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**Article**

## Innovation Indicator 2009: Germany Has Still Some Catching up to Do

Weekly Report

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# Weekly Report

## Innovation Indicator 2009: Germany has still some catching up to do

*On behalf of the Deutsche Telekom Stiftung (Deutsche Telekom Foundation) and the Bundesverband der Deutschen Industrien (Federation of German Industries) DIW Berlin has investigated Germany's innovative capacity for the fifth time in an international comparison. The survey evaluates the ability of countries to create and transform knowledge into marketable products and services (i.e., innovations) using a system of indicators that provides an overall composite indicator of innovative capacity as well as a detailed profile of strengths and weaknesses.*

*Of the seventeen leading industrial nations investigated under the survey Germany only ranked 9th thus remaining in the broad middle range. Relative to its most important competitors Germany loses ground. The US, followed by Switzerland, Sweden, Finland, and Denmark, headed up the list. Germany is particularly successful in its ability to network key participants in the innovation process as well as in international markets of high-technology sectors like mechanical engineering, chemical industry, vehicle manufacturing and medical instruments. Deficiencies in Germany's education and in the financing conditions for innovation and the founding of new companies, plus the regulation of product markets remain the country's greatest innovation system weaknesses.*

A country's innovative capacity—that is, the ability of people and companies to create and transform new knowledge into new, marketable products, services and more efficient processes—can not be measured directly. Therefore this survey uses more than 150 individual measures of innovative capacity to calculate an overall indicator for Germany and sixteen other highly developed competitor nations (Belgium, Denmark, Finland, France, Great Britain, Ireland, Italy, Japan, Canada, South Korea, Netherlands, Austria, Sweden, Switzerland, Spain, and the US) in a series of aggregation steps (see figure 1).<sup>1</sup>

In order to be innovative, a country requires first and foremost a well-functioning national innovation system, in addition to a favourable social climate for innovation. The term national innovation system refers to the enterprises, institutions, and

<sup>1</sup> cf. v. Hirschhausen, Belitz, H., Clemens, M., Cullmann, A., Schmidt-Ehmcke, J., Zloczynski, P.: Innovationsindikator Deutschland. Bericht 2009. A study conducted by the German Institute for Economic Research, commissioned by the Deutsche Telekom Foundation and the Federation of German Industries. DIW Berlin, Politikberatung kompakt No. 51, Berlin 2009; as well as the Deutsche Telekom Foundation and the Federation of German Industries: Innovationsindikator Deutschland 2009. Bonn, Berlin 2009; [www.innovationsindikator.de](http://www.innovationsindikator.de).

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## Method

### Data Sources for the Individual Indicators

The important sources of data for the individual indicators which were used to assess the performance of each country's national innovation system and social environment for innovation were:

- National and international data on research and development, education, trade, production, and employment maintained by the OECD and Eurostat, as well as indicators calculated by the German Institute for Economic Research (DIW Berlin);
- Composite indicators from other authors that assess complex factors influencing national innovative capacity with a similar, multi-step approach, such as the product market regulation indicator (published by the OECD) and the information and communication infrastructure indicator (published by the WEF, in cooperation with INSEAD);
- Comparative international surveys of actors in the innovation process, such as companies (Executive Opinion Survey of World Economic Forum) and people (Eurobarometer, World Values Survey).

### Standardization

In order to standardize and compare the individual indicators, all data were initially applied to a uniform scale – both “hard” facts as well as “soft” opinion survey results. This was achieved through the following transformation<sup>1</sup>:

$$Y_{1bis7} = 6 \times \frac{(Y - Y_{min})}{(Y_{max} - Y_{min})} + 1$$

The formula essentially yields the deviation between Y, the original value for a country, and the country ranked at the top (Y<sub>max</sub>) and bottom (Y<sub>min</sub>). This deviation is then applied to a scale from 1 to 7.<sup>2</sup>

The Y variables have been selected such that – based on theoretical and empirical research results – it can be presumed that a higher value is “better” than a lower one (i.e., that innovative capacity rises in tandem with Y.)

**1** The proposed transformation not only convey the individual indicators (and the derived intermediate results) to a uniform scale but also preserves the relative distances, which are shown by the compared countries on the original scale.

**2** The classification of the scale from 1 to 7 is used since a lot of the individual indicators from the worldwide manager survey of the World Economic Forum are measured in the “raw state” on this scale.

### Weighing and Integrating the Indicators with the Primary Statistical Components

The assembled indicators are calculated as the weighted sum of the components at every stage. The relative weight of each indicator is established “empirically” (i.e., from the data) on the early construction stages of the indicators using principal components analysis. With the first principal component<sup>3</sup>, this method calculates precisely the weighted sum of the individual indicators exhibited by the largest variation between the surveyed countries. The first principal component determines the weight of the individual indicators such that precisely those indicators are “awarded” a relatively high weight that exhibit a large variation between countries and which correspond well with the general direction of variation witnessed with the other indicators. The following rationale informs this approach: One should look for differences in innovative capacity when evaluating a set of advanced countries in areas where the indicators vary to the greatest extent between those countries.<sup>4</sup>

The weighting in the second to last step, in which the seven sub-indicators of “systemic strength” are drawn together, is based on the judgment of experts from the industrial and service sectors who participated in a written survey conducted by the German Institute for Economic Research in 2005 and 2006.<sup>5</sup>

The systemic indicator is weighted 7/8 when integrated with the social-climate indicator to produce the overall innovation ranking. The strong weighting on the systemic side reflects the large importance that a national innovation system has for the innovative capacity of a country. This indicator is based on the wide range of available research results on innovation systems. By contrast, at this point in time relatively little is known about the social climate for innovation – that is, the values and opinions of people and how these factors influence innovative capacity.

**3** This computed values of the first principle components will be applied again to a scale from 1 to 7, in order to do further calculations.

**4** In some cases were the weighting computed by the variances (positive) of the components due to the negative weighting resulting from the principal components analysis.

**5** Cf. v. Hirschhausen, C. et al.

surrounding conditions that influence the process by which innovations arise. The system ensures that highly qualified individuals (education), new knowledge (R&D), and sufficient capital (financing) come together in the process of innovation and that key

players in innovation—particularly companies—are responsive to impulses from partners (networking), other competitors (competition) and national and international customers (demand) and implement new products, services, and organizational solu-

tions (implementation). Each of these seven areas is underpinned by a number of separate indicators, which, taken together, provide a measure of the strength of a national innovation system. The “systemic strength” that is calculated in this fashion has a weight of 7/8 in the overall innovation indicator 2009.

The social climate for innovation found within a country is the remaining factor in the overall assessment. For clearly, there are hidden risks in the effort to develop new technologies and products. In order to be innovative, a society must have the courage to change, trust in the actors who bring about innovation, and hold a fundamentally positive—but not necessarily uncritical—view of science and technology. For this reason, we have evaluated public opinion surveys on the process of change, social capital, trust, and science and technology to arrive at an assessment of a country’s social climate for innovation. This “climate indicator” has a weight of 1/8 in the overall assessment.

By drawing a distinction between seven components of a country’s national “innovation system” and its “social climate for innovation”, an “innovation balance sheet” can be derived, highlighting Germany’s strengths and weaknesses relative to other countries (see box).

### Germany’s middle range position

In the overall ranking of the seventeen countries in the 2009 innovation indicator, Germany with an almost unaltered score occupied 9th place and is still in the middle range of the surveyed group, the US was ranked first (see figure 2). Next to the US Switzerland, Sweden, Finland, and Denmark headed up the list, all of which have a clear advantage to the rest of the competitors.

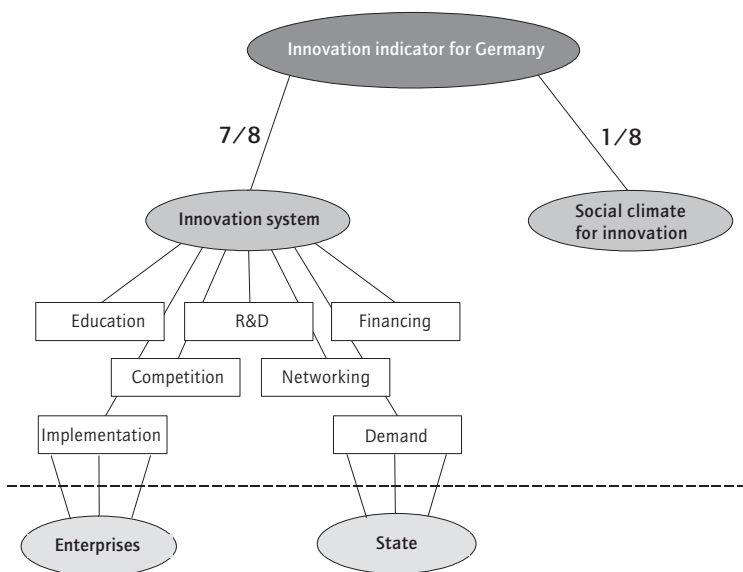
The leading group is trailed by a broad middle range, extending from 6th (Canada) to 15th place (Ireland). Spain and Italy landed at the bottom of the list, as they did in previous years, and were unable to gain ground on the broad middle range of countries.

### No change in the gap to the top

For Germany, changes in individual indicator values—monitored between 2007 and 2009—have only caused a slight shift in the country’s innovation score. At the same time, competitors such as Canada or the Netherlands have made greater progress and thus relegated Germany to a lower rank.

Figure 1

### Composition of the innovation indicator for Germany, 2009



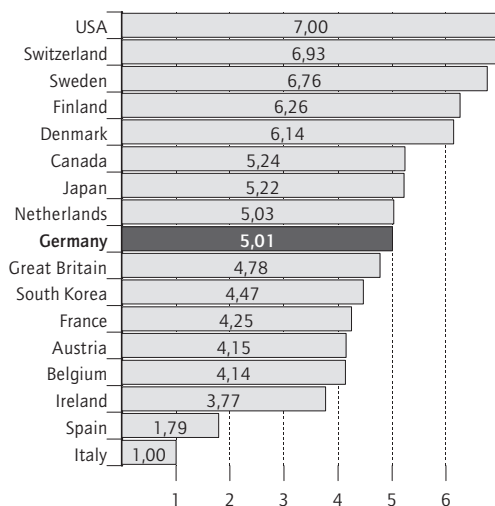
Source: Illustration from DIW Berlin.

DIW Berlin 2010

Figure 2

### Scores and overall ranking 2009

From Rank 1 =7 up to Rank 17 = 1



Source: Calculations by DIW Berlin.

DIW Berlin 2010

While most countries registered a drop in their point score, the United States, Switzerland, Canada, Austria, South Korea and Spain managed to improve their score in relative terms, giving rise to several changes in the ranking table. In 2009, Sweden lost its pole position to the US and was also outperformed by Switzerland. However, the

overall scores of these top three countries remain relatively close together—their nearest competitors, Denmark and Finland, follow after a small gap. In the midrange, Canada, Japan, the Netherlands, Germany and the United Kingdom lead the field, followed by South Korea and then France, Austria, Belgium and Ireland. Towards the bottom of the table, Spain shows marked improvement and gears up to approach the midfield while Italy remains far behind and continues to bring up the rear. Overall, Germany has not managed to gain ground on the respective year’s top-ranked country (Sweden in 2007 and 2008, the US in 2009) to improve its position on an international level (see table).

### Germany's strength and its distinct weaknesses

Germany’s innovation profile is the product of seven system components and the innovation climate. This profile reveals a number of significant strengths and weaknesses (see figure 3).

Germany has strong advantages in the category of networking (3rd place) and innovation-friendly market demand (4th place). Germany also fared well in the overall ranking in the category of market implementation of innovations (5th place) and the research system (8th place). These “systemic strengths” are undergirded by particularly good scores in two areas: the market success of research-intensive industries, and networking of companies and research facilities.

Yet marked weaknesses were also in evidence, despite these strengths. For the first time the educational system (12th place) is not rated as poorest indicator, but rather the innovation financing (15th place). Germany has relative weakness in the areas of “competition and regulation” (13th place). In international comparison, Germany ranked 11th in the overall assessment of its social climate for innovation. Above all is the unfavourable climate for the employment of women and the weak trust in research conducting companies and scientists, which are the factors for the negative result. However, these societal hurdles to innovation stand in contrast to positive aspects, including the relatively outward-looking and tolerant attitudes of Germany’s citizens as well as their optimistic assessment of the benefits and usefulness of science and technology.

### Funding shortages for innovations

Innovation financing remains a grave weakness of the German innovation system. Ranked 15th among

**Table**  
**Innovation indicator scores and rankings in 2007, 2008 and 2009**

Land	2007		2008		2009	
	Rank	Scores	Rank	Scores	Rank	Scores
US	2	6,98	2	6,70	1	7
Switzerland	3	6,81	3	6,55	2	6,93
Sweden	1	7	1	7	3	6,76
Finland	4	6,50	4	6,31	4	6,26
Denmark	5	6,02	5	5,99	5	6,14
Canada	9	5,03	9	4,94	6	5,23
Japan	7	5,49	6	5,32	7	5,22
Netherlands	8	5,16	11	4,89	8	5,03
Germany	10	5,03	8	4,95	9	5,01
Great Britain	6	5,64	7	5,06	10	4,78
South Korea	15	3,74	10	4,91	11	4,47
France	11	4,51	13	4,30	12	4,25
Belgium	12	4,44	12	4,32	14	4,15
Austria	14	3,90	14	4,18	14	4,14
Ireland	13	4,40	15	4,09	15	3,77
Spain	16	1,31	16	1,46	16	1,79
Italy	17	1	17	1	17	1

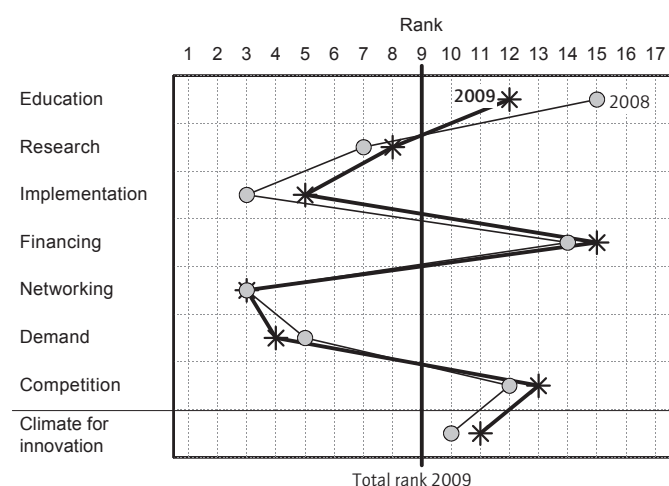
Source: calculations by DIW Berlin.

DIW Berlin 2010

international competitors, this is the country’s worst result since the first evaluation in 2005. Only Japan and Italy offer worse terms of financing for innovative companies. In view of these results, the following fact gains extra significance: the internationally available data used to compute this sub indicator was not yet affected by the financial crisis. Even before the economic downturn, the German innovation system was already hampered by insufficient innovation financing. When seeking a loan or venture capital, both established companies and new entre-

Figure 3

### Germany's ranking for individual indicators



Source: calculations by DIW Berlin.

DIW Berlin 2010

preneurs run into more obstacles here than in other countries. In the evaluation of the domestic money market, Germany moved down four places and now finds itself at rank 15 of the table. Compared to the previous year, access to venture capital has also taken a turn for the worse. In this sub indicator, Germany drops from the 10th to the 13th rank. Furthermore, the company's own assessment of access to loans (a drop from rank 9 to rank 13) and their evaluation of the banking system (from rank 10 to rank 13) have also deteriorated. This overall trend suggests soaring external funding shortages with an especially detrimental effect on the innovation activities of small to medium-sized companies and high-tech start-ups.

### Germany needs to get further detention

Even though ranked 2 scores better than in the previous year one of Germany's greatest weakness lies in the area of education. In the point value no large advancement was made by Germany. The educational system is not well funded compared internationally (12th place). It ranks below-average in quality measures (13th place) such as international university rankings and other quality comparisons e.g. the PISA study. Germany produces relatively few graduates with tertiary degrees (11th place), and also fares poorly in the area of further training (13th place).

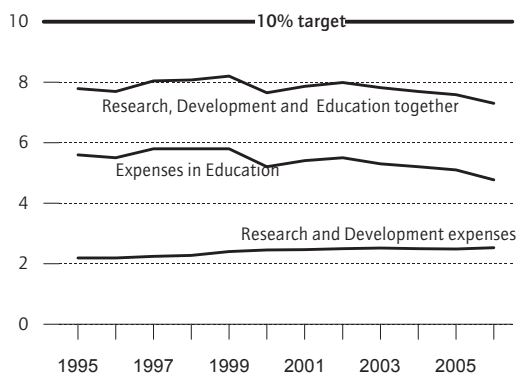
In highly developed economies, investment in research, development and education is considered the crucial basis for lasting wealth. Despite the stated aim of "10 percent by 2015"—a target drafted by the Federal Government and supported by the German Federal States—the country is still miles away from reaching this goal. According to these government targets, investments in research and development should rise to three percent of Germany's gross domestic product and expenditure on education to seven percent of GDP (see figure 4). Contrary to these goals, in 2006 Germany only invested 4.8 percent of its GDP in education and thus remains below the OECD average of 5.5 percent.<sup>2</sup> Measured against the country's GDP, Germany's education budget even decreased, compared to the previous year. In 2007, R&D expenditure (at 2.5 percent of GDP) also remained below the set target. On an international scale, Germany's spending on education and research (7.3 percent) clearly undercuts that of the U. S. (9.7 percent), Sweden (10.2 percent) or Finland (9.5 percent) (see figure 5). In 2006, the country's "funding gap" to its own 10 per

<sup>2</sup> International levels of public and private expenditure on education. See also OECD: Education at a Glance. Paris 2009.

Figure 4

### Germany's expenses in research and development and education

in percentage of the gross national product



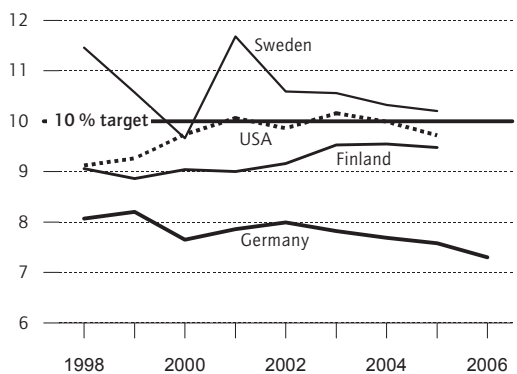
Source: calculations by DIW Berlin.

DIW Berlin 2010

Figure 5

### Germany's expenses in research and development in an international comparison

in percentage of the gross national product



Source: calculations by DIW Berlin.

DIW Berlin 2010

cent goal amounted to approximately eleven billion euros for R&D and at least twenty billion euros for education.<sup>3</sup>

### Women favour more and more natural sciences and engineering

Today more than 50% of university graduates in Germany and other competing countries are women. Yet the percentage of women active in those academic fields that are important for innovative ability,

<sup>3</sup> This calculation is based on education spending after further national differentiation. According to these figures, spending on education amounted to 6.1 per cent of the country's GDP in 2006.

namely engineering, mathematics and the natural sciences (the MINT fields; see figure 7) in terms of graduation is significantly low.

The number of university graduates in engineering, mathematics and the natural sciences grew by 6,700 to 24,600 between 2005 and 2006. Considering the quota of female graduates in these disciplines, Germany gained some ground and moved up the table by six positions. The country now ranks among the leading industrial nations at rank 7 (see figure 6). According to the most recent figures, this trend continued in 2007 with up to 27800 female students graduating in these disciplines at the time of the survey.

Current surveys on first jobs after graduation and employment of women in engineering and science, however, present a slightly different picture. They reveal a lower labour force participation rate over the first five years. By the end of this period, it is ten percent lower than that of their male peers. One of the main reasons for this trend is that almost invariably women will forgo their career for childcare and family duties. Further studies also reveal a bias towards disparate pay levels for male and female graduates of MINT disciplines as well as different chances of reaching high-level positions.<sup>4</sup>

### Conclusions for innovation politics

Among the seventeen leading industrial nations, Germany only ranks 9th in the 2009 innovation indicator. Compared to the previous year, the Federal Republic not only moved down one place in the ranking, but also registered a widening gap to the world's most innovative nations - countries like the United States, Switzerland or Sweden. In view of global competitive pressure, the German economy needs to step up its innovatory efforts. To this end, it requires a better framework. It is up to the Federal Government and the German Federal States to throw a stronger political focus on the country's capacity for innovation.

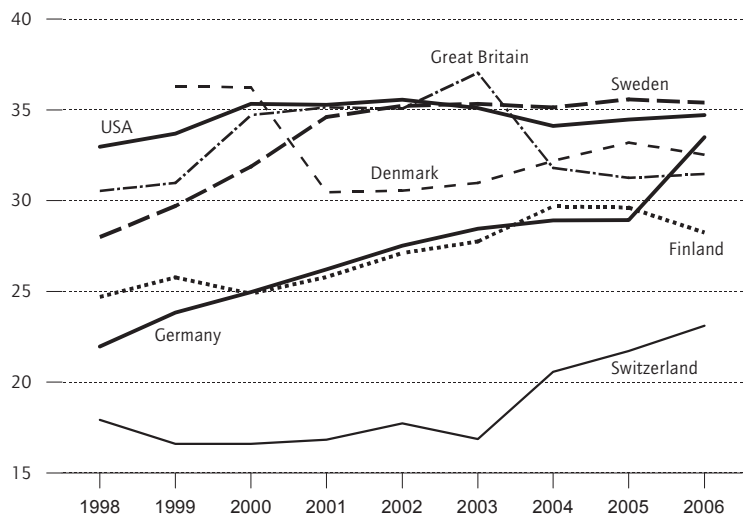
### Support for start-ups and top technologies

According to the innovation indicator, Germany is the global leader in the development and marketing of high technology. With their comprehensive and innovative product portfolio, German manufacturers found themselves in a strong position when the global economic crisis hit. If they manage to keep up

<sup>4</sup> See also: Berufseinmündung und Erwerbstätigkeit in den Ingenieurs- und Naturwissenschaften. Projektbericht des HIS, May 2009.

Figure 6

### Percentage of female science and technology graduates at universities and other institutes of higher education



Source: OECD; calculations by DIW Berlin.

DIW Berlin 2010

their R&D efforts during the current dry spell, they will be optimally positioned for a future boom. On the other hand, Germany demonstrates weaknesses in advanced technology. International comparisons also highlight the country's low number of start-ups and new enterprises specialising in innovative products and services. Policymakers should provide stronger support for high-tech start-ups and the development of advanced technologies. As part of its high-tech strategy, the Federal Government should focus its efforts and funding on areas of advanced technology where the resulting research would also benefit other industries.

### Increase future investments

Many industrial nations consider investing a tenth of their economic performance in research and education - a benchmark of modern innovation politics. Germany still has a long way to go before it approaches this target: in 2006, all private and public spending on education and research only amounted to 7.3 percent of the country's GDP—split into 4.8 percent on education and 2.5 percent on research. For Germany to compete on an international scale, these spending quotas will need to go up significantly.

### Research efficiency: investments pay off

According to calculations by the DIW, the first of their kind for the innovation indicator, scientists in Germany are highly efficient. No other country,

besides Sweden, has generated more economically viable new developments from a given R&D budget. Due to this exceptional efficiency, additional investments would not simply disappear in the system, but serve to improve the country's capacity for innovation.

### **Education: more funding, better quality**

The education system remains one of Germany's most glaring weak points. The system not only lacks funding, but also produces only average learning results compared with the other surveyed nations. This is due to a number of flawed organisational and incentive systems. Any increase in the education budget needs to be accompanied by reforms of the overall educational framework. This is a matter of Federal State politics. Their harmonising efforts must not stop at nationwide specifications for teacher training and educational standards. In addition, the cooperation ban should be lifted to allow the Federal Government and States to resume their collaboration for the good of the country's national education.

### **Shortage of skilled labour: consistent implementation of the Bologna reform**

Germany does not produce enough young academics. Only 22 percent of the country's 25-to-39-year-olds hold a tertiary degree. This places Germany at rank 15 among the 17 leading industrial nations. As a result, the country faces a significant shortage of skilled labour. Here, the introduction of bachelor courses could serve as a stepping-stone for attracting more students to higher education. Despite the bachelor programme's inherent weaknesses, its shorter duration and a more hands-on approach have helped to make studying more attractive. Nevertheless, dropout rates have yet to decrease. Concerted efforts should be made to further refine the Bologna reform—it will be up to policy makers to ensure that all stakeholders harmonise their efforts and coordinate the reform process in order to create high-quality degree courses that preserve the current advantages of the academic programme.

### **Female academics: facilitating occupation**

Over the next two decades, companies will be looking to hire more graduates—most of all in the disciplines of mathematics, information technology, natural sciences and technology (MINT). In view of these developments, it is good to know that these fields of study enjoy increasing popularity among female students. However, surveys also reveal that a relatively large number of female academics resign from fulltime employment only a few years after graduation. A major reason for this development: In Germany, it can be hard to juggle job and family, as surveys among female engineers confirm. The country should expand the availability of day-care facilities and full-time options at kindergartens and schools to facilitate the balancing act between work and child rearing—especially for female academics.

### **Broaden the framework for funding opportunities**

Besides the above-mentioned educational deficits, the relatively difficult access to loans or venture capital remains the German innovation system's biggest weakness. In terms of "financing," one of the study's individual indicators, Germany is third to last in the ranking table. While continuing its current funding regime, the German government should strive to improve the fiscal framework for venture capital funding and consider the introduction of a general encouragement measure for corporate research and development, e. g. via related tax credits.

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