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PUBLIC RESEARCH IN GERMANY:

CONTINUITY AND CHANGE

RAINER FRIETSCH, TORBEN SCHUBERT

4.1 Introduction

The German research landscape is in constant flux. This is not a unique development in the world, but commonplace: if you do not go forwards, you go backwards. However, enforced application orientation, shrinking budgets, increasing shares of project funding, international benchmarks, the quest for excellence, the demand for highly qualified personnel, as well as demographics, are forcing the actors in the German research system to adapt and change. Quarrels about responsibility, influence and financial obligations among the federal states and at the national level exert future pressure on the system.

This means that there is more movement in the system than the usual adaptation to a changing environment. Incidents show that new structures and new policies have a considerable impact on the layout of the German research system. A particularly interesting observation is that there are strong arguments in favour of an increased mission orientation and profile development among the actors of the research system in Germany. At the same time, differentiation in terms of missions has been criticised because of the foregoing of collaboration potentials (Heinze and Kuhlmann 2007). In line with this criticism, it can be observed that universities were constantly pushed in the direction of knowledge and technology transfer as well as to establish science-industry linkages. Thus the two policy paradigms that have emerged could be characterised as differentiation and collaboration.

At the same time, we ask whether the mission orientation and the collaborative activities (the latter especially with respect to industry) in the German public research system could be increased. To this end, this chapter describes some of the new forces that are at play in the German research landscape and that have caused several of the actors to reposition themselves. Here we pay particular attention to direct policy initiatives that have influenced the innovation system as such, as well as changes in the financing structures that have become relevant in particular for the public research organisations.

The remainder of this contribution is organised as follows. In the following section the contribution briefly describes the layout of the German research landscape and the missions and role of the most relevant players therein. In Section 4.3 we describe the major innovation policy initiatives, where we pay particular attention to the question, to what extent they have impacted on the mission orientation. In Section 4.4 we discuss the major actors of the German public science sector in more depth alongside their missions and how changes in the financing modes that occurred over the past years have affected their priority setting. In Section 4.5 we furnish our conclusions.

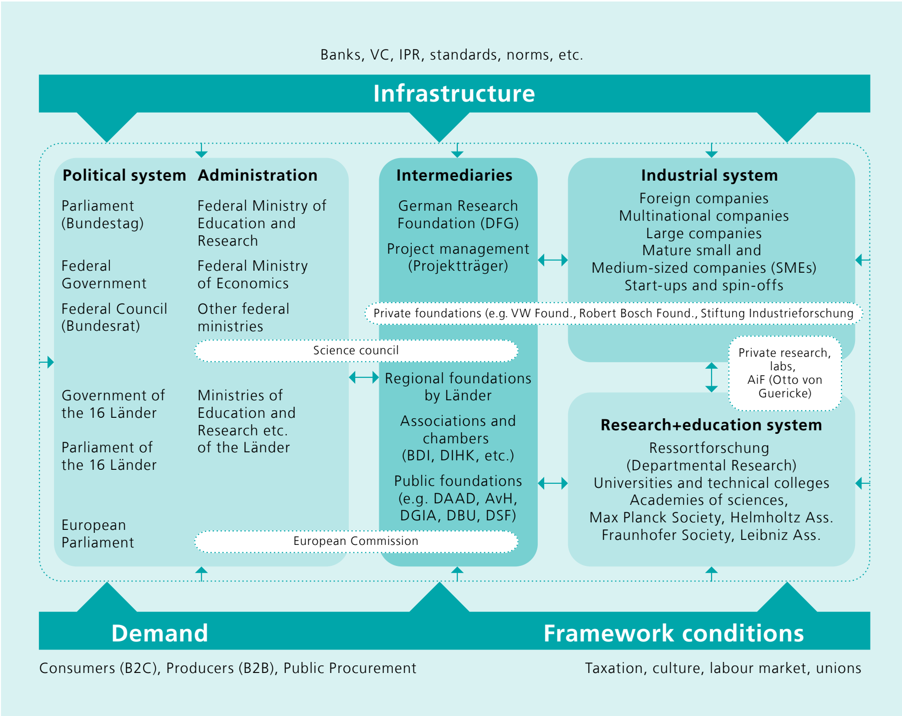
4.2 Germany's innovation system – a theoretical overview and a brief introduction

Nowadays innovation is influenced by a number of factors. Since Schumpeter wrote his work on innovation and the innovative entrepreneur (Schumpeter 1911), the role of and the perspective on innovation have changed considerably. While in Schumpeter's view the owner of a company was the decisive actor in the innovation process, uniting the legal, economic as well as the scientific responsibilities, the complexity of the processes, the division of labour and responsibilities as well as the structuring and target-orientation of research and development changed the layout of innovation at the micro and the macro level. According to Sundbo (1991; 1995; 2001), Schumpeter's era can be called the entrepreneurship paradigm, which characterises the time up to the first quarter or even first half of the 20th century. This was followed by an economic paradigm, where research and development (R&D) processes and the generation of technology and technological solutions became the main driver of the innovation processes. Nowadays, we live in the era of the strategic paradigm, which is still characterised by the strong role of formal R&D activities. However, as innovation is the successful implementation of new products or new processes (OECD and Eurostat 2005), R&D alone is no longer sufficient (cf. Chapter 3 in this volume). Due to the increased complexity of technologies (Kash and Rycroft 2002; Kash and Kingston 2001), the growing importance of knowledge (Berg Jensen et al. 2007; Foray 2004; Lundvall and Foray 1996; Nonaka and Takeuchi 1995; Teece 2003) – especially tacit knowledge – the internationalisation of markets and the internationalisation of knowledge production (Belitz et al. 2006; Patel and Vega 1999; UNCTAD 2005), networking and linkages, as well as the relevance of marketing and image cultivation, strategic aspects have gained importance in the innovation process.

The heuristic of national innovation systems (Edquist 1997; Freeman 1988; Kuhlmann and Arnold 2001; Lundvall 1992; Nelson 1993) takes the multiplicity of actors and institutions into account, which have a direct or indirect effect on the innovation output. It adopts a specific national, regional or sectoral perspective (cf. Chapter 1 in this volume). It is also tailored to reflect the influence of innovation policy, of intermediary institutions like facilitators or funding agencies. In addition, framework conditions, the market side, or finance and taxation might also be a focus of innovation analysis. The systems perspective also allows a differentiated analysis, as not all systems need to have the same layout and the same components. This heuristic is first of all a model of the actors and their relations. Innovations take place embedded in the political, social, organisational and economic sub-systems, constituted by the institutions and organisations that form them. This approach challenges the traditional modernisation theory that assumes one single development path for each national economy (Grupp 1998). Underlying this heuristic is a non-linear or recursive model of innovation processes, which allows the complexity of the process to be better taken into account than the rather simple linear innovation models that were more appropriate in the context of the second paradigm described by Sundbo (Schmoch et al. 2000). At the core of this approach are the industrial system and especially its R&D activities and its directed and target-oriented innovation endeavours. Besides, the public research system is of crucial importance for the success of any innovation system. Innovation policy on the part of government and public administration impacts the innovation activities, either by setting framework conditions and regulations or by directly funding public research as well as private research projects in companies. The education and qualification system which educates and qualifies the necessary, even mandatory human resources, is meanwhile one of the most important preconditions that shape performance. In addition, more on the periphery, but still a relevant sub-system, is society – including culture, risk aversion, or demand in the context of innovation and innovation performance. Furthermore, the financial system supplying the financial resources to invest in R&D and innovation is another relevant sub-system. Taxation and general regulation, including the legal system, which then also includes the intellectual property rights and the effective implementation and use of the legal system, also has an impact. Figure 4–1 depicts a rough description of the German innovation system and its layout.

While the innovation systems approach is meanwhile a well established concept in innovation policy and macro-economic analysis, its implementation in effective policies is less frequent in reality. Even if governments, ministries or agencies claim to have a systemic perspective, the effective real-world, every-day business is still fragmented and characterised by an organisation along technological responsibilities between and within ministries. We can hardly claim here that this situation has been overcome in Germany. However, the new High-tech Strategy 2020 is one important step in this direction. There are still quarrels about responsibilities and competences as well as an organisation that follows traditional paths of technological and functional differentiations.

Figure 4–1: The German innovation system at a glance



Source: Frietsch and Kroll (2010)

The complexity of the innovation process requires that this complexity should also be reflected in innovation policy. The new High-tech Strategy of the federal government takes the systems perspective into account and tries to reflect the complexity of the innovation processes. This is mainly done by moving away from the sectoral or purely technological perspective towards a mission-oriented perspective. The new Strategy starts from the global or big challenges that need to be addressed, and that can be addressed by science and technology. These big challenges are: energy production and provision, mobility, communication, health, and security and safety, which form the five columns of the new High-tech Strategy, and are called demand areas (*Bedarfsfelder*). Derived from these, the missions aim to solve the problems and to tackle the challenges. In addition to the five demand areas, some enabling or key technologies are also mentioned which play a relevant role in several of these demand areas. However, the task is no longer to offer isolated technological solutions, but to move their application and implementation into the focus of the policies. We explain this by citing an example: there is no direct radio frequency identification (RFID) policy or RFID funding programme. RFID may be relevant in the demand area "communication", but also for mobility, health or security and it will be funded by innovation policies based on concrete projects and requirements. This approach becomes even clearer and more understandable when the future projects are taken into account, which form the level below the demand areas. A set of future projects were introduced, among them future cities (more precisely, this is called the CO_2- neutral, energy-efficient and climate adapted city), sustainable mobility, or individualised medicine. It is obvious that a number of technologies are relevant in each of these future projects.

The German innovation system has a multi-level governance structure, both in horizontal and in vertical terms. In terms of science and innovation, essentially two ministries are responsible at the federal level, as well as a set of ministries that focus on certain topics and within which innovation usually plays a subordinate role, while a multitude of ministries and agencies also tackle this topic at the federal state level (*Bundesländer*). Besides, a set of state and para-governmental authorities and agencies are in play at all levels (Frietsch and Kroll 2010).

While the universities are administratively and legally managed at the federal state level, the large public research organisations are either mainly funded by the federal government in Berlin – in the case of Max Planck, Fraunhofer and Helmholtz – or partially funded by the federal government and the federal state where the institute is located – in the case of the Leibniz Association. The German Research Foundation (DFG) – as an intermediary organisation that mainly funds basic research, primarily in universities – is financed by both the federal government and the Bundesländer in equal shares. Universities are legally, administratively, and financially located at the level of the federal states. Following the recent reforms concerning the interaction between the Bundesländer and the central government, they are also almost exclusively financed by the former. However, the central government may co-finance university buildings, in the context of the excellence clusters as one funding scheme of the Excellence Initiative.

The public funding for science and research is aligned along the two dimensions project and institutional funding. The major share of public research funding is allocated as institutional funding, which may however be contingent on performance indicators. At the same time, an increasing share of funding needs to be acquired as project funding by several research performers, especially from national – including DFG – or regional and also European sources (BMBF 2007; BMBF and BMWA 2003; BMF 2009). The goals of project funding especially allocated under different programmes is to steer and channel the research in the public research sector, in universities, but also in companies. Programme funding targets certain policy goals. In the recent years, science-industry collaboration, increased application orientation, SME support, and certain new technologies were among them. Next to the missions of the research organisations and the universities, this is the way to reach certain policy goals.

The German research landscape is also characterised by a huge number of intermediary organisations that help to foster the performance of the system. Among them are the project management institutions, to which the ministries delegate some of the administrative tasks (BMBF 2007). There is also a clear mission orientation in the role of these intermediaries. The already mentioned German Research Foundation (DFG) mainly finances basic research in universities (and some non-university research organisations). There are several other foundations supporting science, research or technology transfer at the regional level. For example, the Steinbeis Foundation is successful as a mediator between science and industry, especially for SMEs and mid-tier companies, on the one hand, and universities and universities of applied sciences on the other hand. Another intermediary body is the German Council of Science and Humanities (*Wissenschaftsrat*), whose task is to advise the federal government and the federal states' governments on the present and future tasks and layout of the higher education system and the research system. The German Federation of Industrial Cooperative Research Associations (AiF/IGF) Otto von Guericke conducts contract research and development for industry (AiF 2008). Recently, technology transfer offices have gained visibility and are seen as relevant institutions by policymakers to move the system towards more application orientation.

Science, technology and innovation performers are manifold and the largest among them have been following a strict mission over decades, targeting certain tasks and scientific areas. The Max Planck Society (MPG) and also the currently 18 institutes of the Helmholtz Association can be located in the area of basic science. The former has a broad spectrum of technologies and research fields ranging from physics, chemistry or biotechnology to social sciences and demography. The latter mainly deals with large-scale research like energy or medicine and biology. They claim to pursue "long-term research goals on behalf of the state and society"[1]. The Fraunhofer Society, on the other hand, is the most important provider of applied research in Germany, thereby also striving to close the gap between science and industry. The members of the Leibniz Association which emerged from the "Blue List" institutes in the 1970s, came into being in 1990, fulfil different tasks, ranging from long-term research to services for other research institutes.

In general, one of the strengths of the German innovation system is the strong and clear division of labour between research associations and societies and also between public and private actors, as well as a strong functional specialisation, which can also be called "mission orientation". The mission of the universities is teaching, basic science, while technology transfer has also been emphasised by policy. At the same time, the performance dimension against which the universities are evaluated is still by and large their ability to produce world class (basic) research. The universities – as a matter of fact – cover the full spectrum of sciences, arts and humanities. Universities are administered and financed by the federal states' governments. Institutional reforms of recent years have changed the governance, the autonomy and in particular the financing structures of the universities. More will be explained in the next section. However, over decades all universities were seen as equal with respect to quality. No such idea as qualitative differentiation existed in Germany. Differences between the universities were ideologically conceptualised as irrelevant or marginal. This has changed in recent years, especially as a result of the Excellence Initiative

1 http://www.helmholtz.de/en/about_us/.

that provides considerable financial resources for concepts that aim for and claim worldwide outstanding research. The concepts that have won this competition so far were clearly boundary-spanning, so not only universities, but also other institutions have been included. They were also interdisciplinary, internationally oriented and especially with explicit science and technology transfer perspectives. Out of this initiative, the Karlsruhe Institute of Technology (KIT) emerged, which is a revolution in the German science system, given the fact that the former university – a regional institution of the state of Baden-Württemberg – and a research centre of the Helmholtz Association – financed by the federal government – merged.

In consequence, new forces have emerged that have pushed the actors in different directions. In particular, the change of the financing patterns has had an immense influence. The shares of institutional funding, especially for universities and the Fraunhofer Society, were reduced in relation to the share of third party funds, meaning these organisations had to reposition themselves.

While the mission orientation was introduced into innovation policy and the national innovation strategy, the clear mission orientation was softened in the research landscape. The questions are why, if this is a strategic move, and if this will have a positive impact on the overall performance of the German innovation system.

4.3 Innovation and research policies in Germany

German innovation policy of recent years or even decades was – among others – focussed on facilitating and fostering the collaboration between science and industry. This intention was essentially driven by two perceptions. On the one hand, the massive investments in the public research system produce a magnitude of relevant and potentially commercially exploitable results. Ultimately, next to general scientific curiosity and the overall enhancement of knowledge, this is what justifies investing taxpayers' money in the science system. On the other hand, the collaboration and interaction, especially with regard to the concrete exploitation and commercialisation of public research results offers a potential for additional – non-public – funding for the budgets of the universities and research organisations, thereby also steering their endeavours towards applicable and commercializable research.

Fostering university-industry collaboration is not a unique idea (Algieri et al. 2011; Schmoch et al. 2000) and many policymakers and governments all around the world have identified the potentials that lie in this collaboration between science and industry. However, the German innovation policymakers have taken this idea seriously and have introduced a bundle of policy measures and instruments dedicated to work towards this goal. The research premium for public research institutes, certain columns within the ZIM programme, a proof of technology funding, or the cluster policies are recent examples of this endeavour (BMBF 2006).

The High-tech Strategy launched in 2006 was a milestone in German national innovation policy. What was new, was the coordination of the innovation policy of several administrative bodies, mainly the Ministry of Education and Research (BMBF), the Ministry of Economics and Technology (BMWi), and several more like the

Ministries of Defence, Transport, or Environment. The core conceptual aims were to increase public expenditures on research – also to reach the 3 % objective of the EU that was adopted in the national policies at that time –, to promote collaboration between public research and industry, and finally to increase the orientation on applied research and the commercialisation of research results (BMBF 2006).

The basic approach of the HTS is based on continuing established and successful policy measures, while improving their coordination and supplementing them with new, target-oriented instruments. New measures were introduced such as the "Cutting-edge Cluster Competition" or the "Research Bonus".

The High-tech Strategy of the federal German government included several means and instruments – not all of them were newly introduced into German science and innovation policy at that time – to support and foster the collaboration of science and industry. For example, the Leading-edge Cluster Competition was a milestone in Germany's science policy with respect to science-industry linkage. The basic principle is to financially support the coordination and collaboration of thematically specialised clusters that were suggested and organised bottom-up. Facilitating regional or local exchange – this is also one of the basic insights from the scientific literature (Koschatzky 2012; Schmoch et al. 2000; Stahlecker 2006) – is the key to a successful policy to link the science and the industry community in certain technological fields. This initiative, that has been in effect since 2007, is organised as a competition, where the partners in a cluster must submit a joint application by the partners, followed by an evaluation by experts. Finally, five clusters per round will be selected, which are funded for 5 years with up to 200 million euros. It is expected that at least the matching amount of funding is invested by the business sector and private investors as well. The goal is the exchange between different actors of the innovation system. Science, industry and further actors in one region shall offer a joint concept that increases their innovativeness. It transpired that the application alone already helps to structure the regional/local activities and connects the actors. A so-called research bonus was introduced in early 2007. It was meant to motivate universities and public research institutes to intensify their collaboration with small and medium-sized enterprises (SMEs). The universities or public research institutes are paid a premium for each contract research project with SMEs.

In the revision and further development of the High-tech Strategy that was launched in 2010 under the title High-tech Strategy 2020, the German government's commitment to supporting the science-industry linkage is continued. A new focus is now laid on the application of the IPR of universities, public research, but also of SMEs. In addition, new campus models aiming to link up universities, public research institutions and industry are to be developed (BMBF 2010).

An equally prominent policy initiative directed to the public research system, in particular, but not exclusively to the universities, was the Excellence Initiative (*Exzellenzinitiative*) which started in 2005/2006. In the context of this programme the German universities had the opportunity to apply for funds from the DFG pertaining to the establishment of graduate schools, the creation of excellence clusters as well as future concepts. While in particular with respect to the future concepts – the above mentioned establishment of the KIT is one result of the Excellence Initiative – have definitely aspects of collaboration-increasing incentives, one must still conclude that the main focus of this programme was from the beginning to advance at least some of the German universities towards the worldwide scientific frontier. So, in general, the Excellence Initiative primarily aimed to create research environments that benefit basic research rather than fostering science-industry collaboration. This is particularly true with respect to science-industry linkages that play, if at all, only a marginal role. The first and second round of this programme (2006/2007) distributed roughly 1.9 billion euros to the German universities, while the third round which runs until 2017 will offer another 2.7 billion euros. The immense sums that were and are at stake led to a wide participation that has strongly influenced the activities and the self-perceptions of the universities.

Thus, in summary, while the High-tech Strategy 2020 tries to strengthen collaborative aspects as well as increase mission orientation, the Excellence Initiative created strong incentives for the universities to increase their basic research tasks. As this might create tensions between the aim of increasing industry-science collaboration and the call for international excellence, we will show in the next section that the pendulum, at least in the universities, has definitely swung to the former.

4.4 The public research system

As already highlighted, the German public science system is a differentiated system both institutionally as well as regards its tasks. Besides the higher education institutions, which themselves can be divided between the universities and the universities of applied sciences (*Fachhochschule*), there are a large number of semi-public non-university research institutes. The majority of the latter belongs to one of the four big research organisations Max Planck Society, Fraunhofer Society, Helmholtz Association, and the Leibniz Association.

In terms of personnel, these four institutes accounted for roughly one quarter of the public science sector in 2009 and thus form a considerable part of the German public science landscape. In more concrete terms, the universities including the universities of applied sciences had roughly 181,000 full-time equivalent (FTE) personnel, among them about 85,000 researchers (BMBF 2012, p. 486), while the number was about 61,000 (36,000 researchers) in the four organisations taken together. Of these 12,000 (6,500) were located in the Max Planck Society, 24,000 (14,000) in the Helmholtz Association, 13,000 (9,000) in the Fraunhofer Society and 12,000 (6,500) in the Leibniz Association (BMBF 2012, p. 489).

Also located in the non-university public research sector are a number of individual research institutes often directly affiliated with the federal states or the central government (*Bund-Länder Institute*). Furthermore, we find a large number of research institutes that are affiliated with the universities via cooperation contracts but are not primarily financed by them (*An-Institute*). While both taken together accounted for roughly 1.3 billion euros of the total budget over the past years (as a reference point, the universities had a budget of 20 billion euros in 2008, see Table 4–1), they constitute highly heterogeneous groups of institutes, which are hardly connected by any common mission or objective (Koschatzky et al. 2008). We will not further discuss these institutes within this contribution.

4.4.1 The higher education institutions

The universities and the universities of applied sciences differ from the big non-university research organisations primarily because only the universities and universities of applied sciences have institutionalised teaching obligations. The non-university institutes, on the contrary, offer teaching only inasmuch as their personnel are also affiliated with the universities.

By 2011 there were 110 universities (including the technical universities) and 231 universities of applied sciences. Additionally, there are 73 "other universities" which have a much narrower thematic focus on special topics. Among them are the pedagogic, theological or sports colleges. In terms of personnel, however, the universities account for 80 %, while the universities of applied sciences account for 17 %. The 73 "other universities" are usually very small and make up the remaining 3 % in terms of staff (Brandt et al. 2011).

While both universities and the universities of applied sciences have the teaching task in common, there are also important differences between them. From a legal perspective, the decisive distinction is that the universities of applied sciences are not allowed to grant doctoral degrees. That implies that the universities of applied sciences focus their teaching tasks on undergraduate teaching up to at most Master's level, while the universities also engage in higher tertiary teaching.

In order to understand the reasons for this 2-class higher education system, it should be noted that the universities of applied sciences in their current form are a relatively new institutional element, which came into existence in the years after 1969. The major reason for the creation of the universities of applied sciences as an additional player was the implementation of the higher education expansion, i.e. the politically fostered increase in access to higher education. While traditionally higher education was the preserve of a small elite and a point of immense social status, today higher education possibilities have been opened up for much larger parts of society. This can also be observed in the statistics: while in 1969 less than 600,000 students were matriculated in a university, this number had reached about 1,800,000 in 1997 (Sternberg 2001).

The major objective in creating the universities of applied sciences was therefore to provide suitable capacities that could sustain the expansion of higher education. Correspondingly, the original aim of the universities of applied sciences was not to increase the research capacities. This explains why also today the universities of applied sciences are focussed on teaching and only engage in research to a limited degree. If they do so, the research is usually of a more applied nature than the basic research conducted at the universities. Furthermore, the universities of applied sciences usually build up strong networks of collaborative research with local companies, many of them small and medium-sized, in order to increase knowledge and technology diffusion as well as offer networking advantages to their students and graduates.

In accordance with this image, Brandt et al. (2011) report that more than 70 % of the university professors report giving highest priority to basic research, while only 22 % of the professors at the universities of applied sciences do so. The latter give, however, the highest priority to applied research (55 %; university professors between 34–39 %). Teaching, on the contrary, is much more important for the universities of applied sciences (60 %, university professors 38–39 %). Furthermore, technology transfer is of lesser importance for university professors. While 22 % of the professors at the universities of applied sciences report high priority for this field of action, at the universities only 5–8 % do so.

4.4.2 The non-university public research institutes

As already mentioned, the non-university institutes, most of which belong to the Big Four (Max Planck, Fraunhofer, Helmholtz, Leibniz), do not have official teaching obligations. Instead, they focus on research. However, the research focus differs strongly. While some are oriented towards basic research, others are focused more on applied research and technology transfer. Like the universities of applied sciences, the non-university research organisations are also a relatively new element in the German public research landscape, having been mainly founded in the middle of the 20th century.

Emerging from the Kaiser-Wilhelm-Gesellschaft which was founded as early as 1911, the Max Planck Society came to existence in 1948. The Max Planck Society with its 80 institutes (most of them from natural science but some also from social sciences and economics) focuses on "world-class" basic research.

The Fraunhofer Society, on the contrary, founded in 1949, was set up as an organisation that is focussed on applied research being conducted with or for actors from the private enterprise sector. Thus the Fraunhofer institutes have a role spanning the boundaries between public science and the private economy. This differentiation is institutionalised in the so-called "domain consensus" (*Domänenkonsens*) which posits that the Fraunhofer Society should be basically responsible for filling the gap between basic research (usually attributed to the universities and the Max Planck Society), applied research and market commercialisation. Today the Fraunhofer Society consists of 80 research centres of which 60 are full institutes, almost all of them from engineering and natural sciences.

Emerging from the Forschungszentren Karlsruhe und Jülich the *Arbeitsausschuss für Verwaltungs- und Betriebsfragen der deutschen Reaktorsicherheit* was established in 1958, which was the original start of the Helmholtz Association[2]. Today the Helmholtz Association has 17 large scale institutes and is by far the largest among the non-university research organisations. Its original mission is defined as to contribute to solving urgent, large-scale societal problems. Traditionally the Helmholtz Association focused on nuclear research. However, due to the increasing societal resistance to this technology which resulted in the final decision to shut down all nuclear reactors in Germany by 2021, the portfolio naturally shifted away from this. Today important topics are among others cancer research, molecular medicine, polar and marine research or health and environment.

2 This name actually dates back only to 1995.

The youngest of the research organisations is the Leibniz Association which is not a tightly managed research organisation, but a conglomerate of many individual research institutes that are equally active in natural, engineering and social sciences. Initially it emerged from the 46 so-called "Blue List" institutes in 1970, and today comprises 86 institutes.

It is probably right to say that while the Max Planck Society focuses on internationally competitive basic research, the Fraunhofer Society deals with applied research and its diffusion to private actors, and Helmholtz works on large-scale societal problems. The Leibniz Association is probably the organisation whose profile or mission is least clear cut.

In summary, the system of actors and tasks which characterise the German public research landscape that evolved from an initially homogeneous university-dominated system is today highly differentiated. These differences in missions have traditionally been sustained by the financing structures, which we will describe below. However, we will also see that, during the past decade, these structures have experienced changes, which has forced some of the players to adjust their missions.

Because some authors have argued that one hampering factor in the German science landscape which inhibited interorganisational collaboration was the strong segregation (*Versäulung*) (Heinze and Kuhlmann 2007), an important question is whether the current changes in the financing structures are likely to reinforce or weaken this traditional differentiation.

4.4.3 Changing financing structures and implications for the institutional missions

Over the past years, a remarkable increase in overall resource expenditures was observed in the public science sector. This is equally true for universities and universities of applied sciences, Max Planck, Fraunhofer, and Helmholtz, as well as Leibniz. As Tables 4–1 and 4–2 exemplify, the total university expenditures rose from 13.6 billion euros in 2001 (including expenditures for teaching) to about 20.6 billion euros in 2008. This corresponds to a yearly average growth rate of 5.3 %. Similar trends can be observed for the four big non-university organisations. Here, the total expenditures increased between 2006 and 2009 from roughly 3.8 billion euros to 4.5 billion euros, which corresponds to an annual growth rate of about 5.8 %. In accordance with the Pact for Research and Innovation (*Pakt für Forschung und Innovation*), the four research organisations received a budget guarantee and a budget increase of 5 % annually until 2015. The intention was to offer planning scope and a growth strategy. In exchange, they have to report their activities and progress in an annual report – the PFI monitoring report.

The universities and the universities of applied sciences

However, while at first sight this might suggest a situation of financial abundance for public research, this is only part of the truth. In particular, when the universities are looked at in more detail, Table 4–1 reveals that the increases in expenditure were largely financed via third party funds.

Over the period from 2001 to 2008, the state basic funds which are largely granted on an unconditional, non-competitive basis, rose by an annual growth rate of only 2.8 %, while third party funding leapt upwards with a growth rate of 12.8 % p.a. Correspondingly, the share of expenditures financed by state basic funds decreased from 85 % in 2001 to approximately 71 % in 2008.

Table 4–1: The university budgets

	2001	2002	2003	2004	2005	2006	2007	2008
Total expenditures in m Euro	13,696	14,896	16,393	16,604	16,798	17,505	19,162	20,661
Administration income in m Euro	320	403	634	730	889	1,655	1,923	1,945
Third party funds in m Euro	1,627	2,139	2,523	2,646	2,823	3,186	3,640	4,033
State basic funds in m Euro	11,749	12,353	13,235	13,228	13,085	12,663	13,599	14,684
Share of state funding in %	85.79	82.93	80.74	79.67	77.90	72.34	70.97	71.07

Source: Statistisches Bundesamt, own calculations

Thus the strong tendency is to shift resources away from unconditional funding towards competitive finance sources – an observation made already by Schubert and Schmoch (2008). Table 4–2 highlights that this tendency is indeed due to a deliberate state shifting of resources away from basic funds towards the financers of public research, in particular the German Research Foundation (DFG), which offers funds for basic research that must be acquired within a comeptitive application procedure. The share of DFG funds as a fraction of all third party funding increased between 2006 and 2009 from 28.8 % to 34.8 %. Similarly, we can observe an increase of third party funds directly offered by the central government (in particular the Ministry of Education and Research). Here the share increased from 19.5 % to 21.2 %. The biggest losers on the contrary were the private enterprises, whose share fell from 26.2 % to 22.9 %. In other words: More money is being invested in the system by federal sources, but so far the policy goal of "more application orientation" in general has not been reached.

Table 4–2: Third party funding in the universities by source

	Central state	Länder and cities	Other public funds	DFG	European Union	International organisations	Foundations	Enterprises
2006	19.5	3.0	3.0	28.8	9.6	0.8	9.0	26.2
2007	20.2	3.2	1.8	32.1	8.1	0.9	8.0	25.8
2008	19.9	2.8	2.0	33.7	8.9	0.4	7.5	24.8
2009	21.2	3.0	1.7	34.8	9.0	0.5	7.0	22.9

Source: Statistisches Bundesamt, own calculations

So, with respect to the universities, several important changes in the financing structures were observed that are likely to impact on the universities' position in the research landscape. First, the overall resources have been greatly increased. Second, this increase was primarily due to increases in third party funding, which again was a result of the state decisions to redirect previously unconditional funds to the DFG that grants research money within an application-based procedure, as well as the resources provided in the context of the Excellence Initiative. Third, funds from enterprises greatly decreased in importance.

In summary, we indeed find strong increases in the resources available for research tasks, while relatively less seems to be available for industry-science research collaboration. While this corresponds to the expressed desire to bring universities back to the research frontier, also in an international perspective, it is at the same time true that the aim to support and sustain knowledge diffusion through the industrial financing of research has lost impetus.

The non-university research sector

Interestingly, this trend to finance the additional research capabilities only via competitive third party funds cannot be observed for all non-university science organisations (cf. Table 4–3). While all four big non-university research institutions were able to drastically increase their budget between 2006 and 2008, only the Fraunhofer Society experienced a steady decline in its share of institutional base funding, while for the remaining institutes it remained stable (Leibniz and Helmholtz) and even went up by 2.5 % for the Max Planck Society.

Table 4–3: Expenditures of the big non-university institutes

	R&D expenditures in million Euro				Share of state funding in %			
	Max Planck	Fraunhofer	Helmholtz	Leibniz	Max Planck	Fraunhofer	Helmholtz	Leibniz
2006	1,303	1,206	2,578	1,069	79.34	37.92	61.92	68.90
2007	1,290	1,319	2,740	1,107	81.60	35.41	62.15	68.50
2008	1,560	1,401	2,992	1,162	82.78	33.90	62.00	68.92
2009	1,533	1,562	3,112	1,299	78.00	32.00	63.89	65.63

Source: Statistisches Bundesamt, own calculation

In consequence, the political dynamics that apply to the universities led to shifts in expenditure from unconditional funding towards competitive third-party funds does not generally find its counterpart within the non-university public research sector. In fact, only the Fraunhofer Society suffered comparable decreases in the amount of basic funding as a share of total expenditures. With regard to the latter, it can be hypothesised that this will push Fraunhofer towards a much more applied focus, because it has access to DFG funds only in exceptional cases. Thus, the increase of total expenditures in the Fraunhofer Society is quite likely to be primarily due to funds relating to applied and diffusion-oriented research. It should be mentioned that the Fraunhofer Society has grown considerably over the past 10 years, almost doubling the number of its personnel. In consequence, the increased application orientation of the system, introduced by policy-makers, is mainly delivered via the Fraunhofer Society and, to some degree, by the universities although we observed that the relative importance of industrial funds for the universities has been constantly deteriorating.

This implies in particular for the institutes of the Max Planck (basic research) and the Fraunhofer Society (applied and transfer-oriented research) that the original missions seem to be strengthened rather than weakened.

4.4.4 Output profiles in flux

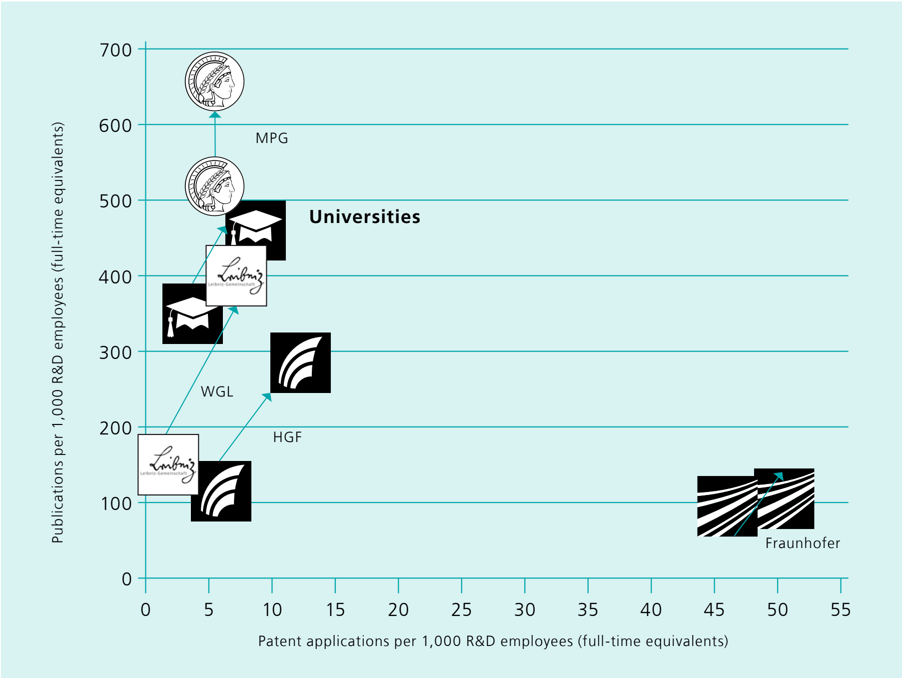
While acknowledging that all major actors in the German public science system experienced an increase in available resources, we also see that for some actors the financial mix strongly shifted in the direction of third party funds. This is true for the universities as well as Fraunhofer. However, while the former basically profited from the increased importance of the third party funds provided by the basic-research oriented DFG, Fraunhofer increased its overall resources through more application-oriented third party funds.

Following this shift in resource orientation, this suggests that the universities are moving much more in the direction of basic research tasks, while putting less emphasis on applied or university-industry collaborative research. The Fraunhofer Society, on the contrary, is likely to strengthen its position in applied research, and linked to that in technology development and transfer.

Indeed, when looking at Figure 4–2 which depicts the evolution of publication intensity (y-axis) and the patent intensity (x-axis) by organisation actor, we can observe that between 1994 and 2008, the universities shifted their output profile strongly in the direction of scientific publications. Over the same period, Fraunhofer retained its high patenting-oriented profile. Likewise, its publication intensity has remained at the same relatively low level since the mid 1990s. The Helmholtz and the Leibniz Societies increased both their publication and their patenting intensity. However, both experienced definitely stronger increases with respect to publishing activities. The Max Planck Society, despite some fluctuations between 1994 and 2008, did not change its position markedly, remaining with its relatively low patenting and relatively high publishing intensities at the other end of the spectrum from Fraunhofer.

In summary, the changes in financing structures are likely to favour re-orientations within the science system that increase the basic research capabilities of the universities, while technology transfer as well as the collaborative industry-public science research collaborations have lost importance. These are likely to be increasingly performed by the Fraunhofer Society (and to a certain degree by the universities of applied sciences). In this light, a dedifferentiation is unlikely to be a dominant feature of the future German science system.

Figure 4–2: Patent and publication intensity (per 1,000 employees) for universities and the four large German research organisations (1994, 2008)



Source: PATSTAT, Web of Science, Statistisches Bundesamt, calculations: ZEW and Fraunhofer ISI

So what we see is that the mission orientation, especially of the two counter poles Max Plank Society and Fraunhofer Society, appears to be strengthened. Furthermore, the universities and to some degree the other two large players are heading towards a greater basic-research orientation. This leads us to conclude that the policy aim of a greater mission orientation is indeed being successfully reached. However, the collaboration among the different players in the innovation system – in particular the establishment of science-industry linkages – appears to have lost importance. This latter conclusion holds, with the exception of the Fraunhofer Society and to some degree the universities of applied sciences.

4.5 Summarising conclusions

The German innovation system is in constant flux, but there seems to be more than the usual change in the system. The innovation systems approach – as the reflection of the innovation actors and their linkages – was taken seriously by German policy-makers in recent years. However, the high functional differentiation and division of labour between core actors – this was one of the central characteristics of the German innovation system in general, and of the public research sub-system in particular, for many years – seems to be softened by new incentives and directives that can be summarised under the title “New Public Management” (Schmoch and Schubert 2009; Schmoch and Schubert 2010; Schubert 2008), but also influenced by shrinking relative budgets and demographic trends.

Nowadays innovation is not successfully implemented based on R&D alone. The increasing complexity of technologies, the internationalisation of markets and of knowledge streams, as well as growing competition, move further parts of the innovation process like collaboration and marketing into the centre of discussion. The innovation system, including innovation policy-making, needs to react to these external changes.

The High-tech Strategy and the High-tech Strategy 2020 both aim – among others – to improve the collaboration and linkage between science and industry, mainly to foster the application and commercialisation of public research knowledge and technologies. While the contribution of the first version of the High-tech Strategy was to formulate a coherent strategy and to increase the coordination between departments in the federal government, the latter mainly moved away from technology-oriented policy-making and introduced a mission-oriented innovation policy.

A mission orientation was and still is the basic feature of the German research landscape. A strong division of labour, structural differentiation, and functional specialisation characterise the system. However, the German research landscape was forced to change recently, mainly by changes in the funding and financing structure. Policy-makers offered incentives and changed some of the framework conditions in order to introduce their policies, among them the increased application orientation. Several instruments were introduced, such as cluster policies, certain columns within the ZIM programme or also less successful instruments, like the research bonus. One of the most striking policy changes was introduced by the Excellence Initiative. Before 2007, when this programme was launched, all universities were declared to be equal with respect to quality of research and teaching. With this new initiative, it is accepted that some of the universities are “more equal” than others. This was driven by the insight that in order to perform world-class research and education, some of the universities need to stand out and catch up with world-leading research institutions.

In effect, the whole German research landscape receives more funding in general, and more third-party funding in particular. So the new policies were mainly transformed into reality, not by increasing the institutional funding (to the same extent), but by increasing third party funding, where competition is the main allocation factor. Empirical evidence suggests that the new policies even enhanced the strong differentiation and functional specialisation. The Max Planck Society with its basic research mission and the Fraunhofer Society with its application mission seem to focus even more on their main tasks. The Leibniz and the Helmholtz Associations are obviously affected more by the external changes and are still located in between basic and applied research. The immense state investments that followed the Excellency Initiative have consistently moved the universities in a basic research direction and, despite policy initiatives such as the High-tech Strategy 2020, have experienced a constant erosion of industrial funding.

This leads us to conclude that, with the exception of Fraunhofer, the increased funds in the system have not strengthened the industry-science linkages. So, while the policy aim of greater mission orientation seems to have been fulfilled, the parallel aim of increasing collaboration appears to have been weakened, in particular with respect to the universities.

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