI	Expertenkommission Forschung und Innovation (Experts Commission for Research and Innovation)
EIB	European Investment Bank
EPO	European Patent Office
ERA-NET	European Research Area Network
ERDF	European Regional Development Fund
ESIF	European Structural and Investment Fund
ESF	European Social Fund
ESFRI	European Strategy Forum on Research Infrastructures
ETP	European Technology Platform
EU-28	European Union including 28 Member States
FDP	'Freie Demokratische Partei – Die Liberalen'
FhG	Fraunhofer-Gesellschaft (Fraunhofer Society)
FAIR	Facility for Antiproton and Ion Research
FP / FP7	European Framework Programme for Research and Technology Development / 7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GG	Grundgesetz (Germany's Basic Law)
GOVERD	Government Intramural Expenditure on R&D
GWK	Gemeinsame Wissenschaftskonferenz (Joint Science Conference)
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HES	Higher Education Sector
HGF	Helmholtz-Gemeinschaft Deutscher Forschungszentren (Helmholtz Association)
HRK	Hochschulrektorenkonferenz (German Rectors’ Conference)

HRST	Human Resources in Science and Technology
HTS	High-Tech Strategy
ICT	Information and Communication Technology
ID	Identification
IGF	Industrielle Gemeinschaftsforschung (industrial collective research)
IP / IPR	Intellectual Property / Intellectual Property Rights
ISCED	International Standard Classification of Education
IU	Innovation Union
IUS	Innovation Union Scoreboard
KET	Key Enabling Technologies
MINT	Mathematics, Information technology, Natural sciences and Technology
MPG	Max-Planck-Gesellschaft (Max Planck Society)
NTBF	New Technology Based Firms
NRP	National Reform Programme
NRW	North Rhine Westphalia
OECD	Organisation for Economic Co-operation and Development
PRO	Public Research Organisations
PVA	Patentverwertungsagentur (patent commercialisation agency)
R&D	Research and Development
R&D&I	Research and development and Innovation
RI	Research Infrastructures
RIS3	Regional and/or National Research and Innovation Strategies on Smart Specialisation
RIS	Regional Innovation System
R&I	Research and Innovation
SB	Scoreboard (of not otherwise mentioned here stands for "EU Industrial R&D Investment Scoreboard")
SPD	Sozialdemokratische Partei Deutschlands
S&E	Science and Engineering
S&T	Science and technology
SME	Small and Medium Sized Enterprise
VC	Venture Capital
VDI	'Verein Deutscher Ingenieure' (Association of German engineers)
VIP	Validation of Innovative Potential of Scientific Research
WGL	Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (Leibniz Association)
WR	Wissenschaftsrat (German Council of Science and Humanities)
ZIM	Zentrales Innovationsprogramm Mittelstand (Central Innovation Programme for SMEs)

European Commission
EUR 27309 EN – Joint Research Centre – Institute for Prospective Technological Studies

Title: RIO Country Report Germany 2014

Author: Wolfgang Sofka

Luxembourg: Publications Office of the European Union

2015 – 57 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online),

ISBN 978-92-79-48969-3 (PDF)

doi:10.2791/80342

LF-NA-27309-EN-N

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doi:10.2791/80342

ISBN 978-92-79-48969-3

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