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Research and Innovation Policy in the U.S. and Germany: A Comparison

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Executive Summary

In this policy paper we analyze and compare the research and innovation system in Germany and the United States. After discussing the underlying concepts of science and technology policy and national innovation systems, we introduce the key science and research institutions of both countries. The German research system is shaped by a strong non-university research sector with close links to industrial research (e.g. the Fraunhofer society). The U.S. research institutions feature world-class universities and a large number of federal laboratories. While both countries display a comparable R&D intensity, the structure of R&D spending differs significantly. U.S. research concentrates on military research and specific civil missions like health research, whereas German research is more diffusion oriented.

The German economy is focused on medium high-tech industries and realizes extremely high export shares. A major pillar of German competitiveness is the *Mittelstand* which excels at incremental innovations and features world market leaders in many small niches (*Hidden Champions*). The U.S. economic structure concentrates in knowledge-intensive services and high-tech industries such as IT Services and biotechnology. Further, its international competitiveness relies to a significant share on its vibrant start-ups and spin-offs. These firms have the potential for radical innovations opening up entirely new markets.

An analysis of German and American innovation policies shows that these address the strengths and weaknesses of both innovation systems. For example, German policies put an emphasis on networking between research institutions and project-oriented financing as well as improvements of the education system, whereas U.S. policies feature a R&D tax deduction scheme and support for small firms and start-ups.

All in all, the German and the U.S. innovation system display many complementarities. Nevertheless, the analysis of the countries' strengths permits the identification of best practices which may help to improve both countries' innovation systems. However, research and innovation policies always interact with the national innovation system. Therefore, not all policies which are successful in one country can easily be applied in the other. Finally, we identify common global challenges which imply common goals for Germany and the United States.

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1 Introduction

Both in Europe as well as in the United States the financial and economic crisis of 2008/2009 and the ongoing economic turmoil emphasizes the need for growth oriented policies to be among the top priorities of the political agenda. There is consensus that technological progress and innovations are the most important drivers of sustainable, long-term growth in advanced economies. Furthermore, innovations in many areas such as renewable energies, mobility, communication, and health technologies will also address the environmental and social challenges of today.

Consequently, in both countries policies regarding the broad field of science, technology and innovation are on the top agenda. However, political rhetoric suggests that the motivation and approach to research and innovation (R&I) policies seem to differ between both countries and their leaders:

- *"The United States led the world's economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that is why innovation is more important than ever. It is the key to good, new jobs for the 21st century. That's how we will ensure a high quality of life for this generation and future generations. With these investments, we're planting the seeds of progress for our country, and good-paying, private-sector jobs for the American people."*

  (Barack Obama, August 5, 2009).

- *"If Germany wants to maintain its position as a leader in advanced technologies, if we want to maintain our current level of prosperity, we have to rely on our ability for perpetual innovation- on our ability to do those things that others cannot do. To the extent that we want to live better than others, to that extent we need to exceed others in the realm of invention and development."*

  (Angela Merkel, July 6, 2011).

While President Obama emphasizes the increasingly keener international competition and the relevance of good-paying, private-sector jobs for Americans, Chancellor Merkel aims at preserving Germany's position in the world economy and prosperity in general, already mirroring fundamentally differing approaches to innovation.

The aim of this paper is to give a brief overview of science, technology and innovation policies in the U.S. and Germany, to analyze and compare the main differences and similarities and to identify common future challenges. This paper proceeds as follows. Section 2 presents the economic framework of innovation and R&D. Section 3 provides an overview and comparison of both countries' key institutions regarding science and technology policy as well as key indicators or R&D performance. Subsequently, we briefly analyze both countries' economic structure and innovation performance in section 4. Section 5 discusses selected German R&I policies, whereas section 6 addresses U.S. innovation policies. Building on that, we compare the strengths and weaknesses of both innovation systems in section 7. Furthermore, we discuss common future challenges in section 8. Finally, section 9 concludes.

2 Definitions and Economic View of Innovation

This section will outline the definitions of research and development (R&D) and innovations from an economic point of view. Furthermore, it will briefly discuss the concept of national innovation systems as well as science and technology policy. As a starting point, the following quote underlines that in advanced economies, growth will not come from increased inputs of capital and labor, but from technological innovations:

> *"Just over a hundred years ago, Scientific American reported that economic progress in Manhattan was near an end because the island could support only a limited number of horses. (...) In the long run, economic growth comes not from cramming more horses onto your island, or more factories into your rust belt, or even more information onto your servers, but from technological breakthroughs—not from more of the same but from the new and previously unthinkable"* (Landsburg 2001).

2.1 Research and Development

According to the widely accepted OECD definition (2002), research and development (R&D) activities comprise "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". R&D is a term covering three activities:

- Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.
- Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
- Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

The main indicator used for international comparisons is gross domestic expenditure on R&D (GERD). This consists of the total expenditure (current and capital) on R&D by all resident companies, research institutes, universities and government laboratories, etc. It excludes R&D expenditures financed by domestic firms but performed abroad.

2.2 Science and Technology Policy

The notion behind science and technology policy is simply the inclusion of science and technology decisions and activities into the network of political, economic and social decisions. A widely used definition of science and technology is given by the OECD (1971):

> “Science and technology policy is concerned with the allocation of resources for scientific research and technical development. It includes government encouragement of science and technology as the roots of strategy for industrial development and the economic growth, but it also includes the use of science in connection with problems of the public sector. Because of the close association of basic research with higher education, this aspect of science policy is difficult to separate from overall educational policy and from (scientific and) technical (workforce) policy.”

2.3 Innovation Systems

An innovation as defined by OECD (2005) goes beyond R&D. It is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. Innovation activities are all scientific, technological, organizational, financial and commercial steps which lead to the implementation of innovations. Some innovation activities are themselves innovative; others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.

The fundament of innovation after all is a creative and interactive process that goes far beyond education and R&D and occurs within a system of norms, institutional regulations and organizations. Freeman (1987) defined these “national innovation systems” (NIS) as “networks of institutions in the public and private sector whose activities and interactions initiate and diffuse new technologies”. Hence, a national innovation system provides a variety of resources to potential innovators. According to that, a country’s innovation capacity depends on the innovation system and on a country’s social climate for innovation. As defined by the BDI/Deutsche Telekom Stiftung Innovation Indicator, conducted by the DIW Berlin in 2009, among the key areas of innovative capacity are: Education, R&D, Networking, Financing, Implementation, Competition as well as Demand for Innovation. In this context, education represents the supply of qualified personnel for all different stages of the innovation process, especially for research. R&D is a main requirement for innovations and the output of R&D is measured in patents and publications. Networking assumes that cooperation and interaction between research institutions and firms provide economic advantages for all actors. Financing of innovation is important all along the innovation process. Thereby public and private funding is equally important. In order to reach the goal of realization of innovations it is necessary to bring new products or services on the market. This is described by implementation. Strong competition is an incentive for efficiency and the desire to be the first to offer a new product or service. Finally, demand as the last sub-indicator is the connection between developer and user. Only if there is demand from customers, firms are willing to invest in innovation activities. In addition the social climate for innovation describes attitudes and values of citizens.

2.4 Innovation Policy and its Justification

Innovation policy aims at improving the innovative output of a country or region. The term innovation policy describes all measures that strive for developing “an optimal mix of policies and instruments for stimulating innovation performance that takes into account possible positive and negative interactions among instruments and ensures balanced support for the range of challenges faced by a nation’s innovation system” (OECD 2010a).

Both Germany and the United States spend a significant share of tax payers' money on science, technology and innovation policies and on the promotion of innovative activities. Such interventions are justified if they lead to more innovations, higher growth and welfare compared to a situation where the government would refrain from implementing these policies.

Economic theory suggests that there is indeed a strong case for state intervention in innovation as well as science and technology policies because pure market outcomes are subject to market failures and prove to be suboptimal. The classical approach emphasizes different aspects of market failures. An important problem is the intrinsic public-good characteristics of information. Firms fail to invest in R&D – although this would lead to innovation – since they cannot completely appropriate the resulting profits. From an overall economic perspective, however, such investments in R&D would result in welfare gains. In addition, beyond the public-good characteristics of R&D, imperfections in financial markets, a shortage of skilled researchers and engineers, or a lack of information about opportunities arising from scientific and technological advances in other parts of the economy or other countries can mean that gainful innovation projects will not be undertaken in the absence of policy intervention. Another approach emphasizes the system nature of innovative processes and therefore focuses on the effectiveness of the national innovation system. Metcalfe (2005) suggests that the primary role of the state should be to foster the emergence of an effective NIS. Arnold (2004) identifies several different failures of national innovation systems which require state interventions. These system failures include failures of institutions like underperforming universities, network failures such as suboptimal flow of knowledge between research institutions and firms, framework failures like a bad regulatory framework or innovation impeding social values and policy failures such missing policy evaluation and no learning processes.

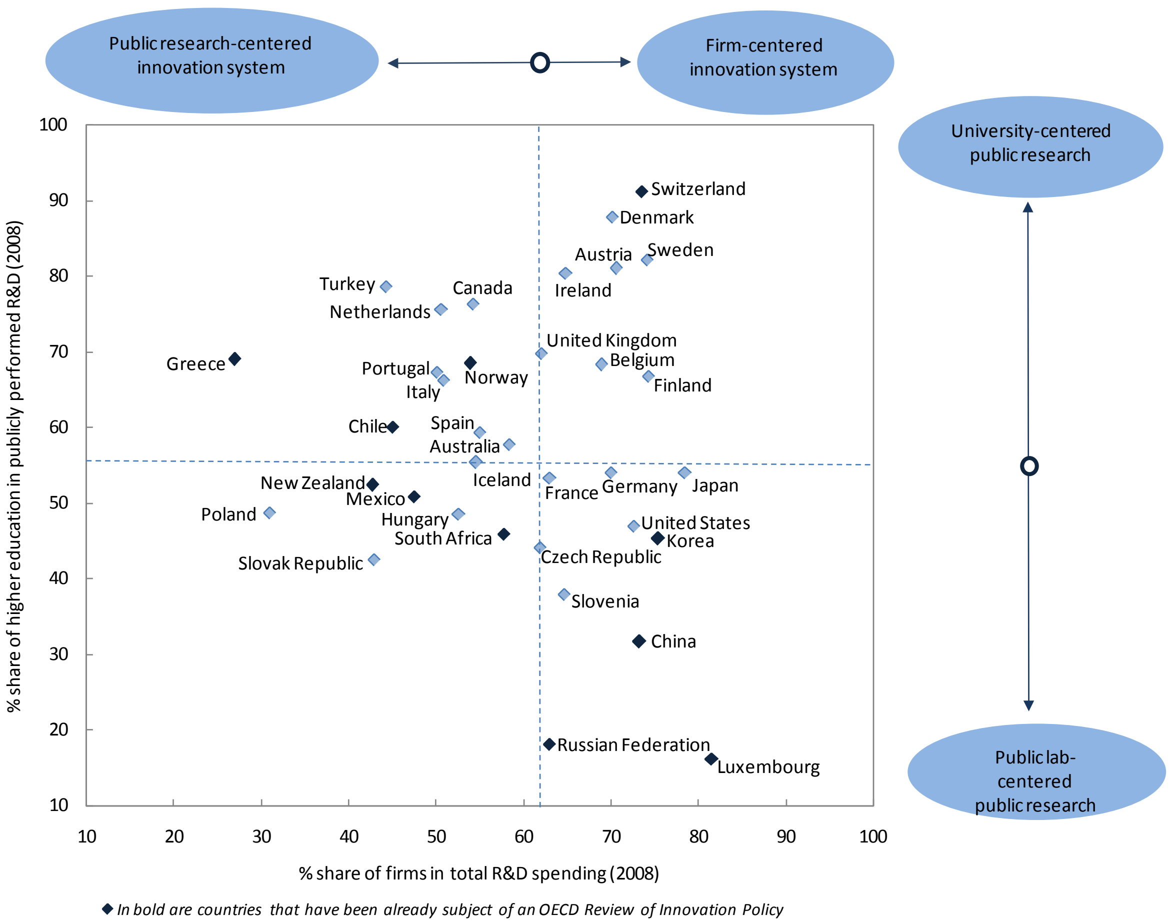
3 Key Institutions and Organizations for Science and Technology Policy

This section gives an overview of the German and American research and innovation system focusing on the key institutions for science and technology policy.

At first glance, OECD statistics suggest that the institutional setup of research and innovation in Germany and the U.S. share some key characteristics.

Figure 1 gives an overview of a number of national innovation systems defined by the share of firms in total R&D spending (horizontal axis) and the share of higher education (i.e. primarily universities) in public R&D. Both the U.S. and Germany display a firm-oriented innovation system and a public-lab-oriented research landscape. However, both countries are close to the average of both dimensions; particularly Germany is close to the international average.

Figure 1: The Innovation system in Germany and the U.S. in an international comparison



Source: OECD (2009).

However, at a closer look, the institutional setup of research an innovation displays several important differences which will be discussed in the remainder of this chapter.

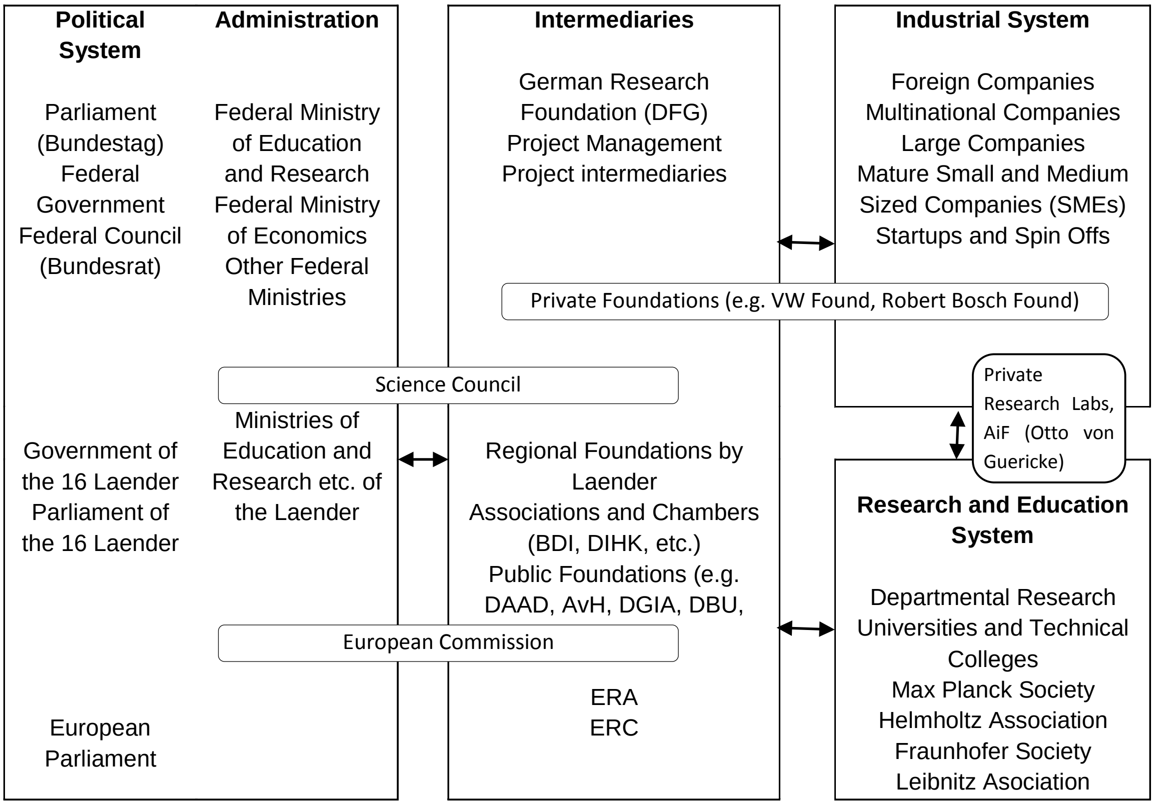
3.1 Germany

In Germany, the research and science policy is a joint task of the federal government and the 16 federal states (Länder). The funding is divided into project and institutional funding. Project funding is granted for individual applications with the goal to support specific research projects of research organizations, firms and universities whereas institutional funding provides basic funding of institutions over a longer period of time.

Figure 2 presents an overview of the key institution of the German innovation system. It arranges the relevant institutions into three main groups:

- The political system: The federal government and state government as well as the European Union.
- Intermediaries like project management organizations and industry associations.
- The research performing sector consisting of private and public institutions performing R&D (e.g. universities) and of the industrial system performing private R&D activities and introducing innovations on the market.

Figure 2: The German Innovation System



Source: Based on Fritsch/Schüller (2010).

The political system

In the German political system, science and technology policies enjoy high priority. As in many other countries, there are two main governmental departments or ministries which focus on science, technology and innovation. These are the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) and the Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie, BMWi). The BMBF mainly concentrates on the setup and design of research programs and the collaboration between universities, other research institutions and firms. In contrast, the BMWi focuses on policies addressing SME and the commercial launch of innovations. Furthermore, other ministries have some specific, relevant competences, such as the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU). Hence, there is no single ministry with comprehensive competences in the field of R&I policies (Fritsch/Schüller 2010).

In addition, there are other important actors in the field of science and technology policy. Firstly, in the federal structure of Germany the states (Länder) are primarily responsible for education and science. Therefore, they play a key role in the education and university system. Furthermore, the European Union is becoming an increasingly important factor in the German research and innovation system. On the one hand, it supports research through its Framework Program for Research, the European Research Council (ERC) and other project-oriented funding. On the other hand the development of the European Research Area (ERA), the Bologna process and other common political projects like the Lisbon process increasingly affect the German research environment.

Due to this decentralized system, the German federal government can influence education policies only in indirect ways, e.g. by providing incentives like the excellence initiative (Exzellenzinitiative). However, in the field of science and technology policy, it is an important actor. One of the main instruments of the federal government is the funding of non-university research institutions. These institutions usually set their research priorities by themselves.

Major policy advisors and councils are the German Council of Science and Humanities (Wissenschaftsrat) and the Commission of Experts for Research and Innovation (Expertenkommission Forschung und Innovation, EFI). The *Wissenschaftsrat* provides advice to the German federal government and the state (Länder) governments on the structure and development of higher education and research. EFI renders scientific advice to the German Federal Government and periodically delivers reports on research, innovation and technological productivity in Germany.

Intermediaries

Project funding and management institutions play an important role in the German science system. A substantial share of public research funding is channeled by intermediary research funding institutions like the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and the German Federation of Industrial Cooperative Research Associations (AiF/IGF) *Otto von Guericke*. Other important research supporting foundations include *Stifterverband für die Deutsche Wissenschaft, Volkswagen Foundation, Thyssen Foundation, Robert Bosch Foundation,* and *Stiftung Industrieforschung*.

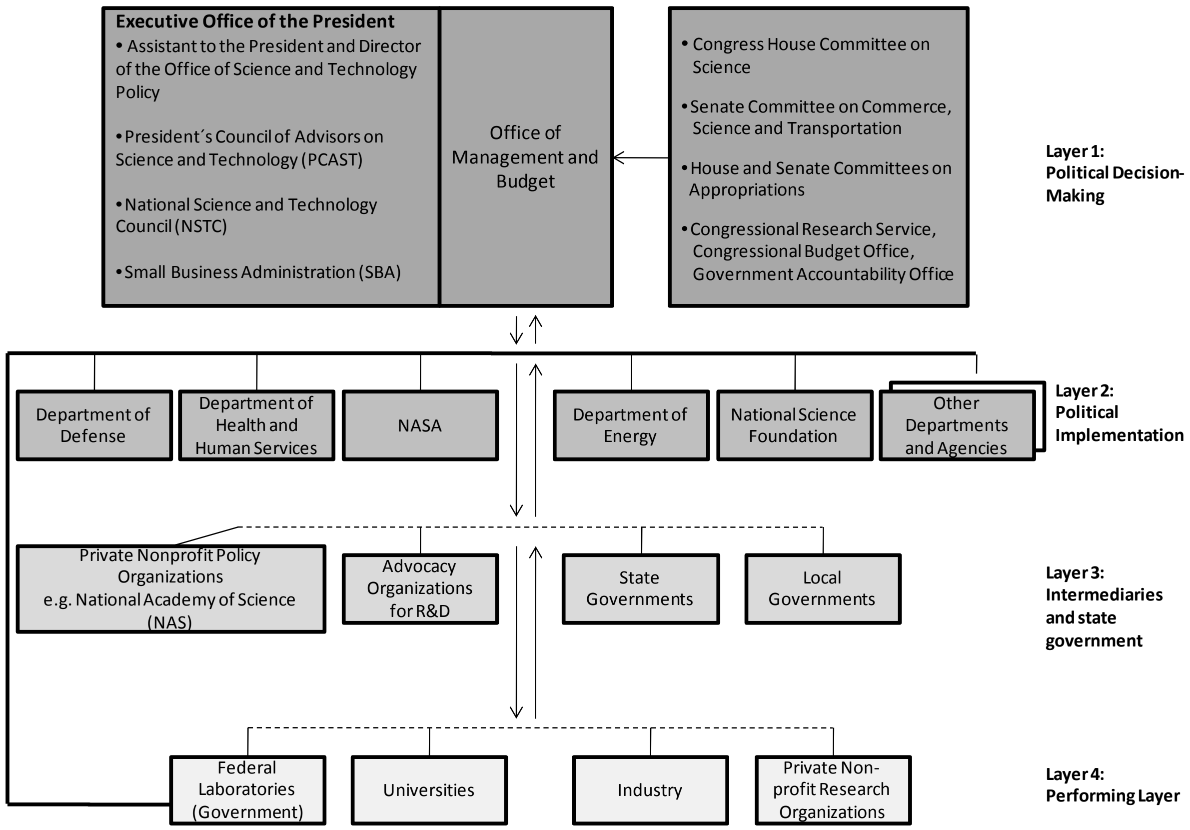
The **research performing** sector is shaped by three major groups of actors:

- A substantial share of R&D and innovative activities is performed by private firms, either completely in-house or in cooperation with other firms and/or public research institutions (see section 3.3 for more detailed data). Generally, German firm sector R&D has a strong orientation on medium-high-technology industries.
- Universities and *Fachhochschulen* (Universities of Applied Sciences) are one of the main pillars of the German research system. There are 415 universities and *Fachhochschulen* in Germany which are mostly publicly funded and organized. The number of private universities is growing, though on a very small scale.
- In an international comparison there is a large number and variety of non-university public research institutions in Germany. The four largest associations are the Max Planck society with focus on basic research, the Fraunhofer society performing applied research and development, the Helmholtz association which concentrates on "big science" like nuclear research, and the Leibniz society serving multiple purposes. Additionally, there are federal departmental research institutions (*Ressortforschungseinrichtungen*), research institution of the Länder and several academies. These institutions attract a substantial part of public funding and additional private project funding.

3.2 United States

The U.S. innovation system is characterized by its large size, diversity, federal structure and competitive orientation. Diverse actors such as government, academia and the private sector are involved in the U.S. innovation system. Figure 3 gives an overview of the U.S. innovation system. Comparable to the overview of the German institutional setup it features the political system, intermediaries, and the research sector.

Figure 3: The U.S. research system



Source: Based on European Commission (2010).

The political system

In the U.S. both the Federal Government and the Federal States are holding the decision making power. The main actors of the Federal Government are the Executive Office of the President and the 15 Executive Departments. Within the Executive Office the Office of Science and Technology Policy (OSTP) is the most important unit. OSTP is responsible for all topics related to innovation, science and technology. Its main aim is to analyze and assess major policies and give advice to the president. Further it acts as a coordinator among federal, state and local governments. The executive Departments fund research in their corresponding fields. The most important departments in terms of funding R&D activities are the Department of Defense, the Department of Health and Human Services and the Department of Energy. In order to promote science and technology in a suitable manner some departments maintain their own R&D agencies, e.g. the Department of Defense has the Defense Advanced Research Projects Agency, which is mainly responsible for military S&T.

The Federal States in the U.S. system are primarily responsible for K-12 education (i.e. education from the kindergarten to the twelfth grade). The federal states also run public funded universities. Some of these play an important role in high-level research. States increasingly compete for innovative high-tech firms by providing attractive tax rates and subsidies as well as through the quality of the infrastructure like schools and universities. The State Science and Technology Institute (SSTI) is an organization serving as a clearing house and information mechanism for state research and innovation activities.

Intermediaries exist within the executive branch and as non-governmental organizations. The executive branch consists of multiple Independent Agencies. Those are created by Congress and the most important agencies according to R&I policies are the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF). The NASA is responsible for the U.S. space program and military aerospace research. The NSF mission is to promote the progress of science, to advance national health, prosperity, and welfare as well as to secure national defense. The NSF supports about 20% of federally subsidized fundamental research (European Commission 2010). This research is mainly accomplished by colleges and universities. Further, multiple private, non-profit organizations play an important role in research policies and communication. The main tasks include education of scientists, funding of research, competition issues and societal impacts. Important organizations are the Council of Competitiveness, the Association of American Universities as well as the National Academies. Whereas the four National Academies collectively derive policy recommendations, shape public opinion and foster the creation of science, engineering, and medicine, the National Academy of Science (NAS) particularly advances the pursuit of scientific and engineering research and provides respective advice to the government.

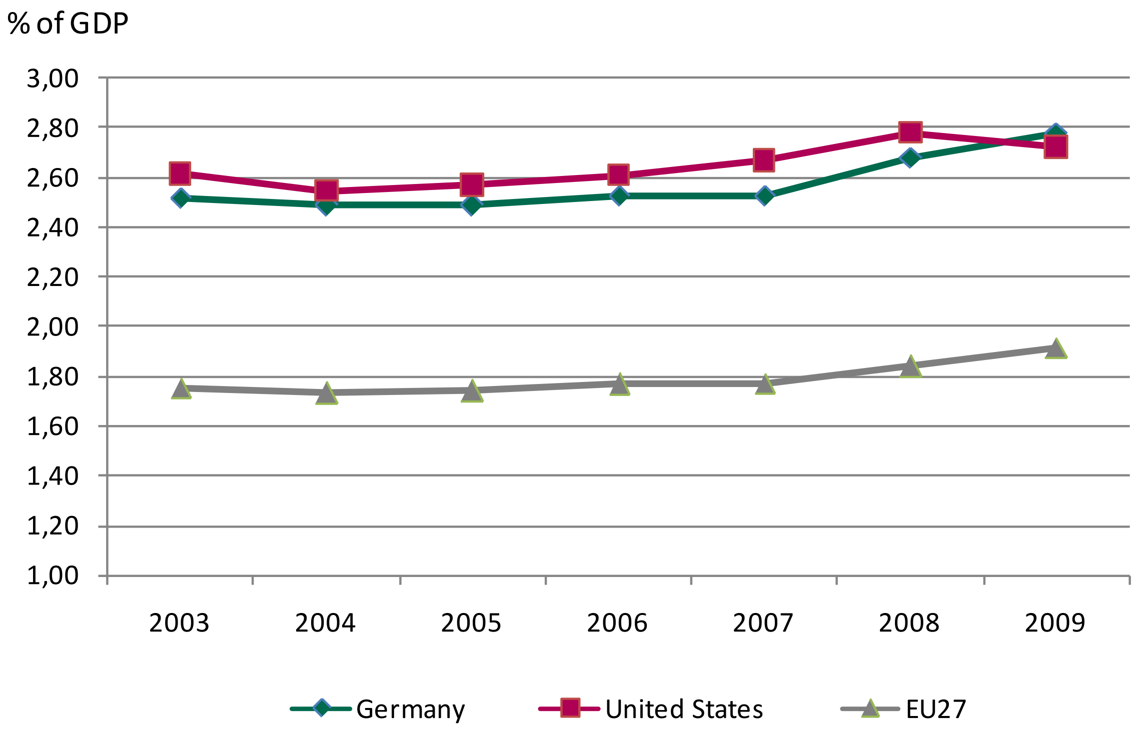
The **research performing sector** is divided into public and private research. Federal laboratories play a major role in the public research system. In total there are more than 1300 federal laboratories with about 60,000 scientists and engineers. More than one third of the governmental R&D funding goes to those laboratories. The Federal Laboratory Consortium for Technology Transfer (FLC) is a private non-profit organization and the link between the federal and the private sector. On the other hand, private research is conducted by private firms or consortia of private firms, in some cases co-funded by the federal or state government. Especially research which is mainly focused on the development of drugs and medical devices is often privately-funded.

Besides public and private research institutions there is a large variety of higher education institutions in the U.S. Those range from community colleges which provide applied education for the local job market to international leading and highly research-oriented universities. Universities in the U.S. are either public (governed by U.S. states) or private (usually non-profit organizations). More than two-thirds of the research intensive universities are established as non-profit institutions. A cornerstone in the relevant legislation was the Bayh-Dole Act of 1980. It allows universities to own the intellectual property rights from federal funded R&D and license them to companies. This leads to the incorporation of technology transfer offices. Their purpose is to implement the principles of the act and to guarantee greater commercialization of their research.

3.3 R&D Performance

'Gross expenditure on R&D' (GERD) is targeted at 3% of GDP by the EU Lisbon Strategy. Figure 4 presents the development of GERD from 2003 to 2009 for the U.S., Germany and the EU27 average. The data show that R&D expenditure increased over time in both countries. As compared to the EU27 average and Germany, for most of the last decade the U.S. spent a higher share of GDP on R&D. In the context of the financial and economic crisis, Germany (2.8%) surpassed the U.S. (2.7%) in 2009 for the first time since 1989 (OECD 2011). However, even with an increase over the last years, both countries still do not reach the 3% target.

Figure 4: Gross domestic expenditure on R&D



Source: OCED (2011), EFI (2011).

In the U.S. a substantial part of more than 60% of GERD is financed by industry. 'Business Expenditure on R&D' (BERD) increased to 2% in 2008, being skewed to large and high-technology firms. Only 15% of BERD in the U.S. is spent by SME. With a BERD of 1.9% in Germany this indicator is around the same order of magnitude. With a 'venture capital expenditure' of 0.12% of GDP in 2008, the U.S. exceeds Germany, where respective investment amounts to only 0.09% of GDP.

With GERD being very close to each other, the composition of R&D expenditures, however, differs between the U.S. and Germany and mirrors the country's economic industry structure (see section 4). The core area of R&D spending in Germany is on medium high-technology industries. According to Schasse et al. (2011), with a share of 53%, investments are much higher than the OCED average, which amounts to 26% in this field. The most R&D intensive industries in this regard are the *automobile industry*, the *machine building industry* as well as the *industrial chemicals* sector. The share of R&D expenditures for leading-edge technologies with 28% is far below the OCED average in Germany and especially below the U.S., where the share of R&D for cutting-edge technologies accounts to 47%. Moreover, the R&D share of the service sector is with 27.5% particularly high in the U.S., especially compared to Germany. Hence, the strong linkages between high-tech ICT services and the leading-edge technology sector are likely to contribute to America's strengths in these cutting edge industries.

As discussed in section 2, there is a strong case for state support in R&D spending. Due to uncertainty, free-riding behavior and suboptimal information free markets tend to under-invest in R&D. According to Schasse et al. (2011) and OECD (2011) data large international differences regarding the governmental support of private R&D expenditures were visible in 2009. Governmental support of private R&D is nearly twice as high in the U.S. (8.9%) than it is in Germany (4.5%). A further important difference is indirect governmental support of R&D. Whereas R&D tax incentives in 2008 amounted to 0.05% of GDP in the U.S., Germany has currently no such tax incentive scheme (OECD 2010).

Looking at R&D expenditures, it is important to differentiate between civil R&D expenditures and funds for military purposes. Schasse et al. (2011) show that the share of expenditures for civil purposes as a share of total R&D expenditures in 2008 is 94% in Germany, whereas the share accounts to only 43.4% in the U.S. More than 50% of total U.S. R&D expenditures are devoted to military research. In absolute numbers this sums up to more than total German R&D spending. Comparing R&D expenditures for civil purposes shows different allocation patterns (see Table 1 in the Appendix). In 2008 Germany placed particular emphasize on industrial productivity and technology, higher education research funds and environmental protection, whereas the U.S. concentrated its civil R&D expenditures on the protection and promotion of human health as well as on space exploration and utilization. German civil expenditures are distributed quite diverse over various technological fields whereas the U.S. concentrates its funding on human health care and space exploration which can be characterized as "national missions". Hence, these numbers indicate that the U.S. research and innovation system may be classified as "mission oriented", whereas research and innovation in Germany may be seen as more "diffusion oriented" (Schasse et al. 2011). With the High-tech Strategy 2020, however, many different, "diffusion oriented" programs and projects are now organized under the umbrella of particular mission-oriented fields of action. These fields of action hence encompass earlier projects and moreover current and new research programs and address pressing global challenges such as Climate/Energy and Health/Nutrition. Section 5.2 elaborates the mission-oriented expenditure focus in Germany in more detail.

4 Economic Structure and Innovation Performance

4.1 Economic Structure

Germany and the United States are both highly industrialized countries with diversified industries. However, their economic structures differ, among other aspects, regarding industry specialization and export performance.

As compared to the U.S. and other advanced economies, Germany has an above average-sized manufacturing sector which accounts for about 30% of GDP. Recent studies show that Germany is a high-wage country with a competitive edge in research-intensive industries (Belitz et al. 2010, 2011). Germany's strengths lie in the manufacturing sector, in particular in medium high-level industries like chemical products, machinery and equipment, electrical machinery and apparatus, motor vehicles and other transport equipment. In contrast, service sector growth lags behind the U.S., which is also true for knowledge-intensive services. Germany performs relatively weakly in the service sector. In spite of increasing international trade linkages and the emergence of outsourcing possibilities in Eastern Europe and Asia, many German manufacturing sectors show a high and stable domestic depth of the value added chain. In comparison, American firms make much more use of global production networks, which leads to outsourcing of substantial parts of the value added chain.[1]

The U.S. shows a specialization on high-tech manufacturing industries like communication equipment, aircraft and spacecraft, office machinery and computers as well as pharmaceuticals. Particularly high investments in the biotechnology-, software- and industrial/energy industry underline the focus of the American economy on cutting-edge technology fields (PwC/ NVCA 2011). Furthermore, the U.S. has a particularly strong focus on knowledge-based services, such as information and telecommunication technologies, professional services as well as on the currently crisis-ridden financial sector (Belitz et al. 2010). These services are not only R&D intensive by themselves, but encourage innovation in other economic sectors, as well.

On the one hand, a country's export performance and structure reflects its industry structure and, on the other hand, it is a measure of international competitiveness. In 2008 Germany was

[1] A prominent example is the iPhone which was developed by Apple in the United States, but most other stages of the value added chain, in particular production, were outsourced to Asian countries.

the largest exporting country in the world (followed by China and the U.S., WTO 2011) reaching an export quota (in relation to GDP) of 39.4% (Destatis 2011). Even though world trade sharply decreased during the financial and economic crisis, German exports rebounded in 2010. The three most important export sectors were automobiles, machinery and chemical goods which together account for about 40% of German exports. In 2009 medium-high technology manufactures in Germany amounted to the biggest export share with 48.4%, followed by high technology manufactures with 20.6% (OECD 2011).

The United States was the third largest exporter in 2008, directly following China and Germany, and reached an export quota of 9.2% (WTO 2011). The most important export sectors were automobiles, pharmaceuticals and semiconductors. Even though total exports were smaller in magnitude than in Germany, with a share of 33.9% of high technology exports and 37.2% of medium-high technology manufactures, the share of high-technology exports is higher than in Germany (OECD 2011).

Germany's international competiveness rests to a good part more on small and medium sized enterprises (SME) which are often family-owned, the so called German *Mittelstand*. In 2008, such firms with less than 250 employees accounted for 99.5% of all enterprises, for 60.5% of total employees and for 52.8% of total value added in the economy (EC 2009). Many of these firms are so called *Hidden Champions*, i.e. relatively unknown firms which are nevertheless global market leaders in a very specific niche. Further, these firms often look back on a long tradition in their industry, show a high R&D intensity and excel in incremental innovations. However, even though those firms contribute to Germany's export success, they usually do not create a significant number of radical innovations.

Even though the U.S. firm size structure is slightly skewed to larger firms, one of the main strengths of the American innovation system is its entrepreneurial performance. That is, in comparison to Germany more firms are being set up, and more of the newly founded firms grow faster. These new, high-growth firms are often termed "gazelles" and have a significant impact on structural change and innovation-driven growth of future industries. Based on the mechanism of creative destruction (Schumpeter 1942), these young, innovative firms replace old structure and contribute to technological and economic progress (see, e.g., Acs and Audretsch 1994, Henrekson and Johannsson 2010.) This is particularly true for output-related measure of innovations (in contrast to input-related measures such as R&D expenditures) and radical innovations. The Silicon Valley is the most renowned example of the U.S. innovation systems' potential to create new firms and even completely new markets.

4.2 Innovative Performance

Science and technology policies and innovation policies in general not only address R&D expenditures and research institutions but also the overall innovation framework as described in section 2.3. This implies that many different policy fields are affected. Global innovation rankings help to compare national innovation systems and to identify country specific strengths and weaknesses. Within this chapter, two important international rankings are discussed in more detail, followed by a short comparison of the results among seven currently important innovation rankings.

The two rankings to be discussed in this section are the composite indicator by the Information Technology and Innovation Foundation (ITIF) as well as the BDI/Deutsche Telekom Stiftung Innovation Indicator. The latter indicator was developed and maintained by the German Institute for Economic Research (DIW Berlin) until 2009. From 2011 onwards it is developed by a new consortium (see Fraunhofer et al. 2011). Generally, the new indicator setup of the BDI/Deutsche Telekom Stiftung Innovation Indicator is a methodological continuation of its predecessor studies, even though a direct comparison to previous results is no longer possible. However, new countries, especially the BRIC (Brazil, Russia, India and China) economies, were included. Whereas the ITIF indicator assesses the global innovation-based competitiveness of 44 countries, the former ranks the 26 most innovative countries in its recent version. Both indicators are aggregated from a number of sub-indicators which address different aspects of a national innovation system. The BDI/Deutsche Telekom Stiftung Innovation Indicator builds upon an economic model that comprises input and output factors of the following fields: the economy, education- and innovation system, the political system and public administration as well as infrastructure, demand and the additional framework conditions. The setup further allows the identification of linkages between different parts of the heuristic model as well as accounting for time lags, for example with regard to the education system, where political changes and investments show their impact only a few years later. The ITIF indicator includes 16 sub-indicators of the following six main categories: Human capital, Innovation capacity, Entrepreneurship, IT infrastructure, Economic policy and Economic performance.[2]

Both the ITIF indicator and the BDI/Deutsche Telekom Stiftung Innovation Indicator share some important aspects, such as an assessment of human capital and the education system, private and public R&D expenditures, innovation financing and entrepreneurial activity. However, whereas the ITIF indicator gives a higher weight to IT infrastructure, the BDI/Deutsche Telekom Stiftung Innovation Indicator, includes additional aspects such as networking between different stakeholders of the innovation system, the competition environment, and demand for innovative products.

The most recent ranking of the ITIF indicator of 2011 ranks the U.S. on place four and Germany on place 16, slightly above the EU-15 average, which is ranked on place 18. According to the ITIF study Singapore, Finland and Sweden are currently the three most (innovation-related) competitive countries in the world. The most recent ranking of the BDI/Deutsche Telekom Stiftung Innovation Indicator ranks Germany on place 4 out of 26 countries, close to the leading group Switzerland, Singapore and Sweden. The U.S., however, lost ground and is placed behind Germany on rank 9.

Overall the performance of the different sub-indicators pictures the relative strengths and weaknesses of a country's innovation system. According to the ITIF ranking of 2011 the U.S. performs particularly strong in the sub-indictors e-*government*, *IT investments*, *business climate and productivity*. The BDI/Deutsche Telekom Stiftung Innovation Indicator of 2009 characterizes the *societal innovation climate*, the *competition environment*, *innovation financing*, and *demand for innovations* as explicit strengths of the U.S. innovation system. In contrast, the ITIF indicator evaluates the U.S. *trade balance*, *FDI* as well as the e*ffective corporate tax rate* with a relatively poor performance, whereas the BDI/Deutsche Telekom Stiftung Innovation Indicator specifies relative improvement potential in the general categories of *R&D and Networking*. Lately unfavorable macroeconomic conditions as well as insufficient investment in R&D are identified as responsible factors behind the downgrading of America's innovation performance (Fraunhofer et al. 2011).

[2] In turn, these main categories include the following specific indicators: Human capital: higher education attainment, number of researchers; Innovation capacity: BERD, GERD, scientific publications; Entrepreneurship: venture capital investment, new firms, IT infrastructure: e-government, broadband telecommunication, corporate investment in IT, Economic policy: effective cooperate tax rate, ease of doing business; Economic performance: trade balance, FDI, productivity.

In the framework of the ITIF, innovation-related competitiveness in Germany shows particular *strengths with respect to its business R&D, productivity and broadband composition.* According to the BDI/Deutsche Telekom Stiftung Innovation Indicator ranking of 2009 the German performance is much more mixed. *Networking, Implementation* and *Demand* belong to the German advantages, while *R&D,* measured by the innovation performance of companies, is just above average. Also in light of the most recent result of 2011 the well functioning network between different actors as well as innovative industries are characterized as Germany's particular strengths. The main specified weaknesses of the German innovation system by the ITIF indicator are the categories e*ducation, new firms*, and *FDI* and – according to the BDI/Deutsche Telekom Stiftung Innovation Indicator ranking of 2009 – bad conditions for *innovation financing*, an under-average *competition framework* as well as the *societal climate for innovation*. Furthermore, a poor performance of the *education system* is continuously identified as a core weakness within the rankings of both 2009 and 2011.

In a comparative view of seven recent innovation rankings, three place Germany close to the leading group, namely the 'Innovation Union Scoreboard' (Rank 4), the 'Global Competiveness Report' (Rank 5) and the 'Innovation Ranking Economist Intelligence Unit' (Rank 6) (Fraunhofer et al. 2011). In contrast Germany achieves a lower position in the framework of the 'Global Innovation Index' (Rank 16) and the 'BCG International Innovation Index' (Rank 14) (Fraunhofer et al. 2011). Overall, most of the indicators identify Germany's innovative companies, the technical infrastructure and its direct innovation output, such as patents, as the most vital strengths. In contrast, Germany's education system and state-regulated framework for innovation, such as insufficient market flexibility, are identified as the major weaknesses by most indicators. Nearly all indicators which allow a comparison over time show an improvement of the German innovation system.

The innovation performance of the U.S. is ranked between fourth and eleventh place by the seven different indicators, hence showing less variance in the ranking positions. Only the 'Global Innovation Index' (Rank 11) judges the U.S innovation system slightly outside the ten most innovation competitive countries. The 'EIU Innovation ranking' and the 'Global Competiveness Report' see the U.S. on place four respectively and the 'Innovation Union Scoreboard' as well as the 'BCG International Innovation Index' on place 6.

Overall, deviating results for both countries result from different sub-indicators employed, different standardization methods, as well as the respective sample of countries considered. Generally, the comprehensive view of the above mentioned indicators show that both countries have specific strengths and weaknesses of their innovation system and enjoy an above country average ranking. While the U.S. is currently characterized by mostly higher rankings, Germany's innovation system has demonstrated strong positive dynamics in recent years, whereas the U.S. innovation performance has recently been relegated to some extent.

5 Research and Innovation Policy in Germany

Sections 3 (key R&I institutions) and 4 (economic structure and R&I performance) revealed the major strengths and weaknesses of the German and U.S. research and innovations system. Building on these results, this section will discuss how policy makers in Germany addressed selected issues to improve the innovation system. The sub-indicators of the DIW Berlin innovation indicator (education, R&D, networking, financing, implementation, competition and demand for Innovation, see 4.2) will serve as a guideline for this analysis. Section 5.2 introduces the High-tech Strategy 2020 as the government's comprehensive strategy for research and innovation policies in future.

5.1 Selected Innovation Policies in Germany

Targeted Technologies

Supporting the development of a *green economy* is a long-term political goal in Germany. Federal R&D expenditure on energy research and -technology has increased by 75.2% from 394.3 Million Euro in 2001 to 691.0 Million in 2010 (BMBF 2010b,c).[3] For more than a decade German politics enforced research and innovation in the field of energy technology, such as feed-in tariffs for renewable energies and technology subsidies. An additional main research focus in Germany over the last decade was the technology field of health and medicine. Federal R&D expenditures grew by 71.0%, from 470 Million Euro (5.17%) in 2001 to 803.8 Million Euro (6.33%) in 2010 (BMBF 2010b,c). Other fostered technologies included biotechnology, with an increase of 25.7% from 318,8 Million Euro (3.51%) in 2001 to 400.6 Million Euro (3.15%) in 2010 and space research- and technology, where federal R&D ex-

[3] Values of 2010 stated in this paragraph are expected values.

penditures have grown from 787.1 Million Euro (8.65%) in 2001 to 974.6 Million Euro (7.67%) in 2010. The respective growth rate over the last nine years is 23.8%. This intensity is to a large extent due to the European Space Agency (ESA). Furthermore, with a federal R&D expenditure share on information- and communication technologies of 7.16% in 2001 and 5.16% of GDP in 2010 ICT were a focal point of public research support (BMBF 2010b).

Education

Amongst other evaluations, the PISA results of the 2000s showed that the performance of the education system is one important drawback of the German innovation system (OECD 2010d). Secondary as well as tertiary education fails to supply sufficient highly qualified human capital. Compared to other countries, particularly the U.S., fewer students acquire tertiary education and additionally the quantity and quality of output, e.g. conducted research, appears flawed. After the financial crisis, with a growing economy and stagnating number of well-educated people, the lack of highly-qualified labor is likely to become problematic.

Recently, however, several actions contribute to an improvement of the education system. The government (federal and state) targets total expenditures on education and research to amount to 10% of GDP by 2015. Further, initiatives like the ‘Higher Education Pact’ and the ‘Pact for Research and Innovation’ were initiated. Different programs initiatives aimed at improving both the quality of schools by better connecting and enhanced competition between the 16 federal states. The ‘Excellence Initiative’ launched by the German Ministry of Education and Research in 2005 seeks to boost research in German universities and to generally increase the quality of research in universities as well as research institutions such as the Fraunhofer Society. For the first time, several German universities were titled as elite institutions (*Eliteuniversitäten*) which marked a paradigm shift in the egalitarian German university system. Moreover, measures aimed at increasing the number of skilled specialists, especially in the fields of MINT (Mathematics, Informatics, Natural sciences, or Technology), more encouragement for women in these fields as well as an expanded scholarship policy are set to improve the German education system further [4].

[4] Source: http://www.bmbf.de/en/6142.php.

Networking & Clusters

Germany exhibits a well-developed innovation infrastructure with long-established networks between research institutions and firms which are supported by institutions like the Fraunhofer and Max-Planck societies, which enjoy an excellent reputation on a global scale (DIW 2009).

To further encourage a successful innovation network, the BMBF has established the provision of funds to support efficient regional and thematic science and innovation clusters and collaborations. BioRegio, a program targeting the Biotechnology sector, was one of the starting points of the recent cluster promotion activities. The Leading-Edge Cluster Program (*Spitzencluster-Wettbewerb)* is not limited to specific technology fields but aims to increase international recognition and competition of already strong and innovative collaborations. This programs does not only benefit winning tenders but through incentives and spill-over effects also non-winning tenders. *Innovation Alliances*[5] provide funding (public and private) and adjust for a better cooperation between industry and public research, especially in cases where research is long-term and requires substantial financial resources. In addition several projects placed special emphasize on regional differences and on the innovation environment in Eastern Germany[6] (Pro Inno Europe 2009).

Financing, SME and technology transfer

Compared to other countries and especially the U.S., German companies face a comparative disadvantage with respect to gaining access to financing innovation, e.g. loans and venture capital. A low score in start-up business venture contributes to the lack of high-tech industry innovation, e.g. in ICT, microcomputers or biotechnology. At present it seems that the German market environment should provide more incentives for investors, managers and scientists to take on the risk of entrepreneurial ventures. Furthermore, the venture capital market, particularly with respect to early-stage financing should be improved. Even though a development of the German venture capital market in style of the American system is visible and will most likely continue in the future, which means not only an enlargement and specializa-

[5] An Alliance set up through an industry initiative with several business partners and research organizations, organized as a long-run project.

[6] ‘InnoRegio - innovative networks in Eastern Germany` or ‘INNOMAN: Innovation management in SMEs in Eastern Germany’.

tion but also an increasing internationalization, investments in start-ups and seeds need to be increased. Respective investments have decreased by 67.2% over the years 2001 until 2010 (BVK 2011).The German *Mittelstand* has an enormous innovation potential but faces financing constraints and SME-specific problems. To address these problems and utilize the potential of the German *Mittelstand* a variety of project-based support and funding instruments for small and medium-size companies were initiated. Project-based loan and grant aid for leading research projects is addressed by the BMBF program *KMU-innovativ* and by the *KfW-Gründerkredit - Universell* or *KfW-Unternehmerkredit* by the KfW Development Bank. Furthermore, *the* BMWi *High-Tech Gründerfonds* (High-tech Start-up Fund) provides funding to young, promising and technology intensive companies. Moreover companies are supported with the supervision and support for their management. The *ERP-Innovationsprogramm* (ERP innovation program) grants loans at favorable conditions to innovate firms.

The *Zentrales Innovationspogramm Mittelstand*[7] (ZIM, Central Innovation Program for SME Support), which was founded in 2008, is currently the single most important federal program to fund R&D and innovation activities of SMEs. It became effective in February 2009 with an increased allocated budget in course of the economic crisis. In September 2011, just under EUR 1.9 billion were spent.[8] The program aims at improving capital access for SME with an enlarged target group of firms with up to 1000 employees and moreover at facilitating application and administration processes.

Besides the ZIM program, other programs support innovation policies for SMEs. *EXIST* is a comprehensive BMWi project supporting institutions like universities, which contribute to an entrepreneurial culture and research intensive start-ups. *SIGNO Enterprise* aims to protect property rights and innovation success from illegal exploitation and facilitates patent applications. In general all programs and projects not only strive for an easier access to funding, but also for a simplification of the promotional framework and, as a specific German strength, additionally support the knowledge-transfer between universities, research institutes and commercialization-oriented firms and industries.

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[7] Merged from the following previous projects and initiatives: ProINNO, InnoNet, NEMO, Innowatt.

[8] Source: cp. www.zim-bmwi.de.

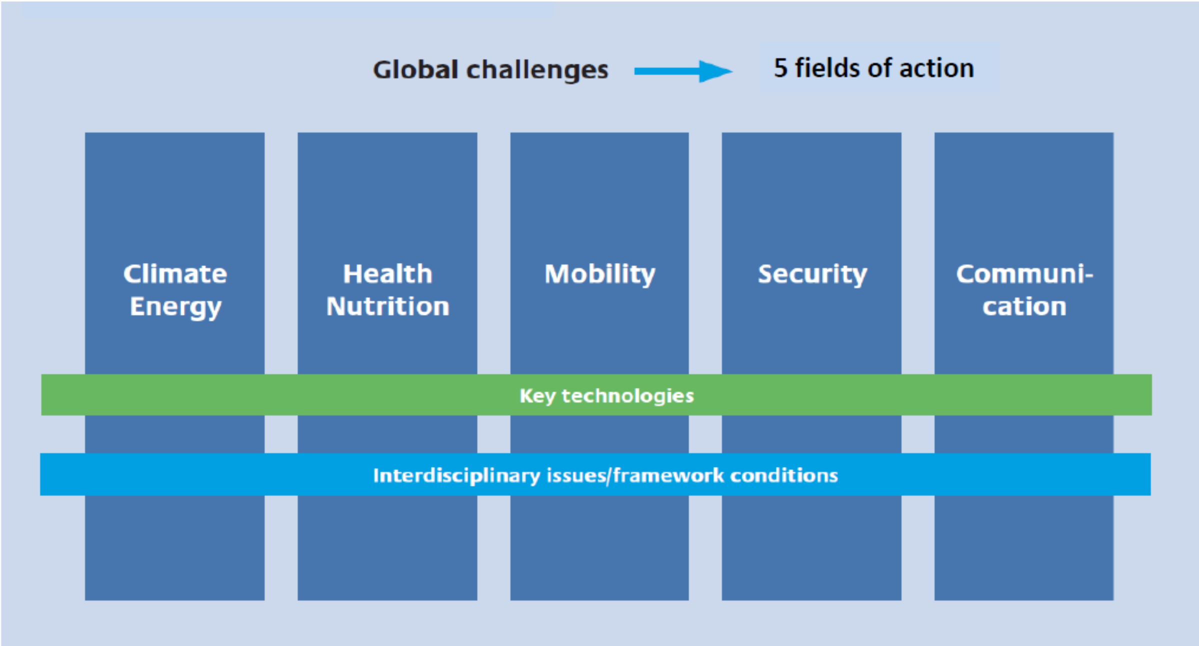
5.2 Future Outlook: High-Tech Strategy 2020

For a long time German research and innovation policy was mainly characterized by a multitude and variety of singular policies and individual programs. The ‘High-tech Strategy for Germany’ (HTS) was first established in 2006 and represented the first cross-departmental framework for Germany’s overall science, technology and innovation policy, with the greater goal of an economic structure encouraging innovation and hence improving international competitiveness. Accordingly a total of €15.6 billion of federal funds was directed to cutting-edge technologies in the period of 2006 to 2009 (Fritsch/Schüller 2010).

In July 2010 the HTS was extended under the comprehensive *High-Tech Strategy 2020 for Germany*. This broad-based approach defines global challenges like climate change or population growth and calls for actions in order to secure economic, social and cultural growth and development. The HTS aims to achieve these goals through several sector-specific and general programs and forward looking projects over the next ten to fifteen years. In this regard demand for promising innovation policies to establish leading market positions and to open up future markets is diagnosed. Moreover special emphasize is set in order to improve the cooperation between science and industry as well as to advance the general innovation environment.

The HTS focuses on “a wide range of different fields of innovation, defined priorities, and introduced new instruments such as the leading-edge cluster competition and the innovation alliances” (BMBF 2011). In light of the above mentioned challenges the federal government (cp. section 3.1) defined five new fields of operation within the HTS: climate/energy, health/nutrition, mobility, security and communication. The central missions within these fields are addressed by mission-oriented projects. Figure 5 graphically illustrates the newly defined fields of action.

Figure 5: The German High-Tech Strategy 2020



Source: BMBF (2010a).

Funding is directed towards technologies which address these specific needs. Besides meeting global challenges via central missions within the above mentioned five fields, the HTS builds upon previous actions (cp. section 5.1).

Since the innovation environment in Germany demands for a particular financial and regulatory support for small and medium sized enterprises, encouraging the German *Mittelstand* to engage in research activities is a major challenge and hence a central-pillar of the HTS. Furthermore, an improved innovation framework addressing and improving the cooperation between science and industry, commercialization in inventions and dialogue of (basic) research with industries and society, and the patent law are all important goals of the HTS.

In addition to the national HTS, the German government wants to extend the approach to Europe, to further improve and coordinate innovation. A coherent policy framework among EU member countries with regard to their research and innovation policies is planned since the year 2000. As EFI (2011) states: "The creation of a European Research Area (ERA) is (…) the key to successful national research and innovation policy" not only to avoid duplication among European Member countries but also to be able to succeed with the growing competition from Asia and North America. Germany's close connection to the first 'Knowledge and Innovation Communities' (KIC) of the 'European Institute of Technology' (EIT) is an example for this. Further internationalization is also planned with respect to a consistent European patent system, with support by the EFI to locate the European patent court in Germany.

6 Research and Innovation Policies in the U.S.

This section will address selected topics in U.S. innovation policy of the last years and describe the most important recent initiatives.

6.1 Selected Innovation Policies

Targeted Technologies

The U.S. technology policy approach in the 2000s was characterized by a concentration on a few strategic areas, such as human health, energy, space research and defense (CRS 2010). With selective presidential initiatives and agencies like the National Nanotechnology Initiative (NNI), an umbrella over different agencies, which develops and coordinates R&D activities, sets budgets and encourages technology transfer, America's federal R&D funding can be characterized as mission-oriented multiagency efforts (CRS 2010). With a share of over 50% of total federal R&D funding, the department of defense still receives most of the nation's R&D expenses. Expenditures however have decreased by 4.4% in contrast to the previous year (CRS 2010).

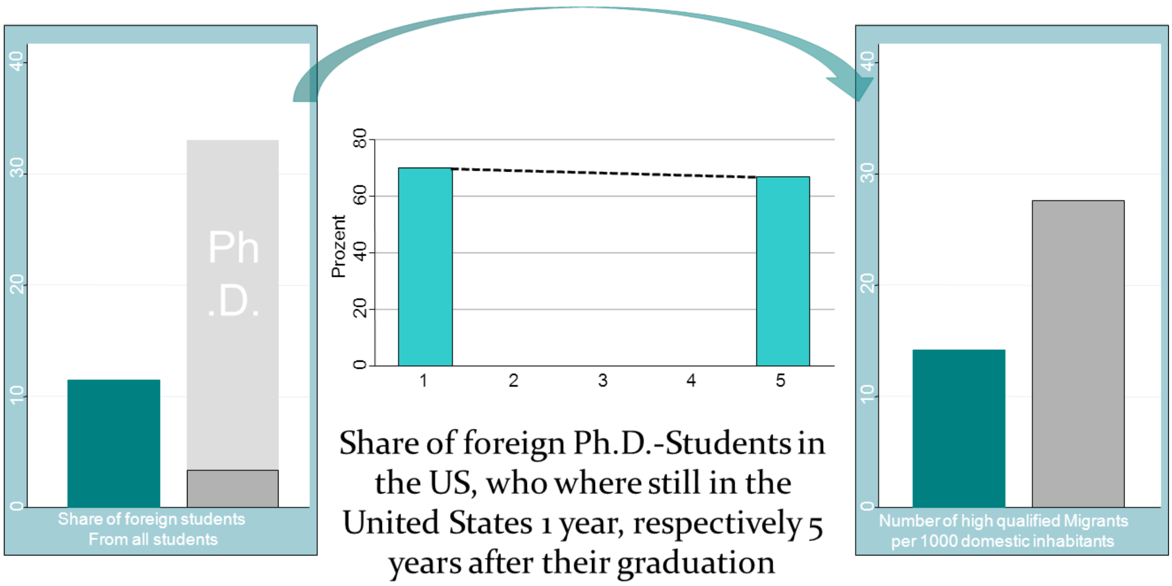
To promote long-term investments for R&D in civil purposes, respective federal funds of the National Science Foundation (NSF), the Department of Energy (DOE)/Office of Science, and the National Institute of Standards and Technology are recently aimed to amount $ 13.3 billion in 2011, which is an increase of 6.6% compared to the previous year. In a longer perspective over the last years from 2006 to 2011, federal R&D funding for the NSF increased by a total of 31.5% and by 41.0% for the DOE/Office of Science (CRS 2010).

Education

In the U.S. most decisive power concerning education policy is assigned to the states and to local levels. Nonetheless the government encourages measures which improve the educational system. The American Recovery and Reinvestment Act (ARRA) in response to the financial and economic crisis is a major contribution. Until the end of September 2010 around 275,000 education jobs (e.g. teacher and principals) were saved or newly employed due to the funding of the program. A major advantage of the American educational system is that the U.S. is able to attract high-qualified foreign students, especially Ph.D. students, and even more important to keep them. Figure 6 shows impressively the difference between Germany and the USA.

The U.S. Department of Education implemented different policies such as the Higher Education Opportunity Act in 2008 and other initiatives to enhance and improve education on all levels starting from primary education to postsecondary education. Furthermore, with the campaign "Educate to Innovate" President Obama together with companies and foundations aim to advance participation and performance particularly in the STEM (science, technology, engineering and math) sector[9].

Figure 6: Foreign students and high qualified migrants in Germany and the U.S.
Students in Germany and the U.S.



Source: DIW Berlin.

Financing

A distinguishing strength of the U.S. innovation system is its highly developed research and innovation funding. The federal research and experiment (R&E) tax credit, offering deduc-

[9] see http://www.whitehouse.gov/issues/education/educate-innovate.

tions on year-to-year increases in R&D expenditure, represents the main instrument of U.S. fiscal policy for research outside of grants and loans. R&D tax credits also exist on the state level and are often linked to national tax credits. The federal SBIR Program (Small Business Innovation Research Program) grants public funds to private businesses and supports innovation in domestic small businesses by a competitive awards-based program. The program unites basic research, small high tech firms and venture capital which are three pillars of U.S. innovation. It was originally implemented in 1982 and since then over 112,500 awards have been assigned. In the 2000s the program was repeatedly reauthorized due to the broad public acceptance. Currently eleven federal departments and agencies, like the National Science Foundation or the Department for Energy participate and provide funds for the program. SBIR funds the critical startup and development stages and encourages the commercialization of technologies, new products and services, which, in turn, stimulates the U.S. economy.[10]

Networking

In line with the prevalent philosophy that the private sector is primarily responsible for commercial research, no national initiatives to promote public-private collaboration exist. Nevertheless there exist some exceptions, which are, however, of minor importance in the U.S. R&I policies. The Advanced Technology Program (ATP) for example, which ended in 2008, was established to promote the development of innovative technologies in cooperation with the private sector. As another example, the Manufacturing Extension Partnership (MEP) was created to enhance the competitiveness of SMEs in manufacturing by transferring technology and know-how through a decentralized network of centers. Although the program has been recommended for closure in the 2000s, the current administration seems to value it more highly and awarded modest budget increases (European Commission 2010).

6.2 Recent Initiatives and Future Outlook

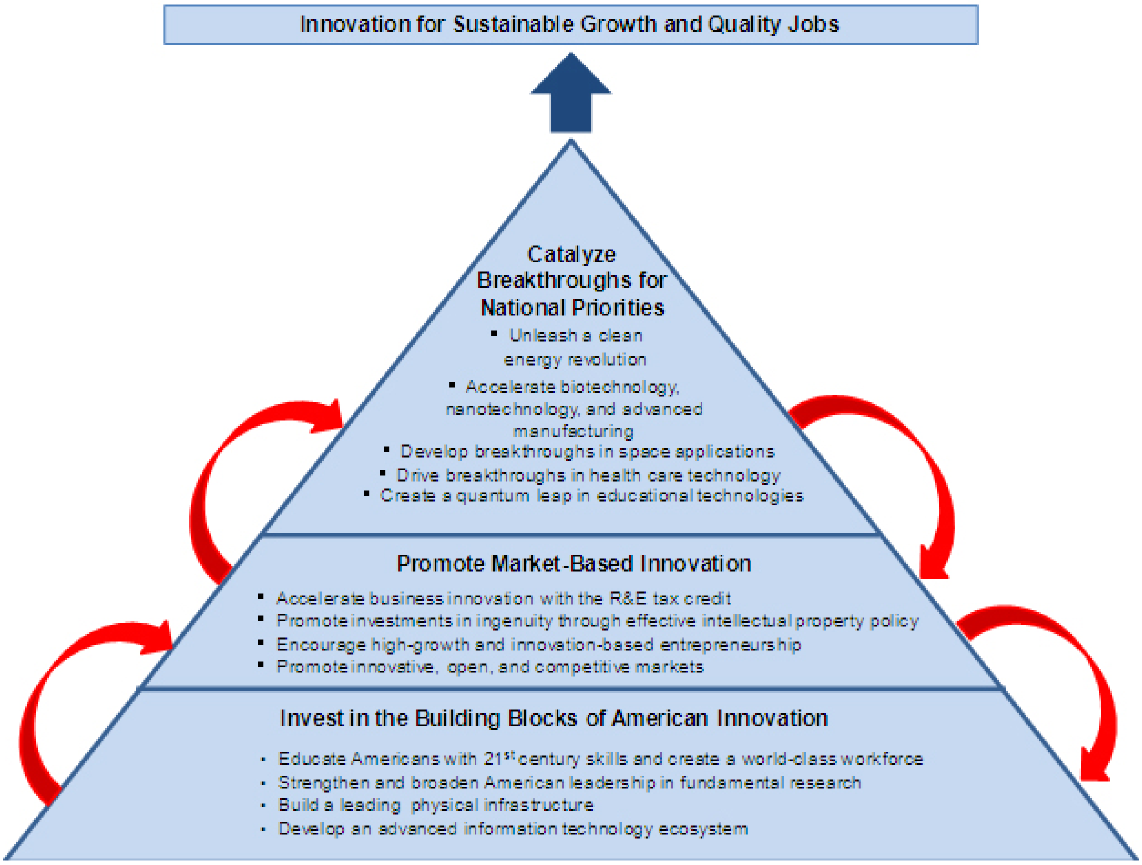
With the beginning of the 21th century and increasing globalization, America's successful innovation policy faces new challenges. The U.S., once owning a dominant position of science and progress, needs to start competing with rising Asian countries, a more integrated

[10] See also: http://www.sbir.gov/about/about-sbir.

European Union and Japan for scientific and engineering talents and venture capital. In addition, corporations as well as science itself are becoming ever more globally integrated.

Not only Europe but also the U.S. aims to devote more than 3% of GDP to R&D. In September 2009 President Obama, setting a new focus on innovation, launched the "Strategy for American Innovation: Driving Sustainable Growth and Quality Jobs".[11] The action plan, building up like a pyramid (see Figure 8), encompasses three key fields of innovation. The Strategy strives for rapid, wide-spread and sustained economic growth, which will ultimately lead to higher income, more jobs and better health conditions.

Figure 8: Americas Key Science and Innovation Policy Initiatives



Source: White House (2011).

11 http://www.whitehouse.gov/administration/eop/nec/StrategyforAmericanInnovation/.

- **Building Block**

  The groundwork aims for investment in the building blocks of American innovation, namely its workforce, scientific research, infrastructure as well as an advanced information technology ecosystem. The latter one entails effort and vigilance to expand high-speed internet and the availability of wireless internet as well as to modernize the electric grid.

- **Market-Based Innovation**

  The promotion of marked-based innovation forms the second step. In this respect supporting small businesses with R&D tax credits and Obama's *Startup America* initiative spurs entrepreneurship and innovation. Besides direct programs, an entrepreneurial environment is created by promoting innovative, open and competitive market structures as well as catalyzing innovation hubs.

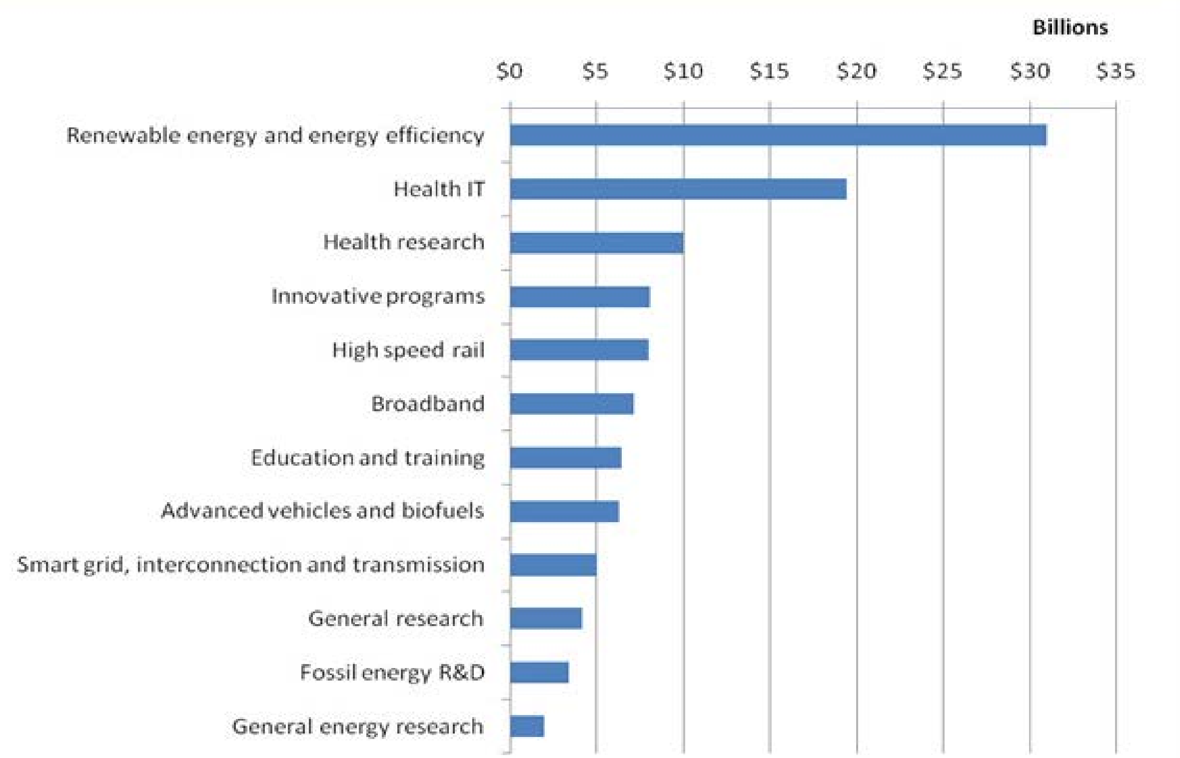
- **National Priorities**

  The third and final part of the pyramid is denoted by spurring breakthroughs for national priorities. In this respect government intervention can play an important role where innovation is crucial but insufficient by its own due to market failures. Such priorities include for example the acceleration of biotechnology, nanotechnology, advanced manufacturing, space capabilities, health IT as well as clean energy sources. The USA is still one of the world's largest polluters; however rethinking in terms of green technologies has only started in recent years.

A range of new initiatives aiming to improve America's economic growth, employment and competitiveness work together and build upon the Administration efforts just discussed. The new ideas comprise a *Wireless Initiative* and *Patent Reform* to overcome the backlog of applications at the U.S. Patent & Trademark Office (USPTO). This reform among others facilitates the application process and reduces the delay in patent processing time from 35 to 20 month. A further target is to improve so-called K-12 education, which aims for the graduation of every student from high-school. An additional new aim is the Start-up America initiative, which seeks to increase start-up companies and to facilitate the entrepreneurial environment. Respective initiatives include early-state financing, a facilitated research breakthrough from university as well as the regulatory environment for starting and growing a business.

As a response to the financial and economic crisis the federal government passed the American Recovery and Reinvestment Act ARRA in 2009. The main impact is to provide USD 787 billion for direct stimulus expenditures and secondly to encouraging innovation on a long-term basis. In fact, 13% of the stimulus package (USD 101.9) is assigned to energy, ICT and R&D activities. Figure 9 shows the investments of the Obama Innovation Strategy. The investments in renewable energy and energy efficiency are enormous. Even though the U.S. green technology strategy is not as mature as Germany's a rethinking of climate and energy policy has taken place. With an enormous investment to the "Office of Energy Efficiency and Renewable Energies" (EERE) (see Figure 9) and by establishing innovation hubs and frontier research centers, more effort is done to "enhance energy efficiency and productivity and bringing clean, reliable and affordable energy technologies to the market place"[12].

Figure 9: Innovation Investments according to the ARRA



Source: White House (2011).

12 Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy: http://www.eere.energy.gov/.

7 Different Innovation Systems and Policies: Learning from Each Other‘s Best Practices

The analysis of the German and American research institutions, its innovation patterns and performance as well as its innovation policies indicate that the country specific specialization and orientation of Germany and the U.S. can be described as complementary rather than competitive. Both innovation systems display a specific setup building upon each country’s economic structure, historical background, political system and societal particularities. Therefore, the German and American innovation systems display specific and unique strengths and weaknesses. In spite of these differences, both systems perform rather well in an international comparison. This is reflected by the fact that particularly the U.S. but also Germany enjoy high rankings in various comparative innovation indicators.

The analysis of both countries innovation policies revealed two particular aspects:

- The first aspects addresses the way innovation policy is pursued: The U.S. political system is a presidential system, thus main actors in innovation policy are the Executive Office of the President. In this system, the president obviously holds an important position concerning science and technology decisions. However, on the following stage the responsibility for the implementation of innovation policy is divided between a large number of Executive Departments.

  In contrast, in the German political system the most relevant decisions regarding innovation policies are made by two ministries (BMBF and BMWi). Prospectively, the European Union will gain a more important role regarding innovation policies which will – inter alia – allow scientific exchange on a broader scale.

- The second aspect reflects the goals and content of innovation policies: The comparison of both countries’ innovation policies showed that these address mainly the strengths and weaknesses, and distinctive features of their respective innovation system. Given this kind of path dependence, it is not possible to draw direct comparisons. However, the overview of both countries’ policies permits the identification of areas in which both countries can learn from each other. This will be discussed in the following.

Germany may benefit from the adoption of American best practices in a variety of ways.

- Germany’s research environment lacks world-class universities with a strong orientation on cutting-edge research. Furthermore, American universities comprise close linkages with firms and industries, which can successfully foster innovations. Event though, first steps on the German side towards an improvement have been taken (e.g. the Excellence Initiative, see section 5.1, Research campus (Forschungscampus) and the Leading-Edge Cluster Competition), there remains space for improvement.
- The American society values to a higher extent entrepreneurial spirit and risk. Hence, there are more start-ups and spin-offs in the U.S. and these newly founded firms grow faster and produce more often radical innovations. Many of these newly founded firms can be characterized as *gazelles,* which have the potential to open up entirely new market niches and they enjoy larger potential markets in the U.S., a naturally given advantage when compared to Germany. In Germany, for example, areas like the Silicon Valley, where a substantial number of successful firms are born, exist only to a smaller extent and smaller in size. Given the advantage of a larger market size in the U.S., a further improvement of the common European market, particularly regarding the introduction of innovative products will be an important task.
- The U.S. system provides more possibilities for financing research and innovations. There is a large market for private venture capital and early stage financing. Moreover venture capital is provided by large institutional investors, which increases the scope of financing. Therefore, providing additional venture capital to increase the number of newly founded, innovative firms could stimulate radical innovations in Germany. However, this will only work if other framework conditions for start-ups are improved alongside. These may include the ease of doing business, demand side parameters and the competition environment. Also, the American SBIR program which directs research funding to small firms is a successful example for small business support. However, such a policy will need to be adapted for the German innovation system.
- Finally, the introduction of a R&D tax credit for SMEs as a technology neutral and project-independent scheme to support private R&D activities could be part of a program to meet higher R&D intensity targets in Germany.

The United States on the other hand, may also benefit from the adoption of German best practices:

- The German economy is characterized by particularly strong medium high-tech industries featuring a home-country-concentrated value added chain with extremely high export volumes, high productivity and high wages. Moreover, Germany is highly effective in producing incremental innovations, thus improving existing products and gaining global leadership in specific market segments ("*Hidden Champions*"). The research and innovation system supports this economic success by a close cooperation between large enterprises, the German *Mittelstand* and research institutions. For instance, the Fraunhofer Society, especially with respect to its financing structure, does in such a way not exist in the U.S. This model of long-term cooperation between industry and research institutions could serve as an example for the United States.
- Moreover, the long and well-established tradition of state-funded, competitive project financing, which demands for a great amount of know-how, is a distinguishing strength of the German innovation system. Such well-targeted funding could not to the same extent be realized through unspecific tax-based financing. Therefore, increasing funds for directed, civil R&D spending may improve the American innovative performance.

8 Common Future Challenges

The analysis so far has shown that Germany and the U.S. can be seen as complementary rather than competitive with respect to both their innovation system as well as regarding their related economic structures. Whereas the U.S. benefits from its entrepreneurial success, Germany is renowned for its systematic progress in traditional industries. We have shown that this is reflected by the countries' respective institutional research framework and their innovation policies. In this sense it might be important to look at the global challenges both countries have in common.

The United States and Germany are facing several economic, ecologic and social challenges. These challenges are global in a sense that no country can solve them on its own, but rather they must be addressed in joint action. Among these challenges are:

- Climate change and energy security: Investments are needed in directed research on a green economy and transformation of the current fossil-based energy system.

- Population aging will be a major challenge in particular in the Western societies. Innovative solutions are needed in order to address the impact of an increasingly larger share of elderly people on economic growth, social security systems and social cohesion in general.
- Global development goals such as the millennium development goals will need global solutions.
- Global Health: much effort is required for globally available personalized and affordable treatments for worldwide existing diseases.
- Global security will be a most significant problem throughout all challenges discussed above. Only if global security is guaranteed and basic economic freedom is sustained, it will become possible to address major issues like the climate change.

Innovation and technological progress is the key to address these challenges. However, these global challenges cannot be met at a national (or European) level. Developing competitive products and opening up new markets requires global cooperation. This is reinforced by the ongoing process of globalization which makes collaboration even more important.

Especially after the financial crisis of 2008/2009 economic growth is the main concern for Western governments and their political agenda. In order to achieve this aim, a successful science and innovation policy spurring domestic economic growth and employment is an important part of the answer. However, many Western economies are still in turmoil and have difficulties with economic recovery. Government debts have skyrocketed and the scope for political action is limited. The trade-off between financing long-term growth oriented innovation policies and reducing public debt will be a major political challenge all over the Western world.

At the same time, many Asian and other emerging economies have grown and are developing rapidly. Those emerging markets do not only focus on factor-driven growth. Instead, a high innovative potential, a large and growing number of skilled workers as well as rising R&D spending and educational investment contribute to their economic growth. With an average annual GDP growth of 13% between 2000 and 2008 and with a recent slowdown of 7.8% in 2009 China has grown to the world’s second largest economy behind the U.S. In the same manner GERD has significantly grown from 0.73% in 1991 to 1.5% in 2008, accounting to around 13% of OECD GERD and BERD in China was 1% in 2008, having increased by 27% annually in real terms since 1997. This constitutes to 12% of respective OECD expenditures in 2007, which accounted to 2% only in 1997. While the majority of R&D investments are flowing to OECD partners and current international R&D linkages are still small, respective numbers are growing rapidly and China is “increasingly considered as an attractive R&D location” (OECD 2010a). Ambitious investment in human capital and a currently exceptionally high share of science and engineering degrees as percentage of all new degrees contribute to economic and innovation growth. As an example, China’s market for renewable energies grew rapidly in the last years and thus has grown up to a strong global competitor in this field.

It is obvious that both, the United States and Germany, cannot meet these challenges in an isolated approach. Instead, international cooperation and coordinated policies should be further intensified. Even if their policies might be different, both countries are connected by a deep collaboration in their science and technology sector and respective policies. Not just that the U.S. is Germany’s most important scientific cooperation partner but also several joint initiatives have been launched. More than 50 bilateral agreements between U.S. and German institutes, organizations and companies have been ratified as well as more than 1500 university partnerships exist. The intergovernmental agreement on Science and Technology (S&T) Cooperation from 2010 is the overarching agreement providing a general framework for co-operation, with its first meeting taken place in September 2011 in Berlin. The U.S. is particularly interested to co-operate with Germany in the fields of advanced manufacturing, the production of lightweight materials, the enhancement of manufacturing efficiency for development of automotive as well as defense- and energy-sector products (White House 2011). Such S&T agreements facilitate and encourage international exchange of research results and innovations and build bilateral ties, with the current main focus lying in the following areas: Renewable Energies and Green Jobs, Medical and Agricultural Breakthroughs, National Defense and Security as well as Cooperation in Space and Understanding the Universe (White House 2011).

9 Conclusions

This paper provides an overview and comparison of German and U.S. research and innovation institutions and policies. Both countries’ innovation systems are shaped by a federal political system which shares competences and powers between the federal government, different states and research institutions with varying degrees of independence. Further, R&D intensity measured as the share of R&D expenditures in GDP is on a comparable level in both countries.

The German research and innovation system is mainly characterized by a strong non-university research sector with a specific strength in research-industry cooperation, such as the Fraunhofer Society. Moreover, the long and well-established tradition of state-funded, competitive project financing and the integration in the European research community are a distinguishing strength of the German innovation system. These factors married with Germany's distinguishing *Mittelstand*, featuring continuous incremental innovations, contributed to the fact that Germany, compared to other economies, came out of the recent financial and economic crisis very well. However, the university system does not feature international top universities and Germany's innovation system displays weaknesses regarding the education system and in the creation of innovative start-ups and financing innovative activities characterized by uncertainty.

The United States research and innovation system benefits from a social climate favoring risk and entrepreneurship, thus fostering private innovative activities. Thus, the international competitiveness of the United States relies to a significant share on its vibrant start-ups and spin-offs. Further, the U.S. innovation system is shaped by a number of world leading top universities, mainly private non-profit organizations. Similar to Germany, the university system is complemented by a system of strong federal and private non-university research institutes. In addition, an innovation friendly financing structure, such as the SBIR program as well as tax incentives for R&D together with an innovation friendly regulatory framework contribute to America's innovation success. In contrast to Germany the allocation of R&D expenditures has a focus on military expenditures.

Overall, both countries display complementarities regarding their economic structure. Thus, their innovation policies mainly address the specific strengths and weaknesses of the respective innovation system. In general, both countries' innovation policies can be characterized as effective and successful in relation to identified weaknesses of a nation's innovation system. This is reflected by high rankings in international comparative rankings of national innovation systems for both countries.

Therefore, a clear-cut evaluative comparison between Germany's and America's innovation system is not very meaningful. Still, there is potential for learning from each other's successful innovation policies. Further, the complementary nature of the countries' economic structure and respective innovation systems suggests that there is much scope for deepened cooperation and joint research initiatives. The fact that Germany and the U.S. face common global challenges and therefore share common goals, underlines the need for cooperation.

10 Literature

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