Chapter 9
The Role of Research in German Universities of Applied Sciences

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Introduction

For the past 40 years, the German higher education system has been enriched by the practice-oriented teaching as well as applied research at the universities of applied sciences (UASs) or *Fachhochschulen*. The current set-up as institutions of higher education (universities) came about by the agreements between the states of the Federal Republic of Germany to standardise in the field of UASs on 31 October 1968. About one third of the UASs have their origin in institutions (i.e. higher technical educational establishments, higher technical colleges), which were founded before 1969. The other third were established in the 1970s, mainly in 1971 and 1972. A renewed wave of establishing UASs took place in the 1990s, mainly in the new *Länder*, but also in the old states. The objective of establishing the UAS was to create institutions that would offer the students, on a scientific basis, a practice and career-oriented education and enable them for self-determined activities in the professions. At the end of 2007, the number of students attending UASs was 545,000 according to the Federal Office of Statistics, which corresponds to 28% of all students in Germany.

Unlike universities, UASs do not have the right to award doctorate or *habilitation* degrees. The typical mix between education and research differs considerably between universities and UASs: lecturers from UASs have a teaching load of 18 h/week and longer lecturing time within the semester. In contrast, lecturers at universities have a 60% time budget for research with comparatively low teaching schedules. In comparison to universities, UASs frequently have, with respect to the offered fields of study, a limited number of courses and lower number of students. In the early stages, research was not considered a profile feature at UASs. However, with the amendment of HRG 1985 (University Act), applied R&D now belongs to the tasks of UASs.

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In the course of the Bologna Process, the UASs have relative quickly modified their academic programmes and introduced a variety of bachelor and master programmes in recent years. This shift was faster than in universities. From the current 3,763 courses at UASs 55.0% lead to a bachelor's degree, 33.8% to a master degree and 11.2% to a diploma. In contrast the data for universities are the following: bachelor's degree: 33.5%, master's degree: 30.6% and diploma: 35.9% (source: www.akkreditierungsrat.de, 2008).

The German higher education system currently comprises some 350 higher education institutions (HEIs), state and state-approved, including the following different types of institutions: (1) universities, (2) universities of applied sciences, (3) colleges of education, and (4) academies of fine arts. The largest groups according to the number are the UASs (184) and the universities (109). Of these 350 HEIs, however, 79 can be excluded as their specialisation is not relevant for the issue we are addressing here, e.g. art and music academies, colleges of theology or social education.

On the whole, the 164 state or private UASs do not have a standardised profile. They vary considerably in terms of enrolments, the study courses they offer (with a broad range of subjects in the engineering sciences, the social sciences and economics) and their R&D capacities. This variation results from the differences in the regional environments of UASs and the areas from which the institutions draw their students. UASs focus strongly on the needs of regional industry and commerce in their areas. These institutions have enlarged their spectrum of tasks since the early 1980s. Among the new tasks and activities, efforts in the areas of technology and knowledge transfer are especially important. Most state UASs have 2,000–8,000 students. They are considerably smaller than universities. There are also a number of UASs, which have – according to the number of students (10,000–15,000) – a size similar to medium-sized universities. Seventy-two per cent of students (1.32 million) attend state universities; private, state-approved universities are attended by only 3% (59,400), whereas 25% (470,000) are at state UASs and less than 1% (8,600) at private, state-approved UASs.

According to the shares of single subject groups, two main focuses can be discerned for UASs (see Fig. 9.1); half of the students (49%) belong to the non-technical areas 'legal, economic and social sciences', 'art, art history' and 'linguistic and cultural sciences', the other half (51%) can be allotted to the technical/natural science disciplines 'engineering sciences', 'mathematics, natural sciences', 'agriculture, forestry and nutrition sciences' and 'human medicine and health care'. The UAS group is very heterogeneous here too, as there are UASs which offer almost exclusively technical/natural science courses of study and others in which economics and social sciences dominate.

In the year 2007, 88,000 students completed a course of study at a UAS, with approximately 42,300 of them specialising in a technical/natural science course of study. In contrast, the number of graduates from universities amounted to 170,100 (79,000 of whom specialised in a technical/natural science subject). Around 13,300 professors work in UASs, in universities about 21,000 (see Statistisches Bundesamt, 2008b). Basic running costs per student amounted to €3,990 in the UASs, whereas

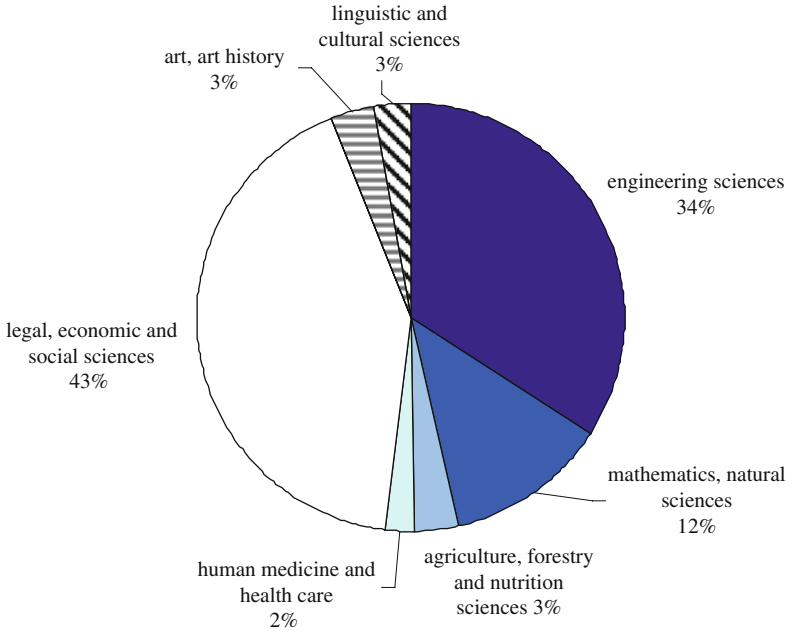

Fig. 9.1 Subject groups in UASs by number of students in 2007. Source: Statistisches Bundesamt (2008b)

in the universities the amount is more than double, at €8,390 (2006, see Statistisches Bundesamt, 2008a). This means that education at UASs costs considerably less than an education at universities. This is not caused by a fundamentally different curriculum structure, although universities have a large number of students of human medicine/healthcare sciences, which are characterised by high basic running costs per student (€26,560). In the last 10 years, the basic costs remained essentially unchanged with a simultaneously increasing number of students, which clearly restricted the financial leeway of the UASs and universities, given the simultaneously growing demands on the quality of education.

The R&D Potential of Universities of Applied Sciences

Within the national innovation system of large enterprises active in R&D, universities and non-university research institutions play a central role along the entire value-added chain, from basic research up to market-oriented R&D; the profile and the sphere of activity the UASs have expanded increasingly in the past years. Besides their contribution through a practice-oriented education – above all in engineering, but also in the natural sciences and economics – their significance as regional knowledge and research anchors or supports in the area of applied R&D is increasing. Many UASs are usually well connected in regional networks and also

possess (profound) knowledge about the regional industrial structures. This does not apply for all UASs ubiquitously, rather, great differences still exist in the experience, professional and personnel potentials and leeway time-wise for application-oriented R&D. This has various reasons: first of all, the unfavourable structural framework conditions must be mentioned. Other than in universities, the UASs, due to their strong focus on teaching, only have a limited number of scientific staff at their disposal who assist the professors in conducting lectures or in research projects.

The degree to which a change in culture and mentality has taken place plays a role in the status of R&D in the UAS. The attractiveness of conducting R&D projects depends for the professors on the extent to which application-oriented research projects attract attention, recognition and support in the institution in question and how the projects are promoted/supported financially by the HEI administration and the governing bodies. Thus the success does not depend only on the personal involvement and interests of individual professors.

According to the calculations of the Federal Office of Statistics, the expenditures of the UASs on R&D in the year 2005, however, still amounted to €673.9 million. This clearly lies below the outlay of the universities (€8.13 billion). The lion's share of the R&D expenditures (see Fig. 9.2) fell to 'engineering sciences' (€360.2 million), followed after a large gap by 'mathematics, natural sciences' (€106.5 million) and 'human medicine and health care' (€83.6 million). The structure in universities differs completely: 18% is allotted to 'engineering sciences', 32% to 'mathematics, natural sciences', 27% to 'human medicine and health care', 8% to 'legal, economic and social sciences', 12% to 'linguistic and cultural sciences', and 3% to

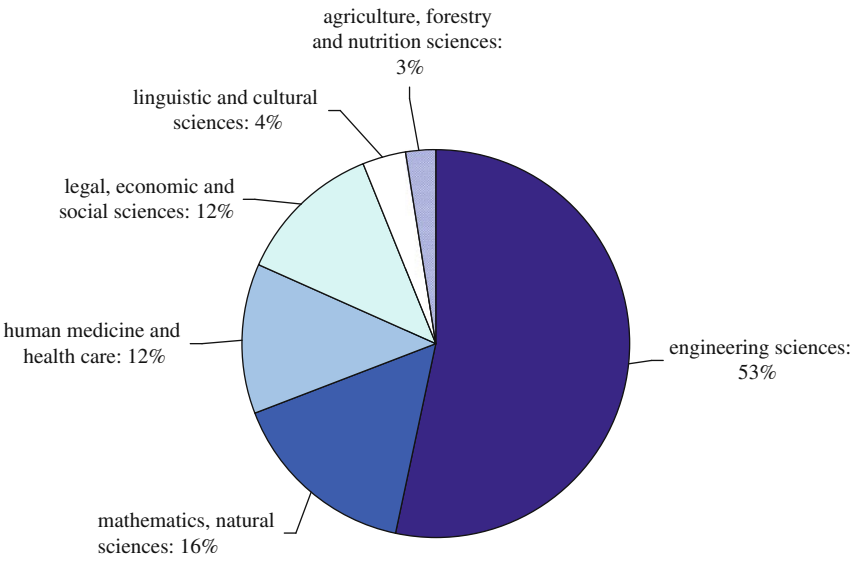

Fig. 9.2 Structure of R&D expenditures by subject groups in 2005 at UASs. Source: Statistisches Bundesamt (2008c)

'agriculture, forestry and nutrition sciences'. The considerably higher status of the 'engineering sciences' expresses the stronger application orientation of the R&D activities in the UASs.

National Policies for Research in Non-university Institutions

Strategic Goals and Guidelines for Research

The development of UASs is shaped to a high degree by the higher education policy objectives of the *Länder*; the financial support by the sponsoring ministry determines the performance of educational and research tasks. In view of the disastrous household situation in all *Länder*, funding has been cut considerably in the last 5 years, especially in 2003/2004. In the last 5 years, amendments were made to the universities acts of the *Länder*, giving applied R&D in UASs greater importance. In the meantime, R&D has become an official mission at UASs in all *Länder*, although with varying degrees of importance: in 11 *Länder* it is regarded as an official mission independent of the educational mandate and in five states it is a mission within the context of their educational mandate.

The view of the UASs as primarily teaching institutions coloured the policy of the *Länder* for many decades. Since the beginning of the 1970s, the UAS landscape has altered in many and varied ways. The various recommendations on the part of the Science Council (*Wissenschaftsrat*) on the role of the UAS contributed decisively in this context (Wissenschaftsrat, 1981, 1991, 1993, 2000, 2002). The tasks of application-oriented R&D and technology transfer gained considerably in importance in the UASs. In connection with application-oriented R&D its function for teaching is repeatedly emphasised: it is a structural requirement because research establishes the relation to work practice among the teaching staff via cooperation with industry and supervision of the students' bachelor or master theses in firms. Without this constant feedback with professional practice and the changes therein, successful courses of study providing professional qualifications would not be possible.

Priority-Setting Between Teaching and Research

The typical ratio of teaching to research differs clearly between the UASs und universities: UAS lecturers complain frequently about their teaching commitments of 18 h/week during the semester (semester hours), in addition the lecture period in a semester at the UASs is longer than at universities. Lecturers at universities have a 60% research share in their time budget with comparatively few teaching hours. In contrast to universities, UASs – measured by the number of courses – frequently have a limited teaching load and fewer students. There are, however, possibilities to reduce the extent of the teaching commitments if R&D work is conducted instead.

This is regulated differently from one federal state to another. In the most favourable case, a reduction to 9 h/week is possible if R&D projects are being carried out on a large scale. However, only a small number of professors in UASs can profit from this regulation. In a study on research in UASs (Kulicke & Stahlecker, 2004), Fraunhofer ISI came to the conclusion that in most of the 69 UASs investigated only a small number of professors conducted any R&D projects at all: in almost half the share of these professors out of all UAS professors lay between 11 and 30%, for a further 37% the share varied between 31 and 60%.

Personnel limitations result not only from the high-teaching commitments at UASs, but also the almost totally missing middle level of academic and administrative staff and the restricted possibilities to hire qualified graduates as staff (only possible in the framework of cooperative doctoral theses, i.e. in cooperation with an university with the right to award doctorate degrees). In addition, the self-conception of the professors also plays a role to a certain extent, if they concentrate on tuition in view of the high-teaching commitment. The incentive and motivational instruments available to HEI management were mostly not so strong in the past to effect short-term, tangible changes in behaviour of this group. The room to manoeuvre on the part of the HEI management to reward professors' R&D activities by reducing teaching hours varies from one federal state to the other, but is on the whole limited. A number of indications in the recent past signal that, on the whole, the interest of UAS professors in application-oriented R&D has greatly increased. The public promotional programmes encouraged this trend, also the fact that technology transfer and the acquisition of third-party funds play a heavier role in the allocation of basic funds to the UASs by the *Länder*.

Funding of Research

R&D was defined some years ago in the state university law as one of several tasks of the UAS, but no commensurate increase in UAS budgets for such activities took place, nor have any concrete guidelines been introduced to specify the extent of research to be undertaken. Thus the scope for R&D in UASs is determined primarily by public promotional programmes, which are run either by the *Länder* or the federal government. Not all *Länder* implement such programmes. This applies above all to the larger states such as North Rhine-Westphalia, Baden-Württemberg and Lower Saxony. They mainly promoted the development of human resources and infrastructure. Programmes which finance individual R&D projects can offer more funding.

Three types of programmes should be differentiated:

(1) Programmes which target a stronger collaboration of firms with universities, UASs and research institutions (e.g. PRO INNO II or ZIM – *Zentrales Innovationsprogramm Mittelstand*); the focus is on small and medium enterprises (SMEs) whose innovativeness should be strengthened. The research partners in universities, UASs or non-university research institutions can also be promoted. In this programme HEIs are important research partners of SMEs.

Besides universities (share 41.0%), UASs also have a strong position (12.7%) (see Kulicke, Bührer, & Ruhland, 2006).

(2) Programmes which promote joint projects between industry and science in selected technology fields and make high demands of the technological project goals and the innovation potentials of the participating research partners. UASs only seldom participate in such technologically demanding projects, at most as junior partners of large firms, universities and non-university research institutions.

(3) Programmes which are tailor-made to suit the UAS capabilities. They aim to strengthen the R&D potentials of UASs, so that they can primarily carry out application-oriented R&D projects for and with SMEs.

Since 1992, the category (3) programmes of the Federal Ministry of Education and Research (BMBF) in chronological order are: 'Application oriented research and development at Universities of Applied Sciences' (aFuE), 'Applied Research at Universities of Applied Sciences in cooperation with Business' (FH^3, since 2004) and 'R&D at Universities of Applied Sciences in Cooperation with Business' (FhprofUnd, since 2007). These three programmes had different strategic goals for the development of UASs, aimed to develop the area of R&D step-by-step into a profile-enhancing characteristic.

The first programme, aFuE, was aimed at enhancing external funding at UASs, i.e. the success of such institutions in obtaining third-party funding for application-oriented R&D projects. From 1992 through 2003, the BMBF received a total of some 5,800 applications (see BMBF, 2003 and Kulicke & Stahlecker, 2004). Of these, 951 received support, with total project funding of €83 million. In 2004, the BMBF implemented a shift in focus towards supporting regional research consortia at UASs which are relevant for business and industry. This re-orientation of funding policy objectives was set for stronger interdisciplinary and inter-institutional cooperation, through which UASs should cooperate with partners from business (preferably SMEs), science (research facilities, universities) and partners from other fields. This was also reflected in the new programme name: Applied Research at Universities of Applied Sciences in cooperation with Business – FH^3. The focal point was to strengthen the capability of UASs to work in consortia (see Kulicke, Zimmermann, Kroll, & Bührer, 2008). Hence industry-relevant cooperative projects of UASs were promoted, whereby special attention was given to the cooperation with SMEs in this region. Through the support of interdisciplinary and inter-institutional cooperation, these UASs should be put in the position to have stronger involvement in research consortia. It was thereby intended that structural deficits of staffing at UASs (the absence of professional 'academic middle level', i.e. academic staff below professor/lecturer status, such as junior or assistant lecturers, and research fellows and assistants) are compensated and their R&D potential in regard to participation in research consortia is strengthened. By means of the FH^3 Programme's requirement that science partners must be integrated in the single R&D projects, a greater cooperation of UASs with other elements of the innovation system should be achieved, above all with universities and non-university research

institutions. The promotional programme FH^3 received a total of over 1,500 applications in the period 2004 until 2006, of which 255 were promoted. With a subsidy amount totalling €52.9 million, this corresponds to an average of €207,000 per approved application.

The programme FhprofUnd continued to promote UASs with similar instruments to FH^3. In 2007, €23.2 million were granted for 106 projects (mean: €219,000). It

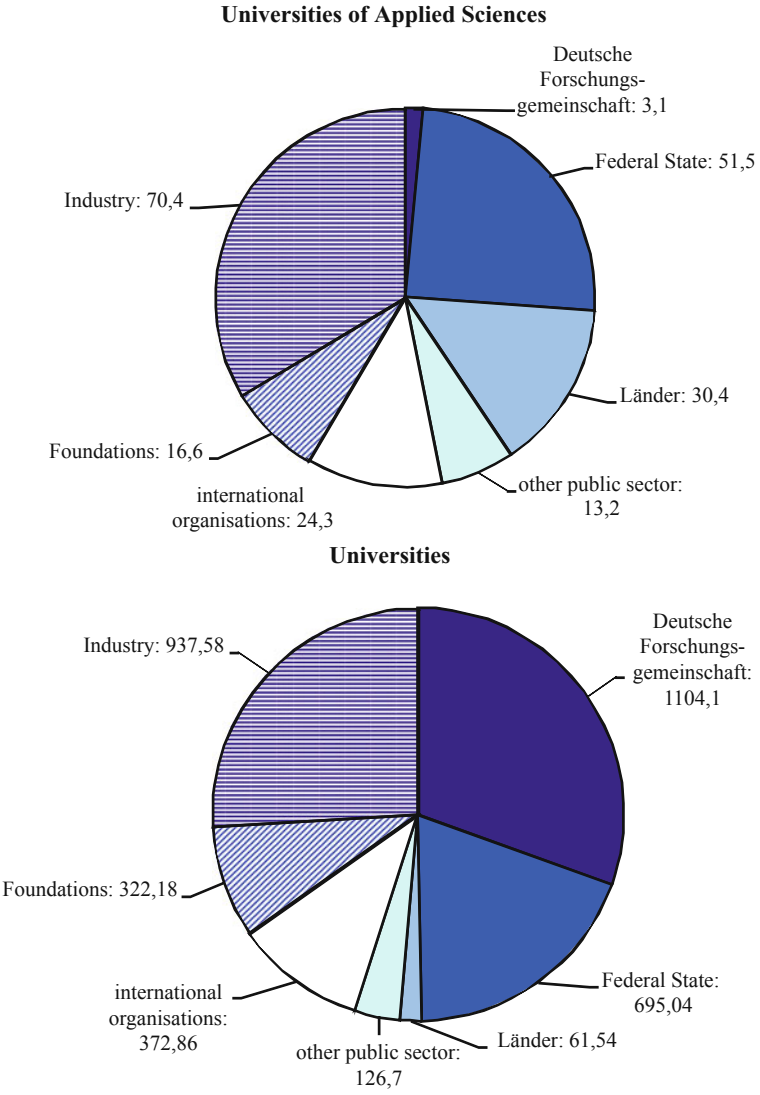

Fig. 9.3 Source of third-party funding (€ million) in 2006. Source: Statistisches Bundesamt (2008a)

presented a line of funding in the programme *Forschung an Fachhochschulen*. In addition, the BMBF has been promoting the study of engineering at UASs since 2006 by means of the new funding line *IngenieurNachwuchs*. Moreover, a higher participation of UASs in the specialist programmes, such as microsystems technology or optical technologies in the funding line 'Profil-NT' is supported. This is aimed to attract to UASs more well-funded specialist programmes which promote ambitious R&D projects.

Länder have also been running several promotional programmes for many years, promoting application-oriented R&D at UASs. Up to now, however, all the promotional programmes for UASs had too small subsidy amounts measured against the number of applications, i.e. many good applications could not be supported. The BMBF funds have been greatly increased since 2007. The promotional measures of the BMBF and the *Länder* have undoubtedly contributed to the fact that applied R&D for knowledge and technology transfer to the firms could be developed into a second characteristic profile for the majority of UASs in the past 15 years, besides their practice-oriented teaching profile. The *Länder* are utilising the financial scope afforded them by the higher status accorded to the promotion of innovations within the European Fund for Regional Development (EFRE). For the period 2007 until 2013 they are planning to expand R&D in universities and UASs. The measures of the federal government in its High-tech Strategy (see BMBF, 2007) are also heading in this direction, the main concern here being to build up research capacity in science, which the UASs will also profit from even if they are not the main addressee of the measure.

As the UASs can utilise basic funding for R&D only to a limited extent, third-party funds remain the crucial source for R&D for UASs. Public financiers play a large role in these third-party projects. Particularly striking, however, is the great significance of industry compared to universities. Whereas the German Research Association (DFG) provides the universities with considerable funds for research purposes, this does not apply to the UASs, as their R&D projects are not directed towards basic research. Figure 9.3 also points out the very large differences between UASs and universities as regards the amounts of third-party funds.

Research Strategy in Non-university Institutions

Institutional Strategy and Priority Setting

The extent to which R&D is performed in UASs depends on a number of factors: some of the UASs evolved out of engineering schools and they understood themselves as purely teaching institutions. Only gradually, in the course of the last decades, have some of the professors increasingly devoted their attention to conducting application-oriented R&D. UASs of this type are to be mainly found in southern Germany. On the other hand, UASs in the new *Länder* evolved out of HEIs with an R&D tradition of many years, in which the majority of the professors regularly carried out R&D projects. A further group is formed by UASs in *Länder* which

promoted the R&D capacities and competences of their UASs in the last decades by the targeted use of promotional programmes. Size also plays a considerable role. In the many small UASs, their role as teaching establishments dominates, with R&D projects only conducted by individual professors. One cannot speak of an R&D strategy of the UASs as a whole here.

The study of Kulicke and Stahlecker (2004) shows the following results, based on interviews with 69 rectors or pro-rectors of 69 UASs: The status of R&D has increased over the years at all UASs and further efforts are being made to expand this. The representatives of UASs classify the framework conditions totally differently. The reasons given were the succession of generations presently taking place (young R&D-oriented professors increasingly replacing older colleagues with stronger affinity to teaching). But these efforts are limited through funding available and an almost non-existent professional academic middle-level staff. Essential instruments to intensify research at UASs are: support for the establishment of focal research areas, allocation of internal research budgets, further financial incentives (e.g. performance-oriented budgets), reduction of teaching load, establishment of competence centres across departments, consideration of R&D orientation with new appointments, intensification of cooperative PhD procedures, expansion of At-institutes, etc. Thereby the group of professors involved in research should be expanded and applied R&D put on a broader base.

There are great differences at UASs if one compares the number of professors conducting research with all other professors. The average of this quota lies at approximately 33%, the median value at 28%. The band width ranges from 4 to 100%. The regional distribution of UASs with professors doing research shows that there are considerable differences among the *Länder*: the UASs in the new *Länder* show a considerably higher proportion of research active professors compared to those of western German institutions. The higher proportions in the new *Länder* originate from a different research culture; a number of UASs emerged at the beginning of the 1990s from facilities which had university status. Conspicuous is the predominantly small share of professors involved in research in most of the southern German UASs, where less than a quarter of the professors pursue research.

As the proportion of professors doing research at most UASs is low, the indicator 'third stream funding per research professor' yields totally different values, i.e. clearly higher results than the Statistical Federal Office is giving for the indicator for 'third stream funding per professor'. There is also a considerable spread between the UASs. The average value lies at €48,300, the median value at €41,300 and the highest results at €100,000 or more. A high share of professors doing research does not necessarily mean a high level of third-party funding.

The interviews of Fraunhofer ISI with the representatives of 69 UASs already revealed a trend which has clearly grown stronger in the recent past (see Kulicke & Stahlecker, 2004). The *Länder*, as governing bodies of the state-run UASs, are increasingly pushing to build a stronger profile based on teaching and research. In a number of UASs, which had not previously possessed an explicit R&D strategy, this set off a strategy discovery process in which an appropriate strategy was developed. The switch to bachelor's and master's study courses also made considerable impacts

on the status of R&D in the UASs: in order to compete with universities, research-oriented master's degree courses were established on a larger scale. Research-based teaching modules are a pre-requisite for the accreditation of these courses. As a result, work in R&D will become a stable component in many UAS departments so that they are attractive for students in the future.

The Organisation and Management of Research

The Fraunhofer ISI study (Kulicke & Stahlecker, 2004) also revealed the organisational weaknesses and frequently low capacities in the UASs for R&D. In the majority (85.5%) of the 69 interviewed UASs, R&D projects are either implemented within the normal business operation of the department as a key activity or – equally important – with other organisational entities, such as central facilities of the institution (24.6%), in special facilities of the department (24.6%) or – organisationally independent from the UASs – in At-institutes (30.4%). Two thirds of the 69 UASs maintain At-institutes, which are often run by a lecturer, but mainly have their own staff. In about one third of them, employees below the professor level are working for the At-institute. These institutes are judged by the interviewed persons mainly positively under the given basic framework conditions at the UAS (no academic middle-level staff, low flexibility in employing/retaining qualified employees, intensive teaching load, inflexible financial management system and others). Advantages are: support of research climate at the UAS, improvement of the quality of the teaching, representation of the UASs as regional competence centres for R&D, and fund-raising for research areas that are normally not accessible for UASs. It was stressed that At-institutes make the administrative process for implementing contracts with industry considerably easier.

Collaboration with Universities and Industry

As already mentioned, in its programme FH^3 and the successor programme FhprofUnd, the BMBF has promoted cooperation between UASs and enterprises and with science partners, above all with universities, since 2004. The Fraunhofer ISI appraisal study (Kulicke et al., 2008) on the impacts of FH^3 depicts a broad spectrum of R&D cooperation partners for the promoted UAS, i.e. cooperation with quite different institutions takes place on a regular basis or from time to time (see Fig. 9.4). One hundred sixty-two professors from all large- and medium-sized UASs as well as a large number from smaller institutions in Germany participated in this study. In first place in the category 'several times' are SMEs (72.1%), followed by large enterprises (61.7%) and universities (52.7%). Only one single interviewee stated that projects are typically carried out without external partners.

No information is, however, available to what extent UASs have entered into strategic alliances with enterprises, universities or non-university research facilities. The enterprises which were partners of UASs in the promoted R&D projects were

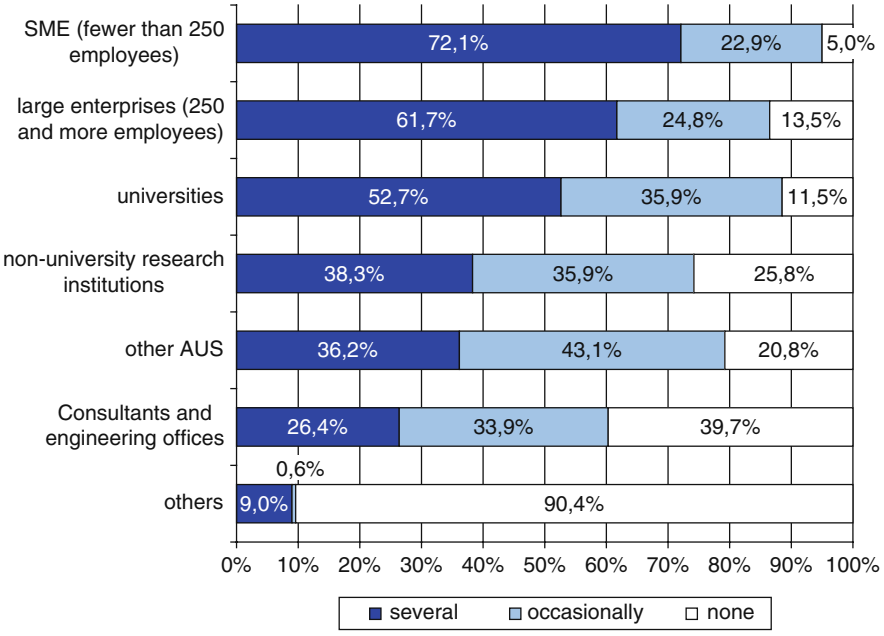

Fig. 9.4 R&D Partners of the UASs. Source: Kulicke et al. (2008)

also questioned. A total of 95 firms participated in this survey. They also have a dense network of cooperation partners. As far as entering into strategic alliances was concerned, UASs were scarcely mentioned. This type of function is most frequently the preserve of other companies (named by 29.8% of the 95 enterprises) or – already with a distinctly lower status – domestic and foreign universities (13.6 and 13.8%).

Most federal government programmes promoting R&D in firms have for many years required cooperation with other enterprises or with universities, UASs or non-university research institutions as a pre-requisite. This has led in the last 10–15 years to a much closer coalescence of industry and science. The UASs also profit from this. However, this applies almost exclusively to the area of application-oriented R&D. Basic research or pre-competitive research does not take place in UASs, not even in cooperation with universities. The latter collaborate in R&D projects of this type with other universities, non-university research facilities and large enterprises.

Human Resources and Careers

In 2007, UASs in Germany had a total of 12,900 professors, 7,900 positions for academic staff and 15,400 positions for non-academic staff (Statistisches Bundesamt, 2008b). Personnel structures at UASs differ from those at other types of HEIs (see BMBF, 2003). With few exceptions, professors do the teaching at UASs. The job profile is initially homogeneous, which means there is no division in

teaching or R&D-focused activities. In their teaching duties, they are supported and complemented by additional instructors (some of whom have temporary appointments). The number of such instructors (title: '*Lehrbeauftragte'*) varies depending on the type of department and UAS. There are, however, far fewer of these positions than professors. In order to be able to work at a UAS, professors require specific qualification profiles. These qualifications include completed higher education studies, along with proof of special competence in scientific/academic work or of special artistic abilities. This special group of required qualifications, which is set forth in the Framework Act for Higher Education and implemented by the higher education acts of the *Länder*, reflects the special requirements pertaining to teaching at UASs. The close links between career experience and scientific qualification requirements are considered to be especially conducive to the fulfilment of the educational mission of UASs. In some *Länder*, UASs also have research assistants. In some *Länder*, professors at UASs also have the option of taking 6-month leaves of absence from teaching and research, at regular intervals (usually, every 4 years), to carry out work aimed at bringing their knowledge up to the latest standards in their field. In 2001, laws pertaining to employment of higher education teaching staff were amended in order to reform salary scales for professors. As a result, the salary scale for UAS professors is now basically the same as that for university professors.

The problems of UASs conducting R&D projects due to their lack of personnel resources have already been addressed. The following data shows the human resources for R&D: most R&D personnel are employed at universities. The Federal Statistical Office estimates for universities in 2006 a total of about 70,600 persons in the R&D area, which corresponds to a share of 71% of the entire R&D personnel in HEIs. This figure admittedly also contains the personnel for comprehensive universities, as well as colleges of education and theology, but their share is very small. The second largest group with about 25,000 is found in the medical institutions of the universities, which corresponds to a share of 25%. UASs only account for 3,400 (3.4%) and art colleges 877 (0.9%) of personnel for R&D. This data underlines that the human resources in UASs are extremely limited for performing R&D, but they can be greatly extended via the successful acquisition of research projects (from public bodies or industry). In the past years the scale on which application-oriented R&D is conducted in UASs has clearly risen. Public promotional programmes have primarily contributed to this, but also measures within the individual UASs, in which the professors were offered incentives to conduct R&D along with their extensive teaching load.

A central problem for UASs is the short-term of many R&D projects and, with that, the problem of employing and keeping staff active. In the study by Fraunhofer ISI of 2004, the 69 UASs interviewed referred to the following issues: the project employees usually (92.8%) have short-term contracts corresponding to the time span of the R&D projects. Regular non-fixed term employees play a complementary role (40.6%). Many qualified graduates find more attractive job opportunities outside the UAS – in particular, in the private sector. Cooperative PhD procedures are a possibility to attract qualified graduates for R&D projects: the candidates do their doctorate at a university, but are still employed at the UAS. Especially, universities from

eastern Germany are open to such methods, but this does not seem to be popular in western Germany.

The Allocation of Resources for Research

As the room to manoeuvre of the UASs for teaching and application-oriented R&D are determined to a great extent by the regulations in each federal state and by their promotional programmes, there is no standardised pattern Germany-wide for how the institutions allocate money and working time to research for individual staff members. There are no uniform rules on how much time could be used for research, for example, a fixed percentage of working time. Until a few years ago, it was entirely up to individuals in the UASs to determine how they spent their time, as long as they fulfilled their teaching obligations. In most UASs only limited incentives to research existed, as the teaching commitments clearly dominated and the HEI management often only had little leeway to provide professors with a breathing space to conduct application-oriented R&D projects by reducing their teaching workload. This does not apply to all UASs, however, as already mentioned above. In the past years changes have taken place in many UASs, triggered not least by the pressure among the UASs themselves to create stronger profiles and in their bid for demarcation from the universities. This resulted in not only the heads of the UASs, but also individual faculties or departments defining their strategic orientation more clearly than before, fixed on teaching and research focuses and giving R&D activities a higher status. It is now regulated when and under which circumstances a reduction of tuition obligations is possible in order to support research activities, which persons can profit from this, and how the teaching workload will be fulfilled. However, it is not to be expected that in the years to come a great majority of the professors in UASs will perform R&D regularly, but the group of professors performing R&D should grow considerably, compared with the situation today.

Research Performance in Non-university Institutions

The Extent and Output of Research

If one utilises common indicators to measure the outputs of R&D, as are customarily used, for example, for universities or non-university research institutions (patents, number of publications in peer review journals or the like), then UASs perform relatively badly. A study by Fraunhofer ISI of the spin-off potential in universities, UASs and non-university research institutions in Germany (Kulicke & Schleinkofer, 2008), also contains an estimate of the number of patent applications filed by UASs and universities (see Table 9.1). Only 37% of the HEI patents are applied for by UASs, the majority of patents are filed (63%) by individuals, enterprises or other organisations. The composition underlines the importance of the (technical) universities in the patenting area: 89.7% of all HEI patents originate from universities.

Table 9.1 Patent applications in 2005 by patentees and type of universities

	Technical universities ($n = 17$)	Universities ($n = 65$)	UASs ($n = 96$)	Total
Patent applications by university or UAS	282 (12.1%)	516 (22.1%)	62 (2.7%)	860 (36.8%)
Patent applications by individuals or enterprises	443 (19.0%)	854 (36.6%)	179 (7.7%)	1,476 (63.2%)
Total	725 (31.0%)	1,370 (58.6%)	241 (10.3%)	2,336 (100.0%)

Source: Own calculation acc. to Fraunhofer ISI surveys.

In particular, the 17 technical universities are responsible for 31% of such patents. Only 10.3% stem from UASs. However, in view of the low personnel R&D capacities in UASs and their strong application orientation, this is still quite a high share.

Application activity is concentrated within a few universities: over 50% of all patents stem from 20 universities. The number of patents from the universities correlates above all with the number of professors, the number of scientific staff in the engineering sciences, in mathematics and natural sciences and with the amount of third-party funds acquired from industry.

Seventy-seven out of 96 UASs applied for a total of 241 patents in 2005. This corresponds to an average of 3.1. The other 19 UASs did not file for patents in this year. Compared with the average values for technical universities (42.6) and the other universities (21.1), this indicator is naturally very low. Mechanical engineering and instruments are the most significant technology fields with 123 and 74 patents respectively in the UASs, no applications were made in the area medicine/health care science. As for the university patents (from technical and other universities), most patent applications originate from the technology fields of chemistry (819 patents), instruments (547 patents) and mechanical engineering (472 patents). In 2005 no UAS published more than 10 patents. The UAS patent numbers were determined by the number of scientific personnel as a whole and in engineering.

The Fraunhofer ISI study of 2004 on research activity in UASs (Kulicke & Stahlecker, 2004) was able to identify, for the years 2000–2003, a total of 6,005 R&D projects which were conducted in the 97 UASs examined. The technology and thematic areas of R&D projects correspond with the teaching focuses of the UAS: The area of information technology occupies the first place (incl. multimedia and production engineering; share: 23%); many projects (523) fall into the multimedia field. Another big share (17%) is taken by the technology area, ‘material research, physical and chemical technologies’, which accounts for a variety of current projects in the areas of metrology and analytical techniques, as well as measurement and control engineering. Of great importance is mechanical engineering, which was to be expected due to the traditional strength of UASs in this field. Similar importance applies to economics (share 10%). The other topics or fields of technology are of minor importance even though the number of projects is not that small.

The financial volume of the 6,003 projects also shows a wide range, without the small projects dominating. UASs implemented a number of projects with a financial volume of €500,000 or more, which is considerable when taking into account their capacities. The founder is of importance here: projects financed by the EU (average approx. €270,000), public foundations (€150,000) and *Länder* (€144,000) or state departments (€133,000; including the respective subordinate offices) show, on average, substantially higher project funding than those of other donors (e.g. business: €37,000). This shows clearly why public support programmes are very attractive for UASs.

The Relevance of Research for the Regional Community

In the analysis of the 6,005 R&D projects which the investigated UASs carried out in the years 2000 until 2003 (Kulicke & Stahlecker, 2004), we also inquired about the commissioning clients. With respect to the number of projects, enterprises are in top position as sponsors for R&D projects at UASs: 27% of all projects where information is available on founders were financed by business, compared to federal government (25%) and states (23%). Projects financed by business are mostly small in volume, very practice-led and with a short time frame. Most of the interviewed UASs from the old *Länder* consider regional location of client enterprises as highly important. The structure of the regional economy, as well as the compatibility of subject area coverage of the UAS with the sectoral structure of regional business, plays an important role. In the new *Länder*, the orders from business clearly are on a lower scale than in many West German UASs. The reasons for this are primarily the fewer R&D activities in the regional businesses, as well as the lower density of enterprises. Representatives of those West German UASs attaching less importance to the regional economy gave the following reasons: supra-regional networks of professors, high degree of specialisation of the UAS in combination with a few similarly specialised enterprises in the region, supra-regional reputation of the UAS, and the strengthening of R&D activities within the UAS still being in an early stage.

Publicly financed projects differ from business financed ones in the following ways: 'holistic character' (thematically comprehensive), handling of partial projects within research consortia, possibility of interdisciplinary cooperation across faculties, long-term (with the possibility of employment of qualified staff) as well as higher project volumes. In contrast, contracts from businesses normally have the following features: dominance of applied research as an input into the internal predevelopment or pre-competitive product development, addressing partial aspects of product or process development, solution of detail problems by the UAS, broad spectrum of product and process-oriented service delivery, and short-term projects with relatively low volumes.

Half of the interviewees pointed out that the annual R&D potential for orders from regional business have little relevance, as the university-specific conditions in research are the decisive factors limiting more research contracts from business and not their potential. Where quantitative data on the annual R&D potential for

contracts from business was available, it varied between a couple of hundred thousand and €2.5 million. For most of the UASs which were examined (almost 57%) the number of potential regional customers (at least 50) could be considered relatively large.

Typical competitors for R&D contracts are other regional universities (UASs and universities). Non-university research facilities on the other hand hardly play a role: however, partnership relations between UASs and the mentioned institutions frequently weigh more than the pressure of competition. Problems with the implementation of R&D projects are usually observed not on the part of enterprises, but rather on the side of the UAS. The reason for this is, according to reports of UASs, the problematic situation in the areas of research and teaching: A high teaching load and a limited number of non-teaching academic middle-level staff lead to problems with personnel deployment and a lack of flexibility in HR management.

Also in the latest study of the Fraunhofer ISI (Kulicke et al., 2008) on research in UASs (Evaluation of the Promotional Programme FH^3), the question was examined what relevance the regional economy has for UASs. The interviewed professors stated that the UAS departments in which the promoted R&D projects were conducted were mainly integrated in a comparatively dense network with other institutions for which they had carried out R&D projects in the past 5 years. A good half had thereafter realised similar projects several times on behalf of SMEs from the region (54.2%) or of SMEs outside the region (52.2%). The corresponding statistics for large enterprises from the region are 29.8% as well as 52.2% for large enterprises outside the region in which the UASs are located. Public promotional programmes dominate as the main financers (78.1%).

The Relevance of Research for the Development of Professional Expertise

A precondition of qualitatively demanding master's programmes at UASs are application- and research-oriented courses. The latter aim is to put students in a position to work independently, following scientific principles and to apply scientific methods and findings. Besides research-oriented master's programmes, corresponding bachelor courses are also being offered (target: Bachelor of Science or Bachelor of Arts), which aim to qualify graduates to actively participate in research tasks. Research-oriented master's programmes aim to enable the graduates to take part in more highly qualified professional activities with a comprehensive theoretical–analytical orientation, as a rule for active participation in research tasks.

The share of research-oriented teaching events in the curriculum of the department or institute lies, according to the 159 professors who were interviewed, in the framework of the evaluation of FH^3 (Kulicke et al., 2008), at present on average at 16.9% (median value: 15.0%). However, the spectrum is large and ranges from 0 to 60%. The majority (59.4%) of the professors interviewed assumed that this share will rise slightly, as a result of the FH^3 project. However, only 14.5% expected a noticeable increase.

Table 9.2 Number of research-oriented qualifications as an output of the FH^3 project (already realised or expected)

	Share of UASs with such theses (%)	Average number per project
Diploma theses	77.5	3.7
Bachelor theses	48.4	4.1
Master's theses	61.9	2.4
Cooperative doctoral theses	51.0	1.3

Source: Kulicke et al. (2008).

In the evaluation of the promotional programme FH^3, we also examined to what extent the promoted R&D projects led to research-oriented qualifications. We understand hereby diploma, bachelor's and master's theses, as well as cooperative doctoral theses. The answers of the 159 professors who managed a promoted project and participated in the survey show that in many UASs such theses were already made possible by the FH^3 project or are expected to be made possible (see Table 9.2). About half expected bachelor theses and cooperative doctoral theses (i.e. in cooperation with a university with the right to award doctorate degrees). It must be taken into consideration that the three first named categories in the course of the transformation of study courses to bachelor/master degrees are not free of overlapping. The largest output consists of research-based diploma theses.

Dilemmas and Challenges

The entire German higher education landscape is presently in a phase of upheaval, characterised by many and varied developments, by numerous demands for a structural re-organisation, and at the same time, limited basic funds. Examples include:

1. The Bologna Process to create a common European HEI area, which opens up the possibility for the UASs, among others, to make their curricula internationally compatible by developing bachelor and master's study courses;
2. The develop of research capacities at HEIs, primarily at the universities and strengthening cutting-edge research;
3. Reductions in the general state funding (above all limit budgetary funds by the governing bodies);
4. Introductions of performance-related remuneration systems for professors and the allocation of funds to HEIs and faculties or departments according to performance criteria;
5. Extending the freedom of HEIs, in particular to strengthen their own profiles;
6. Abolishing university professors' privileges in the law governing employees' inventions and improving the political will to utilise the innovation potential in universities.

The present promotion of excellence in the HEI area is practically bypassing the UASs. The federal government, above all in its High-tech Strategy (see BMBF, 2007), has been supporting the building up of research capacities at universities and non-university research institutions considerably since 2006. The goal of building up internationally recognised research focuses is hereby emphasised. The allocation of the extensive promotional funds is based on the principle of 'Strengthen the strong'. Focuses lie not only on the performance of research, but also on their utilisation via commercial applications. UASs profit only to a very small extent from this programme. The UASs, however, in the conversion of the study courses to bachelor and master's degrees, are under political pressure to sharpen their profiles and develop competitive competence fields. In contrast to the universities, the UASs have a structural problem, then as now, to conduct nationally and internationally visible R&D. An academic middle-level engaging in research is missing, as well as a corresponding basic funding which would compensate for the higher teaching workload of the UAS professors, and allow them more leeway for creative R&D work and commercialisable activities. In addition, both options would give UASs the possibility to offer graduates a perspective to work in the area of application-oriented R&D, which is not subject to the pressures of project financing which only provides short-term security. The UASs are generally confronted with the problem that they are not in a position to build up a stable, permanent basis of personnel resources outside longer term publicly funded R&D projects.

But the status of R&D has increased over the years at nearly all UASs and further efforts are being made to expand this. There are very different constellations in terms of the driving forces for a stronger role of R&D in UASs. First, the *Länder* as the governing bodies of the UASs have an important impact. But there are major differences in the extent to which individual countries extend the scope of the UAS for R&D through the allocation of resources or special government programmes. Another important factor is the extent to which the UAS presidents support activities in R&D by a generous allocation of available funds. In recent years there were very large differences between the various UAS administrations, with the consequence of large differences in their R&D orientation. The third group under the driving forces are the professors themselves. Their interests in R&D, experiences and contact networks ultimately determine how they exploit their low margin from the high teaching load. Other important driving forces are the support programmes of the BMBF for R&D projects. In recent years, however, on all these different levels the value of R&D has increased. In particular, there were no differences in the political objectives of the *Länder* and the BMBF.

Representatives of UASs classify the framework conditions totally differently. The reasons given were the succession of generations presently taking place (young R&D-oriented professors increasingly replacing older colleagues with stronger affinity to teaching). Essential instruments to intensify research at UASs are as follows: support the establishment focal research areas, allocation of internal research budgets, further financial incentives (e.g. performance-oriented budgets), reduction of teaching load, establishment of competence centres across departments, consideration of R&D orientation with new appointments, intensification of cooperative

PhD procedures, expansion of At-institutes, etc. Thereby the group of professors involved in research should be expanded and applied R&D put on a broader base. Within a background of considerably fewer finances and personnel, when compared to universities the applied research and development has expanded rapidly within UASs over the last decade – thematically as well as content-wise. Contributing factors were the improvements in the structural environment of R&D within UASs, as well as the supply of support programmes either tailor-made for UASs or open to such facilities.

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