OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

Michael Nusser
Sven Wydra
Juliane Hartig
Sibylle Gaisser

Options for action to strengthen the international competitiveness of research-intensive and knowledge-based branches in Germany

Summary

March 2007
Working report no. 116

SUMMARY

Due to their high expenditures on research and development (R&D) and the new technologies applied in these branches (e.g. bio-, nano-, and information technologies), research-intensive and knowledge-based branches (e.g. the pharmaceutical industry, medical technology, vehicle construction, electronic data processing services) possess great potentials to develop new or improved processes, products and services. As a result, new markets emerge, and the competitiveness of traditional branches can be strengthened. These research-intensive and knowledge-based branches are therefore of great significance for economic growth. This leads to the creation of new jobs and the guarantee of existing ones. This is very important for a country like Germany, which is poor in natural resources.

Innovations are usually the key to strengthening the international competitiveness of research-intensive and knowledge-based sectors. They emerge in innovation systems, in which various actors participate in an interactive, interdisciplinary and collective process with multiple feedback effects. Therefore, within a systems of innovation not only all sub-systems (among others, science/education, industrial actors, demand) must be strong, but they must also be well linked together. Not the individual factors or actors, but the interplay and the networking of top-performing sub-systems and the actors therein are decisive for innovative capacity. This implies that continual improvements in supply-side and demand-side factors, as well as their networking along the entire value added chain are necessary in order to strengthen international competitiveness.

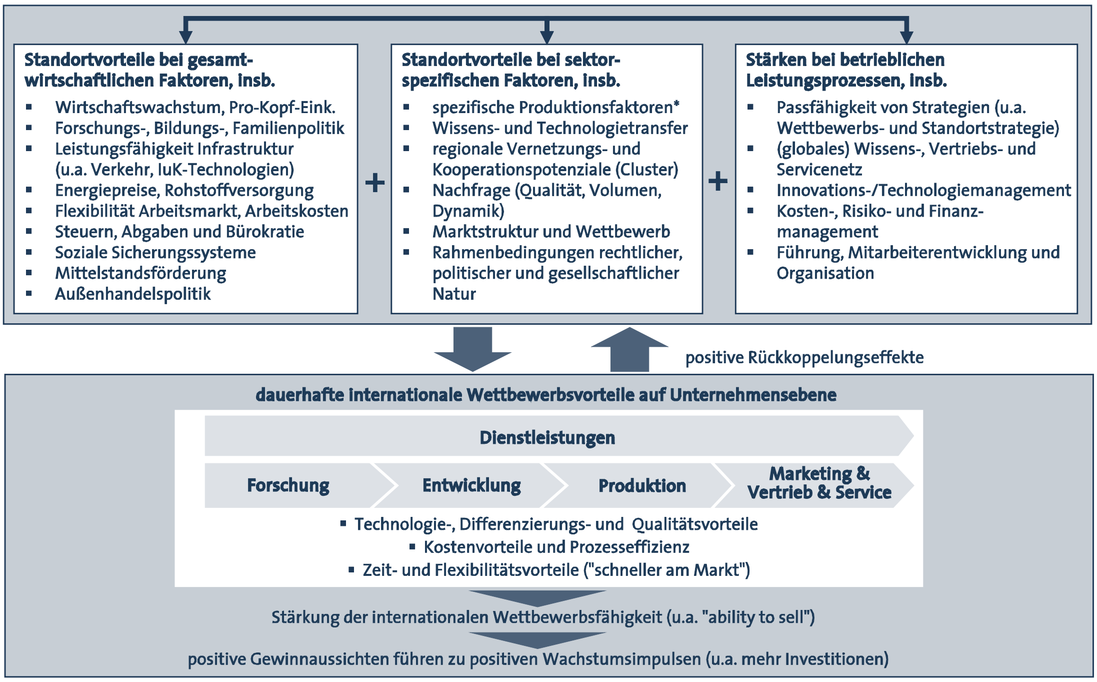
Starting from a systemic perspective, the objective of this TAB Innovation Report is to develop options for action in order to strengthen international competitivenes of research-intensive and knowledge-based branches. Thereby, existing potentials in the business location Germany should maintain and extend, as well as barriers to inovation should remove. The investigations focused on the following questions:

> What overall economic significance do research-intensive and knowledge-based branches have for the location Germany?
> Which supply-side and demand-side factors are crucial to achieve competitive advantages in these branches?
> How attractive is Germany as a location for research-intensive and knowledge-based sectors with regard to these supply-side and demand-side factors?
> Which options for action do the actors from industry, science and politics in

Germany have to make the research-intensive and knowledge-based branches more competitive internationally?

In order to answer these questions, a »3-pillar concept« to evaluate international competitiveness was developed (Figure 1), which contains a balanced proportion of overall economic and branch-/sector-specific factors as well as factors influencing the output performance of companies.

FIGURE 1 »3-SÄULEN-KONZEPT« ZUR BEWERTUNG DER WETTBEWERBSFÄHIGKEIT



* "weiterentwickelte" sektorspezifische Faktoren: u.a. Verfügbarkeit Personal (z.B. Ingenieure, Naturwissenschaftler), (technologisches) Wissen, (Risiko-)Kapital

Quelle: Nusser 2006

Main results of the pharma location analyses

Many analyses in this innovation report were carried out taking the pharmaceutical industry as an example, as the pharmaceutical branch is one of the most research-intensive and knowledge-based branches of the economy and therefore well suited to targeted, in-depth investigations. In order to create a value added in comparison with already existing pharmaceutical location studies, the pharmaceutical branch was examined on a very disaggregated level, namely that of disease categories. These differentiated results can serve in the future as the basis for R&D main focuses, among others.

The internationally comparative output-oriented R&D pipeline-analysis within the project framework (Chapter V.2) arrives at the conclusion for Germany that the most positive development tendencies can be recognised for the indication area cancer, which is the most researched disease category worldwide. In the pre-clinical phase, a very strong growth dynamic was observed in Germany during the period 1995–2005 in the area cancer. This means an increase by the factor 5.4 in location attractiveness (research projects conducted in the location Germany) and by the factor 6.3 for competitiveness (research projects conducted by German enterprises at home and abroad). Thus Germany's share was clearly increased compared to the twelve nations observed (e.g. USA, the UK, Japan, France, Switzerland), from a level of under 3% in 1995/96 to circa 8% in the years 2004/05. The results for clinical research (Phase I-III) are similarly positive, but in more moderate form. If the output-oriented results are linked with input-/process-oriented indicators (Table 1), then the following connections can be recognised: in the indication area cancer with the best output performance, all input- and process-oriented indicators perform very well.

Competitive advantages can be seen everywhere, compared with important competitor countries (values > 3). Not only on the supply side (quality of basic research and clinical research, availability of qualified personnel) and the demand-side (market attractiveness), but also in the networking of supply-side and demand-side factors in clusters and networks (cooperation science-science, cooperation science-industry), the indication area cancer takes first place (in the quality of clinical research in second place). These results suggest that innovations emerge above all in systems of innovation, in which the interaction and networking of top-performing sub-systems and actors function well.

This implies that strength and weakness analyses as well as action options only for single steps or actors in the value-added chain do not suffice to make the business location Germany and its research-intensive and knowledge-based enterprises internationally more competitive in the long term. For this reason, a holistic approach along the entire value-added chain was selected for the competition analyses and to derive options for action, which takes all relevant supply-side and demand-side factors, plus their networking adequately into account. In the following two sections, firstly the overall economic significance and important output figures (patent and export statistics) of the research-intensive and knowledge-based branches are described by means of selected indicators.

TAB. 1 GESAMTBEWERTUNG VON INPUT- UND PROZESSORIENTIERTEN INDIKATOREN ÜBER KRANKHEITSBILDER IN DEUTSCHLAND IM VERGLEICH ZU DEN WICHTIGSTEN KONKURRENZLÄNDERN

Krankheitsbild	Qualität Grundlagenforschung	Qualität klinische Forschung	Koop. Wissenschaft u. Wissenschaft*	Koop. Wissenschaft u. Wirtschaft	Verfügbarkeit qualifiziertes Personal	Marktattraktivität
infektiöse und parasitäre Krankheiten	3,0	3,1	3,2	2,9	3,6	3,0
Neubildungen/Krebs	3,4	3,3	3,8	3,3	3,7	4,0
Nervensystem	3,2	3,2	3,4	2,8	3,5	3,5
psychische und Verhaltensstörungen	3,1	3,1	3,2	2,7	3,4	3,5
endokrine Erkrankungen, Ernährungs- und Stoffwechselkrankheiten	3,0	3,1	3,5	2,9	3,5	3,7
Verdauungssystem	2,6	2,8	3,2	2,6	3,3	3,0
Herz-Kreislauf-System	3,4	3,5	3,7	3,2	3,6	3,8
Blut, blutbildende Organe, Störungen mit Beteiligung des Immunsystems	3,4	3,3	3,6	3,1	3,7	3,6
Sinnesorgane (Auge, Ohr, Nase)	2,6	2,8	3,2	2,6	3,3	2,8
Atmungssystem	3,0	3,0	3,3	2,9	3,3	3,2
Haut, Unterhaut	2,9	2,9	3,1	2,6	3,2	2,8
Muskel-Skelett-System, Bindegewebe	2,9	2,9	3,4	2,7	3,3	3,2
Urogenitalsystem	2,8	2,9	3,2	2,6	3,2	3,0

Quelle: Fraunhofer ISI 2006 (1 = sehr ungünstig und 5 = sehr günstig im Vergleich zu den wichtigsten Konkurrenzländern) (n = 77 Teilnehmer). * Diese Frage wurde nur FuE-Einrichtungen gestellt.

High innovative and economic capacities

The results of the TAB Innovation Report on the overall economic significance of research-intensive and knowledge-based branches (Chapter II) reveal the great importance of these branches for the business location Germany. This can be explained in that not only do they act as motors for innovation, i.e. as »producer«, but also as customers and suppliers of innovations, and last but not least, their contribution to added value, employment and exports greatly strengthen the business location Germany.

Innovations are frequently traced back to external knowledge sources or impulses. In their role as »innovation motor«, research-intensive and knowledge-based branches are responsible as customers of the upstream suppliers for 48% of all product innovations and as suppliers of technologies for 55% of all product and 58% of all process innovations in the downstream sectors. Thus they strengthen Germany's technological competitiveness not only through their own R&D activities, but also as external stimuli. The pharmaceutical industry, for example, with a share of about 15% R&D employees in the total number of employees and a share of R&D expenditures in turnover of 14–15%, is one of the most research-intensive industrial sectors in Germany. In 2004, over 4 billions euro were spent on R&D. As buyers of innovative intermediate inputs, they stimulate additional R&D activities to the tune of about 4 billions euro R&D expenditures in the upstream supplier sectors (e.g. in chemical and biotechnology firms). These R&D spillover effects, however, display a strong »R&D dependency« of the German pharmaceutical industry on firms abroad, e.g. on license purchases from US biotechnology firms.

The research-intensive and knowledge-based branches in Germany are responsible for about 50% of the total value-added in Germany. However, strengths and weaknesses also become apparent. So Germany, measured by value-added per capita in the high-tech technologies (e.g. vehicle construction) is in the lead internationally, but for cutting-edge technologies (such as pharmaceuticals/ biotechnology) as well as knowledge-based services (e.g electronic data processing services) is on the other hand often »beaten«.

Round 37% of the total jobs can be directly allocated to the research-intensive and knowledge-based branches. Moreover, by investment activities (e.g. construction) and expenditures for intermediate inputs, the research-intensive and knowledge-based branches are additionally linked with other industrial sectors through delivery commitments and induce thereby additonal, indirect employment effects in upstream supplier sectors (e.g. building/construction branch) (Chapter II.4). With regard to employment development, in the research-intensive industrial branches since 1993, despite an increase in production of 4.5% p.a., jobs have been cut by 1.7% p.a. due to increased productivity. However, in cases where R&D and innovations have been pushed rapidly ahead (e.g. automobile construction), increases in personnel numbers have also been announced in favourable economic situations. To create new and safeguard existing jobs, however, the knowledge-intensive service branches, but also the non-knowledge-intensive service branches (e.g. transport, hotel, cleaning businesses) will be of great significance in the future.

Patent and export statistics inspire confidence

Patent and export statistics are significant R&D indicators of the technological performance of countries. They sketch a positive picture for Germany, for they point to a high technological performance in the German research-intensive industrial branches. The German competitive position is much more unfavourable for the knowledge-intensive services. These results will be explained in the following.

The development of patent intensities (patents per 1 million gainfully employed persons) indicates a strong dynamic and continuous increases in the »production of technological knowledge« (Chapter IV.3.1.2): between 1995 and 2003 Germany occupied an absolutely top position with high-tech patents (cutting-edge technology such as pharmaceuticals and high-tech technologies like e.g. vehicle construction), not only in growth (almost doubling the patent intensities), but also in the absolute level compared with the important competitor countries. Similarly positive developments were also noted for the less research-intensive branches (around 50% growth).

The picture for export-import statistics is also positive (Chapter II.2). Germany is strongly interlinked with the world economy (in 2004 10% of world exports and 7.6% of world imports). Germany exhibits high technological competitiveness in exports. The USA and Germany have the largest shares in world trade with research-intensive goods, followed by Japan and Great Britain. For the export surplus (exports minus imports) Germany in 2002 was in second place with an export-import rate of 1.5 for research-intensive goods behind Japan (2.5), clearly ahead of the USA. Cutting-edge technologies are gaining in significance in world trade. The share of R&D-intensive goods in cutting-edge technologies in world trade rose from around 16% at the beginning of the 1990s to circa 21–23% at the beginning of the new millennium.

In this context, a sharp rise of intermediate input imports must be taken into consideration (Chapter II.2). Between 1995 and 2002 the share of foreign value-added in German export goods rose sharply from barely 31% to just circa 42%, since 2000 in a reduced form. Especially research-intensive branches display in part a really strong rise in intermediate input imports. However, the export-induced share of the domestic gross value-added in the German has risen from just under 16% in 1995 to just over 23% in 2005. The rise in exports has thus overcompensated for the sinking domestic value added share. The integration of cost-effective intermediate inputs from abroad appears thus to have increased the international price competitiveness of the domestic industry.

In the knowledge-intensive service branches, the export rate rose from 6.4% to 9.8% between 1994 and 2002, but Germany still remains a net importer. Therefore the German competitive position for knowledge-intensive services is to be judged as more unfavourable than for research-intensive goods.

BUSINESS LOCATION GERMANY: STRENGTHS AND WEAKNESSES

Locations in the USA, Japan and Europe and their innovation actors are engaged not only in an ever harder innovation competition against each other, but are also increasingly confronted by competition from emerging countries in Eastern Europe and Asia. These countries are increasingly advancing into the previous specialisation fields of the industrialised nations, among other in the high-tech goods (e.g. automobile construction). For this reason, established industrialised countries like Germany must constantly open up new and higher-grade production and export areas, in order to be able to maintain their competitive position. In this respect, the analyses reveal serious weaknesses along the entire value-added chain, which suggest that Germany will not be able to retain its present competitive position in the long term.

So the positive picture of the patent or foreign trade statistics, for example, becomes cloudy if the input-oriented innovation indicators are regarded, which are leading economic indicators for future technological performance. Whereas Germany occupied the absolute top positions in the 1970s and 1980s for important R&D input indicators in the international comparison, many indicators have deteriorated drastically since the beginning of the 1990s. These developments will be commented on for the input indicators knowledge base, education and skills in more detail below.

Knowledge base

The data collected in this TAB Report show that existing competitive advantages with regard to the (technological) knowledge base, which is of essential significance for the research-intensive and knowledge-based branches, is threatening to erode in the long term. Since the beginning of the 1990s the industrial (above all in small and medium-sized enterprises), but also the national R&D dynamic in Germany has been very low (Chapter IV.3.1.2). The countries in North America (such as the USA, Canada), Northern Europe (among others Finland, Sweden) and Asia (e.g. Japan, Korea, India, China) display a clearly higher R&D dynamic by contrast. So Germany, measured by the R&D share of the GDP, slid from place 3 in 1991 to place 9 in 2004/2005. The turnover share of new products sank from 31.0% in 1987 to 27.5% in 2004. The state share of industrial R&D expenditures was curtailed from circa 14% of the industrial R&D expenditures in the 1970s to circa 4% in 2003. Also, the investment components in the R&D budgets of research-active companies, which are effective indicators of the locational ties, sank from 11% in 1989 to 8% in 2003. The ties to the R&D location Germany appear to be diminishing. Also, the number of young technology-oriented firms in all research-intensive and knowledge-based industrial branches has been decreasing in Germany since 2002. Regarding R&D personnel, who are important for implementing new knowledge into competitive processes, products and services, Germany had to record a cutback of minus 7% between 1991 and 2003 (compared to +35% between 1979 and 1991), while important rival countries have been enjoying positive developments in R&D personnel since 1991 (e.g. the USA +37%, the EU average +29%).

The absolute level of R&D activities regarded on its own, although important, is not an indicator for the efficacy and efficiency of the R&D processes. Many factors indicate however that the German R&D dynamic will not suffice to maintain the present level of international technological competitiveness in the long term. Against this background, the high-tech strategy of the federal government initiated in 2006 and the again increasing industrial R&D expenditures in some branches are pointing in the right direction. Whether this is sufficient will depend decisively on the R&D dynamics of other competitor countries. China e.g. quintupled its real R&D expenditures between 1995 and 2004 with an annual growth rate of 20% and in 2004 was already in third place worldwide, behind the USA and Japan.

Education and skills

The development and application of research-intensive and knowledge-based processes, products and services pose special and in part new requirements for the employees. On the one hand, the quantitative availability of qualified staff, and on the other hand the adaptability of the skill profiles to meet these requirements, comes under scrutiny. As the following remarks show (Chapter IV.4.1.2), the competitive advantages still existing at present with regard to the availability of highly qualified workers will be turned into competitive disadvantages, if the efforts to take countermeasures are not greatly intensified.

Adaptability: in some areas the adaptability between the required and the existing skill is too low. Above all, interdisciplinarity is lacking which is of increasing importance in science and industry, and a teaching syllabus which takes the needs of industry inadequately into account is often criticised by industry. Small and medium-sized technology firms are increasingly confronted with bottlenecks for qualified personnel with appropriate knowledge in the areas of production, marketing and sales. According to experts' opinion, the increasing internationalisation processes have been inadequately considered in the educational institutions (e.g. in the areas language tuition, intercultural management know-how). In addition, as a result of the demographic change, future consumer spending structures will alter (e.g. increasing significance of health care); as a result, almost every sixth workplace in Germany will in future be »re-structured« with consequences for the required skill profiles.

Availability: the investigations of personnel availability show a differentiated picture at present. In some research-intensive and knowledge-based branches like the pharmaceutical industry, the software and telecommunications area, or the technical and R&D service providers, very small bottlenecks with highly qualified personnel are visible at the present time. Many other research-intensive industry branches, in which engineering science know-how plays a particular role, already have great difficulties in recruiting staff. Above all in vehicle construction and instrumentation technology (e.g. instruments with regard to medical, control and measurement techniques) the unmet demand for academics lay between 2001 and 2003 at over 20%, in the fields of mechanical engineering and the electrical industry between 15% and 20%. The results show that in this context small and medium-sized enterprises (SMEs) have often great problems with recruiting adequate qualified staff.

Thus the already existing personnel bottlenecks for highly qualified staff, above all for natural scientists and engineers, will become even more acute in the future, as the supply (among others, of graduates) is clearly limping along behind the growing demand for staff on the part of industry and science. With a view to job demand, studies show that between 1975 and 2004 the number of those gainfully employed with degrees from universities/advanced technical colleges almost tripled. Many factors suggest that this trend of knowledge intensification will continue in the future (among others, due to the increasing significance of emerging cross-sectional technologies, or the political goal to spend 3% of GDP on R&D). The demand for qualified personnel will therefore increase again powerfully in the future. If this growing demand for personnel cannot be met, then growth and employment potentials will remain unutilised.

Unexploited potentials: future personnel bottlenecks could be relieved if available worker potentials were used efficiently. Germany, however, lags far behind important competitor countries with respect to integrate highly qualified women, older workers, and young persons, and with regard to exploit the potentials of further training and education are concerned (Chapter IV.4.2.1).

Women are among the greatest potentials of highly qualified workers. In Germany, around 50% of first-year students and graduates are women. These potentials are less and less exploited as the professional development continues. In the German higher education sector in the year 2001, the share of female researchers is modest at roughly 21%, e.g. in comparison with Finland (37%). The same applies to the share of women with teaching authorisation at universities: 9% in Germany compared to 36% in Finland and an EU-15 average of 26%. A similar picture emerges for the share of women in R&D personnel in industry (10% in Germany as opposed to 18–23% in Scandinavian countries). In the German publicly funded research sector, the share of female researchers is also low, with ca. 22% compared to over 35% in other European countries.

Also in the integration of older persons in working life Germany lands far behind in the international comparison, with an employment rate for persons between 55–64 years old of just under 40% in 2004. Countries such as Sweden, Norway, Switzerland, Japan, Denmark and the USA have shares of 60–70%. Besides high costs for the pension scheme, innovation potentials, such as e.g. the older workers' great store of experience, remain untapped. And this against the background that the share of persons in work who are 55 years or older will rise in the course of the demographic change from ca. 11% in 2000 to about 23% in 2025. This means that almost every fourth worker will be older than 55 in the year 2025.

The potentials of many young people remain untapped due to the present great inequality of opportunities in the German education system. The chance of starting a college/ university education is more than seven times greater (factor 7.4) for children coming from the social origin group »high« than for children originating from the social group »low«.

In the course of technological development, knowledge and skills must always be refreshed through further education and training. Many indicators (e.g. number of companies which offer employees further education or training, number of participants and course hours attended, expenditure per year and participant) show that Germany lags behind important competitor countries (place 13 of the 21 OECD countries studied in 2003). In addition, Germany has lost more ground in the interval since then.

Demand

The concept of lead markets points to the meaning of demand for competitiveness; a high level of demand and a high quality of domestic demand can considerably strengthen the international competitivenes of research-intensive and knowledge-based firms in the long term via the following mechanisms: if pressure to solve a problem exists, then clients can articulate new needs which cannot be met by existing processes, products or services, thus driving innovation on. An example of this could be climate change and the demand for a 3-litre car. In this context, demanding and quality-conscious private and industrial customers with a high receptiveness to innovations and a great openness for technology are described as »lead users«. It appears to be more favourable for a country, the more independent »lead users« there are. If a country or its »lead users« adopts global demand trends faster and earlier than other countries, then lead markets profits in the form of increased domestic value-added (incl. foreign trade successes) and jobs can emerge. »Lead users« should therefore be integrated into the R&D processes by the innovation actors as early as possible, in order to discover how adaptable new technological solutions are. This requires close customer-supplier-producer relationships. The investigations show (Chapters IV.5.1.2 and IV.6.3) that competitive advantages in industrial customer demand exist in Germany.

Germany possesses lead market positions on the demand side e.g. in automobile construction and in branches in which process technology for industrial clients is involved (e.g. instruments with regard to medical, control and measurement techniques, mechanical engineering, environmental technology, technical industrial goods components). This lead market position is favoured by a very strong industrial basis (especially in high-tech technologies such as vehicle construction) and by preferences on the part of industrial clients for qualitatively top-value and top-performance, flexibly deployable and above all cost-efficient machines, plants, software systems and technical components. An important trigger is the cost pressure in Germany (e.g. high labour, environmental protection and energy costs). The preferences of German industrial clients lie in the global trend, such as for example the cost pressure will increase in many countries in the long term due to the fact that a lot of production factors will become scarcer (e.g. rising raw material prices, already high wage dynamics in Asian and east European countries).

This positive picture clouds over, however, if private demand is also included. In the case of private customers' demand for research-intensive and knowledge-based goods, many other North American, Scandinavian and Asian countries have competitive advantages. The results of the TAB Innovation Report present the following picture (Chapter IV.5.1.2):

Demand level: the USA lies clearly ahead of Japan with regard to consumption expenditure, followed by Germany and Great Britain. Germany`s share of worldwide private demand has moreover decreased since the beginning of the 1990s. In the demand for R&D-intensive goods and knowledge-based services per capita, Germany is to be found in midfield and for GDP per capita (indicator for the purchasing power of innovations) even in the bottom third in an OECD comparison. It can be concluded from this that the low domestic demand for instance (above all in the private consumer sector) in Germany could permanently weaken the strong exports, also because a critical mass of private demanders giving impulses for innovations could be missing.

The future sales market growth potentials lie primarily in the east: exports to Eastern Europe and Asia increased between 2001 and 2005 annually by 8–10%, the average export growth amounted to just over 5% p.a. Asia's share will presumably rise from presently 13% to ca. 18% in 2015, wherby Europe's share will shrink from 72% to 67%, although eastern Europe will gain shares. The greatly increasing share of Asia in future global sales markets will result not only from their stronger integration in world trade and the international division of labour and the economic growth linked thereto, but also due to the different age structure of the population compared with established industrialised countries. Due to the demographic change alone, countries like the USA and Germany will no longer be so important for demand from 2010 onwards, whereas Asiatic countries with a younger population structure (e.g. India) will gain in demand importance in the future. We can conclude from this that German research-intensive and knowledge-based enterprises would be able to achieve considerable export advantages in the future by means of intensive market research of these future lead-markets, also by integrating the customer needs structures of these emerging countries in the R&D processes.

Demand quality: Although the customers in Germany have a high level of quality awareness, thereby stimulating R&D activities, Germany is in the categories »technological level of local customers« as well as in »state demand for progressive technological products«, however, in the mid-table of the OECD comparison. Due to these facts, Germany is located in midfield of the 17 observed OECD countries in the question of demand quality.

Also attitudes towards technology, science and risk influence consumer preferences whether to buy innovative products. As far as willingness to take risks, or reservations about technology are concerned, Germany is found either in midfield or in the bottom third of the OECD table. Only for low-risk technologies, whose benefits are clearly recognisable (among others, life will be healthier, work will be more interesting, new opportunities for future generations) does the German demand behaviour not form a barrier to innovation.

Networks and clusters

New technologies (e.g. bio-, nano- and IC technologies) require a new knowledge base in the R&D and production processes. The number of scientific disciplines required increases, due to their interdisciplinarity. The new technological knowledge and additionally needed disciplines do not necessarily belong to the previous experience pool of companies and R&D institutions. This implies that no or only few actors will be in a position in future to manage the entire innovation process efficiently alone, so that to a greater extent than at present recourse must be taken to external knowledge (for example, from universities, R&D institutes, young technology firms). An efficient networking within powerful innovation networks is therefore essential for innovativeness in the future. Companies above all in research-intensive and knowledge-based branches must rely on cooperations.

Analyses of cooperations between science and industry for the pharmaceutical industry show slight competitive disadvantages, compared with important competitor countries (Table 1). Only in a few indication areas such as e.g. cancer do slight competitive advantages exist. The investigations point out that SMEs above all are inadequately integrated in existing clusters and networks (Chapter IV.6.1.2). In addition, the clusters and networks in Germany frequently appear to be strategically too research-oriented and technology-driven and still too little oriented towards customer needs structures, existing regional technology profiles or entrepreneurial innovation strategies.

OPTIONS FOR ACTION

On account of these partly drastic weaknesses, prompt action on the part of actors from politics, science and industry is acutely needed, to take countermeasures if the competitiveness of research-intensive and knowledge-based branches is to be strengthened. Such a target can be explained by the great contribution to value-added, exports and employment. The systems analysis approach selected here in addition convincingly sets forth that isolated measures do not go far enough. It seems on the contrary to be absolutely necessary to take the entire value-added chain into account. The options for action to strengthen the competitiveness of research-intensive and knowledge-based branches can be summarised as follows.

Coordinated innovation policy

The results of international comparative analyses of policy approaches show certain success criteria to which politics should be oriented in future, so that policy instruments can lead to the desired success (Chapter IV.2). Many of the following success criteria have already been integrated in policy measures today, but not in the necessary breadth. The main challenge consists in completely implementing them in concrete measures in daily political practice.

Policy measures should in future be more interconnected and better coordinated on regional, national, Europe-wide and if neccesary, also international levels, in order to improve adaptability. This implies among others intensified interlocking of various policy departments. If need arises, national targets should be proactively introduced on an international level (e.g. norms and standards). Policy measures should deliberately »strengthen strengths further«, which assumes the collection and regular up-dating of regional, respectively national competence and technology profiles. As research-intensive and knowledge-based branches are closely interlinked with each other, and in addition considerable R&D spillover effects from these branches radiate to the entire German innovation system, innovation policy measures which are aimed at promoting single technologies and/or branches should always keep the whole system in mind.

R&D activities in research-intensive and knowledge-based branches can necessitate high initial investments and are often conducted over several years. Long-term reliability and predictability of framework conditions are therefore essential for actors from science and industry. Good transparency and stable legal and political framework conditions are crucial. At the same time, when policy targets, priorities and strategies are being decided, all relevant stakeholders (among others, science, industry) should be involved at an early stage, in order to develop politically binding, mid-term oriented concepts (e.g. national strategies and sub-strategies for technology fields and/or branches) which all actors can jointly support. These strategies should not be communicated only in the national state, but also abroad, in order to maximise visibility for domestic and foreign investors. Furthermore, the policy measures should encompass the entire value-added chain. The success of policy measures should be measured by selected quantitatively defined objectives whereas the criteria should be developed in a discursive process. Learning processes can be stimulated by means of evaluations, target-performance comparisons and identification of good practice examples.

In the administrative processes accompanying the policy measures, necessary steps of the process should be better linked and unnecessary process steps should be eliminated. Furthermore, a stronger orientation towards the needs of the science and industry actors should be developed within public authorities.

Knowledge base and knowledge transfer

Knowledge base: Germany lies behind important competitor countries with regard to R&D dynamics. Thus existing competitive advantages in the knowledge base will erode in the future. In order to combat this danger, a permanent intensification of the state and industrial R&D dynamic is called for. As far as the state R&D promotion is concerned, an instrument mix could be structured as follows (Chapter IV.3.1.3).

In 70% of the OECD countries, indirect R&D promotional instruments (e.g. R&D allowances/»tax credits«, research bonuses) are applied, which aim at all R&D-performing actors and those ready to commence performing R&D. Target groups should be the SMEs, above all, and knowledge-intensive service companies. The promotion should take place irrespective of the technological direction and branch membership. The state is not confronted with the problem of information here (as is the case with direct promotion), which technology, enterprises or networks to promote. It is known that this type of promotion contains the danger of free-rider effects and manipulation. In order to avoid this, indirect promotional instruments should be coupled to relatively unambiguous and narrowly defined R&D dimensions (e.g. direct R&D personnel expenditures).

The currently applied direct promotion (e.g. specialised programmes of the BMBF, BMWi, BMU or R&D programmes such as PRO-INNO, EXIST-SEED) to remove specific barriers to innovation and to promote cutting-edge technologies (e.g. biotechnology, nanotechnology) has proved worthwhile and should be retained. Provided that these promotional programmes, however, are a substitute for indirect widespread promotion, the indirect promotional rate should be lowered or direct promotional programmes should be abolished. The predominatingly broad thematic design of the Geman research landscape takes the existing competences into account and should be continued. However, the present programme diversity in innovation policy (»promotional jungle«) should be reduced, in order to increase transparency and prevent double promotion. The administrative effort should also be reduced.

In order to optimise research promotion, stricter competitive allocation criteria, a better integration of the representatives from applied research in »peer-review« processes, the establishment of continuous evaluation processes with quantitative success controls, as well as the intensification of alternative promotions (e.g. foundations) should take place. In the promotion of cutting-edge technologies, established procedures such as foresight studies and technology roadmaps should be increasingly utilised, including many innovation actors in order to obtain »nearer to market« solutions.

As far as the strategic R&D direction is concerned, the state-promoted but also the private-sector R&D processes should be oriented more consistently than previously towards national and international customer need structures (in particular in the respective lead markets). This implies among other things that applications for promotion should contain a market potential estimate, a presentation of the national and international marketing opportunities, possible barriers to market entry as well as tailormade marketing strategies to overcome them. Equally, a greater integration of strong partners for exploitation in the promotional projects could be meaningful. In order to increase the adaptability of the R&D strategies, the exchange between domestic enterprises and R&D institutions about their innovation strategies should be intensified. In addition, in a long-term discursive process based on prognoses for the future, the public promotion of educational profiles should be better coordinated in future with the innovation strategies and skill requirements of the science and industrial actors.

Knowledge transfer: precisely the companies in the research-intensive and knowledge-based branches rely on a broad academic knowledge base. An efficient organisation of knowledge and technology transfer and an efficient knowledge flow between science and industry (in both directions) are therefore of crucial significance for these branches. The action options which are presented below start with the efficiency of the transfer infrastructures, personnel mobility and start-up dynamics (Chapter IV.3.2.3), as weaknesses have also been identified here (Chapter IV.3.2.2).

Transfer infrastructures are of crucial importance so that potential cooperation partners are able to come into contact with each other, or collaborate better in networks. In order to increase the efficiency and effectiveness of transfer infrastructures even further, science-allied, industry-allied and independent transfer offices should align themselves more than now to their core competences and specialise more. This implies, on the one hand, focusing on a promotor function (e.g. building up and taking care of contacts). On the other hand, intermediaries should focus on their function as supporters in the administrative area and the

PR tasks involved in the transfer (e.g. assistance in finalising contracts and questions about promotional programmes, processing information to be suitable for target groups). In addition, there should be institutions specialised in offering advice, which require expert knowledge which is not available on a broad basis. These include advice on patent protection, technological problems, skill development measures, for instance. These services could be provided in a higher quality than up to now. In the course of this increasing specialisation, a cross-institutional concentration of resources should be aspired (e.g. transfer office for several R&D institutions and universities). Transfer and exploitation institutions should network more closely, and precisely in view of regional aspects and technology-specific aspects (e.g., jointly conduct contact forums, networking activities in order to have a Germany-wide access to technology-specific offers of expertise from other intermediaries).

The requirements to the know-how of transfer office staff regarding technical and business administration skills, personality as well as »soft skills« (e.g. interpersonal skills, negotiation skills, competence in mediation and presentation) are high. For instance, they have to assess the technological realisation potential, the market chances and competing technical solutions. Further education of the transfer office employees as well as recruiting experienced experts is therefore required. A flexibilisation of Public Services Law is being considered (e.g. salary tied to commercialisation success). In addition, continual evaluation processes as an instrument of quality control and to identify docking points for learning processes should be embedded.

In order to increase personnel mobility, existing barriers to personnel exchanges between science, industry and public authorities (e.g. transfer of pension claims) should be consistently dismantled. All innovation actors should be more actively promoted the temporary changing of sides. In industry there are successful models for example where the inventors with their promising idea switch within a concern temporarily to the organisational unit where the idea will be further developed up to serial production. The same would be conceivable between science and industry. The framework conditions for the immigration and stay in Germany of foreign scientists should also be improved.

If start-up companies fail, then it is mainly due to inadequate commercial knowledge and strategic competence in the start-up team, too low own capital base, a false estimate of the financial requirements, lack of integration in networks or false advice given by the support network. For this reason the options to act should start here. In the public promotion process, an external committee of experts from science and industry should critically appraise business plans with a view to marketability and competitiveness of the business model (e.g. with respect to the unique selling proposition). Personal talks between promotional administration, committee of experts and team of founders are helpful. Moreover, inexperienced founders should be coached by experienced experts in the development of enterprise concepts and strategies, at least in the starting phases.

The availability of capital is crucial for starting-up firms. In promoting start-ups the competitive market selection process should not be disturbed, or at least as little as possible. Public promotion should only then take place if a financing mix from various private and public sources (i.e. borrowed capital, own capital and cash flow/turnover) is available. A generous public financing package should be avoided if possible, because in this cases enterprises frequently are too little market-oriented and develop too little cost consciousness. Against this background a degressive form of public promotion should always be preferred, i.e. the state share of financing should decline as the promotion continues.

In order to improve start-up culture, the culture of entrepreneurship and independency should be more firmly established, and communicating »success stories« to the broader public would be helpful (»model effect of successful founders«). In addition, the bureaucratic barriers especially for SMEs should be further dismantled.

Education and skills

The following options for action in the area education and skills should be taken into consideration (Chapter IV.4.3):

Step up educational activities for technology-related professions: in the future we must reckon with considerable bottlenecks with qualified personnel. Bottlenecks in natural sciences and engineering science areas could be countered by mobilising all social classes as well as women, among other measures. This requires a freer interchange within the education system, among other factors. A swifter change between single levels of the school system should be possible (e.g. university entrance without the university-entrance diploma »Abitur« on the basis of entrance tests). In order to raise the share of women in technology-related subjects measures such as e.g. »Girls go Informatik« and »Girls' Days« should be complemented by a stronger embeddedness of the gender thematic, among others in technical subjects in universities and R&D institutions. Also soft instruments to improve the image of natural science and engineering science courses of study and careers among young people should be increasingly utilised (e.g. introduction of a subject technology in schools, pupil labs, integrating »success stories« of successful scientists in school tuition). Additionally, direct incentives can be applied (e.g. reduce tuition fees for technology-related subjects).

One pre-condition for stepping-up educational activities on a broad front is a more transparent provision of appropriate information, about current developments and future labour market conditions, as well as about educational opportunities and courses of study, among other topics. In Finland, for instance, a central and easily understood website was created which offers information on all available further training and educational programmes. In addition, university applicants should be given the chance to acquire realistic insights into the course requirements. Forms designed with a longer-term perspective (e.g. trial studies, summer courses, practical study experience over several weeks) are to be preferred here.

Better exploitation of existing qualified work force potentials: to prevent future personnel bottlenecks, existing qualified work force potentials and available »hidden reserves« at home should be better exploited. This means above all to raise the quota of older workers and women among the employed, as well as stepping up further training and education, but also in the long term to attract highly qualified foreign staff. With respect to integrating older workers it is advisable to abolish the incentives for early retirement. First reactions are already recognisable, but the necessary change in perspective has not been completed yet. The principle of lifelong education and further training must be more effectively internalised and implemented in all processes and organisational culture of the innovation actors. Activities to date will not suffice to bring about the necessary change in perspective. More institutional and infrastructural incentive structures should be created in order to push further education and training activities on a broad front (e.g. further education vouchers, special university courses for older persons). In further education and training it has proved successful to directly combine knowledge communication, exchange of experiences between participants and coaching e.g. in solving changed tasks within the company.

In order to attract foreign scientists in greater numbers, targeted incentives (e.g. attractive chairs) must be linked to unbureaucratic administrative processes (e.g. single form to complete).

In order to integrate highly qualified women better in industrial, scientific and public processes, the Finnish model could serve as an ideal example which meaningfully intermeshes various instruments, creating family-friendly structures (e.g. childcare in small groups with very flexible opening times). Besides, more family-friendly working time models and work forms such as telework, as well as women-oriented offers of further education have supportive effects.

Adapt financing structures: against the background of unequal opportunities in the German education system, it must be considered to what extent the financing mix of the education system should be adapted. Education experts regard the absolute amount of expenditures on education less critically than the way these are distributed among the educational areas kindergarten/pre-school, school and university. The largest private financial contributions are made in the pre-school area. Therefore state education investments in the areas preschool/school should be increased as here essential foundations for later success, performance but also for attitudes towards science, technology and risks are laid. In the area of pre-school education/ schooling greater value should be laid on qualified personnel. Higher investments in the further education and training of kindergarten teachers and school teachers are just as necessary as the adaption and up-dating of teaching matter.

Increase the efficiency of the education system: international comparisons of pupil performance show that successful countries distinguish themselves among others by the implementation of a clearer external performance inspection of schools and by delegating the personnel decision-making competences decentrally to the schools (e.g. in recruiting teachers). In addition, the splitting up of the school system into various school types should be implemented at a later age. Also a stronger integration of the private sector in school management should be taken into consideration. The transfer of these aspects to Germany should be examined in order to raise the quality of education at schools. A stronger integration of the private sector suggests itself as one means of increasing system efficiency in the education system. Also parts of the budget of educational establishments or a proportion of teachers' salaries should be linked to clearly defined success components. With a view to limited public funds, state financing funds should be supplemented in future by more private financing means (among others, public-private partnerships, funds, foundations, private sponsorships).

Increase adaptability of skill profiles: the acceptance of degrees/diplomas at all levels of edcation can be increased if the teaching content are better designed to meet the future need structures of potential employers from industry, science and the civil service than up to now. For example, educational institutions (e.g. when appointing new university professors/ chairs) could orient themselves more than in the past to the technology portfolio of regional clusters or the profiles of top-performing competence networks. To this end, in future educational institutions and potential groups of employers must coordinate earlier and more intensively than now, in a continuous process with a long-term perspective, what their future skill needs could be. The identification of future needs should not only be »industry-driven«, but be based on a critical discourse among all participants, as well as on regularly conducted scientifically-neutral foresight studies about skill requirements. Finland already implements this, in that various institutes elaborate prognoses of labour market needs especially in the highly qualified area. In addition, a continuous registration of target-performance deviations between the future need and the future offer should be carried out.

With a view to skill profiles needed in the future, the TAB Report analyses show that the ability to inter-disciplinary and international team work should be more strongly promoted in the future. The inter-disciplinary requirements of future-oriented technologies (such as bio-, nano-, IC-technology) should be better communicated in the relevant courses of study than at present (e.g. medicine, informatics, chemistry). In addition, technology-related education institutions should include important business management subjects in the curricula in a targeted fashion (such as new financing and risk management instruments, intercultural management know-how). At the same time, besides the acquisition of solid specialist knowledge and appropriate creative problem-solving techniques, increasingly »soft skills« such as ability to work well in a team, network management know-how, presentation/ communication techniques should be promoted, as these skills are helpful when working in networks. Also international education subjects like e.g. kowledge of foreign languages and knowledge of internationally oriented analytical instruments (e.g. international oriented market research and technology monitoring analysis methods) should be increasingly integrated in the curricula.

Promote international opening of educational institutions: in order to make Germany more attractive for foreign students and stays abroad more interesting for German students, not only teaching content, but also the structures of the education institutions (e.g. examination regulations, creation of international university networks and their linking with international non-university R&D institutions) must be made more open and flexible in order to keep pace with the internationalisation processes (e.g. by broadly based Bachelor/Master's structures and increased modularisation and flexibilisation of individual study courses). Unbureaucratic administrative processes to realise stays abroad are of assistance here. In order to attract foreign students on a long-term basis, the foreign students should be offered the outlook of a permanent residence permit. In addition, the international student and teacher exchange should be driven by pre-determined goals which should be included in the regular university evaluations and allocations of funds.

Demand

The options for action for the area demand can be summarised as follows (Chapter IV.5.1.3):

Integrate users more and earlier: innovation actors from industry, science and politics should integrate the customers, consumers and citizens interactively in their innovation processes at an earlier stage than at present. This has a double impact for the innovation actors: on the one hand, a faster and broader market penetration is usually achieved (e.g. through greater acceptance due to a better adaptability of technological solutions), and on ther other hand, the innovation actors receive timely suggestions for improvements and further development potentials. The greater opening up e.g. of enterpreneurial innovation processes (»open innovation« philosophy) in the direction of national and international end users/target groups and the regular active strategic integration of actual and potential customers, scientists, suppliers and other external persons (e.g. from related sectors and disciplines) in industrial innovation processes leads as a rule to an expansion of the innovation success, as national and international market, industrial and technology trends are identified early on. The risks linked with such an opening (in particular knowledge drain) must be minimised e.g. by means of contracts.

Improve utilisation competences: by investments in education and further training, consumers and industrial players can be made aware not only of innovative processes, products and services, but also be placed in a position to utilise them. Partnerships between innovation actors (e.g. politics and business) are helpful here in achieving a broadly based effect (e.g. through jointly organised projects, information events, courses, further training, favourable or free offers of advice).

»Cost-effective« infrastructure and end products: in order to make the demand for innovative products and services and their utilisation possible, often infrastructure pre-conditions must be first created (e.g. investments in the universal provision of Internet connections). Competition should play a role here, so that the products and services can be offered to the consumers at a cost-effective price. Frequently, a cost-effective access to related technologies is supportive. This requires possibly a liberalisation of key industries such as telecommunications. In order to stimulate an initial demand for innovations, time-limited degressive subsidies for new processes, products and services can be meaningful (e.g. for renewable energies). It is important that the innovative products and services or the new technology are competitive after a certain time in competition with other existing products, services or technologies.

Increase awareness for innovations: an open attitude towards innovations and new technologies can favour the acceptance and receptiveness for innovations. Existing reservations in the population must be taken seriously by politicians, science and industry, for only so can a societal climate be achieved in which innovations are openly accepted. A critical discussion of new technologies can contribute to a more need-oriented, possibly even country-specific design of new technologies. Sustainable measures to increase openness vis-à-vis science, technology and innovation should already start in the schools providing general education (e.g. in primary schools). Through the reform of teaching curricula and integration of new technologies in daily school routine can a (thoroughly critical) openness be generated. However, not only the infrastructure should be provided in schools (e.g. PCs, Internet connections, opportunities to experiment), but above all the teachers must be interactively involved as promotors and correspondingly trained and further educated.

Reduce uncertainties: in order to reduce uncertainties e.g. about safety and quality in innovations in new technology fields, easily understood information material on the chances and risks of these innovations as well as the relevant applicable laws, standards and norms should be provided for the public, at best free of charge. An open and objective information policy and campaign on the part of industry, science and policy-makers can strengthen public trust in a long-lasting way. The collaboration between politics, science and the media should be improved in this context so that the information reaches the citizens directly more often than is now the case. Internet presence (among others, with interactive websites) as well as newsletters, branch guides, free publications, telephone hotlines or events can be of use hereby. At the same time, safeguarding and strengthening consumer rights (e.g. mandatory labelling) can be important for building up trust and risk reduction. In order that measures to stimulate public debates and information campaigns achieve the desired widespread impact, coordination by various ministries, respectively innovation actor groups is necessary.

Demonstration projects can help to test new technologies and thus reduce uncertainties. Producers and demanders should both be involved in demonstration projects, as e.g. problems and necessary adaptations on the part of the demanders can be directly communicated to the producers. Successful demonstration projects and their results should be made widely known as a contribution to reducing uncertainties. Regulations can also positively impact demand behaviour. Nationally and internationally coordinated standards (e.g. pertaining to safety or quality, data on product composition) and norms can reduce information costs and the risk for demanders and thereby create trust. Standards and norms can also guarantee the compatibility and interoperability of various applications and thereby reduce adoption costs, above all if they are open to technological further developments. In this way they support a timely, broadly based demand for innovations.

Networks and clusters

Research-intensive and knowledge-based branches cooperate with especial intensity. Due to the increasing significance of clusters and networks, in the past national innovation and technology policy was already extended to include cluster and network approaches. The results of the TAB Innovation Report indicate that the clusters and networks are frequently not yet strategically optimally positioned and SMEs are often still inadequately integrated in existing clusters and networks. Against the background of the analysis of success factors for cluster and network policy, significant success criteria can be summarised as follows (Chapter IV.6.1.3):

Policymaking should exert a coordinating and supporting influence on cluster and network formation (e.g. providing incubator and production areas or transport infrastructure), and not control. Regional development strategies designed to encourage cluster and network formation as well as promotional projects should be more strongly integrated in a dynamic association with innovation decisions and strategies of leading multinational enterprises with an »open innovation« philosophy. The strategic direction of regional clusters should take the spatial conditions into account and above all dock on to existing (technological) strengths, bundle and further develop them (»strengthen the strengths«). A regional development strategy which is directed towards attracting companies and R&D institutions must start with the location factors in their complexity. The active development and implementation of a technology-oriented regional marketing concept is meaningful which underlines the regional technology-specific competences, and presents the region as an innovative location (e.g. with respect to knowledge base, qualified personnel, excellent research institutions, good education/further education and technology transfer system, friendly bureaucracy, attractive living conditions) not only internally, but also externally (e.g. events at home and abroad).

In addition, care must be taken that the transformation to market-/ application-oriented clusters is successful. Clusters and networks should in future orient themselves much more strongly towards national, but also global customer need structures. The structures of such clusters and networks should be sustainable and internationally competive. With this end in view, more foresight processes, roadmap procedures, technology assessments and international comparative studies should be carried out, in order to register changed global market, industrial or technology trends at an early stage.

Above all in more mature clusters/networks the »opening outwards« and internationalisation should be intensified. These external supra-regional/ international cooperations are important in order to continually receive sufficient new impulses and information (e.g. about international market exploitation potentials and global technology trends) and to avoid »lock-in« effects. After cluster and network approaches were integrated in innovation policy in recent years, less the quantity of networks than the quality should be in the focus in future. Skill development measures (e.g. building up network management competences) as well as the explicit adoption of skill targets in the network goals are helpful in this. In addition, existing achievements should be developed further (e.g. networking the networks and clusters, diffusion of information and experiences about activities already carried out). Continuous evaluation and improvement processes (among others, on the basis of qualitative and quantitative success criteria) should be institutionalised, whereby care should be taken that the process remains highly transparent. The results could provide a platform for comparisons and learning processes. This prevents, among other things, that permanently state promoted »artificial networks« are created.

The willingness to cooperate in the case of SMEs is often low compared with large enterprises, but also their ability to cooperate (e.g. insufficient financial means and too few personnel). Therefore, the integration of SMEs in clusters and networks is still inadequate. Economic potentials (e.g. broader market penetration, better utilisation of capacity), e.g. through production and marketing partnerships at home and abroad, are frequently not exploited. Therefore support for SMEs in networking, respectively integration in network structures combined with R&D promotion appears sensible (e.g. by means of indirect promotional instruments). For the networking part, a balanced mixture of technically innovative actors (e.g. research institutions) and network partners well versed in marketing and sales (e.g. internationally active SMEs, large global players) should be chosen. When SME networks are being formed, greater consideration should be paid in network promotion to learning about cooperation management, and not only the impetus to network building.

The performance of successful clusters is greatly influenced by the integrated companies and the competitiveness and output performance of these enterprises. Above averagely successful enterprises with profitable growth are characterised by their resolute pursuit of a consistent business strategy which is coordinated with their core competences. The success is also based on the facts that they systematically open up new sales markets (among others, in Asia, Eastern Europe), optimise their value-added processes worldwide from factor cost and competence perspectives (but retain their core competence »in-house«), continuously invest more in research and development and their innovative ability and increasingly have recourse to cooperation networks. In addition, they make continual use of innovative financing and risk management instruments (e.g. sensitivity analyses, scenario techniques), as well as strongly focusing on the further training of employees. All these success factors can be understood as options for action for the industrial innovation actors.

CONCLUSIONS

The TAB Innovation Report shows that future international competitiveness not only depends on the effectiveness and efficiency of state action, but also to a considerable extent on the effectiveness and efficiency of scientific and firms' output performances and thus on the actions of the actors from science and industry.

While important competitor countries of Germany have invested enormously in recent years in research and development and in education system reforms in order to strengthen their international competitiveness and safeguard sustainable economic growth, Germany has a great need to catch up in this area. The study identified considerable weaknesses along the entire value-added chain, which endanger the international competitiveness of research-intensive and knowledge-based branches in Germany in the long term. If the research-intensive and knowledge-based branches located in Germany are to be made more competitive internationally and permanently, single intervention measures are inadequate. On the contrary, a »holistic systemic approach« is necessary, which takes all relevant supply- and demand-side factors, as well as their networking along the entire value-added chain sufficiently into account.

The points of departure to strengthen the international competitiveness of research-intensive and knowledge-based branches on a long-lasting basis lie in the following fields: increases in the state and industrial R&D dynamic, a more efficient education system, a better exploitation of the potentials of the qualified work force, a demand culture open for innovations, more strongly market-oriented cluster and network policies, as well as increasing the R&D output performance of industry and science. The derived options for action in these fields could serve in the future as a reference framework and platform for an intensive dialogue among actors from politics, industry and science.

The Office of Technology Assessment at the German Bundestag is an independent scientific institution created with the objective of advising the German Bundestag and its committees on matters relating to research and technology. Since 1990 TAB has been operated by the Institute for Technology Assessment and Systems Analysis (ITAS) of the Karlsruhe Institute for Technology (KIT), based on a contract with the German Bundestag

TAB

OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

BÜRO FÜR TECHNIKFOLGEN-ABSCHÄTZUNG
BEIM DEUTSCHEN BUNDESTAG

KARLSRUHER INSTITUT FÜR TECHNOLOGIE (KIT)

Neue Schönhauser Straße 10
10178 Berlin

Fon +49 30 28491-0
Fax +49 30 28491-119

buero@tab-beim-bundestag.de
www.tab-beim-bundestag.de