BOX 11 Lead markets

Retrospective analysis of successful innovations, e.g. the video recorder, the fax machine or mobile communications, has shown that the scientific results were known long before a technology 'took off'.[62] It was only with the market breakthrough that local companies were able to obtain an advantage over foreign competitors in terms of experience with production and applications.

If two or more pioneers produce different technological variants of the same functionality, the one which is accepted first by a market, the lead market, establishes itself internationally and displaces alternative constructions in the 'Lag Markets'. The delay cannot be explained by lack of interest in innovation or opposition to technology. One country is not generally late or leading in the application of innovations. A whole series of factors all exert influences (legislation, cultural differences, the market power of good alternatives, regional entrepreneurial knowledge, marketing channels, availability of specialist personnel, etc.). It is therefore difficult to predict future lead markets in any individual case.

activities and the broad mobilisation in Germany represent important tasks and a successful start has been made. We have pointed out potential for further development: improved coordination with the *laender* and within the European Union, transparent information about future budget allocations, a plausible selection of the specific fields of innovation, and increase attention paid to services, and to sustainability innovations. The German government should continue to pursue this course energetically.

C 6 GROWTH POTENTIAL AND CUTTING-EDGE TECHNOLOGY

Innovation successes

Research and innovation are the foundation for the economic success of Germany. This is valid both over the longer-term, and recently for the economic upswing of 2006 and 2007, which was supported in particular by technology exports. Germany accounts for about a third of the world trade with R&D-intensive goods, and for many years has ranked second (relative to its population size) for globally relevant patents. Government and private expenditure on R&D is increasing again. At first sight the balance seems to be positive, but a more detailed analysis indicates structural problems.

Continuing weakness in cutting-edge technology

The analyses of R&D, foreign trade and patent activity in the EFI Innovation Studies show that the German innovation system has systematic weaknesses. Germany achieves its success in the area of high-level technology, but in an OECD comparison is only has a low ranking for cutting-edge technology. In particular the relatively mature sectors of chemistry, mechanical engineering and automotives account for the largest part of German R&D, patents, and exports.

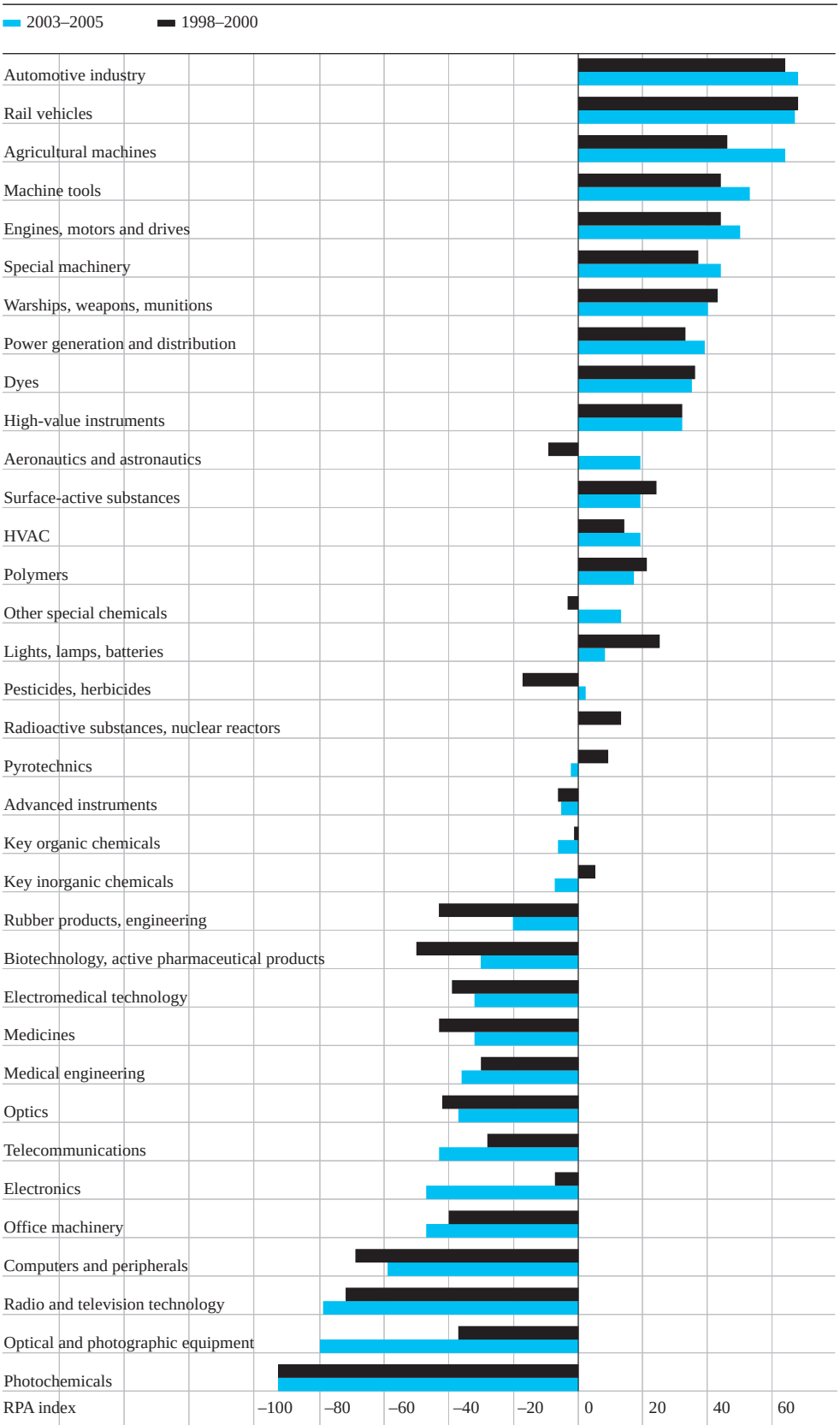
The R&D activities of German companies show marked patterns of specialisation which differ from those of other countries. For the OECD member countries overall, their R&D work has concentrated on cutting-edge technology, that is in areas in which the average R&D intensity is more than 7.5 per cent. For some years there has also been a clear shift in favour of R&D in the services sectors. At the start of the 1990s, about 30 per cent of all R&D capacities in the OECD were deployed in the less research-intensive sectors, including the so-called high-level technology. This proportion has meanwhile fallen to about 25 per cent. Germany diverges considerably from this trend, with a fairly constant level of more than 50 per cent of R&D capacity devoted to high-level technology. Put simply, while other countries are directing R&D capacities increasingly into services and cutting-edge technology in order to benefit from the above-average growth in these sectors, Germany continues to concentrate on high-level technology.

The focus of the R&D is reflected in a corresponding concentration of German patent applications in the field of high-level technology. There are disproportionate numbers of patents in the fields of chemistry, automotive construction, mechanical engineering, and electrical engineering.[64] Figure 5 shows that when it comes to internationally-oriented patent applications in cutting-edge technologies (e.g. computers, electronics, information and communications technology, pharmaceuticals) Germany's position is unfavourable.

It is also possible to demonstrate corresponding patterns of foreign trade specialisation. High-level technology products are exported most frequently from Germany, whereas the German imports are more dominated by raw materials and cutting-edge technology. Cutting-edge technology is only involved in about a quarter of the total exports of 428.3 billion

Germany's patent specialisation in high technology, 1998-2005

FIG 05



RPA (Relative Patent Advantage): A positive sign indicates that the field has a higher significance within the country in question than for the average of all countries.
Source: Frietsch (2008).

BOX 12 The chemical industry in Germany and Great Britain from 1840 to 1910[63]

The development of the chemical industry in the second half of the 19th century shows how rapidly a country can lose its technological advantage, and the importance of close cooperation between commerce and science (in this case the newly established discipline of chemistry).

Until 1840, the British chemical industry dominated the production of inorganic chemicals. Current main products such as ethylene, benzene, and propylene were unknown. About 1850, the idea arose that artificial dyes could be used in the textile industry. The discovery of the first synthetic dye, Mauve, by Perkins in 1856 catapulted the chemical industry into a new phase, and organic chemistry became the most important branch of the industry.

Perkins made his discovery in the laboratory of August Wilhelm Hoffmann, a German chemist who like others had moved to England because of the better working conditions and established himself as a leading organic chemist. British companies dominated the production of artificial dyes until the 1870s. All comparative advantages appeared to lie at this time on the side of the British chemical industry. Great Britain was affluent, its industry had the necessary expertise, could draw on major reserves of coal tar, and had the larges customer base, because artificial dyes were used primarily in the textile industry.

Yet within a few decades this comparative advantage had been lost or was no longer effective. By 1890 the German industry dominated organic chemistry. In 1913, German companies produced 140 000 tonnes of artificial dyes, Switzerland 10 000 tonnes, and Great Britain only 4 400 tonnes. America had become one of the largest producers of inorganic and some organic chemicals, but was dependent on German suppliers, who provided the dyes. Within three decades Britain had lost its leading role to the German chemical industry.

Which factors were significant for this development? In 1865, Hoffmann returned to Berlin and established leading research laboratory for organic chemistry. Soon research laboratories were introduced in the companies in the chemical industry. Companies and science managed to organise an intensive and mutually beneficial exchange of information. German universities trained chemists, who then researched in commercial laboratories to develop new organic compounds and to identify applications. Great Britain missed this development. The British banks were conservative, the elite universities of Cambridge and Oxford were sceptical of the 'useful' natural science of chemistry. In addition, the German patent system since 1877 provided incentives for inventions, and in contrast to France and Great Britain, the barriers to market entry were comparatively low.

euros in 2005. A large volume of exports, 328.6 billion euros, involved high-level technology.[65] Germany's trade balance is approximately in equilibrium for cutting-edge technology. The export successes were therefore achieved exclusively with high-level technology products.

The statistics give a consistent picture: R&D, inventions and innovations in Germany are mainly coming from relatively mature industries and in the field of high-level technology. With the products of these industries, German companies generate considerable foreign trade surpluses. But Germany has a weak position in the cutting-edge technology.

Advantages and dangers of focussing on high-level technology

Germany's specialisation in high-level technology has proved its value over a long period and has had numerous positive consequences. The export of high-level technology products currently secures jobs in Germany and generates welfare. The rapidly growing newly industrialising countries represent good markets in the medium-term for German high-level technology products. The specialisation can also create important efficiency advantages, with opportunities to organise financing, vocational training, and other institutional factors to suit the dominant sector of the economy.

However, Germany cannot rely on being able to maintain this specialisation advantage over the longer term. In particular the classic German sectors of chemistry, the automotive industry and mechanical engineering will lose importance over time as domestic employers. The wages of German employees are only adaptable within limits, and parts of the production are already being transferred to low-wage countries. The R&D activities of German companies will then either follow the production locations or be relocated to countries where the engineering and research work is less expensive. In addition to this, other countries are also catching up in the technologies in which Germany has so far been in a leading position.

Therefore, Germany will in future be dependent to a greater extent on accessing new value-creation potential, above all drawing on results from basic research. Germany was very successful in this respect in the case of the chemical industry in the late 19th century (Box 12). New technologies and resultant new industries can develop quickly. Nations without the requisite flexibility to react rapidly run the risk of losing touch with the developments. Germany has experienced this a number of times in the second half of the 20th century. Numerous developments in the fields of semiconductors, computers, and biotechnology were only noticed in Germany after some considerable delay. Despite good successes in basic research, the German innovation system has not mastered the step to the commercialisation of important inventions in these fields. The specialisation of Germany on high-level technology has thus been preserved, new industries with a strong position on the world market have only been based Germany in exceptional cases. Economically, Germany is therefore dependent on mature sectors in which the competition from newly industrialising countries and other competitors is becoming increasingly fierce. In order to release itself from this dependency in part, a new orientation towards cutting-edge technology is necessary.

Improve conditions for new industries

How can Germany continue to use and expand its established strengths while at the same time making provisions for the future and offering a fertile soil for new approaches? This question is faced by all other countries in Europe. We see two main options: Firstly, the creation of good conditions for starting up new companies with a high growth potential. Secondly, the R&I-support of the German government should in general be directed more towards cutting-edge technology.

A particularly important role in radically new forms of value creation is played by young, science-based companies.[66] Europe only makes use of this source of growth to a very limited extent. The Sapir Commission Report (2003) gives the example that in the USA more than half of all new drugs come from companies which are less than 10 years old – but in Europe only 10 per cent of all new active substances are produced by young companies. 12 per cent of the largest US-companies are less than 20 years old – against only 4 per cent of the largest companies in the EU. Europe in general offers poor conditions for the growth of new companies. And in Germany in particular no start-up dynamic has developed for 'Schumpeter goods', as has been prevalent in the USA since the 1960s.

German start-up weakness

The German weakness when it comes to starting up new enterprises is particularly striking. In this field Germany performs poorly across the board. The regular surveys within the framework of the Global Entrepreneurship Monitor (GEM)[67] show that new enterprises in Germany are comparatively rare. The climate for founding new enterprises still tends to be inhospitable.

Above all when it comes to start-ups in R&D-intensive industries and in knowledge-intensive services ('Schumpeter goods') Germany shows only weak activity. Figure 06 shows the percentages of companies starting up and closing down in the research-intensive industry and in knowledge-intensive services. In both cases, Germany is in the lower left quadrant, indicating an underdeveloped entrepreneurial dynamic.

Long-term risks

New enterprises represent an experiment for an economy, testing the viability of technologies and business models. Inventions and scientific findings may seem very promising, but without trying things out by starting up a new enterprise it is often not possible to make any reliable assessment of possible future successes. If there are few new start-up companies, then the risk is that new knowledge and new technologies in Germany will not be adequately commercialised very often. Even if German research institutes and universities carry out successful research, the results will only generate value locally if it is also possible to transfer them to applications in Germany. Of course inventions can be licensed. For example, the licenses taken out by the team of the Nuremberg research Karlheinz Brandenburg relating to the MP3 standard have provided the Fraunhofer Gesellschaft with a very welcome flow of revenue. But the first devices using the standard were developed in Silicon Valley, not in Germany. And compared with the value creation in other countries the license fees are relatively small.

Causes for the poor start-up record

There are various reasons for the poor start-up record in Germany, and it is also influenced by the long-standing underdevelopment of an entrepreneurial culture. The situation regarding financing and taxation, and a wide range of bureaucratic obstacles to starting up new enterprises also contribute considerably to an unfavourable situation. The removal of constraints to innovation in the tax system, in particular relating to carrying forward losses and the approach to venture capital financing, could increase the incentives to start up new companies and would help to make the German innovation system more flexible and dynamic. Such incentives would also generate in influx of private capital and reduce the current dominance of state financing in the early phase of setting up new enterprises.

BOX 13

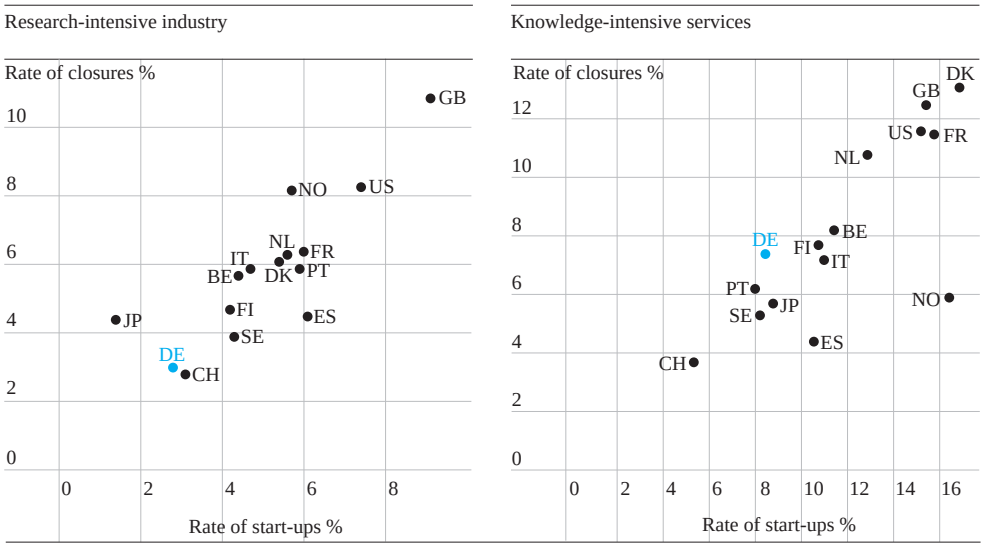
Results of the Global Entrepreneurship Monitor (GEM) 2006

The Global Entrepreneurship Monitor (GEM) is a long-term project supported by a consortium of international research institutes to monitor entrepreneurial activities, with standardised surveys of frequencies of start-ups, entrepreneurial motivation and other parameters in 42 countries.

The results of the survey in 2006 again show a very low entrepreneurial motivation in Germany. Only 2.9 per cent of 18- to 64-year-olds had tried to start up their own business, putting Germany in 34th position. Of the German new entrepreneurs a relatively high percentage felt obliged to choose self-employment, in contrast to the opportunity-orientation common in other countries such as the USA and Great Britain. The low involvement of women in entrepreneurship is also striking.

Out of 37 countries, Germany ranked 16th for entrepreneurial activity and 13th for new enterprises with medium or high technology intensity. Respondents criticised the following factors in Germany: poor support for self-employed by social values and standards (34th out of 37), poor link to entrepreneurship in school education / vocational training (31st / 35th out of 37), poor support for women starting up in business (36/37). The big strengths of Germany were the physical infrastructure, the protection of intellectual property, and state subsidies.

Start-ups and closures in selected countries[68] FIG 06



Not including banks and insurance companies. Data for 2004 or the nearest available year.
Source: Eurostat, US SBA, UK SBS, INSEE, Statistical Office of Japan, ZEW. Calculations by ZEW.

Making it easier to start up in business

In comparison with other European countries, German legislation does not make it easy for entrepreneurs to set up a new company. This is particularly the case when the founders want to limit their personal liability. The costs for setting up a 'GmbH' are comparatively high, and the process takes longer than in other countries.

When setting up knowledge-intensive companies in Germany, the 'GmbH' is often appropriate, but it faces competition in the European Union from other options.[69] The boom in new enterprises starting up in Germany as 'limited companies' has led the legislators to propose the reform of the GmbH-legislation. In particular the level of capital required to set up a 'GmbH' is to be lowered. At the same time, however, the liability regulations are to be made tighter. The proposal has led to a controversial discussion.

The German federal government should ensure that the reform of the GmbH Act is considerate of the needs of young entrepreneurs. It must be possible to set up a limited liability business quickly and without excessive costs. A goal should be to offer online business registration, which is already available in Great Britain and is planned in other European countries. European competition for new enterprises is now underway. The success of the government reforms will decide whether Germany is successful in the competition for innovative activities. Germany must develop from being the country of new ideas to the country of new enterprises, in order to be successful as a location for innovation in the long term.

Policy measures – First successes and the need for further action

Financing new enterprises must be made easier, and a long term improvement is needed in the conditions for then nurturing their growth. The German federal government has already taken steps in the right direction with numerous initiatives. The Hightech Start-up Fund is an important institution for the early phases of financing high-technology companies. It invests risk capital in young technology companies aiming to commercialise promising research results. Seed financing of 500 000 euros can be provided for the companies. The

High-Tech Start-up Fund has some 270 million euros available. Most of the funds come from private sources.

Independent research institutions and universities are also intensifying the transfer of technology. Since February 2002 inventors at universities are no longer 'free inventors' within the scope of the former Employee Inventors Act, and now the university has the right to decide about the exploitation of intellectual property. Technology transfer is a duty of the universities, and a challenge which many of them have been slow to respond to. Currently, technology transfer is often troublesome and is regarded by many researchers as unnecessarily bureaucratic. Businesses and scientific institutions have the responsibility to improve their cooperation and the transfer of knowledge from research to application.

Other developments also give grounds for optimism. German universities have set up some 70 chairs in the field of new enterprises and entrepreneurship. Students are no longer only trained for careers in large and medium-sized companies but are also prepared to start up their own company or work in a new enterprise.

The 'Exist' Programme of the Federal Ministry of Economics and Technology and the associated 'Exist' measures to provide seed funding, start-up grants, and research transfer help are intended to stimulate spin-offs from universities or research institutions. New enterprises are also supported by the GO Bio Programme of the BMBF. Research teams from the field of biotechnology wanting to start up in business in the next decade can draw on a total of 150 million euros of state aid. The working groups will be expected to develop new methods in the life sciences, develop potential applications and prepare the commercialisation. The explicit goal of this form of promotion is the establishment of biotechnology companies. It is not yet possible to make a final assessment of how successful these measures will prove, but the overall goal is right: increased support for young companies and improved commercialisation of research results.

However, these successes may be thwarted by the poor social esteem in which entrepreneurs are held, the disadvantages imposed on innovations in the tax system, and bureaucratic constraints. State aid and financing only have a limited range, and it is very important to create incentives for private investors in order to provide the new enterprises with more growth opportunities. Further efforts are also necessary to make Germany an attractive location for new enterprises.

Taking more risks, providing more aid for cutting-edge technology

Germany has so far been successful with its specialisation in incremental innovations. But this cannot go on indefinitely. Innovation policies are also an element of risk management

BOX 14 Technology transfer

Researchers and implementers do not have to work in the same organisation. Often research results originate outside the innovating companies, e. g. in universities or research institutions. Discoveries and technical information then has to be transferred, which in some cases necessarily involves the original researcher and inventor, for example in a new enterprise.

If knowledge and technical information are linked to individuals, then innovations can have specific local effects for value creation. There are macroeconomic benefits because value is created at the place where the knowledge is generated. This can lead to the formation of clusters and in the longer term to regional agglomerations in which knowledge, capital and specialist are all readily available.

BOX 15

Resistance to innovation

Not everybody has an interest in the success of an innovation. The process of creative destruction means that there will be losers as well as winners. Resistance to innovation can also be motivated by fears or cultural prejudices and may express itself at various levels – in the society, between competitors, or at the level of individuals.

Resistance is likely to be stronger the more radical an innovation is. For a radical innovation, a company will probably have to implement completely new technologies or forms of organisation at considerable cost.[70] In the case of completely new technologies and business strategies the innovators will initially have to convince financiers, customers, suppliers, employees and many others. In 1980 it was much more difficult than today to find financial support (venture capital) to start up biotechnology companies.

Incremental innovations, on the other hand, can often be introduced while preserving many parameters of the technology or organisation, so that there is less resistance – there are hardly any innovation losers. Incremental innovations often follow on from a radical innovation, because the diffusion of an innovation often leads to quality improvements, learning effects, and stepwise adaptations.

Resistance to the introduction of innovations is often encountered within a company.[71] Employees can lose their jobs if new machines are introduced (process innovation). Industrial robots in the 1980s became symbols of the fear of unemployment due to process innovation and rationalisation. These are known as the Liabilities of Newness.[72]

for Germany. New enterprises, particularly in cutting-edge technology, are an important way of testing and identifying new potential for value creation. The German federal government should take decisive steps to remove the constraints encountered by new enterprises, in particular regarding financing and taxes. A number of measures have already been adopted with regard to other problems, such as the high costs of setting up a business and inadequacies in entrepreneurial training in the university sector. Further progress must be made along this path. We already see positive signs for a new orientation.

The implementation of new knowledge and new ideas in commercially viable products is of vital importance if Germany is to remain internationally competitive. The German federal government should attach increasing importance to the conditions for radical innovations. Obstacles to such innovations should be removed to make it easier for the industries of the future to develop. Support should go primarily to cutting-edge technology, in order to open up long-term growth potential in Germany.