market or not to consider it in the first place. Research institutions, which are rarely able to offer a tenure track, should try to cooperate with universities here.
– The career goals of young scientists are very varied. Many staff members in research institutions do not intend to stay working in science indefinitely. Their careers outside science must also be supported effectively. Permanent employment options are not always relevant in such cases.
– The best possible support should be provided to prepare young scientists for a career in research. This includes offering opportunities to gain teaching experience, to spend time in other countries, and to apply for research grants and funds to set up research networks. Generally, young scientists should be systematically involved in decision-making processes within the institutes.
– A regular evaluation of working conditions for scientists in Germany is important, and the first Federal Report on the Promotion of Young Scientists (BuWiN) is welcomed. It should appear at regular intervals. A positive aspect is the intention to extend the report to include key areas such as promoting young researchers in the private sector or the analysis of special groups in addition to gender comparisons.

B 3 KNOWLEDGE AND TECHNOLOGY TRANSFER

In recent decades, publicly-funded research institutions in all industrialised countries and in emerging economies have become very important for the dynamics of innovation.[43] The EFI Report 2008 already drew attention to this important development. In particular under difficult financial circumstances, research and innovation policies should aim to intensify knowledge and technology transfer, because science can make a considerable contribution to commercially-successful innovations.[44]

But attention should not be directed solely to engineering and natural science disciplines. With services also becoming increasingly important in Germany, it is necessary to view knowledge in a broader sense. Service innovations are often knowledge-intensive, but frequently they are characterised by a low technology intensity.

Key forms of knowledge and technology transfer BOX 09

– Education and further training
– Research contracts and consultancy
– Strategic cooperation
– Licensing and rights exploitation
– Spin-off companies

Statistical analyses[45] show that the contribution of such innovations to increased productivity and welfare can be just as significant as the contribution of technologically-driven innovations. Engineering and natural sciences are immensely important, but not the only sources of innovations; the humanities, cultural and social sciences can also create innovations and must receive specific consideration in the R&I policies.

Supporting the entire breadth of knowledge and technology transfer

Knowledge and technology can be transferred in various ways (Box 09). The most important way is through teaching at universities and research institutions. Elite universities do more than produce Nobel Prize winners – the vast majority of their graduates will be doing practical work. The curricula must take this into account. Research institutions also offer intensive preparation for subsequent innovation-oriented activities in companies. New research findings and methods are transferred very effectively by graduates from universities and research institutions who move into the business sector. Therefore in particular in the course of the Bologna Reforms, close coordination is required between businesses and institutions of higher education. There should not be excessive political intervention concerning course structures and contents. The institutions of higher education would then be able to adapt their curricula to the employment market situation and the requirements of the subject. Personal technology transfer can be even more effective if all students have an opportunity to gain knowledge about business management in the course of their studies.

A further form of knowledge and technology transfer is through external research contracts and consultancy

BOX 10

Srategic cooperation in Public Private Partnerships

Catalysis Research Laboratory (CaRLa) of BASF and Heidelberg University

CaRLa is a joint project of BASF and the University of Heidelberg, supported by Land Baden-Wurttemberg. Six post-doc researchers from each partner work together on the development of homogeneous catalytic converters. Basic research is carried out at CaRLa, but in addition processes are also developed for specific requirements. Fields of application for homogeneous catalysts include resource-conservation in the production of chemicals and the avoidance of waste products, opening up new, cost-effective methods for the production of existing and new products. The projects are financed equally from private and public funds. This applies both for the infrastructure and also for the on-going costs for personnel and fixed assets. The project will be evaluated for the first time in the autumn of 2009.

MerckLab at the Technische Universität Darmstadt

In the joint laboratory of the Technische Universität Darmstadt and Merck KGaA scientists of both institutions have been researching since May 2006 on novel inorganic composite materials which are suitable for printable components for high-performance electronic applications (print electronics). A total of ten co-workers are employed in the Merck Lab. Merck invested about a million euros in setting up and equipping the laboratory. The annual running costs, also amounting to a million euros, are shared equally by the two partners. The TU Darmstadt contributes primarily in the form of personnel and contributions in kind. A period of cooperation of five years has initially been agreed on. Merck registers patents and markets the results.

Deutsche Telekom Laboratories (T-Labs) at the Technische Universität Berlin

The Deutsche Telekom Laboratories set up in 2005 are integrated in the Production and Innovation Department of Deutsche Telekom and at the same time is also an associated institute of the Technische Universität Berlin. A year after it had been established, a subsidiary institute was created at the Ben-Gurion University in Beer Sheva (Israel). In early 2009 a further research institute of Deutsche Telekom was opened in Los Altos (USA).
The T-Labs are structured in the segments Strategic Research and Innovation Development. Focal points are intuitive operation, integratable service components, intelligent access, infrastructure and inherent security. Currently, more than 300 experts and researchers are working in the T-Labs – half of which are Deutsche Telekom employees and the other half staff or students of TU Berlin, with some 180 working at the Campus.
Currently four Chairs funded by Deutsche Telekom are occupied, and others are in planning. The T-Labs have been established without a time limit. The rights for all inventions lie with Deutsche Telekom.

work. Here Germany can look back over a long and successful tradition. In key sectors such as chemistry, mechanical engineering and road vehicle construction there are well functioning links between universities and research institutions and on the one hand and the business sector on the other hand.

Various institutions such as the Fraunhofer Society institutes or the IGF (Industrial Joint Research and Development),[46] provide the German innovation system with a clear advantage in an international comparison. There is also a successful tradition of support for companies by researchers at universities and research institutions, for example through the Steinbeis Foundation.

Encouraging strategic cooperation agreements

Strategic cooperation agreements are becoming increasingly frequent, involving institutionally anchored long-term cooperation between private and public partners. An interesting example for the latter form of cooperation are the Deutsche Telekom Laboratories (T-Labs) – a research laboratory set up jointly by the Deutsche Telekom AG and the Technische Universität Berlin. Other examples are Merck Labs at the Technische Universität Darmstadt, and the Katalyselabor CaRLa at the Ruprecht-Karls University Heidelberg (Box 10). Germany has little experience so far with such forms of cooperation. These partnerships still present considerable challenges for both sides in view of the differing cultures,

legal constraints, and problems of resource allocation. The Expert Commission emphasises that these Public Private Partnerships must as far as possible preserve the freedom of the research institutions and universities – in particular concerning the publication of research results. Cooperation could otherwise lead to excessive dependence. Public Private Partnerships offer considerable opportunities, because they are frequently long-term projects and bring together complementary strengths in research and development. Active political support should be provided for further partnerships. Experience with Public Private Partnerships should be made available for a wide group of companies and research institutions.

Licensing of industrial property rights is another main form of knowledge and technology transfer. The complexity of licensing is underestimated in many scientific organisations. The search for licence users requires excellent market knowledge and a well-developed communications network. The negotiation of licence contracts is often difficult, because this involves achieving a balance between the interests of the license holders and the license users. Business and science need to find appropriate models of cooperation. It is not only the obligation of science to ensure successful cooperation. In their own interests, business companies should also respect the special characteristics of scientific organisations and basic research.

New enterprises are a particularly sustainable form of knowledge and technology transfer, because non-codified knowledge of the researcher can be transferred and applied effectively. But this can raise complex questions for the universities and research institutions regarding the transfer or licensing of industrial property rights, the involvement of the scientific institution in the new enterprise, offering the entrepreneur a right of return, and deciding what support the university or research institutions can offer those setting up a new enterprise.

Improving the organisation of knowledge and technology transfer at universities and research institutions

The amendments made in 2002 to the German Law on Employed Inventors (including the elimination of the "University teacher privilege") have far-reaching consequences for the universities and research institutions. These are still going through a process of adaptation, but effective organisational and procedural models for knowledge and technology transfer are gradually developing. The patent exploitation agencies which were initially developed have not on the whole been successful, and it will be necessary to search for better solutions. A particular problem has been that aid for the agencies has only been provided in the past by the Federal Government, and then only for short periods, which meant that stable structures and processes could not be established. Furthermore there has not been any independent evaluation of the utilisation of the aid.

The transfer offices have to cope with a wide range of complex demands, but many of them have relatively inexperienced staff because the salary levels have often been set too low. In addition it is necessary to integrate the scientists who are involved. A fundamental reorientation is required on the part of the scientists if the work of the transfer offices is to succeed. An international comparison shows that there is still considerable scope for improvement in Germany.[47]

Political support can be provided for the optimisation of knowledge and technology transfer, first of all by identifying and communicating positive and negative examples. In order for promising models to be implemented, bureaucratic barriers must also be cleared out of the way. The Expert Commission has already drawn attention to the need to offer universities and research institutions more scope for their activities (Box 08). Currently, those involved in knowledge and technology transfer soon find themselves in legal grey area. A "Freedom of Science" law could create room for suitable organisational solutions.

Revenues from the licensing of industrial property rights and expertise cannot play a dominant role in financing public research, in either the short or long term. The macroeconomic benefit of knowledge and technology transfer can not be fully internalised by the universities and research institutions. The revenues from knowledge- and technology transfer as such (licensing and sale of company shares) even for very successful US research universities only amount to some two to four percent of the research budget of the institutions. Nevertheless, knowledge- and technology transfer has a considerable macroeconomic benefit.

This provides a justification for providing state aid for knowledge and technology transfer.

Above all there is a need for professionally-managed transfer offices which have a good network with the business sector and what the companies require, and which also understand the details of research processes and incentives. The logic of basic research must be respected, and scientists cannot compelled into knowledge and technology transfer by bureaucratic measures. On the contrary, cooperation must offer attractions. In order to be successful, transfer offices must offer incentives to both the scientists and the transfer personnel. These include recognition of transfer achievements when deciding on appointments and promotions, as well as offering economic incentives.[48]

BOX 11 **Patenting**

Patenting with a grace period

Almost all patent organisation now use examination systems, i.e. the provision of a patent is dependent on meeting various criteria. The examination is carried out by personnel of the relevant patent offices, and it is quite possible that these offices reach different conclusions about the patentability. The criteria specified by the European Patent Office or the Deutsche Patent und Markenamt (DPMA) are Novelty,[49] Inventive step[50] and Industrial application.[51] An invention is new if it does not form part of the state of art. It is based on an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art. And it is susceptible of industrial application if it can be made or used in any kind of industry, including agriculture. In the European Patent system an invention is no longer new if it has previously been made public in some way, e.g. in the course of a scientific publication or a presentation at a conference or a trade fair. In the USA, the inventor or applicant can apply for a patent within a grace period of one year after a publication (by the inventor or applicant) without the publication giving grounds for a loss of patent.[52]

First to file vs. First to invent

In the USA they use the first-to-invent system, in which the right to a patent goes to the inventor who can give proof of having been the first to have made the invention on which the patent is based. This means that an inventor can receive a patent even if they are not the first to file it at the patent office. In cases of conflict, special interference proceedings examine the claim of the applicant inventor. Such cases are rare, but the first-to-invent principle causes high documentation costs, because the time of the invention must be documented internally, and plausible evidence must be collected.

In Europe, the first-to-file system is used. The first applicant receives the patent, even if they are not the original inventor.

Introduction of a grace period in the patent system

Universities and research institutions have had to weigh up since the reform in 2002 between publication or patenting, between long-term research cooperation or licence receipts in the short term, and between licensing or setting up a spin-off company. A particularly difficult situation arises as a result of the processing times for reports of inventions. In this case, the publication of the research results as quickly as possible can conflict with the intention of filing a patent. In the case of scientific results, it often only becomes apparent in the course of discussions with other specialists that they have a relevant application potential. With the introduction of a period of grace in the patent system it would be possible to resolve this conflict to a large extent. In the USA it is possible to apply for a patent within one year after a publication, without this being held to impinge on the novelty of the invention.

Such a regulation should not lead to legal uncertainty.[53] Rather, the grace period would make the work of the transfer office easier, because the invention can be discussed with potential license users at an early stage without threatening the patent protection. Ideally, the grace period for patent applications would be recognised by all parties to the Patent Cooperation Treaty (PCT). This would have the advantage that scientists would then not have to delay the publication of their research results until a patent has been applied for. A trilateral regulation involving the three major patent systems in Europe, the USA and Japan would also be an option. In exchange for the recognition of the grace period in Europe, the USA could then replace its first to invent rule by the first to file rule which applies

in Europe (Box 11). The German Federal Government should work intensively towards such a solution in negotiations in the European Union and with the USA and Japan.

Close the gap in support for the validation of research results

Results of publicly-financed research frequently require further development before they are suitable for transfer to business companies and acceptable for private financing. This takes place in "validation projects", which act as a bridge between invention and innovation. Public support of such projects is advisable, but it is currently only provided in individual cases (Box 12).

The Expert Commission approves of an expansion of validation support. This should be open for all technologies. In contrast to private financing, high-risk projects should also be accepted for support – the public measures should not simply duplicate private decision-making processes. Project evaluation must also draw on the market knowledge of experts from science and business. This necessity is also considered in Chapter B 4.

Supporting spin-offs from universities and research institutions

A very effective way to transfer technology is to establish enterprises as spin-offs from universities and research institutions. A new enterprise is often a very good way to transfer new knowledge from science to practical applications. In addition, such new enterprises also create employment opportunities for highly-qualified professionals at the location where the knowledge is generated. The Federal Government has created an extensive range of instruments for this with the EXIST Programmes and other measures. Some of these programmes are now being evaluated. If the measures can be shown to be successful, they should be continued in a suitable form.

Transfer offices have to provide very different support for new enterprises than they do in the case of licensing activities. Spin-off enterprises are less common, but in some cases they can generate much more value for the research institutions which are financially involved.

BOX 12

Validation research in GO-Bio and EXIST Transfer

GO-Bio is a promotion programme of the Federal Ministry for Education and Research (BMBF) which prepares scientists for setting up a company. With GO-Bio they are to develop new processes in life sciences and set up their commercial exploitation. The budget of this programme is up to 150 million euros annually.

EXIST research transfer is a programme of the Federal Ministry for Economics and Technology which supports outstanding research-based new enterprise projects which require complicated and risky development work. In a first phase the technological feasibility is established and prototypes developed. A business plan is also drawn up and the company founded. In a second phase, development work is finalised, business operations begin, and steps are taken to acquire follow-up funding.

If the research institute has a holding in the new enterprise this can solve a financing problem. The new company often has to acquire patent rights which are owned by the university or research institution, but does not have adequate liquidity to pay for them. A solution is to exchange the industrial property rights for shares in the new company which are made over to the university or research institution. However, such models are still rare and are viewed with scepticism in some quarters. Policy-makers can provide support here by highlighting successful examples.

Entrepreneurial training and support for new enterprises should complement one another. Many universities and research institutions now have new enterprise centres, which support the young companies and also offer students an opportunity to gain insights into planning and setting up a company. This is of key importance for promoting an entrepreneurial culture, but universities and research institutions must receive the resources and the freedom to initiate such measures.

Recommendations

Public research provides important impulses for innovations in business companies. Universities and research institutions in Germany are very active in this respect, and many German companies have been working successfully with them for a long time. However, in the opinion of the Expert Commission, the knowledge created in the public sector could be put to better use. In particular the German *mittelstand* does not utilise these sources of information often enough. Policy-makers have more possibilities to support the transfer of knowledge and technology:

- Knowledge- and technology transfer can be organised in many ways. Universities and research institutions have to find the solutions which are best for them. R&I policies should provide incentives and initiate independent evaluations, but not demand specific processes and structures.
- R&I policies for the organisation of knowledge and technology transfer can identify and communicate good examples.
- Public Private Partnerships should be promoted energetically.
- The Expert Commission urges the introduction of a "Grace period" in patent law.
- The Expert Commission recommends the development and regular evaluation of further instruments to validate the commercial applicability of research results.
- Germany needs to catch up in particular with research-based new enterprises. The involvement of universities and research institutions in spin-off companies should be made easier by the Federal Government and the relevant *laender* ministries.
- Entrepreneurial training should be offered at all universities and research institutions.

RESEARCH AND INNOVATION IN SMALL BUSINESSES B 4

Small and medium-sized enterprises (SMEs)[54] play a key role in the German economy. According to an estimate of the Institut für Mittelstandsforschung Bonn (IfM Bonn), some 70 percent of the total workforce of German companies in 2007 were working for these smaller businesses.[55] In the commercial services sector, about 75 percent of the workforce were employed in SMEs, and about 60 percent in the manufacturing sector.[56]

Smaller businesses are particularly prevalent in the services sector. There almost half of the employees registered for social security payments are working in small- and micro-enterprises with up to 49 employees. The proportion of the total work force in Germany working in the services sector rose from 54 percent in 1980 to 72 percent in 2007. Changes in productivity and demand are favouring the growth in services, and the trend to tertiarisation is coupled with the growth in significance of smaller businesses.

Since the begin of the 1990s, employment in the manufacturing sector has been declining, while it has been increasing in the services sector.[57] Under this aspect, among others, the small and medium-sized enterprises are a pillar for the economy. Therefore the conditions provided for them are equally as important as those for the large companies and under no circumstances should they be neglected.

Types of smaller businesses

85 percent of small and medium-sized businesses are active in the services sector, and 15 percent in the manufacturing sector. Of the smaller businesses in the services sector, 25 percent are in turn active in knowledge-intensive sectors. Five types of SMEs can be distinguished, each with specific functions for the economy.[58]

Type 1: Regularly researching small and medium-sized businesses have a high R&D-intensity,[59] and particularly high in the case of small- and micro-enterprises of this type (Box 13). This group of companies is therefore very significant for the dynamics of innovation.