level, a strong national science system is required. The ultimate aim is to develop a national innovation strategy that defines targets that can be duly implemented and measured. Standards such as the three-percent target for R&D expenditures of EU countries, as discussed above, are of little use to countries that so far have fallen short of the specified target by more than half. For these countries, the three-percent target should be replaced by more realistic objectives.

Improved efficiency in administrative structures and simplified bureaucratic structures, e.g. with regard to planning and permission procedures, could help to successfully commercialise innovations. What is more, they are also a prerequisite for applying resources provided by the EU Structural Funds in a sustainable, efficient way. From the outset of allocating funds to structurally weak regions, it is vital to ensure that the resources allocated contribute to an increase in productivity. On the part of the EU, it is imperative to introduce a suitable monitoring system that will safeguard the designated utilisation of funds.

Finally, the institutional environment in these countries will have to be improved. Transparency International's corruption indicator suggests that for some of the Southern European countries corruption continues to be a massive problem.[19] Other indicators, which aim at assessing the overall institutional environment for companies, also testify to a poor track record for some of these regions.[20] Without the necessary legal certainty and institutional framework conditions, it will not be possible to attract foreign investors, and neither will it be possible to persuade domestic investors to invest in regional enterprises.

CONTINUALLY IMPROVING THE ATTRACTIVENESS OF GERMANY AS AN R&D LOCATION A 3

Over the last decade, the economies of all OECD countries have undergone a development towards a knowledge-based economy. As regards value added, export and employment, there is a continuous increase in the proportion of industries and service areas that are characterised by a high degree of knowledge intensity. This process is accompanied by a structural shift towards research-intensive goods, a growing proportion of highly qualified personnel, and an increasing relevance of patents and other forms of securing intellectual property.

The individual OECD countries pursue different strategies for growth and specialisation. The United States, Great Britain and Canada, as well as several Scandinavian countries, are focussing on cutting-edge technologies and on continuously developing their services sector. In some cases – in the US and Great Britain for example – this also implied that national governments knowingly accepted redundancies in the industrial sector. Other countries decided to maintain and modernise their traditional industrial structures. Germany in particular, but also Japan, thus embarked on modernisation strategies in their manufacturing industries. Since 1990, and even more so since 2000, Germany has been attaching great importance to high-value technologies, and this has lead to significant improvements in its competitive position. However, in cutting-edge technology fields with particularly strong international growth, Germany continues to display deficiencies.[21]

Challenges posed by new producer countries for cutting-edge technology

For R&D-intensive goods and cutting-edge technologies in particular, global competition has intensified considerably. Not only do the leading industrialised countries compete with each other – they are also increasingly exposed to competition from emerging economies that have for the last few years been pursuing offensive innovation strategies. Notably in the area of cutting-edge technology more and more Asian countries are positioning themselves on the market. In fact 35 percent of the worldwide value added in this highly competitive segment of manufacturing

can be attributed to Asian countries, and this trend is due to continue. China has managed to outperform Japan and is now, after the US, ranked second place in the leading list of cutting-edge technology goods producers. Other emerging countries from Asia are pushing themselves up in the global ranking: thus South Korea has surpassed countries such as France and Great Britain as a cutting-edge technology goods production location. Taiwan, Singapore, India and other aspiring economies are also pursuing ambitious development strategies that are directed at innovation and cutting-edge technology.[22]

In the international race for innovation, the European countries have been consistently falling behind. In 2007, European countries held a mere 25 percent share in worldwide value added in the market for cutting-edge technology. The US managed to maintain their share of 31 percent despite the fact that they, too, are subjected to major challenges brought about by Asian countries. Germany is currently caught in a difficult position between ambitious emerging countries and classical producers of cutting-edge technology such as the US and Japan. Germany's industrial innovation strategy, characterised by strong high-value technology and the skillful adaptation of cutting-edge technologies, has proved successful over the last few years. Considering the massive innovation efforts made by other countries as well as Germany's own structural deficiencies in critical cutting-edge technologies, it seems questionable whether this strategy will continue to be successful in the future.[23]

Globalisation of research and development

The worldwide relocation of production sites is accompanied by the globalisation of R&D. Multinational companies conduct their R&D activities in various locations around the world, often seeking the proximity of highly dynamic markets. For many host countries, R&D investments by foreign multinational corporations have a major impact on the domestic economy and innovation system. To safeguard a country's competitive edge, it is crucial to launch new R&D centres whilst also securing existing business locations of foreign enterprises. This is especially true for countries in which foreign R&D expenditures account for a particularly high proportion of national R&D expenditures. In Great Britain, the proportion of industrial R&D expenditures attributable to foreign enterprises has gone up from 30 percent in the 1990s to nearly 40 percent in the last decade. A similar trend can be observed in Canada (35 percent) and Sweden (36 percent).

In the United States, R&D expenditures of foreign enterprises have also increased continuously, with figures currently ranging between 14 and 15 percent.[24] Several European countries – primarily small, export-oriented economies – specifically target foreign multinational companies to invest in R&D. Among these countries are Ireland (72 percent), Belgium (59 percent) and Austria (53 percent). New EU member states such as Hungary (67 percent) and the Czech Republic (55 percent) are also gaining a profile as locations for R&D centres (see Chapter A2). A similar policy is pursued by China (see Chapter B5), as well as Brazil, India, Singapore and, more recently, Russia. All of these countries are successfully competing for foreign enterprises to establish new R&D centres in their respective countries.[25]

Foreign enterprises have also come to play an essential part within Germany's R&D system. The proportion of the national economy's total R&D expenditures that is attributable to foreign enterprises has gone up from a good 17 percent in the 1990s to currently more than 27 percent (see Table 1). This upturn was particularly significant between the years 1993 and 2001. Since 2001, foreign enterprises have increased their R&D expenditures in Germany by nearly the same growth rate as that of domestic businesses.[26] In terms of employment of highly skilled personnel[27] and collaboration with other companies and research organisations in Germany, R&D branches of foreign enterprises are becoming ever more important. In 2009, R&D employment and expenditures of foreign enterprises in Germany totalled EUR 12.3 billion. Here, the most important industries included other transport equipment (with a proportion of 85.9 percent of foreign enterprises), pharmaceutical industry (52.5 percent), as well as computers, electronics and optics (31.7 percent).[28]

In the course of the last few years, German companies have increasingly undertaken to relocate production sites to international locations. As a result, certain R&D activities have also been shifted.[29] This applies to development activities – especially in cases where a company produces for the host

R&D expenditures of foreign multinational enterprises in Germany

TAB 01

	Internal R&D expenditures			R&D personnel		
	in million euro	sectoral structure in percent	pro-portion in percent	number (FTE)	sectoral structure in percent	proportion
Industry (WZ 2008)						
Manufacturing	**10,685**	**87.1**	**27.6**	**73,546**	**86.6**	**26.8**
Chemical industry	440	3.6	13.8	3,800	4.5	17.6
Pharmaceutical industry	2,044	16.7	52.5	8,329	9.8	44.0
Computers, electrical engineering, optics	1,843	15.0	31.7	14,763	17.4	29.5
Electric equipment	382	3.1	28.7	3,484	4.1	26.6
Mechanical engineering	932	7.6	20.7	7,878	9.3	20.8
Automotive engineering	2,030	16.5	14.7	16,885	19.9	19.2
Other transport equipment	1,766	14.4	85.9	8,980	10.6	80.7
Information and communication	**534**	**4.4**	**20.9**	**4,986**	**5.9**	**22.7**
Scientific and technical services	**715**	**5.8**	**27.2**	**4,288**	**5.0**	**18.0**
Economy in total	**12,273**	**100.0**	**27.3**	**84,975**	**100.0**	**25.9**

Source: *SV Wissenschaftsstatistik*. Calculations of DIW Berlin (German Institute for Economic Research).
Cf. Belitz (2012).

Proportion of German companies' foreign R&D expenditures of overall R&D expenditures

TAB 02

Year	1995	2003	2005	2007	2009
	Foreign R&D expenditures in billion euro				
Industry (WZ 2008)					
Manufacturing	**4.9**	**10.2**	**11.3**	**8.8**	**10.7**
Chemical industry	2.5	1.6	1.2	1.6	0.7
Pharmaceutical industry	–	1.7	2.1	2.1	3.7
Mechanical engineering	–	0.6	0.7	0.8	0.5
Computers, electrical engineering, optics	–	2.5	2.3	1.2	1.8
Automotive engineering	–	3.5	4.8	3.0	3.6
Other industries	**–**	**0.7**	**0.2**	**0.6**	**0.6**
Economy in total	**5.1**	**10.9**	**11.4**	**9.4**	**11.3**
	Proportion of foreign R&D expenditures, in percent				
Manufacturing	**23.1**	**30.0**	**30.7**	**24.2**	**27.4**
Chemical industry	35.6	34.4	29.7	29.9	25.4
Pharmaceutical industry	–	50.1	51.8	69.2	54.0
Mechanical engineering	–	32.2	27.2	29.4	19.5
Computers, electrical engineering, optics	–	36.5	31.6	20.2	33.2
Automotive engineering	–	21.3	26.5	15.6	18.3
Other industries	**–**	**30.8**	**10.1**	**27.3**	**25.7**
Economy in total	**23.1**	**30.0**	**29.9**	**24.4**	**27.3**

Source: *SV Wissenschaftsstatistik*. Estimates of DIW Berlin (German Institute for Economic Research).
Cf. Belitz (2012: Table 2–3).

country's local market and has to adapt its products to local demands. But it also applies to a company's actual research activities; provided that the relocation leads to cost savings and that access to local know-how and research organisations is available. Between 1995 and 2005, R&D expenditures of German companies abroad steadily increased from EUR 5.1 billion to EUR 11.4 billion. Within this period, the proportion of foreign R&D expenditures of the overall R&D expenditures of German companies rose from 23 percent to 30 percent. Table 2 illustrates that German companies only briefly decreased their R&D activities abroad[30]; this was the case between 2005 and 2007, following a phase of strong internationalisation. Since 2008, German R&D activities abroad have been re-intensified considerably. By 2009, R&D expenditures of German companies abroad had gone up to EUR 11.3 billion, which equals 27 percent of total R&D expenditures.[31] German businesses primarily conduct their R&D activities in the United States and in Germany's neighbouring countries. More and more, the new Asian research locations and the new EU member states also serve as R&D locations for German companies.[32]

Political framework conditions increasingly important for securing locations

Multinational enterprises choose their business locations based on economic criteria such as access to attractive markets and technologies and the availability of skilled personnel and researchers. Germany, being a highly developed research location and Europe's largest market, is well positioned in this regard and has an overall positive R&D track record. Since 2007, foreign enterprises have invested approximately EUR 4 billion more in R&D in Germany each year than German companies have invested abroad.[33] Yet, today's companies' location decisions are more and more influenced by innovation-related political conditions in the target country. Here, strategic measures to attract industrial settlement and promote R&D, as well as tax regulations and patent policies are becoming increasingly relevant. In this respect, Germany fares relatively poorly in international comparison, which is largely given to the fact that Germany does not offer tax credits for R&D – a measure that has been increased in many other countries.[34] In their previous reports, the Expert Commission has repeatedly stressed the importance of R&D tax credits. So far, the Federal Government has not implemented this measure – despite their declaration in the 2009 coalition agreement.

A further factor that influences multinational companies' location decisions are national regulations for patent protection and the tax treatment of income from licensing. In terms of establishing R&D centres and allocating patents to locations, tax arbitrage considerations are also important: patent portfolios and related research are preferably concentrated in regions that offer particularly favourable taxation on licensing revenue. In this regard, Germany is behind in the game, which is resulting in an increasing distortion of competition.

In view of this, the Expert Commission expresses its concern that a race for the most favourable taxation conditions for licensing revenue in Europe is currently in full swing. In 2007, the Netherlands and Belgium were the first to introduce "patent box regulations", followed in 2008 by Luxembourg and Spain. For 2013, Great Britain, too, is planning to introduce this measure.[35] Patent box regulations permit companies in certain circumstances to apply a reduced tax rate of up to 10 percent on their licensing revenue. Governments that promote such regulations are hoping to improve both the attractiveness of the location for foreign enterprises and the framework conditions for research and development. The latter remains dubious however, as it is not the R&D activities as such but only the exploitation of patents that is being rewarded through tax regulations. Instead, there are grounds for suspecting that measures like these will lead only to the tax-induced shifting of patent portfolios – at the expense of other countries that do not offer comparable tax benefits. As the Expert Commission already pointed out in their Annual Report 2011, this causes serious threats for Germany as an R&D location. In the meantime, the subsidy race is further accelerating in several European countries.

The impact of R&D internationalisation on Germany as a location

In order to assess the impact of R&D internationalisation on Germany as a location, it is necessary to find out whether German companies' R&D activities

abroad actually supersede domestic R&D – or whether R&D abroad in fact complements domestic R&D. Although at this stage a definite answer to this question cannot be provided, recent scientific studies suggest that they largely complement each other.[36]

Surveys on company acquisitions by foreign enterprises also suggest that such acquisitions do not necessarily lead to a shifting of R&D activities to the home country of the new parent company. In Sweden for instance it has been observed that, following the acquisition of Swedish companies by foreign enterprises, Swedish R&D activities indeed remained in the country. Similarly, a survey on company acquisitions in Spain shows that a relocation of R&D into the home country of the acquiring company is likely to happen only if the purchasing party comes from a country with a much higher degree of technological development, such as the United States.[37]

Even if R&D activities of German companies abroad at least partially replace their domestic R&D activities, questions concerning the macroeconomic impact of this development remain. It would be worrying to find that such shiftings are profitable for the companies involved but unfavourable for the whole economy because positive R&D repercussions (externalities) in the home country have been disregarded. Smaller companies in particular might have to bear the negative effects of this if they cease to benefit from new business and impulses attributable to those larger companies. In fact, a company's geographical proximity to the R&D activities of other enterprises plays a key role in creating such positive spillover effects.[38] But of course it is also true that German companies conducting R&D abroad do also benefit from spillover effects from local companies; Silicon Valley may serve as a prime example for this.[39] Numerous German companies, among them Bayer AG, Robert Bosch GmbH, Daimler AG and Siemens AG, are conducting R&D activities in close proximity to Stanford and Berkeley, thereby receiving vital stimulus for innovation projects within the global parent corporation.

While the positive externalities of business ventures abroad are clearly factored in by companies, their corporate perspective does not allow for considering the macroeconomic consequences. Companies have to follow a business rationale, and this perspective makes them neglect the negative social and economic consequences that such relocation may have on Germany as a location. This can however lead to imbalances on the labour market for highly qualified personnel. For instance, in the context of the migration of the microelectronics industry, graduates from the respective fields were unable to find suitable employment options in Germany. What is more, Germany's domestic research organisations have had to go without the application-related stimulus and co-operation opportunities that would otherwise be available. Thus it has been the case that specialised public research organisations were lacking collaboration partners at home – and more often than not, this resulted in research organisations increasingly seeking fields of activity abroad.

Foreign and domestic skills as mutually enhancing factors

Industrial R&D clusters that are effectively integrated into the economic, research and educational sectors can only be secured in the long term if unique skills are available on a national level. In fact a worldwide thematic clustering as described above is an unavoidable and necessary development. In the international competition for R&D activities, Germany has a location advantage in the automotive, mechanical engineering and chemical industries – a competitive edge that needs to be maintained. In other sectors, such as the information and communication industry, the pharmaceutical industry and biotechnology, Germany will be able to succeed if German companies also conduct their R&D in international locations. This would enable them to reap the benefits of spillover effects from local companies in the target country. Examples include the Silicon Valley for network technologies and the east coast of the United States for pharmaceutical and biotech clusters. Yet, for such a strategy to lead to the desired results it must be actively reinforced by a reverse technology transfer from German ventures abroad to competence centres in Germany. It is the responsibility of businesses to implement suitable organisational models of international collaboration.[40] Policy-makers can pave the way by developing new structures for international collaboration between students and scientists and by offering binational platforms for innovation.[41]

To complement these efforts, Germany will have to ensure that it remains attractive, and further improves its attractiveness, as an R&D location for foreign enterprises. Germany can position itself by providing a highly-developed R&D environment, e.g. by means of collaborations with German research organisations. How to excel in this regard has been demonstrated in Switzerland. Here, examples include the long-standing collaboration between the IBM research centre and the ETH Zurich, and the development of joint research centres by universities and foreign enterprises such as the SAP research centre in St Gallen. Intensive institutional collaboration between German research organisations and higher education institutions on the one hand, and foreign enterprises on the other hand, should be systematically targeted and fostered. This would lead to the launch of new domestic research centres and, as a result, to increased value added and employment in Germany.

As regards German research organisations that are publicly funded, intensified commitments abroad will only lead to the desired results if they succeed in benefitting both parties, i.e. Germany and the target country. Over the last decade, numerous initiatives have been launched. Here, it is essential to critically assess if the knowledge flows resulting from this are bidirectional and mutually enhance each other. This aspect will be further dealt with in Chapter B5, on the example of China.

A 4 THE ENERGY TRANSITION AS AN INNOVATION OPPORTUNITY

The disasters at several nuclear power reactors in Fukushima in the spring of 2011 triggered a broad, intensive social and political debate about the future of energy supply in Germany. This was followed by a legislative package that was adopted by the German parliament on 30 June 2011. Among other things, it provides for a step-by-step decommissioning of all German nuclear power reactors by the year 2022.[42] To complement this nuclear phase-out, it is also planned to significantly reduce the use of fossil fuels as a means of climate protection. This "Energy Transition" *(Energiewende)* shall be facilitated not only by a considerable improvement in the production, transport and application of energy that is technically usable, but also by a significant increase in the use of renewable energy sources generated from e.g. the sun, wind, biomass, and geothermal sources. In implementing this energy shift, Germany aims to phase out nuclear energy, while at the same time achieving their self-defined objectives in terms of climate protection.[43]

The Expert Commission would like to comment on three dimensions of the Energy Transition: (1) responses from the German innovation system in the field of non-university research institutions,[44] (2) changes in the Federal Government's research and energy policy, and (3) the relevance of the Energy Transition for innovations in Germany as an industrial location. The Expert Commission is aware of the fact that substantial strategic adjustments in the area of research and innovation require a sufficiently long preliminary phase. Hence, the current status should be considered as no more than a provisional snapshot.

The Fraunhofer-Gesellschaft (FhG) has dealt with nuclear energy and fossil energy conversion only to a limited extent in the past.[45] Their focal points in the field of energy have been, and still are, renewable energy (solar, wind, biomass), energy efficiency technologies, energy-efficient buildings and building components, intelligent electricity networks, as well as energy storage and electromobility. The Fraunhofer-Gesellschaft also comprises an Energy Alliance, a co-operation in which 15 out of the 60 existing Fraunhofer institutes participate.[46] The Fraunhofer-Gesellschaft does not see the necessity to make major adjustments to their R&D focal areas as a result of the Federal Government's energy shift. The reason for this is that the FhG portfolio planning is already directed at further expanding and complementing its strengths in the key fields mentioned above.

The Helmholtz Association (HGF) focuses its activities on renewable energy, efficient energy conversion, nuclear fusion, as well as the "technology, innovation, society". As a response to the new energy legislation, several new strategic "Helmholtz Energy Activities" *(Helmholtz Energieaktivitäten)* have been launched within the HGF,[47] and some of these promise to take effect in the near future. For the 2015-2019 funding period, HGF is also planning to further advance its efforts in the area of renewable