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The Evolving Role of Academic Institutions in Innovation Systems and Development

The Role of Universities in Economic Growth – The German Situation

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The Role of Universities in Economic Growth – The German Situation

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Abstract

German history is characterised by a long period with many small independent states with a really unified realm established only at the end of the 19th century. The German university system traces back to the foundation of the University of Berlin at the beginning of the 19th century according to Humboldt's concept, with a clear orientation to basic research. It developed in parallel to a prosperous economic situation, where Germany became a leading industrialised country. This period was interrupted by World Wars I and II, but the 1960s were again characterised by economic prosperity. The role of universities slowly changed with the growing relevance of knowledge-based technologies and increasing economic problems linked to the challenge of globalisation and the erosion of the social security system. As a consequence, universities are expected to directly contribute to economic progress by technology transfer, and they are increasingly submitted to quality assessment in order to improve the performance and efficiency of scientific research. However, the major contribution of universities to society will not be research, but teaching, as the scarcity of highly skilled staff will be a crucial problem in a mid-term perspective. Although the present gradual economic decline implies considerable turbulences in the universities, they will get more support in future due to their central role in the knowledge society.

1. Introduction to the German Context

Germany as a nation has its roots in the 8th century; originally the term "German" only referred to the language in the eastern part of the realm of Franconia. Since that time Germany existed in various configurations, partly as kingdom, partly as empire. In all of these political structures, Germany consisted of a variety of smaller states with a high level of autonomy, which is the basis for the strong federal system shaping the present political situation. The state of Prussia developed into a dominant central power in the 18th century and established a stable German realm (Deutsches Reich) in the period of 1871 to 1918. The strong position of Prussia had a high impact on the political and cultural orientation of Germany in general.

The 19th century was also a period of considerable industrial and economic growth, in parallel triggering the considerable strengthening of the education and science

system.[1] This extremely prosperous period was terminated by the First World War in 1914. In 1918, the German Reich was followed by the so-called Republic of Weimar which was characterised by enormous political instability. The major reason for this unstable situation was the permanent economic crisis which favoured the empowerment of Hitler and the establishment of National Socialism. This chapter is not appropriate to discuss all the disastrous problems linked to this regime; but in the context of the development of science in Germany, the expulsion of intellectuals and leading scientists has to be explicitly mentioned.

The Second World War initiated by Hitler led to the severe destruction of many industrial enterprises and linked to that, enormous economic problems. A further consequence was the separation of West and East Germany into the Federal Republic of Germany, under the auspices of the western allied countries France, the United Kingdom and the United States, and the German Democratic Republic, under the auspices of the Soviet Union. West Germany was integrated into the western alliance by an association to the NATO in 1963 and more importantly, with the European Economic Association in 1957, later on the European Economic Community and the European Union.

In West Germany, the 1960s were characterised by enormous economic growth, the so-called "economic miracle", which turned Germany into the most important economic power in Europe. The most relevant political event after the Second World War was the reunification of Germany in 1990. This enlargement of German territory and population additionally strengthened Germany economic and political weight. In 1991, West Germany including West Berlin had a population of 64.5 million inhabitants, East Germany including East Berlin 15.8 million inhabitants; thus the share of the East German population was 19.7 %. At the same time, the costs for the economic and social integration of East Germany proved to be enormous, and even today the financial flows from West to East Germany are considerable; the social and economic balance between East and West Germany has not been achieved yet and will need a further decade at least.

However, German unification is only one reason for the economic problems in Germany; first signs of stagnation already became visible in the 1980s. These problems may be documented by a variety of economic indicators, but they are well illustrated by the development of unemployment. In long time series since the beginning of the 1950s, the number of unemployed people after the Second World War had a level of about 2 million and steadily decreased until the very low level of 150,000 by the middle of the 1960s (Figure 1). By the end of the 1980s, the number of about 2 million unemployed was reached again. After the unification, unemployment increased up to a level of 4.5 million in 2004 and in recent years it even increased up to 5 million. Besides all methodological insufficiencies in the

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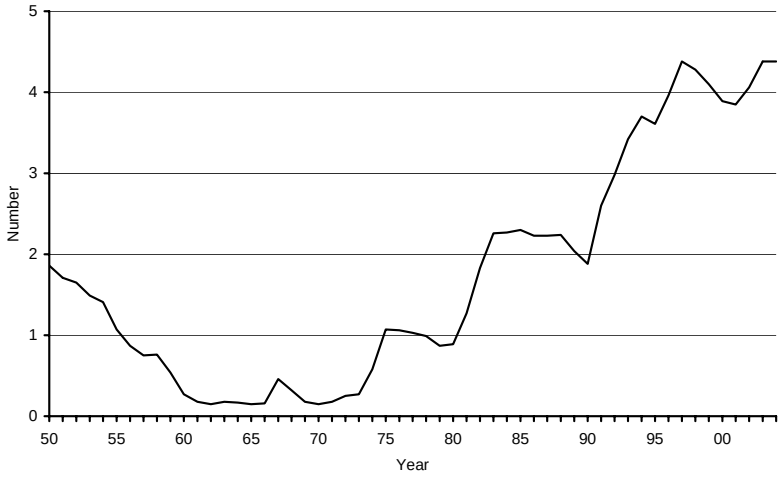
[1] For a detailed description of this period, see Keck (1993).

interpretation of unemployment data, the general economic problems of Germany became visible in recent years. The major reasons for this development are

- German unification in 1990
- the challenges of globalisation, in particular the movement of low-tech industries towards countries with lower wages
- the insufficient move of German industry towards leading-edge technology
- the inflexibility of the German labour market
- the crisis of the social security system.

Figure 1: Number of registered unemployed persons in Germany



Source: Statistisches Bundesamt

German industry has a traditional focus on mechanical engineering and basic materials chemistry which both may be qualified as high-level technology. In contrast, German industry has no special focus on microelectronics, information technology, fine chemistry or biotechnology, which may be qualified as leading-edge technology.[2] The comparison with other industrialised countries shows that countries with a stronger focus on leading-edge technology are more successful in the world market. Therefore Germany must move towards other industrial sectors in order to maintain competitiveness. At present, the most important sector with a high R&D level is the automotive industry with an increasing focus on leading-edge technology, for instance in the context of automotive electronics or advanced materials.

In principle, the German economy may be qualified as capitalistic, but in the prosperous period of the 1960s, the concept of social market economy was introduced. It is characterised by a high level of social security with regard to

2 As to the definitions of high-level technology and leading-edge technology, see Legler et al. (2006: 7).

unemployment, health risks and retirement pensions. This concept implied a high level of social welfare and security,[3] and it is maintained until today, although the financial basis is being eroded by the increasing number of unemployed and retired persons and a decreasing number of employed people financing the social security system. It is unavoidable that this system cannot be preserved in the next years and that social security in Germany will decrease considerably. As the crisis of the social security system largely linked to the general economic problems, it seems to be foremost a consequence than a reason of the economic crisis. However, a further cause of the crisis of the social security system is the low birth rate and linked to that the increasing imbalance between young and old people.

Beside these obvious economic problems, it has to be stated that the economic power of Germany is still considerable. In 2002, Germany had 82.5 million inhabitants and a gross domestic product of $ 1,984 billion; therefore Germany is, in economic terms, the most important country in the European Union and also the largest as to the number of inhabitants. To summarise, in the last two decades, Germany's economy was less dynamic than that of other countries, a development which is documented in the moderate average growth rate of the gross domestic product of 1.6% between 1990 and 2002 (Albrecht et al. 2004). Therefore the relative position with reference to other industrialised countries became weaker, but Germany is still one of the largest economies world-wide and ranks in fifth position behind the United States, the Peoples' Republic of China, Japan and India.[4] The rank of India and China before Germany is a new phenomenon and means an important challenge, but also a big chance for the German economy which has a distinct focus on exports.

2. The Position of Academic Institutions in the German National System of Innovation

As described in Section 1, the situation in Germany has been characterised by economic growth since the 1960s, and in parallel, a tremendous increase of the R&D budgets of enterprises, universities and other research institutes can be observed as well (Figure 2). As the depiction in Figure 2 is dominated by the enterprises, the situation for universities is separately illustrated in Figure 3 which documents their steadily increasing R&D budget.[5] The sharp increase between 1991 and 1992 is striking; it is linked to the fact that until 1991 the universities of West Germany are considered exclusively, and after German unification the universities of East Germany have been included since 1992.

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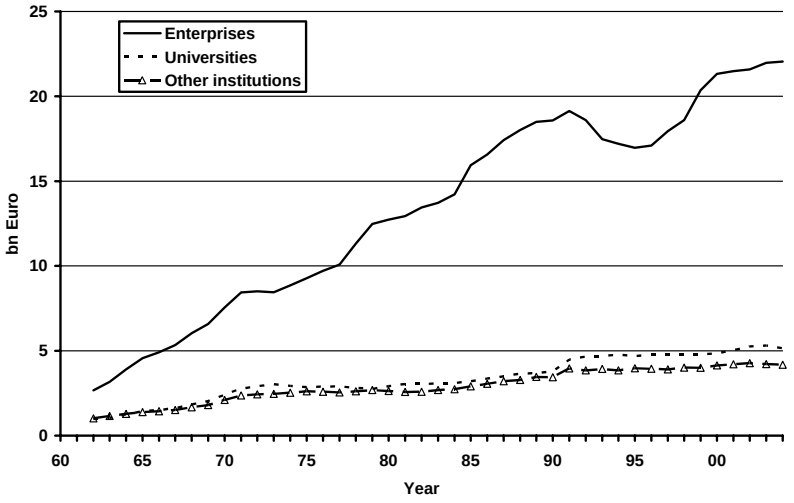
3 Linked to that, the level of criminality is quite low.

4 Calculated in purchasing power parities (http://de.wikipedia.org).

5 Only in the last documented year, a slight decrease appears due to decline of external funding from industry.

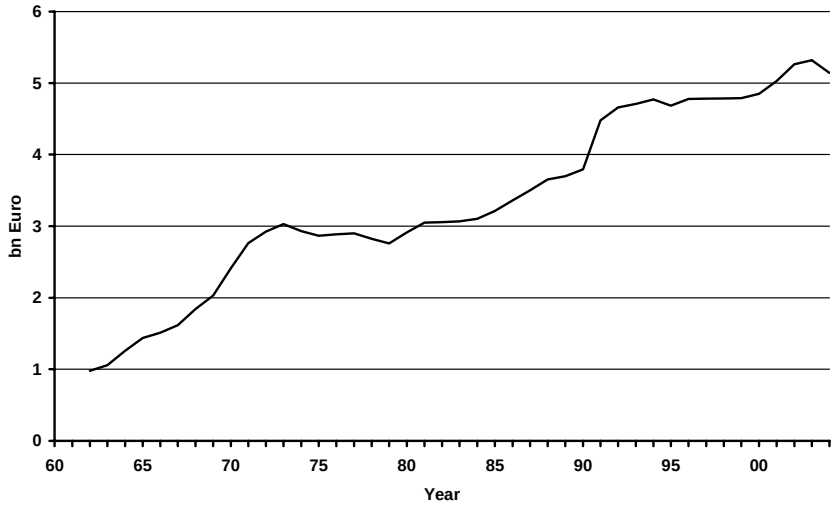
The impact of German unification on universities is less important than often assumed. Whereas the share of the East German population at the beginning of the 1990s was about 20 %, the number of East German students was only at a level of about 10 % (IW 2006). In 1991, the share of East German scientific publications was about 12 %, which declined to 9 % in 1993 and increased to 18 % in 2001 (Legler et al. 2004). So the level of university activity in terms of education and research in the new Eastern States was moderate at the time of unification and has considerably improved since then. As to scientific quality, German unification implied a distinct drop of the German citation rates (Schmoch 2005). This is partly linked to a limited scientific impact of East German papers, but primarily to their insufficient orientation towards western journals. Meanwhile, the citation rates of 1990 have been attained again. All in all, the efforts to integrate East German universities were considerable, but the process of increasing the number of students and of reaching a high level of scientific output in terms of quantity and quality has been successfully accomplished. The general target to equal the structures in East and West Germany has been largely attained in the field of science.

Figure 2: R&D expenditures of major organisational sectors in Germany (in real terms)



Source: BMBF (2006), BMBF (2004), BMBF (2000), BMFT (1993), own computation

Figure 3: R&D expenditure of German universities (in real terms)



Sources: BMBF (2006), BMBF (2004), BMBF (2000), BMFT (1993), own computation

As to the contribution of universities to the German economy, the main factor is the provision of a competent labour force. So in the 1960s and 1970s, teaching is far more important than research with regard to economic growth. With the rise of the knowledge-intensive economy, illustrated in the growing relevance of R&D, the contribution of university research to economic performance becomes more relevant, but teaching still remains the most important element, in particular in the disciplines of engineering and natural sciences (Martin/Salter 2001). The German university system is multi-facetted and consists of different types of high-level education institutions. One important type is (full) universities with a broad spectrum of disciplines, all in all one hundred universities where 35 operate own clinics (Table 1). However, people generally do not consider the offer of clinical facilities as the most important contribution of universities to society, as many other public and private institutions run clinics as well. So the major contribution of universities in the medical sector is the development and application of advanced medical treatments.

Table 1: Number of different types of high-level education institutions in Germany

Institution	**Number**
Universities	100
thereof	
with clinics	35
with engineering dpts.	17
Pedagogical schools	6
Theological schools	16
Art schools	52
Polytechnical schools	168
Administration schools	29
Total	**371**

Source: Hochschulrektorenkonferenz (HRK)

Seventeen universities run engineering departments. These universities, sometimes called technical universities, originally were pure engineering high-level schools, but increasingly integrated other disciplines and achieved the status of university. But in most cases, the engineering departments are still dominant. Already in 1899, the technical universities obtained the right to assign doctorates in engineering, and thus were acknowledged as academic institutions (Manegold 1978).

Thirteen of the 100 universities are organised by private agencies, but these universities still play a minor role, as they teach only about 0.54% of all students at all universities and they are not engaged in research. In most cases, the private universities are focused on few disciplines, primarily in economics. The low level of private universities is linked to the public policy to provide university education at a high level of quality without tuition fees. With the increasing scarcity of public money, many federal states are going to introduce tuition fees, but still at a moderate level in comparison to private universities.

In addition to universities, six pedagogical schools, sixteen theological schools with parochial agencies, 52 art schools and 29 administrative schools can be counted among the high-level education institutions in Germany. With regard to their contribution to the economic needs of society, the 168 polytechnical schools, sometimes called polytechnics, polytechnical or universities of applied science,[6] have to be mentioned as relevant actors. Compared to full universities, their courses are less theoretical and more oriented towards application. The average length of the course of studies at polytechnical schools is about three years, compared to five to six years at universities. With reference to public agencies, the number of students in polytechnical schools represents about one third of those in full universities. The polytechnical schools are strongly oriented to teaching; their contribution to research is negligible.

For an improved understanding of the size of the German higher education system, it is useful to look in further detail at the number of students. In 2004, 1.9 million students were registered at German high-level institutions, thereof 1.4 million at universities. So with reference to the population, 23.8 students per 1,000 inhabitants were registered, thereof 16.6 at universities and 7.2 at other institutions. This means that on average, a university has about 13,700 students, other institutions about 2,200.

Since the beginning of the 1970s, enormous efforts were undertaken to increase the number of students. At universities, 410,000 students were registered in 1970, 1,188,000 in 1990.[7] So within 20 years, the number of students increased by the

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6 In German: Fachhochschulen

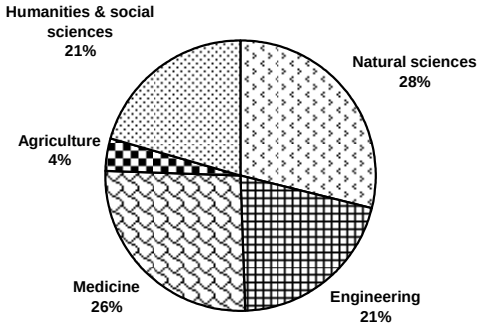
7 With reference to West Germany (IW 2006).

factor 2.9. In 2000, the number of students was a little bit higher, at 1,311,000, but this difference is primarily due to the inclusion of East Germany.

In 2004 about 220,000 students successfully passed their final examinations, thereof about 98,000 achieved university diploma or master's degrees and 23,000 doctoral degrees.

The present structure of research at (full) universities is characterised by large shares of disciplines relevant for technological application, in particular natural sciences, engineering, medicine, and to a lesser extent, agriculture (Figure 4). However, the share of about 20% of the humanities and social sciences is quite high by comparison to other industrialised countries.

Figure 4: Research expenditure at German universities by disciplinary field, 2003



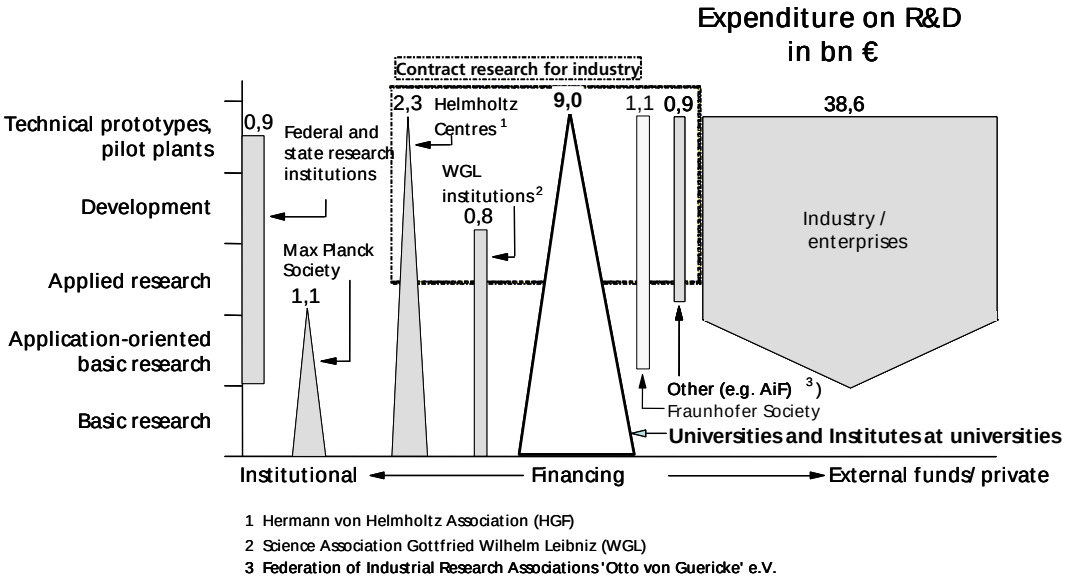
Source: BMBF (2006)

In the German research landscape, the universities are only one among a broad variety of public research organisations and private industrial enterprises. The tremendous increase in the R&D budgets of universities since the 1960s also applies to other research institutions (Figure 2), in particular the enormous growth of the R&D activities of firms is striking, but a high share of their activities refers to experimental development. Nevertheless, firms represent the largest organisational sector in research. With the growing relevance of knowledge-based technologies, German firms substantially engaged in knowledge production and developed a considerable absorptive capacity and thus became appropriate partners for universities.

Among the research institutions with public agencies, the universities are only one of a broad variety of other research organisations. Therein, the most important ones are the Helmholtz Centres, the Max Planck Society, and the Fraunhofer Society (Figure 5). All public non-university organisations taken together represent about 80% of the

university research. Thus, there is also an explicit competition within the public research sector between universities and non-university institutions. The high share of non-university institutions is again based on the division of labour between central government and the federal states. On the one hand, the federal states are responsible for the basic funding of universities; the central government strives to get a high relevance in research by supporting non-university institutions. In consequence the non-university institutions are primarily financed by the central government.

Figure 5: Depiction of the German research landscape, 2004



Source: Fraunhofer ISI, BMBF (2006)

As to their general orientation, the Max Planck institutes are engaged in excellent basic research and primarily rely on institutional funding.[8] The main areas of Max Planck institutes are physics, biology, and chemistry, but there is also a relevant share in the humanities and social sciences. In general, the mission of Max Planck institutes is to conduct forefront research in important or strategic fields of science with an adequate concentration of personnel and equipment, to quickly enter newly developing fields, especially those outside the mainstream, or fields that cannot be covered sufficiently at the universities, and to conduct research that requires special or large equipment or research that is so costly that it cannot be undertaken at universities. Some of the leading researchers of Max Planck also teach part-time at universities, but the general focus of Max Planck institutes is on research. Due to this general orientation, the Max Planck institutes are able to perform better than universities, for instance, in terms of publications per researcher. An indicator for the

8 The following description of German non-university institutions is largely based on Encarnação/Schmoch (1997: 302 ff).

excellent performance of Max Planck institutes is that most German Nobel Prize winners are from Max Planck institutes.

Although the Max Planck institutes are focused on basic research, their activities increasingly provide results that are useful for industrial application, for instance in the fields of chemistry or biotechnology. Therefore, the Max Planck Society has established a specific office to apply for patents related to inventions of their researchers and in particular to look for appropriate license partners. This patent and license institution called Garching Innovation was established in 1970. In Germany, it is acknowledged as the most professional institution for the transfer of public research results to private partners. In the last years, Garching Innovation has also been engaged in supporting the establishment of start-up companies in addition to their patent and licensing activities.

The Fraunhofer Society has a distinct orientation towards applied research and is primarily financed by external funds, in particular from industrial enterprises. The Fraunhofer Society's mission is the distinct counterpart of the Max Planck Society's. The Fraunhofer Society was founded in 1949, but it was not until 1973 that it obtained its present role. The decision to strengthen the Fraunhofer Society has to be seen in the context of the intense discussions that were taking place at that time about the technological gap between Europe and the United States and the more active technology policy being implemented by the German federal government (Schimank 1990). Nearly all of the 58 Fraunhofer institutes have a specific technical focus covering the areas of information and communication technology, life sciences, microelectronics, surface technology and photonics, production, and materials. The major transfer mechanism of Fraunhofer research results to industry is contract research which represents about 40% of the Fraunhofer activities. However, the Fraunhofer model could not exist in an isolated way; the research activities are closely related to those of other research institutions, in particular universities. The main element of such relationships is the joint appointment of a full professor as director of a Fraunhofer institute and to a university chair. At the university, the Fraunhofer director can carry out basic research funded by institutional funds of the university, and he is in close contact with other academic researchers. At the same time, the university gets acquainted with the needs of applied research, as the Fraunhofer director is a member of the faculty and can directly influence its research policy. A further important element of this close relationship to universities is the direct access of Fraunhofer institutes to qualified students.

In relation to its number of researchers, the rate of Fraunhofer publications is low compared to Max Planck researchers, whereas the number of patent applications is high. Again, this structure reflects the opposite missions of Fraunhofer and Max Planck. In recent years, the support of start-ups of former Fraunhofer researchers is becoming a more relevant mechanism of technology transfer, as well as the licensing of Fraunhofer patent applications and know-how related to software.

The first Helmholtz centres were founded in the late 1950s, when the allied forces gave Germany permission to perform nuclear research; at that time, they were called large research centres (*Grossforschungseinrichtungen*). Following the pattern of US and British national laboratories, all Helmholtz centres initially worked in various areas of civil nuclear research. Since the late 1960s, other areas of research have been added, such as aeronautics, computer science, and biotechnology. It is not possible to describe the research orientation of Helmholtz in terms of simple categories like basic or applied. Their activities include

- basic research requiring large research facilities
- large projects and programmes of public interest, requiring extraordinary financial, technical and interdisciplinary scientific resources and management capacities
- long-term technology development, including pre-industrial fabrication.

In the 1980s, the focus on civilian nuclear research was abandoned, so that in present times, only a limited share of the Helmholtz activities are still linked to that field. Therefore the mission of the Helmholtz Association is less clear than that of the Max Planck Society and the Fraunhofer Society. In recent years, a move towards a stronger focus on basic research can be observed, but the debate on the role of the Helmholtz centres within the German research landscape is not terminated.

Against this institutional background, the universities have to define their specific role within this differentiated research landscape. Their major mission is still the education of highly qualified students and the conduct of basic research, but in recent years technology transfer was added as third mission into the university law (*Hochschulrahmengesetz*).

3. Mapping the Academic System in Germany

The historic roots of the present university system in Germany trace back to the founding of the Berlin University in 1809/1810 which was located in Prussia. Due to the prominent role of Prussia in the foundation of Germany, as described in Section 1, the concept of the Berlin University became the paradigm for the universities in Germany in general. The model of the Berlin University was conceived by German idealist philosophers, in particular Wilhelm von Humboldt, and is therefore often called Humboldt University (Keck 1993: 108). The "classic order of knowledge" according to Humboldt's ideal can be described by four elements of the "constitution of science" which may be characterised as institutional decoupling of science by four major separations:

- "separation of cognition and property
- separation of ideas and interest
- separation of theory and practice and

- separation of science and state" (Spinner 1994: 87ff).[9]

These separations were introduced to permit independent research activities by universities without a government or private enterprises exerting influence. This concept induced a distinct orientation of universities towards the generation of pure knowledge and thus towards basic research. Humboldt's concept was revolutionary in the context of that time which was characterised by a strong central government which tried to control nearly everything. This general orientation of universities in Germany persisted until the 1960s and then partly eroded, due to the growing relevance of knowledge-based technologies. This change is visible in the position of the universities in the depiction of the German research landscape according to Figure 5 where they are positioned in the middle of the diagram; this means that their activities are no longer based exclusively on institutional funding.[10] Furthermore, the orientation of university research is still focused on pure basic research and application-oriented basic research, but there are also relevant activities in applied research and even development. A decade ago, the universities were still located more on the left side of the diagram with a stronger focus on basic research.

In the funding system of public research in Germany, the federal states (Länder) provide base funds for the universities which are used for teaching and research without a clear budgetary separation. Up to now, most universities have not established an accounting system which would allow for a clear distinction of the activities which these base funds are spent on. In consequence, all available statistics on university research are based on estimates.[11] Despite these restrictions, some statements about the structures of German universities are possible. The total expenditures of the higher education institutions for education and research are estimated at about € 20.2 bn for 2002, about 44% of these expenditures, thus about € 9.0 bn, were spent for research and development. Within the university budget, external funds play an important role; they are primarily used for R&D activities. The share of external funds tremendously increased since the beginning of the 1980s and in particular during the 1990s. The absolute level of base funds decreased in real terms in the last decade, in particular since about 1997; in the "old" western states, the stagnation of base funds began even in 1996. Against this background, the increase of the total R&D budget, depicted in Figure 3, is due to the growing relevance of external funds. The share of external funds within the total R&D budget rose from 22% in 1980 to 38% in 2004 (Figure 6), and it can be assumed that this share is more than 40% in the present situation. This figure is an average value for all disciplines, so that in some disciplines in the natural and engineering sciences, it

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9 Translation by the author.

10 The new funding structure is explained further below.

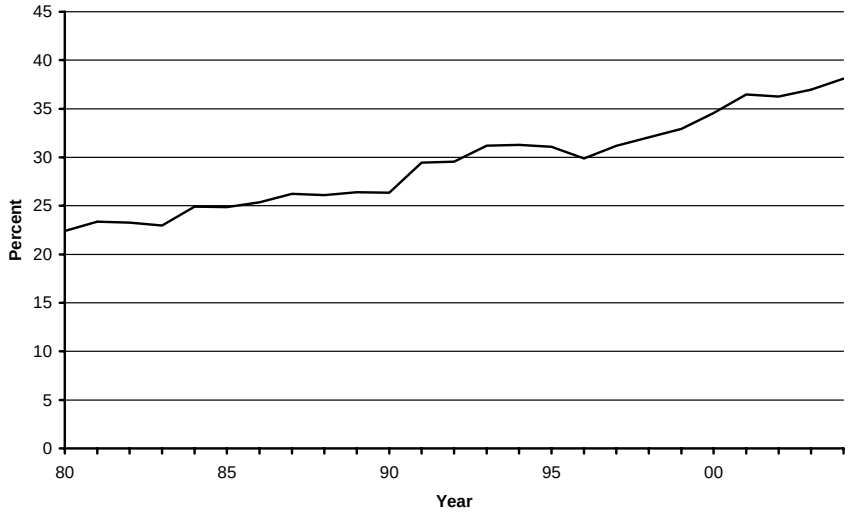
11 As a further problem, the statistics from universities are not available for recent years and stem from different, not completely consistent sources.

is even distinctly above 50% (Haug/Hetmeier 2003: 56 ff). In consequence the R&D activities of many disciplines heavily rely on external funding.

Reliable statistics for the sources of external funds are available but only for 1997 (WR 2000b). According to this, the largest share of external funds is provided by the German Research Association (*Deutsche Forschungsgemeinschaft, DFG*) (Figure 7). The German Research Association is a government agency which is primarily oriented to supporting research at universities with a focus on basic research. But in recent years, an increasing share of DFG-funded research projects is linked to application. At second position of external funding of universities is the federal government, in most cases represented by the Ministry for Education and Research (*Bundesministerium für Bildung und Forschung, BMBF*). Whereas the topics of DFG-financed projects can be suggested by the professors themselves, projects of the BMBF are generally linked to specific programmes, and most projects are linked to collaborative research with industrial enterprises (*Verbundforschung*), an activity which was introduced in 1984. The projects of BMBF are generally quite application-oriented, but they also sometimes support basic research projects.

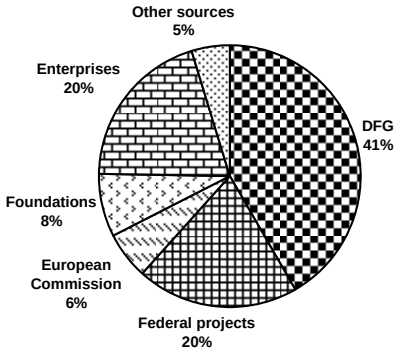
The contribution of enterprises to the external funding of university research is equivalent to that of BMBF. The share of funding of the European Commission with reference to the total research budget is still modest, but for some fields such as microelectronics, biotechnology or materials sciences, its relevance is very high. As a general trend, the share of funding by enterprises and by the European Commission is steadily growing. The external funding by foundations primarily comes from the *Volkswagenstiftung* which mostly promotes basic research similar to the orientation of the German Research Association.

Figure 6: Share of external funds within the R&D budget of universities[12]



Sources: BMBF (2006), BMFT (1993), HRK (1996), WR (1993, 2000b), Encarnação/Schmoch

Figure 7: Sources of external funds of German universities, 1997



Source: WR (2000b)

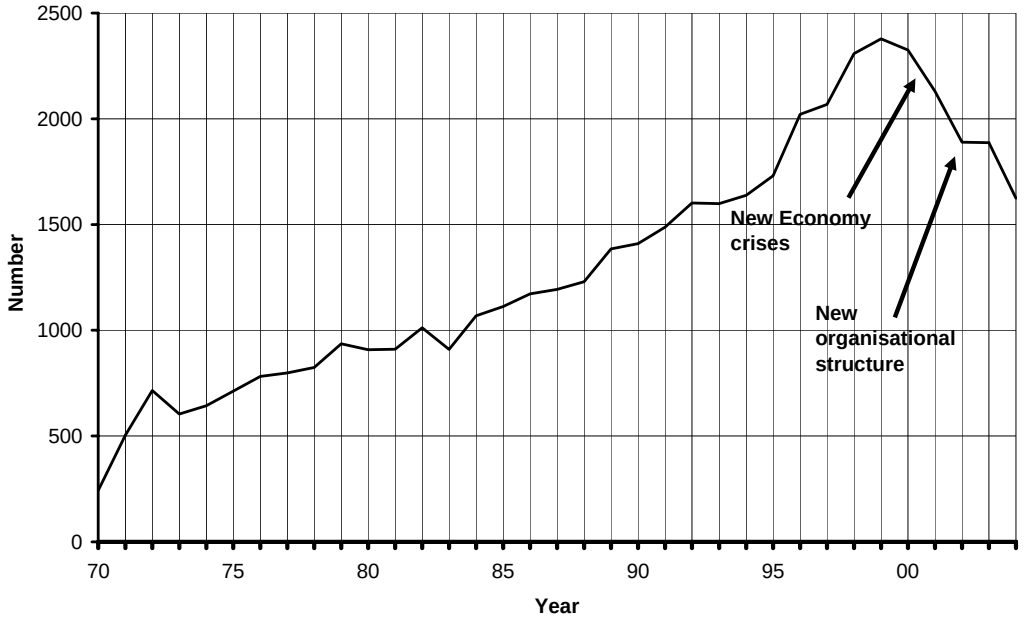
The increasing relevance of external funding at universities implies an organisation of research in the form of projects with a definite length and deliverables. In the case of projects on behalf of BMBF, enterprises or the European Commission, the orientation towards application purposes gets more important, and the universities are no longer free in the choice of their research topics. They have only the alternative to participate or not to participate in such projects, but in view of decreasing basic funds, they must engage in these projects to a certain extent. This implies that Humboldt's ideal of the clear separation of ideas and interests, theory and practice, and of science and state is only partly maintained. The growing dependence on

12 Data for 2004 projected.

external funds implies that the competition between universities for external funds is a major characteristic of their situation in recent years.

The performance of universities is increasingly assessed by their contribution to technology, a requirement which is directly reflected in the steady growth in the number of patents generated by universities (Figure 8). The substantial decrease of patent applications in 2001 is linked to the crisis of the New Economy at that time, in particular in high-technology sectors and the decrease in 2002 to a new organisational structure of the transfer units at universities. Although a further decrease in 2004 can be observed, there are clear indications that patent applications by universities will rise again in the next years after an adaptation to the new organisational structure.

Figure 8: Patent applications of German universities at the German Patent and Trademark Office (Deutsches Patent- und Markenamt, DPMA)



Source: Database PATDPA (STN), computation by Fraunhofer ISI

The change of the organisation of intellectual property issues at universities is linked to a change of law. Since the end of the 1950s, professors had the privilege to exploit inventions generated in the context of their university research on their private behalf. In contrast, inventors in private enterprises have to notify their inventions to their enterprise, and then the enterprise decides whether it intends to exploit the invention and apply for a patent for it. The special regulation for university professors was introduced with the assumption that the level of university-based inventions was negligible, so that was not necessary to introduce a special organisational structure for this purpose. Meanwhile, the number of patent applications of university origin

achieved a level of more than 2,000 applications per year, and the need for a new legal regulation became obvious. Therefore the so-called "professors' privilege" was abolished at the beginning of 2002, and now the professors have to notify the universities of their inventions, comparable to the situation in private enterprises. However, the application of patents, the identification of potential license partners and the bargaining of appropriate license agreements requires substantial expertise and therefore each federal state established at least one transfer unit (*Patentverwertungsagentur, PVA*), and these units are partly supported by the federal government. The introduction of PVAs was a necessary step to take the financial risk of patent applications and to identify appropriate license partners, so that the professors can be relieved of these time-consuming activities and can focus on their main duties in education and research. However, the establishment of the transfer units is still in a transition period, but they increasingly gain experience, and in the long run a further increase of university patenting can be expected.

The direct contribution of universities to technology as reflected in patent activities does not cover all technology areas, but it is focused on knowledge-intensive ones. Most of the patent applications have a disciplinary background in chemistry and mechanical engineering. The institutional basis of this focus is a specific strength of German industry in these sectors. In addition, universities provide patent applications in electrical engineering and in medicine at medium level, and physics at a low level. On average, the contribution of universities to the German domestic patent applications is at a level of about 4.5% (Schmoch 2004). This share is not very high, but with regard to the primary orientation of universities to basic research still substantial. When the focus is directed to specific knowledge-intensive technologies such as biotechnology, semiconductors, organic chemistry, materials, control, surface technology, medical technology or polymers, the share is substantially higher, with a level between 10 and even 30%, whereas in low-tech fields, the contribution of universities is negligible. So universities fulfil their primary mission to engage in complex research.

The application-oriented research activities of universities have to be assessed within the broader framework of industrial activities in Germany. As described in Section 1, German industry is focused on high-level technology and in the next years it will have to effect a change in the direction of leading-edge technology. Therefore, the German government strives to increase industrial activities in leading-edge products and thus supports R&D activities. In this context, universities are expected to play a substantial role.

The increasing societal expectations that universities should actively engage in knowledge and technology transfer leads to corresponding political expectations. Therefore a clear trend in favour of short-term results is visible, whereas long-term research is increasingly neglected. Many political actors have an insufficient understanding of the university focus on complex areas and are not aware that this

contribution of universities to low and medium technology is and should be moderate. Furthermore, the user needs are often insufficiently differentiated. Many small and medium-sized enterprises need technology solutions at a low and medium level; for these purposes universities are not the appropriate partners (Meyer-Krahmer 2000). With regard to the more applied needs of small and medium-sized enterprises, Fraunhofer institutes are often the more appropriate partners compared to universities. Furthermore, the polytechnical schools with their distinct focus on applied topics should play a more important role, but still the infrastructure in terms of staff and technical equipment is insufficient for these purposes. However, some federal states have started initiatives to strengthen the role of polytechnical schools with regard to technology transfer to small and medium-sized enterprises (Kulicke et al. 2004).[13]

4. The Current German Debate

The current German debate on universities is decisively influenced by the increasing scarcity of public funds in general and in particular public funds for research. Therefore Humboldt's ideal of complete freedom of research is no longer maintained in strict terms, but the question of an effective use of public money for research gets more attention where the term "effective" is often linked to "economically useful and profitable".[14] In this context, a relevant arena for debate is a criticism in recent years of the performance and flexibility of research at universities (Schimank 2001, Krucken 2001, Wissenschaftsrat 2000a, Krull 2005). In particular, universities are blamed for distributing their funds in an egalitarian way and not on the basis of performance criteria, so that they cannot build up clear profiles. In former decades, it was an explicit target of education policy that all universities provide high-level education in all disciplines, so that the quality level in all universities was largely similar. This basic orientation of the German university system is the direct opposite of the US American one, which is characterised by some outstanding universities and a large number of low-level universities, often without own research activities.

In the context of demand for an improved performance and flexibility of the universities, "new public management" (NPM) has become a key word since the 1980s (Schimank 2005). NPM is characterised by the call for more market orientation, less regulation and strong leadership. "The 'traditional' German university was once described … as a combination of political regulation by the state and professional self-control by an 'academic oligarchy'" (Schimank 2005: 363). So the traditional organisation of German universities is largely the opposite of the NPM model. As a consequence of this debate, Germany is going to introduce assessment

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13 The state Baden-Württemberg, the so-called Steinbeis Foundation has established an effective network with institutes of polytechnical school to support technology transfer.

14 Archibugi (2006) characterises this trend as "neo-liberal revolution".

activities similar to the research assessment exercise (RAE) in the United Kingdom. For instance, the German Research Association has established an institute for research information and quality assurance (*Institut für Forschungsinformation und Qualitätssicherung, IFQ*) which is supposed to assess all German public research institutions in about five years. In parallel, the German Research Council (*Wissenschaftsrat*) is starting a rating activity referring to disciplines with the aim to cover all relevant disciplines within the next five years. Many states and universities collect performance indicators with the aim to link the level of base funds to performance (Lesczensky/Orr 2004). However, the impact of these measures on the base funds is still limited, so that in the perspective of the universities, the acquisition of external funds is more relevant. In the present situation, the research governance of the universities at the micro-level is dominated by the search for external funding.

As a recent trend, the universities are achieving increasing autonomy as to the use of their financial resources, staff recruitment – including professors – or their organisational structures. This transfer of competences from the federal states to the presidents of the universities is still an on-going process, which has been accomplished to varying degrees in different states. It implies a new distribution of power within the universities, with higher clout for the president and his or her central administration to the disadvantage of the committees of professors. On the one hand, a stronger central administration means strong units can be strengthened and weak units can be straightened out or even shut down to achieve a clearer profile, on the other hand, the central administration needs improved access to reliable information on the performance of the multiple units of the university. This is one reason for the growing relevance of the various assessment exercises mentioned above. It is obvious that there is internal opposition to these new structures, and it will take several years until a new appropriate balance of power is achieved.[15]

As to the situation at full universities, the requirement of an effective knowledge transfer increasingly comes into conflict with the organisational structures of a public institution characterised by low flexibility and long response times to external requests. As a reaction, many technology transfer activities are not organised directly in the university, but in its close environment, for instance in private firms of professors or as public associations or foundations (Bierhals/Schmoch 2000, Schmoch 2003). One relevant form of these external activities is the so-called "An-Institute" which is a research centre located near the university, but which is legally independent of the university. Based on cooperation agreements with the university, the director of an An-Institute is in parallel a part-time professor at the university. The An-Institutes generally get base funds from the federal states where they are located, but they have to acquire the majority of their funds from external sources, similar to

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15 In the context of this debate, a research group examining the governance of research recently published a set of theses on the "framework of capable publicly financed research" in Germany (Forschergruppe 2007).

Fraunhofer institutes. As rough estimate, the activities of An-Institutes in technology-related areas have a volume of about one third of all Fraunhofer institutes combined, but it is impossible to enumerate the technology transfer activities in the environment of the universities in a more precise way, due to the broad variety of organisational types and transfer mechanisms (Bierhals/Schmoch 2000). As a reaction to this trend, the universities try to build up new internal organisation structures in order to achieve a higher visibility in transfer. This change towards more effective and flexible organisation units will have an impact on the university system in general.

In the context of the economic problems, public awareness for supporting innovation is increasing. Against this background, many activities at the central government and in particular at the state level are being undertaken to support technology transfer from universities to industry. In this context, science parks are established or initiatives are started to create competence clusters with networks of universities and enterprises in specific technology areas.

A further relevant novelty is an agreement between the central government and the federal states to provide additional research funds to excellent universities (*Elite-Universitäten*) selected in a specific competition. One effect of the presently ongoing selection procedure seems to be that the participating universities introduce new organisational structures implying the establishment of clearer profiles and more flexible organisational units. So the deep-rooted resistance to reforms of many decades (Schimank 1995) may be broken up due to the prospect of substantial additional funds.

To summarise, there is a trend towards assessing universities too one-sidedly, only by their success in technology transfer. In the long run, the specific role of universities in basic research has to be adequately acknowledged. With regard to economic roles, a reform of teaching seems to be more relevant, as it has to be taken into account that a large share of the graduates will not work in scientific organisations, but in enterprises. With this in mind, teaching in many disciplines can be improved considerably. Recent studies show that in about ten years, economic development in Germany may be substantially hampered by a scarcity of skilled staff, in particular of university graduates in the natural sciences and engineering (BMBF 2005, 2006). In this perspective, higher quality of teaching implying a higher success rate of students may be more crucial than more effective technology transfer. Furthermore, it will be necessary to attract a higher share of female students in the natural and engineering sciences. However, the debate on the scarcity of skilled staff is still only beginning.

Finally, the universities have to take care of the reputation of the non-technical disciplines and to show their relevance to society. If they are not successful in this regard, the share of these disciplines will steadily decrease.

5. Conclusions

In a more general perspective, the present situation in Germany can be characterised as a period of transition. This refers to a transition from abundance to scarcity which is not really accepted by society. So people notice that for instance the purchasing power of private households has steadily been reduced during the last decade, but they still try to keep the old standards in all areas of life. This implies that necessary reforms for adapting to the new structures in the context of globalisation and the ageing society will be introduced, but quite slowly. Many experts state a downward spiral, as the necessary reforms are introduced too late. On the other hand, the strengths of Germany are still considerable, so that a re-stabilisation is probable, however, at a lower level of resources. Among these strengths, the high quality and competences of the labour force, the high level of industrial innovation, as for instance reflected in patent activities, and the excellent infrastructure, have to be mentioned. Although large parts of the German economy are still focused on high-level technology, an increasing number of firms is successful in leading-edge technology as well.

With regard to universities, the consequences of this transition are reflected in different aspects which are sometimes contradictory. The first consequence is the reduced availability of funding for scientific research, and the universities try to maintain the former level of funding by an increasing acquisition of external funds. Although not all possibilities for external funding have been totally exploited yet, there will be an upper limit, so that the universities have to cope with restricted resources even more than in the present situation.

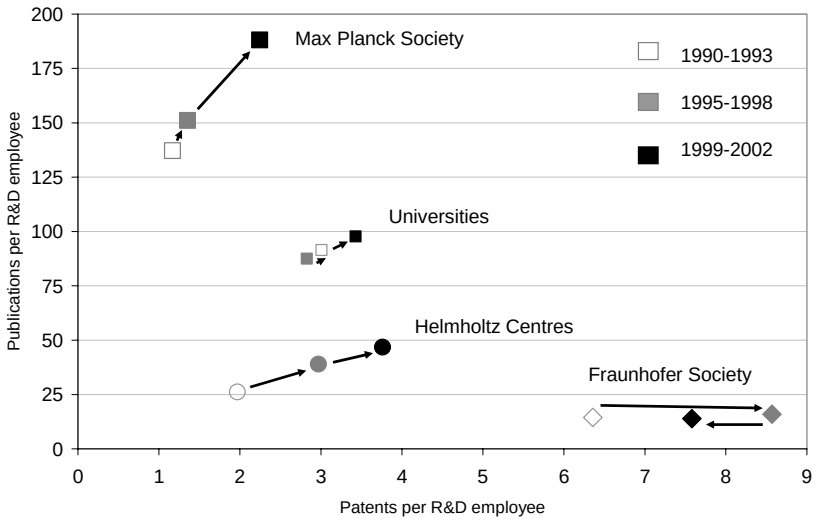
At the same time, policy-makers and scientific organisations try to enhance the efficiency of scientific research by organisational reforms, the introduction of new incentive structures and by regular assessments of institutions and research groups. In this regard, Germany is still in an early stage compared to other countries such as the United Kingdom, the Netherlands, or Australia, and it is likely that the German universities have a long way to go until a new structure will have been reached. In the present situation, too strong a focus of the evaluation exercises on scientific excellence in basic research is obvious which does not sufficiently reflect the broad spectrum of activities in the context of research and the division of labour between different research groups and research institutions.

A second aspect of the transition period is the increased call for knowledge and technology transfer activities. In principle, universities have to play a relevant role in the re-structuring of the German economy towards leading-edge technologies and knowledge-intensive services. Although the mechanisms and structures in the context of knowledge and technology transfer from universities can be improved in various aspects, the contribution of universities to technology is already quite high in the present situation (Schmoch 2000). A key problem in this context is the potential

conflict between the requirement for excellent basic research and increased technology transfer. In any case, there is an on-going debate whether basic science and transfer activities are contradictory or not (cf. Van Looy et al. 2004 and the papers cited therein). Whatsoever, we know some cases where professors actively engaged in technology transfer have to fulfil many different duties, encompassing the bargaining with companies, research, teaching, supervision of junior and senior researchers etc., so that their regular duties in teaching are called into question. Against the background of the scarcity of public funds, self-evident solutions such as the support of transfer-active staff by additional staff in teaching will not be realised. So the rating institutions have to think about improved evaluation models, where transfer activities are considered as equivalent to scientific excellence.

On the macro level, the attempt to cope with the demand for scientific excellence on the one hand and for more technology transfer on the other hand is reflected in an increase of publications as well as patent applications in all scientific institutions since the beginning of the 1990s as illustrated in Figure 9. In particular since the middle of the 1990s, a distinct enlargement of activities in both dimensions is obvious. This statement applies to universities and non-university institutions, and even the Max Planck Society shows a clear growth of the number of patent applications. Obviously, the Fraunhofer Society is the major exception of this general trend with a decrease of patent applications in recent years and the persistence of low publication numbers. As to the patent numbers, the Fraunhofer Society over-emphasised the patent activities in the middle of the 1990s, so that the recent decrease can be interpreted as consolidation. The extremely low level of publications is owed to the inadequate representation of European engineering journals in the Science Citation Index (SCI). However, the opposite orientation of the Max Planck and the Fraunhofer institutes as describes above is well reflected in Figure 9, and the universities prove to have an intermediate position between these extreme poles.

Figure 9: Number of SCI publications and of patent applications of scientific institutions in Germany with reference to R&D employees (in full time equivalents)



Source: Heinze/Kuhlmann (2006)

The change towards higher emphasis on knowledge and technology transfer is part of a more general trend to look for results of university research in the shorter term. Against the background of scarcity of funds, policy increasingly has to justify its investments by the corresponding results, so the funding of universities has to be justified by research results useful for society. However, it is quite difficult to prove investments in basic research by directly visible results, as by definition the results of pure basic research are often not applicable at all or its results can be linked to applications only in a long-term perspective.

The orientation towards application implies a strong pressure on the universities to focus on the medical, natural and engineering sciences and to reduce the social sciences and humanities in exchange. This erosion of the social sciences and humanities reflects the present public discourse with a focus on the economic prospects of Germany in the context of globalisation. Other possible contributions of universities to society, for instance, with regard to ethics in life sciences or the orientation of human beings in a world with a high level of technology, or changing social structures in a context of increasing unemployment or higher relevance of non-German inhabitants, are relegated to the fringe.

A further relevant trend for universities is the progressing European unification that already has a high impact on standards of university teaching. At present, first activities in establishing common standards for assessing and comparing research performance can be observed. This change will enforce the trend towards regular assessment already described above.

The scarcity of public funds will lead to a broad introduction of tuition fees, but these fees will still be moderate compared to the fees at private universities. So there is no indication that private universities will achieve a relevant share in the German university system. They will be limited to few disciplines, and even there, they have to show their higher quality compared to public universities.

Beyond all discussions about research and the third mission activities of universities, their crucial role in the education of highly skilled personnel will become more relevant.[16] At present, the responsible policy-makers try to displace this topic, but in about ten years the availability of highly skilled personnel will be visible as a crucial factor for the competitiveness of the German economy. In this context, universities have to think about a better didactic training of their personnel and an improved relation between students and teaching staff in order to raise the success rate of students. In addition, it will be necessary to attract more female students to the fields of natural sciences and engineering, and finally, the attractiveness for foreign students has to be improved as well.

A recent relevant event for universities is the clearer division of labour between the central government and the federal states (*Länder*), wherein the *Länder* get the full responsibility for the universities. The consequences of these new structures are not clear yet. Some experts see a general improvement of teaching and research linked to the strengthened competition between the *Länder*, other experts complain about the increasing structural differences between the *Länder* as to the standards of teaching and research and see a reduced mobility of students and a growing gap between universities in poor and rich *Länder*. The supposable consequence may be that poor *Länder* reduce their teaching in engineering, as many of their graduates get jobs in large enterprises in rich *Länder*. Thus it will be necessary to find appropriate compensation mechanisms to ensure a sufficient provision of graduates in these disciplines.

A further consequence of the on-going re-structuring of the German university system will be the higher specialisation of the universities in specific fields with the aim to get a clearer profile. The present ambition, that all universities cover nearly all disciplines at a similar quality level, cannot be maintained in the long run. Already now, some universities have already achieved a distinctly higher quality level of teaching and research (Friedmann et al. 2004, Wegner et al. 2004) and this development will move on. As to the structures in about fifteen years, an extreme scenario may be the American university structure with a limited number of excellent universities and a high number of universities with a low teaching level and no

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16 In a similar way, Archibugi (2006) argues that in recent years, the emphasis of the knowledge transmission from universities to enterprises has been emphasised to extensively.

research at all. Probably, this situation will not occur in Germany, but a more distinct differentiation will be established in any case.

Despite all turbulences in the present situation of re-structuring, the role of universities will become more relevant already in a mid-term perspective, as their adequate contribution to knowledge-based industries and services is crucial for the competitiveness of the German economy.

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