The Research-Based Pharmaceutical Industry as a Chance for the Business Location Germany

A study on behalf of
PhRMA (Pharmaceutical Research and Manufacturers of America),
representative of leading pharmaceutical research and biotechnology companies in the United States,
and the German LAWG (Local American Working Group)

We express our thanks to all participating companies:

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Preface

In today's political discussions, the pharmaceutical industry usually comes up mostly in relation to cost increases in the public health system. Such discussions generally overlook the industry's positive contributions to innovation and employment in Germany. These contributions are all the more important in the context of Germany's employment problems, which prompted Federal President Dr. Horst Köhler to exclaim, "Work has priority!"

The pharmaceutical industry offers industrialized countries huge job growth potential. Recent years show a clear shift in investment flows, with Germany losing out in decisions about locating research centers and production plants. By contrast, other countries have established themselves as favored locations, getting a jump-start over Germany in some areas of the value chain.

In short, Germany is losing the pharmaceutical industry's urgently-needed innovation power and its related employment potential. This lack of exchange with an innovative industry could also negatively impact our universities, public research organizations, and biotech companies. Thus the trend must be vigorously counteracted.

Thus, this study seeks to identify the pharmaceutical industry's potential contributions toward increasing German innovation and employment. We hope it can begin a dialogue among political and industry leaders to create the necessary framework for growth. Although some initiatives have recently begun, they are not yet sufficient to propel Germany ahead of its global competition.

For their support of this study, we would like to thank PhRMA (The Pharmaceutical Research and Manufacturers of America), the trade association of pharmaceutical research companies in the United States, the German LAWG (Local Area Working Group), and its participating companies. Special thanks to Ms. Henriette Hentschel and the strategy team of the LAWG, who actively assisted this study, as well as the authors of the study, Dr. Annett Tischendorf (A.T. Kearney) and Dr. Michael Nusser (Fraunhofer ISI).

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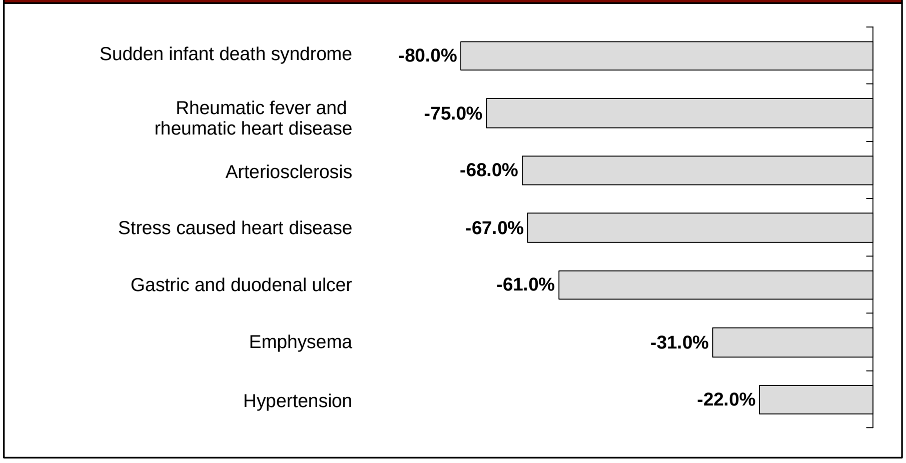
1 Introduction

1.1 The Pharmaceutical Industry's Economic and Innovative Power

The pharmaceutical industry is important to the German business and innovation climate. Traditional industry reference numbers, such as sales or direct employment, fail to capture the industry's full economic significance. Pharmaceutical companies have profound effects on upstream economic sectors through their spending on intermediate inputs (including chemical products and business-related services) and investments (in buildings, lab equipment, and manufacturing plants). Furthermore, these companies' salaries, compensation, and contributions to compulsory social security systems have a stabilizing effect on the economy as a whole. Thus, our study analyses many components of strengthening German business through its pharmaceutical sector.

Several examples demonstrate the importance of the pharmaceutical industry's innovative power and product development. Innovative medications improve individuals' chances of surviving some diseases (such as sudden infant death syndrome, see figure 1.1), and can reduce the likelihood and impact of other diseases (such as arteriosclerosis). The average life expectancy in Germany has increased by about five years since 1980, thanks in no small part to new medications. Furthermore, these medical innovations have improved not only the length but the quality of life, especially for the aged.[1] Indeed, the frequency of disease in seniors decreased from 26.2 percent to 19.7 percent from the beginning of the 1980s to the end of the 1990s.[2]

Fig. 1.1: Decrease in deaths for selected diseases through innovative medicaments (1965-1999)



Source: EFPIA (2005): A key asset to medical progress

Until recently, we have lacked a universally valid definition of an "innovative medication." However, a definition from the Verband forschender Arzneimittelhersteller (VFA, the German Association of

Research-Based Pharmaceutical Companies) includes the following six criteria:

- New medications to treat diseases that could not previously be medically treated
- New modes of action to treat diseases that could not previously be adequately treated
- New ways of administration that improve the availability and/or decrease the side-effects of known medications
- New technologies that decrease the risk of medications
- Using known medications to treat new indications
- Developing therapies involving combinations of known medications

Numerous studies have been performed on the health-related benefits of innovative medications (such as reduced hospital stays or reduced time off work).[3] Therefore, this study only marginally analyzes such questions. Instead, it focuses primarily on the question of how the research-based pharmaceutical industry will strengthen the German business and innovation climate.

1.2 Interviewed Companies: The International Research-Based Pharmaceutical Industry

This study examines the significance of the international research-based pharmaceutical industry for Germany. For that purpose, 15 companies are representative, as shown on the following map:

These companies are subsidiaries of multinational pharmaceutical companies headquartered elsewhere but with locations in Germany. To simplify matters, we will refer to these 15 companies as “the interviewed companies” or “the research-based international pharmaceutical industry”.

Worldwide sales of the parent companies (of the interviewed companies) amounted to approximately 240 billion EUR in 2003. They spent approximately US$35 billion for research and development (R&D).[4] The sales of the 15 subsidiaries located in Germany amounted to approximately 7.3 billion EUR in 2003. About 40 percent of these sales came from innovative products introduced to the market within the past five years.

The interviewed companies, most of them members of the VFA, employed approximately 18,300 people in 2003. By comparison, all VFA companies combined had 85,100 employees, and the entire German pharmaceutical industry had 118,700.[5]

1.3 Methodology

The present study consists of two main parts.

Part 1 under authorship of the Fraunhofer Gesellschaft:

The first part is authored by the Fraunhofer-Institut für System- und Innovationsforschung (Fraunhofer ISI). It first analyzes the economic significance of the interviewed companies, in employment, qualification, and other factors. It then demonstrates Germany's deteriorating competitive position as a location for pharmaceutical R&D during the last three decades. Finally, it quantifies the resulting missed employment potential using an "un-leveraged chances" scenario.

To calculate employment effects, Fraunhofer ISI's input-output model split the German economy into 71 economic sectors (see appendix table A-1), based on current input-output tables from the German Federal Statistical Office (Statistisches Bundesamt) for the year 2000. The model then adjusted results to 2003 using statistical sources. The input data for Fraunhofer ISI's input-output model are based on written interviews with the 15 companies discussed above. With a questionnaire their spending and investment behavior in 2003 was measured along the 71 economic sectors. To guarantee high-quality results, the questionnaire was discussed with the company representatives in a preparatory workshop. We also used telephone interviews and a glossary on important terms and definitions to ensure answers were complete and standardized. Sensitive company information has not been shared among the companies. Appendix 1 provides a detailed description of the model.

Part 2 under authorship of A.T. Kearney:

The second part is authored by A.T. Kearney Management Consultants. It addresses the question of Germany's strategic position along a "value chain" that includes R&D, Production, and Distribution/Marketing sectors. This analysis is based on interviews with the 15 companies discussed above, as well as interviews with selected experts and a thorough literature review. In addition, this second part of the report includes selected examples of ways that other countries—both established and developing—have created an attractive framework for expenditures and investments in the research-based pharmaceutical industry. It explores other industries, such as optical technologies and medical engineering, to demonstrate that Germany can indeed successfully provide support to innovative industries. Finally, this section draws conclusions on the best opportunities to realize gains in employment, and the timeframe required to do so.

Fraunhofer Gesellschaft

Part 1:

The Research-based International Pharmaceutical Industry as Important Economic Factor and Missed Employment Opportunities in Germany

(Fraunhofer Gesellschaft)

2 The Research-Based International Pharmaceutical Industry as an Important Economic Factor in Germany

Michael Nusser, Thomas Reiss, Philipp Seydel, Rainer Walz, Sven Wydra (Fraunhofer ISI)

2.1 Significance of the Research-Based Pharmaceutical Industry for the National Economy

The German national economy's development potential depends heavily on knowledge- and research-intensive industries. As a highly developed country with a shortage of raw materials, Germany has little choice but to rely on innovation to compete internationally. Promising innovative economic sectors—and the technologies used there (e.g., biotechnology, information technology, and communication technologies)—open up new markets and competitively reorganize traditional industries. Developing, producing, and commercializing innovative products creates new jobs and secures existing ones.

The pharmaceutical industry is part of the research-intensive economic sector, along with industries such as medical engineering and vehicle construction. In pharmaceuticals, 15.7 percent of employees work in R&D, and 12.1 percent of sales are spent on R&D—both ranking first among all German economic sectors in 2001.[6] On the other hand, important competitors such as the United States (USA) and the United Kingdom (UK) boast even higher percentages than Germany on both measures.[7]

Pharmaceuticals' impact on the German economy is often discussed only in terms of its costs to the public health system. However, innovative medications produce considerable economic benefits.[8] Such benefits include:

- Easing burdens on public health (by, for example, reducing hospital stays),
- Easing burdens on pension systems (by, for example, avoiding early pension eligibility),

- Easing burdens on medical care systems (by, for example, delaying the need for care or reducing the care required),
- Increasing in health-related quality of life (by, for example, reducing morbidity and mortality),
- Increasing total economic production value (by, for example, avoiding temporary disabilities, or decreasing their length),
- Creating new employment, and securing existing employment, through research, development, production, and distribution of innovative medications.

2.2 Direct and Indirect Employment Effects

The interviewed companies give work to 18,300 employees

The interviewed companies provided work to about 18,300 employees in their companies in 2003 (*direct employment effect*).

However, direct employment insufficiently measures the industry's effect on the national economy. The interviewed companies also add value through their investment activities (such as setting up research labs and manufacturing plants) and their spending on intermediate inputs (such as the R&D services of universities and biotech companies). Such connections with other economic sectors, both upstream and downstream, create additional *indirect employment effects*.

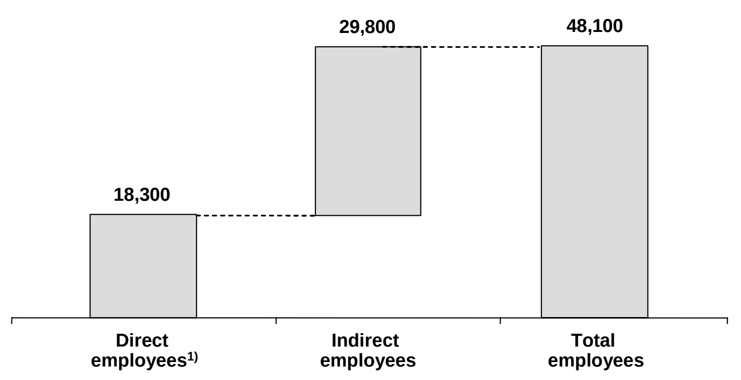
This study used Fraunhofer ISI's input-output model to determine those indirect employment effects in 2003 (see Appendix 1 for a detailed description of the model). The model divides the German economy into 71 economic sectors based on classifications of the German Federal Statistical Office. It then analyzes indirect employment effects based on the following:

- Jobs in public research organizations (e.g., universities, non-university research organizations)
- Jobs in small- and medium-scale biotech companies
- Jobs in upstream sectors (e.g., chemical industry, business-related services such as engineering), and downstream sectors (e.g., public health services)

Each job at the interviewed companies creates 1.6 additional jobs

The interviewed companies' indirect employment effects in 2003 totaled 29,800 employees. In other words, each of the 18,300 direct jobs at the interviewed companies induced another 1.63 jobs in other economic sectors. Summing the direct and indirect employment effects, we get a total employment effect of 48,100 (see Figure 2.1).

Fig. 2.1: Employees (direct and indirect) in 2003



1) Interviewed companies (n = 15)
Source: Calculations Fraunhofer Research 2005

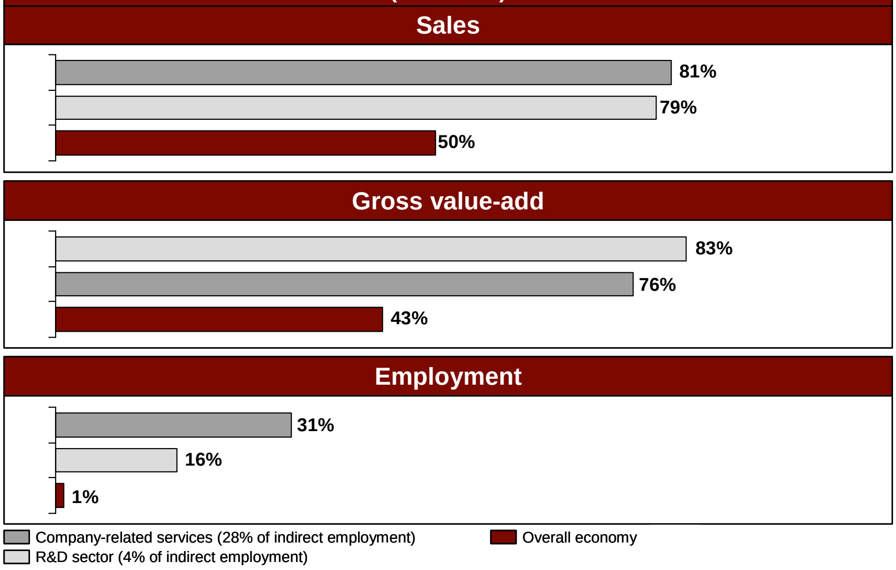
The Deutsches Institut für Wirtschaftsforschung (DIW) recently conducted a similar study for the pharmaceutical industry as a whole, which showed an indirect employment effect of 1.07 additional jobs in upstream economic sectors.[9] Our larger employment multiplier (1.63 additional jobs) is explained primarily by the interviewed companies' stronger connection to more employment-intensive service sectors. Whereas service sectors comprised about 85 percent of the total indirect employment effects for the interviewed companies, they comprised just 68 percent in the DIW study.

Because of the large indirect employment effects, to adequately assess overall effects on the national economy we must undertake a detailed structural analysis of supply interrelations. Such analysis shows that the interviewed companies induce employment effects primarily in knowledge-intensive and thus "higher-grade" service sectors. Of the 29,800 indirect employees, 28 percent are in business-related services (e.g., engineering), 5 percent are in public health services, 4 percent are in R&D services (e.g., through university clinics and biotech companies), and 3 percent are in data-processing and data banks. A current Prognos study notes that each of these sectors boasts huge future potential because of society's ongoing structural change towards a service economy.[10]

The interviewed companies strengthen promising service sectors

For example, as shown in Figure 2.2, from 2001 to 2020, the Prognos study predicts strong above-average growth in sales, gross value added, and employment for business-related services and R&D services (32 percent of the indirect employment effects). While the study predicts just 1 percent employment growth for the national economy as a whole, business-related services will grow by 31 percent and R&D by 16 percent. As noted above, 85 percent of the 29,800 indirect employees will be in the service industry as a whole. In this sector employment is expected to grow by 9 percent—again, far better than the 1 percent employment growth for the national economy as a whole.

Fig. 2.2: Forecasted growth in sales, gross value-add, and employment (2001-2020)



Note: Based on 1995 prices. Assumptions of the Prognos study: annual growth 2001-2020: World economy 2.6%, European economy 2.0%, world trade 4.3%
Source: Fraunhofer Research 2005 (data basis: Prognos 2002)

Consumption spending of direct and indirect employees secures jobs

In addition to these indirect employment effects, we also measure "consumption-induced" employment effects.[11] Both direct and indirect employees receive salaries and other compensation. Those employees spend a share of that compensation (after taxation, and deduction of social contributions and savings) on their own demands, or consumption. The consumption spending of the 18,300 direct and 29,800 indirect employees amounted to approximately 850 million EUR in 2003. In total, 13,000 jobs are related to this private demand.

2.3 Jobs for Highly Qualified Employees

2.3.1 Significance of Education and Qualifications for the National Economy, and Current Trends

The market diffusion of innovation requires a workforce that has learned how to use technological knowledge in products and processes. Distributing and using innovations also requires the build-up of complex communication and distribution channels.[12] A country must have a sufficient number of highly qualified employees and jobs in order to be able to transfer R&D knowledge into internationally competitive products. A national lack of highly qualified employees—or jobs for them—may lead to remarkable lasting competitive disadvantage. For example, other countries may be able to use technological knowledge won by national R&D more quickly; meanwhile struggling countries can never move quickly enough to import foreign technological know-how.

Reports of the Bundesministerium für Bildung und Forschung (BMBF, the Federal Ministry of Education and Research) on German technological competetiveness[13] show that

- The worldwide economic trend toward a "knowledge economy" requires more R&D in high technology sectors, and a science-based education,
- Many other countries, including the United States, Canada, Sweden, and Switzerland, clearly invest more in university education than Germany (measured as a share of gross domestic product),
- Germany lost in international competition in its availability of well-trained specialists,
- Medium-term, significant public financing bottlenecks in university education will heighten the importance of private financing sources (e.g., public-private partnerships, foundations, private supporters, tuition fees),
- Because of those bottlenecks, as well as simple demographic changes resulting in a lack of highly-qualified young employees, companies' internal training programs will become increasingly important.

Employees on all levels must increase their knowledge and performance standards in order to meet the requirements of Germany's "knowledge economy" and not threaten Germany's long-term international competitiveness. In order to do this, however—and to avoid the "brain drain" of qualified employees abroad—the German economy must provide a sufficiently large number of promising jobs.

Because of ongoing technological development, employees' professional and educational qualifications continually become obsolete. Knowledge and practice have to be updated again and again. This requires a commitment to "lifelong learning" on the part of employees—and it also requires remarkable investments in training on the part of companies.

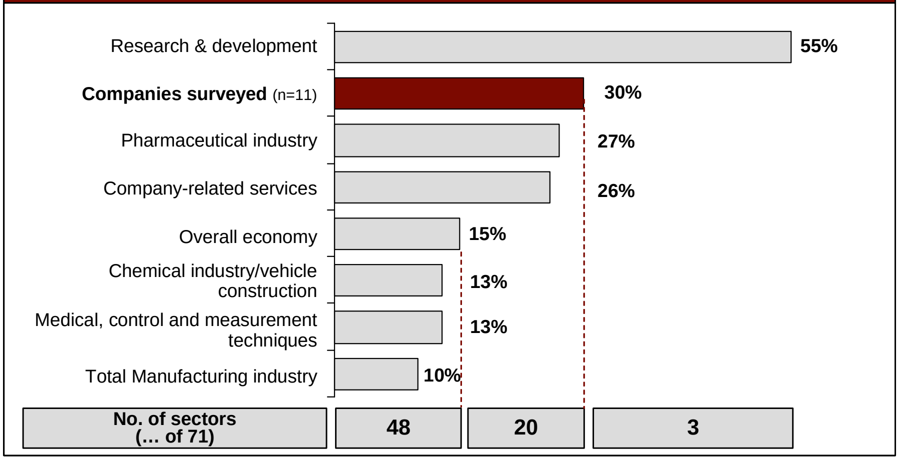
So do the interviewed companies strengthen the German business climate? Let's examine the extent to which they provided jobs for highly qualified persons and invested in their employees' training in 2003.

2.3.2 Highly Qualified Employees: Employment and Promotion

The share in graduates of the interviewed companies,30%, is very large

Thirty percent of employees at the interviewed companies are graduates of institutions of higher learning, representing an above-average share compared to other industries (see Figure 2.3). Of the 18,300 direct employees, approximately 5,500 graduated from universities and universities of applied sciences ("Fachhochschule"); of those, approximately 2,200 received a doctoral degree. Thus, the interviewed companies employ twice as many graduates as the average of overall economy (15 percent), and three times as many as the total manufacturing industry (10 percent). In comparison to other economic sectors—e.g., chemicals, vehicle construction, medical, control and measurement techniques—the interviewed companies show also significantly larger values. Altogether, only 3 of Germany's 71 economic sectors employ a larger share of graduates.

Fig. 2.3: Quota of university graduates
(% of overall employees of the sector)



1) Interviewed companies: values 2003. Other sectors: values 2001.Values are relatively stable in terms of time. Values for the chemical industry do not include the pharmaceutical industry.
Source: Calculations Fraunhofer Research 2005 (data basis: Eurostat Labour Force Survey, international ISCED classifications 5a and 6)

Why so many graduates in the pharmaceutical industry? An important reason is the increasing significance of biotechnology. In the future, almost every new medication brought to market will be treated with biotech methods in one or more phases of its development, or will otherwise benefit from biotech know-how.[14] This requires a high level of knowledge in several different scientific disciplines (e.g., biology, chemistry, biochemistry, bio-computer science, process engineering, physics) for both R&D and production.

As shown in section 2.2, the interviewed companies induce indirect employment largely in knowledge-intensive service sectors such as business-related services and R&D services. The analysis shows that 17 percent of the 29,800 indirect employees have graduated from universities and universities of applied sciences (“Fachhochschule”) —again, above the average of overall economy (15 percent).

The interviewed companies invest heavily in professional training

On average, the interviewed companies applied approximately 1,300 EUR per employee to training in 2003 (“human resources spending”). This puts them well above average national values (see table 2.1). The Institut der Deutschen Wirtschaft (IW), which collects data on companies’ training spending every three years, found that companies nationwide in 2001 spent an average of 869 EUR on training per employee.[15] The Statistisches Bundesamt, within the scope of the Europe-wide Continuing Vocational Training Survey (CVTS), using a more restrictive definition of training than IW, found an average value of 624 EUR per employee nationwide in 1999.[16]

Table 2.1: Spend for on-the-job training 1) (in €)		
Companies surveyed (n=12) (2003)	**Average of overall economy**	
	Institut der Deutschen Wirtschaft (2001)	**Statistisches Bundesamt (1999)**
1.319	**869**	**624**

1) Values are not directly comparable due to different definitions, however, the core statement has not been changed.
Source: Calculations Fraunhofer Research 2005, Institut der deutschen Wirtschaft 2004, Statistisches Bundesamt 2001.

2.3.3 Employment of Well-Trained Women

Germany fails to sufficiently take advantage of the capabilities, skills, knowledge, and innovation potential of women, according to BMBF reports on technological competitiveness.[17]

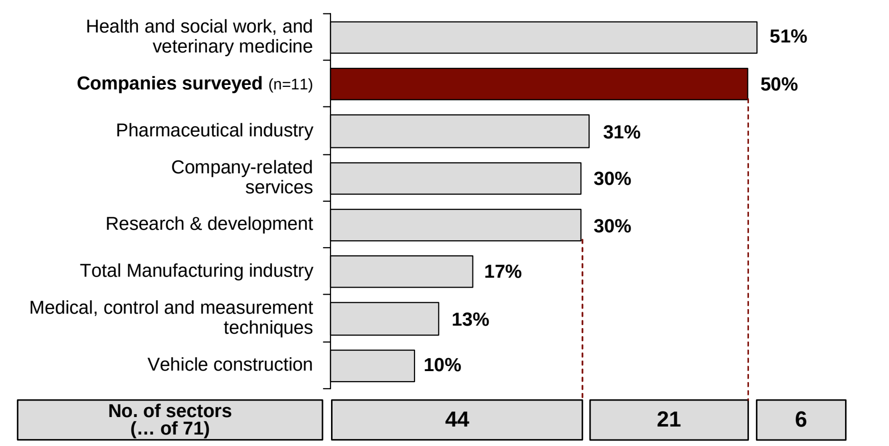
Women's qualification levels are exceedingly high. In many countries (e.g., Sweden, Finland, UK, Italy), women form the majority of applicants, students, and graduates at universities. In Germany, approximately 50 percent of the graduates of tertiary education are women. However, the share of women in ongoing professional development (e.g., doctoral degree, university research, professorship, leading positions in the economy) is decreasing. Compared to Germany, Scandinavian countries boast far larger shares of women employed in R&D or teaching at universities. To be open to new potential economic innovation, Germany must increase its share of women in the workforce, especially in the advanced professional phases of development.

So how do the interviewed companies do when it comes to employing highly qualified women?

50% of the graduates in the interviewed companies are women

The results show that 50 percent of the directly employed graduates at the interviewed companies are women (see Figure 2.4). This share is about three times as large as the relative value of the total manufacturing industry (17 percent). Even compared to the entire pharmaceutical industry (31 percent), or to other economic sectors such as R&D (30 percent) or vehicle construction (10 percent), the interviewed companies boast a far better share of women. Altogether, only six of 71 economic sectors in Germany show a larger share of women graduates.

Fig. 2.4: Quota of female employees among overall university graduates
(in %)



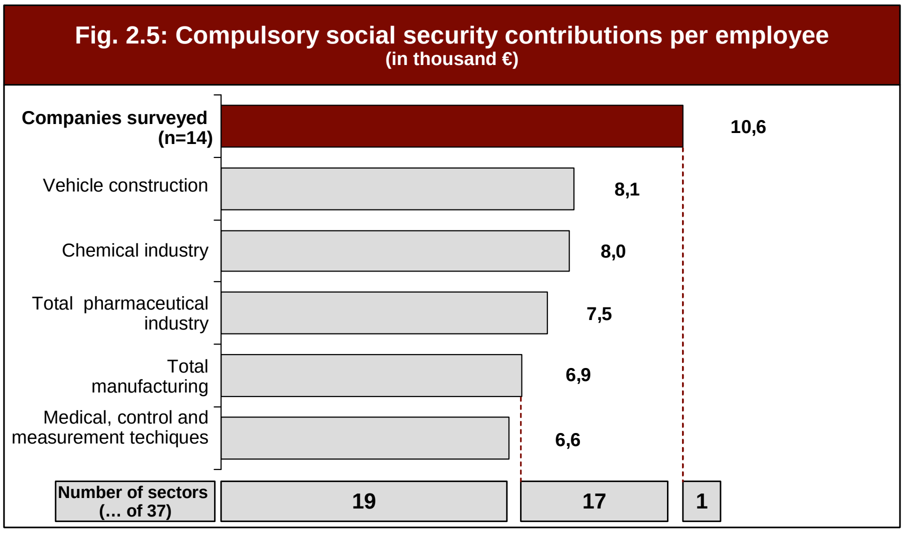
1) Interviewed companies: values 2003. Other sectors: values 2001. Values are relatively stable in lapse of time
Source: Calculations Fraunhofer Research 2005 (data basis: Eurostat Labour Force Survey, international ISCED classifications 5a and 6)

2.4 Direct Contribution to Social Insurance Systems

Current political discussions frequently address the pharmaceutical industry as a contributor to the increasing costs of health care, costs which are especially troubling in the face of decreasing revenues for governmental health insurance. In fact, not only health insurance but most social insurance systems face a heavy burden: low economic growth (and associated flat salaries) and high unemployment reduces revenues. In this light, the following section examines the stabilizing effect of contributions made by the interviewed companies to such social insurance programs in 2003. The comparison is made to just 37 sectors of the producing industry (see Appendix 1, Table A-1) rather than all 71 sectors due to limited availability of data.

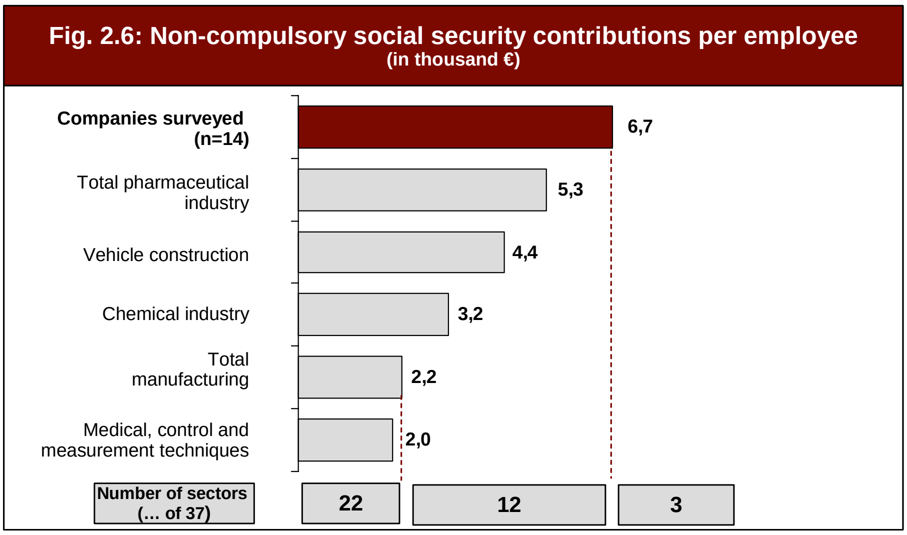
The interviewed companies strengthen social insurance programs

The interviewed companies made annual payments to compulsory social security system of approximately 10,600 EUR per employee in 2003 (see Figure 2.5). The corresponding value for the whole pharmaceutical industry as a whole was about 7,500 EUR per employee. Other sectors also rank far behind the interviewed companies, including vehicle construction (8,100), chemicals (8,000), and medical engineering (6,600). The average value for the total manufacturing industry was just 6,900 EUR per employee. Only one of its 37 sectors outpaced the interviewed companies.



1) Interviewed companies: values 2003. Other sectors: values 2002. Values are comparable due to a very small income increase and minor changes in social security contributions in 2003. Values for the chemical industry do not include the pharmaceutical industry.
Source: Calculations Fraunhofer Research 2005 (data basis: Statistisches Bundesamt 2004, Fachserie 4, Reihe 4.3)

Contributions to non-compulsory social security insurance (i.e., companies' pensions) suggest a similar picture. The interviewed companies made annual contributions of 6,700 EUR per employee in 2003 (see Figure 2.6). The comparable figure for the entire manufacturing industry is just 2,200 EUR; even the pharmaceutical industry as a whole ranks behind the interviewed companies with 5,300 EUR per employee. Merely three of the 37 economic sectors show larger values.



1) Interviewed companies: values 2003. Other sectors: values 2002. Values are comparable due to a very small income increase and minor changes in social security contributions in 2003. Values in the chemical industry do not include the pharmaceutical industry.
Source: Calculations Fraunhofer Research 2005 (data basis: Statistisches Bundesamt 2004, Fachserie 4, Reihe 4.3)

3 “Un-leveraged Opportunities” in the Pharmaceutical Industry – Missed Employment Potential in Germany

Michael Nusser, Thomas Reiss, Sven Wydra (Fraunhofer ISI), Rainer Nägele (Fraunhofer IAO)

3.1 Un-leveraged Opportunities in Research and Development

3.1.1 Significance of Research and Development for the National Economy

As a rule, innovations result from a “well-aimed production of technological knowledge.” Therefore, R&D is one of the most important factors explaining the long-term economic growth of a national economy.[18] Expenditures on R&D is an investment in new knowledge, and is a starting point for the innovative processes and technological development required for new products, processes, and services.

R&D expenditures—the largest item among innovation spending—shows the improvement of technological knowledge. So R&D expenditures can help us assess future technological competitiveness when we seek to measure a country’s “innovation potential.” Combining this “input” indicator with “output” indicators (e.g., patent applications and grants, sales of innovative products) quite accurately predicts the future ranking of national economies in promising technological markets.

The BMBF reports on Germany’s technological competitiveness[19] draw the following picture:

- **Decreasing significance of Germany as R&D location**: International comparisons of R&D expenditures ranked Germany substantially atop its competitors in the 1970s and even into the 1980s. But in the first half of the 1990s, the R&D weights shifted toward Asia (including Japan, Korea, and China) and North America. Germany no longer renews and expands its technological knowledge capital as fast as its competitors.
- **Minor public R&D commitment compared to important competitive countries**: Experts from several economic research institutes have demanded a clear political agenda toward

education, public and industrial R&D, and innovations.[20] This is the only way that Germany can remain an attractive long-term R&D location for scientists and companies, providing employees with sufficiently high qualifications and the cooperation of internationally acknowledged scientific R&D organizations.

As a rule, what makes a main industrial R&D is the structure of market demand (i.e., national per capita spending on innovative products). To a certain degree, industrial R&D can also be positively influenced by public promotion (including subsidies and public demand for innovative products). For example, the United States during the 1960s and '70s promoted R&D in the armaments and aeronautics industries, which considerably impacted the development of information and communication technologies.

- **Increasing significance of R&D-intensive products and knowledge-intensive services**: Positive development of research-intensive products and knowledge-intensive services will best boost economic indicators such as production, value added, exports, and employment.

- **Too limited R&D expenditures for high technologies and high-quality services**: For many years, German industrial R&D on high technologies (including pharmaceuticals, biotech, and communications engineering) has lagged behind its competitors such as the United States. For decades, Germany prioritized for applying and realizing top research results—even when they were largely imported. Now many experts are demanding an increased German commitment to top technology research as prerequisite for further growth and employment.

  The increasingly-held view is that high-quality knowledge-intensive services (such as R&D services in high technology companies) drive innovation. This is mainly true of high technology R&D and knowledge-intensive high technology sectors. In these areas, though there are positive tendencies, Germany still shows considerable "R&D gaps."

3.1.2 Decreasing Significance of Germany as an R&D Location within the Pharmaceutical Industry

Pharmaceuticals is one of the most R&D-intensive economic sectors, and many pharmaceutical products involve promising high technologies.

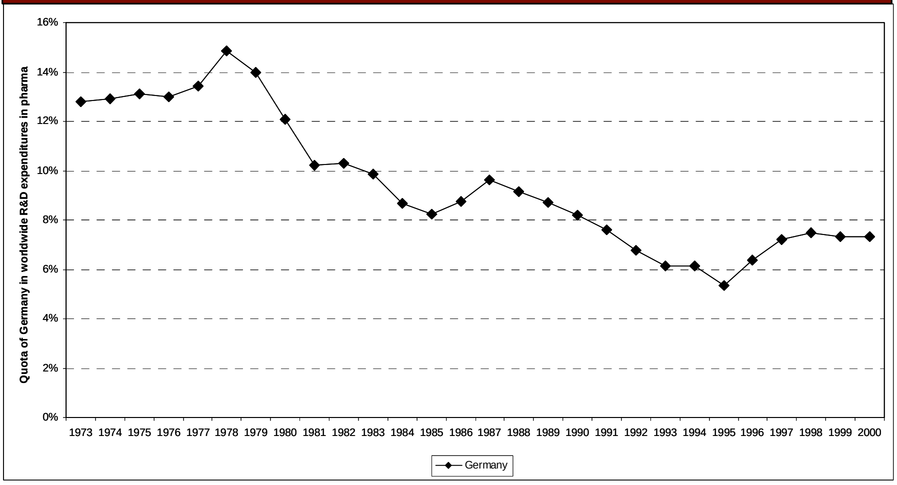
Internationally standardized statistics from the Organization for Economic Cooperation and Development (OECD) provide data comparing R&D structure.

Germany's position as an R&D location has clearly deteriorated

Using these OECD statistics, the long-term developments in industrial R&D expenditures in pharmaceuticals in Germany show a clear decrease in activities:

- **Decreasing significance of the pharmaceutical industry in Germany compared to other economic sectors**:[21] Among the most important 15 OECD countries, R&D expenditures in pharmaceuticals as a percentage of all manufacturing clearly increased, from just below 5 percent in 1973 to 10 percent by the end of the 1990s. Thus, the weight of these pharmaceutical industry within the R&D portfolio of industrial countries has approximately doubled since 1973. In Germany, however, this weight *decreased* in comparison to other economic sectors (e.g., vehicle construction). In 1973, pharmaceuticals accounted for a 6.5 percent share, ranking above the OECD average. Then it steadily decreased until reaching approximately 5 percent in 1995. Since 1997, the weight has again started shifting towards the pharmaceutical sector as compared to other industries.
- **Strongly decreasing significance of Germany for worldwide R&D expenditures in the pharmaceutical industry**: Germany's share of worldwide pharmaceutical R&D expenditures decreased from about 13 percent in 1973 (and 15 percent in 1978) down to about 5 percent in 1995 (see Figure 3.1). Since 1996, the trend has turned back positively, rising to a share just above 7 percent in 2000.

Fig. 3.1: Germany's share of worldwide [1)] R&D expenditures in the pharmaceutical industry (1973-2000)

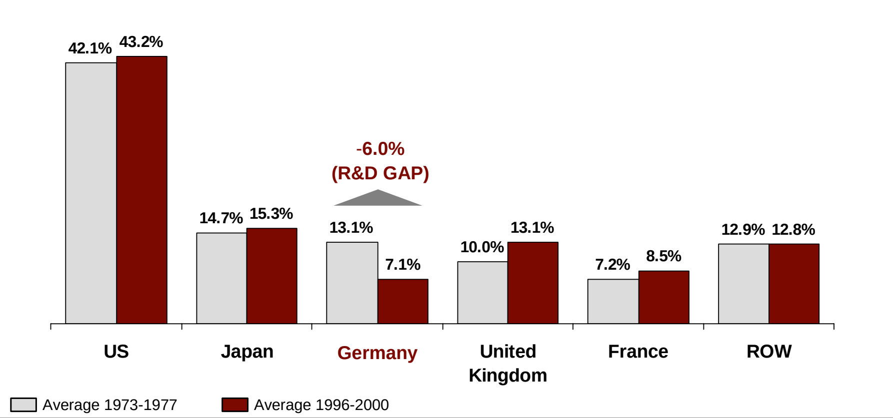


1) OECD 15 countries: Australia, Denmark, Germany, Finland, France, Ireland, Italy, Japan, Canada, Netherlands, Norway, Sweden, Spain, USA, and the United Kingdom.
Source: Calculations Fraunhofer Research 2005 (data basis: OECD, ANBERD database, 2004)

The picture these numbers draw is somewhat murky. Indeed, absolute German pharmaceutical R&D expenditures clearly increased during the last three decades—as a rule by annual growth rates of more than 5 percent. But compared to its important competitors, Germany's dynamics are clearly weaker; for example the USA and UK both boasted annual growth rates of more than 10 percent. Figure 3.2 demonstrates the result of this development. Whereas countries such as the USA and UK improved their relative position as locations for R&D, Germany's position clearly deteriorated.

Comparing countries' industrial R&D expenditures across a variety of data sources, a current study suggests that different data sources within a country can change the picture of its pharmaceutical sector.[22] For example, data collected by national pharmaceutical associations (such as PhRMA) rank the USA higher in its R&D expenditures than do the OECD statistics. However, it decisively leaves unchanged the OECD results for Germany derived above. In other words: *Any statistics show Germany's competitive position as a location for pharmaceutical R&D clearly deteriorating.*

Fig. 3.2: Worldwide R&D expenditure in the pharmaceutical industry (1973-2000)



1) OECD 15 countries: Australia, Denmark, Germany, Finland, France, Ireland, Italy, Japan, Canada, Netherlands, Norway, Sweden, Spain, USA, and the United Kingdom.
Source: Calculations Fraunhofer Research 2005 (data basis: OECD, ANBERD database, 2004)

Germany's competitive position as an R&D location depends strongly on the surveyed industry.[23] It's not just pharmaceuticals: Germany's significance as an R&D location also dwindled in other sectors between 1973 and 2000, including electrical engineering (from 13 to 8 percent) and communications engineering (from 10 to 6 percent). In other sectors, however, Germany became more important as an R&D location, including vehicle construction (from 10 to 23 percent) and aviation and aeronautical engineering (from 5 to 13 percent).

3.1.3 The Pharmaceutical Industry as a Catalyst for Innovation

We cannot determine the impact of an economic sector on the entire national system of innovation solely through its own R&D expenditures. An economic sector can generate decisive impulses for innovation in upstream and downstream economic sectors by purchasing or supplying innovative products. For example, demand for innovative pharmaceutical products could stimulate innovation among its suppliers (including biotech companies), in both products and processes. Therefore, the pharmaceutical sector can be a positive catalyst for innovation in Germany as a whole.

First let's examine the pharmaceutical sector as a *purchaser of innovative intermediate inputs*. Its significance is roughly measured by the size of its R&D expenditures, which is typically included in the products purchased from upstream economic sectors ("intermediate inputs from supplier sectors”). This included R&D expenditures on intermediate inputs is called “incorporated” R&D.

Pharmaceutical companies are important purchasers of innovative products

Our study calculated the extent of incorporated R&D supplied to the pharmaceutical sector for the year 2000. For that purpose, we differentiated between incorporated R&D from home (e.g., R&D services of German biotech companies) and that imported from abroad (e.g., import of R&D services from U.S. biotech companies). The results show the pharmaceutical industry strongly interlinked with upstream R&D-intensive economic sectors from home and abroad. For each 1 billion EUR of demand for German pharmaceutical products, the pharmaceutical sector gets (see Appendix 2 for a detailed description of our calculations):

- 38 million EUR of incorporated R&D from home. This amounts to 3.8 percent of the demanded product value. This figure ranks pharmaceutical industry second among the 71 sectors.
- 134 million EUR of incorporated R&D from abroad. With 13.4 percent of the demanded product value, the pharmaceutical industry ranks first among the 71 sectors.

Since the pharmaceutical sector’s total production volume was 20.4 billion EUR in 2000[24], incorporated R&D from home totaled approximately 775 million EUR. Incorporated R&D from abroad totaled approximately 2.750 million EUR. This value shows the German pharmaceutical industry’s strong dependence on R&D-intensive intermediate inputs from abroad.

Pharmaceutical companies are also important suppliers of innovative products

Additionally, the pharmaceutical industry also plays an important role as a *supplier of innovative intermediate inputs* for downstream sectors. According to a current study from the Zentrum für Europäische Wirtschaftsforschung (ZEW) and the Niedersächsisches Institut für Wirtschaftsforschung (NIW)[25], the pharmaceutical industry is a highly significant innovative supplier, especially for the service sector (e.g., public health services). Altogether, nearly 13 percent of the service sector’s incorporated R&D purchases come from the pharmaceutical industry. With this, the pharmaceutical industry ranks second among the 71 sectors, and also ranks as a top supplier of innovations.

Its deteriorated R&D competitive position handicaps the entire German system of innovations

So the decreasing significance of Germany as an R&D location since the beginning of the 1970s has not only negatively influenced the pharmaceutical sector. It has had negative radiating effects on the entire German system of innovations. Germany has failed to leverage the innovation and employment potentials of the promising technological markets in pharmaceuticals and biotech as well as interrelated potentials in their upstream and downstream economic sectors.

3.1.4 Theoretical Employment Potential: Model Calculations for the "Un-leveraged Opportunities" Scenario

Section 3.1.2 discussed Germany's decreasing significance as a location for pharmaceutical R&D. The following analysis looks at the missed opportunities or "un-leveraged chances" inherent in that position. To do so, let's assume that in 2000, Germany's relative position as an R&D location vis-à-vis important competing countries matches that of the early 1970s. This first step allows us to quantify Germany's "R&D gap" for the past thirty years. The analysis then calculates theoretical employment potentials within this "un-leveraged chances" scenario. The calculation examines both direct and indirect employment effects as well as job provision for highly qualified employees.

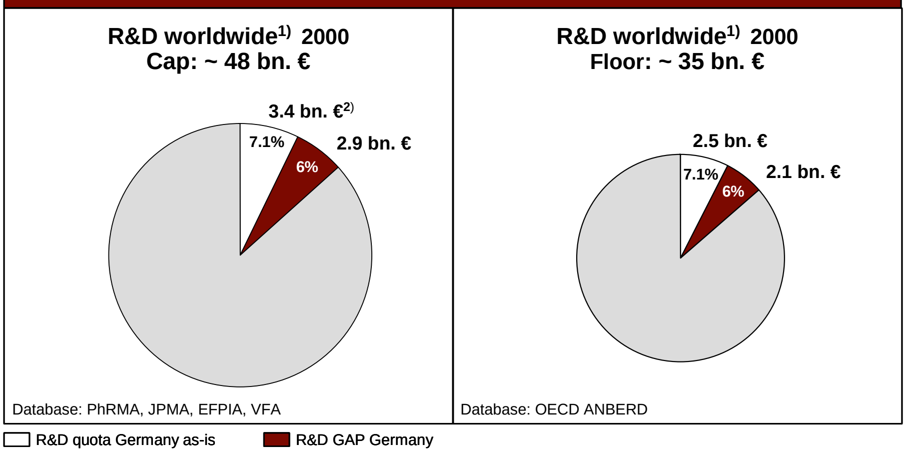
Several international data sources can help quantify the R&D gap. They use different definitions of R&D, and different data collection methods. None of the data sources can be qualified as "better" or "worse" because their data collection is focused on different objectives. The following analysis thus uses ranges of numbers to objectify the results. We use the year 2000 for the calculations.

In most cases, when national pharmaceutical associations (including PhRMA, JPMA, EFPIA, and VFA) collect R&D data, they use a broad definition of R&D. For example, PhRMA treats expenditures on utilization surveys (expenditures on phase IV studies of medications already on the market) as 100 percent R&D expenditures. In general, the pharmaceutical associations break R&D expenditures into internal and external sectors. For example, PhRMA includes all R&D projects *financed* by the pharmaceutical industry, regardless of whether they were executed in the pharmaceutical industry or a different industry (e.g., research commissions to external R&D organizations). Since the end of the 1980s, this R&D outsourcing to other sectors has been considerably increased. Using the national pharmaceutical associations' data, in 2000 worldwide R&D expenditures totaled approximately 48 billion EUR. We'll use this value as the upper limit for our calculations.

On the other hand, the OECD uses a narrower definition of R&D. For example, OECD treats only selected categories of utilization surveys as R&D expenditures. OECD also focuses on who performs the R&D activity. It therefore covers only R&D expenditures in the internal sector—for activities executed in the pharmaceutical industry itself. Using the OECD data, in 2000 worldwide R&D expenditures totaled approximately 35 billion EUR . We'll use this value as the lower limit for our calculations.

As Figure 3.3 shows, German pharmaceutical R&D expenditure in 2000 was in the range of 2.5 billion EUR (lower limit: 7.1 % x 35) to 3.4 billion EUR (upper limit: 7.1 % x 48).

Fig. 3.3: R&D GAP Germany, 2000



1) Worldwide at upper limit refers to USA, Japan, European members of EFPIA. Worldwide at lower limit refers to OECD 15 (s. fig. 3.2). Differences due to different demarcation of countries amount to less than 1 billion EUR.
2) Calculation logics (exemplary): 3.4 = 7.1% * 48 billion EUR
Source: Calculations Fraunhofer Research 2005. Data basis: PhRMA (2005): Pharmaceutical Industry Profile 2005; EFPIA (2002): 2001-2002 The year in review; JPMA (2002): Data Book 2002; VFA (2004): Statistics; OECD: ANBERD database (2004)

Our "un-leveraged opportunities" scenario assumes that the R&D gap of 6.0 percent (see Figures 3.2 and 3.3) is permanently and completely closed. In other words: We calculate the theoretical employment potential by assuming that in 2000 Germany's relative competitive position in R&D matches that of the early 1970s. Closing the R&D gap of the past three decades requires additional R&D expenditures. As Figure 3.3 shows, a permanent and complete closure of the R&D gap would involve a sum between 2.1 billion EUR (lower limit) and 2.9 billion EUR (upper limit).

Germany's failure to grow R&D expenditures as quickly as the rest of the world squandered the opportunity to create new jobs. A permanent closure of the R&D gap, with its associated increases in R&D expenditures, would mean that new jobs could develop in Germany. New jobs would be created in R&D departments of pharmaceutical companies, public research organizations, biotech start-ups, and upstream economic sectors (sub-supplier industries such as biotech providers and producers of lab equipment).

R&D decisions rarely involve transferring planned investments in other areas (production plants, say, or marketing & distribution) to R&D. On the contrary, companies determine the R&D expenditures required for long-term international competitiveness. As a rule, the parent company identifies a required amount of future investment in R&D projects. Then subsidiaries worldwide compete for these R&D projects.

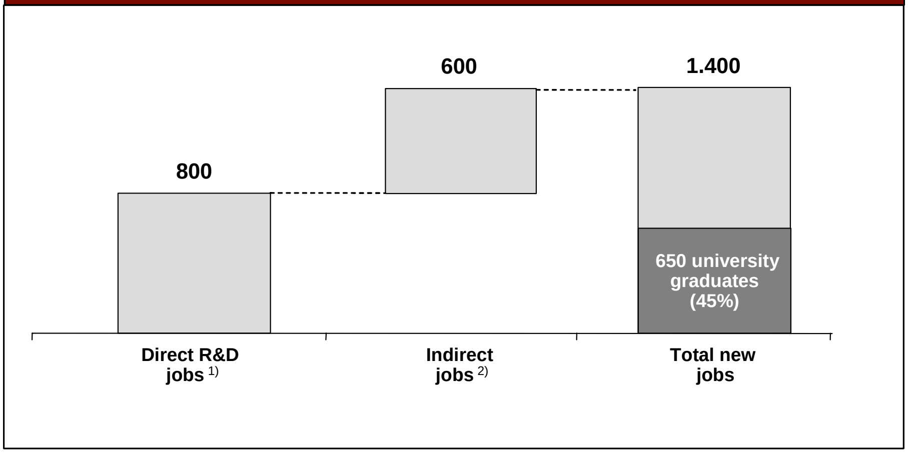
Therefore, in calculating theoretical employment potential, we assume that the sole result of permanently closing the R&D gap is *additional* R&D expenditures in Germany. In other words: Pharmaceutical companies—whether their parent companies are located in Germany or abroad—invest more heavily in German R&D. R&D monies authorized by the parent company are spent in Germany rather than other countries. These expenditures do not diminish other spending in Germany, such as on the value-added steps of production, marketing, or distribution. No existing jobs are substituted out in these calculations.

100 million EUR additional R&D spending creates 1,400 total jobs

We used the Fraunhofer's input-output model (see appendix 1) to calculate the employment effects for the year 2000. The resulting employment potential from the "un-leveraged chances" scenario can be summarized as follows:

- **Size of employment multipliers**: Every additional 100 million EUR of R&D expenditures done permanently in Germany generates approximately 1,400 jobs (see Figure 3.4). About 800 of these represent direct R&D employment in pharmaceutical companies, biotech companies, and other R&D organizations. Upstream economic sectors (including business-related services) generate 600 indirect jobs. About 45 percent of the 1,400 jobs are for highly qualified graduates of universities or university of applied sciences ("Fachhochschule").

Fig. 3.4: Employment potential through sustainable additional R&D expenditures of 100 million € per year



1) Pharmaceutical companies, biotechnology companies, public R&D organizations
2) In upstream sectors (e.g. business related services, biotechnology /lab providers)
Source: Calculations Fraunhofer Research 2005

30,000 - 41,000 jobs through permanent and complete closing of R&D gap

- **Complete closing of the R&D gap**: A permanent and complete closing of the R&D gap (13.1 percent instead of 7.1 percent) in 2000 would result in additional R&D expenditures of 2.1 to 2.9 billion EUR (see Figure 3.3). This would generate 17,500 to 24,000 new direct R&D jobs, including those in pharmaceutical and biotech companies and public R&D organizations (*direct job effects in R&D*). Upstream sectors would generate an additional 12,500 to 17,000 jobs (*indirect job effects*). Thus the total employment effect is 30,000 to 41,000 jobs (see Figure 3.5). About 14,000 to 19,000 of these jobs would go to highly qualified graduates (approximately 45 percent of the total effect). In other words: Germany's deteriorating competitive position as an R&D location since 1973 has meant a missed employment potential of 30,000 to 41,000 jobs (*missed direct plus indirect employment potential*).

New R&D jobs cannot be created in just a few years. Consider the UK: Its relative competitive position as an R&D location has clearly improved since 1973 (see Figure 3.2). During that time, the UK's number of pharmaceutical industry R&D employees increased by about 700 per year, from 10,000 in 1975 to 29,000 in 2002.[26] From

1996 to 2002, the number of biotech companies increased from 180 to approximately 330.[27] Approximately 50 percent of all biotech companies are related to the health sector, and the average UK biotech company employs approximately 22 R&D employees.[28] So the UK's new biotech companies have generated approximately 250 R&D jobs per year since 1996. In addition, R&D jobs develop in public R&D organizations (e.g., university clinics). Thus, the UK's increasing attractiveness as an R&D location led to total annual increases of just over 1,000 R&D employees during the past years.

Fig. 3.5: Model calculation "Missed employment potential"

R&D expenditures Germany in 2000 (in Mrd. €)

R&D expenditures (in billion €)	actual	Potential if ... R&D share		
	7.1%	9.0%	11.0%	13.1%
Upper limit	3.4	4.3	5.3	6.3
Minimum level	2.5	3.2	3.9	4.6

R&D gap Germany in 2000 (in billion €)

R&D gap (in billion €)	actual	Potential if ... R&D share		
	7.1%	9.0%	11.0%	13.1%
Upper limit	0	0.9	1.9	2.9
Minimum level	0	0.7	1.4	2.1

Employment potential[1)] (in thousand)

	Potential if ... R&D share		
	9.0%	11.0%	13.1%
Total employees	10-13	20-27	30-41
In academics	4-6	9-12	14-19

1) Direct job effects in R&D plus indirect job effects in upstream economic sectors
Source: Calculations Fraunhofer Research 2005

As this example shows, we cannot expect the R&D gap to close immediately. As a rule, employment increases occur gradually over a period of many years. So Figure 3.5 shows how employment would increase through Germany's stepwise (rather than immediate and complete) closing of the R&D gap. Garnering a share of "only" 9.0 percent of worldwide R&D expenditures, Germany would generate an additional 10,000 to 13,000 jobs, including about 4,500 to 6,000 jobs for highly qualified employees. Likewise, a share of 11.0 percent would generate approximately 20,000 to 27,000 jobs, including about 9,000 to 12,000 jobs for graduates.

4 Summary of Part 1 Results

The results of these analyses can be summarized as follows. As Chapter 2 explained, in 2003, the interviewed companies:

- In addition to 18,300 direct employees, generated indirect employment effects of 29,800 jobs in upstream and downstream economic sectors,
- Contributed to the provision of qualified jobs in having 30 percent of their employees as higher-education graduates, as well as by spending 1,300 EUR per employee on company training, both above-average measures of contributions to the strength of the German economy,
- Used the capabilities, knowledge, and skills of women in having 50 percent of their graduates as females, an outstanding investment in Germany's innovation potential,
- Stabilized revenues through payments into compulsory social security system as well as contributions into non-compulsory security systems such as company pensions.

The primary results of Chapter 3's analyses and calculations are:

- Germany's competitive position as a location for pharmaceutical industry R&D clearly deteriorated during the past three decades. Germany's share of worldwide pharmaceutical industry R&D expenditures decreased from about 13 percent in 1973 to approximately 7 percent in 2000.
- An "un-leveraged chances" scenario can calculate missed employment potentials. If Germany's relative competitive position as an R&D location had remained unchanged from 1973, there would have been an additional 2.1 to 2.9 billion EUR in pharmaceutical industry R&D expenditures in 2000. This means that Germany has failed to leverage about 30,000 to 41,000 jobs during the past decades.
- Every 100 million EUR of future permanent R&D expenditures in Germany will generate approximately 1,400 jobs; 45 percent of which will go to highly qualified graduates from universities or university of applied sciences ("Fachhochschule").

The following chapters will examine whether Germany is sufficiently attractive as an R&D location to realize the theoretical employment gains. For that purpose, we will explore what measures other countries took to permanently strengthen their pharmaceutical industry and thus heighten their international competitiveness.

Part 2:

Realizing Additional Employment Opportunities in Germany

(A.T. Kearney)

5 Germany's Significance to the International Pharmaceutical Industry

5.1 Research and Development

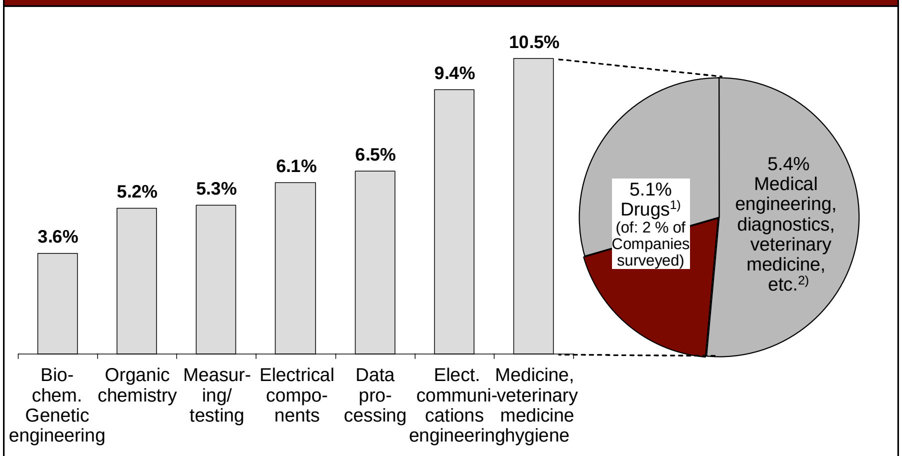
5.1.1 Significance of R&D and Current Trends

R&D is the starting point for future innovations, and therefore plays a central role in the pharmaceutical industry. The industry's exceptional innovation power is reflected in part by its extensive patenting activities. Patents are of major importance to the pharmaceutical industry because developing a modern medication requires an investment of about 800 million USD and a great deal of economic risk.[29] A company will make such an investment only if adequate protection exists—in the form of a patent. The patent protects the product from being copied. The patent guarantees that the product's price emerges through qualitative competition with comparable products on the market. Without this opportunity for competitive pricing, there is no incentive to innovate, and no company will take the risk of investing in R&D.

Pharmaceutical companies with major patenting activities

Measured by their patenting activities—as an indicator for the industry's technological competitiveness—the interviewed companies rank among the most innovative companies of Europe and even the world (see Figure 5.1).

Fig. 5.1: Patent applications per industry sector (selection)
(in % of overall applications, 2003)



1) IPC class A 61k (direct applications and PCT applications)

2) IPC classes A 61-63, ex A 61k (direct applications and PCT applications)

Source: European Patent Office (2003): Business Report; A.T. Kearney analysis (2005)

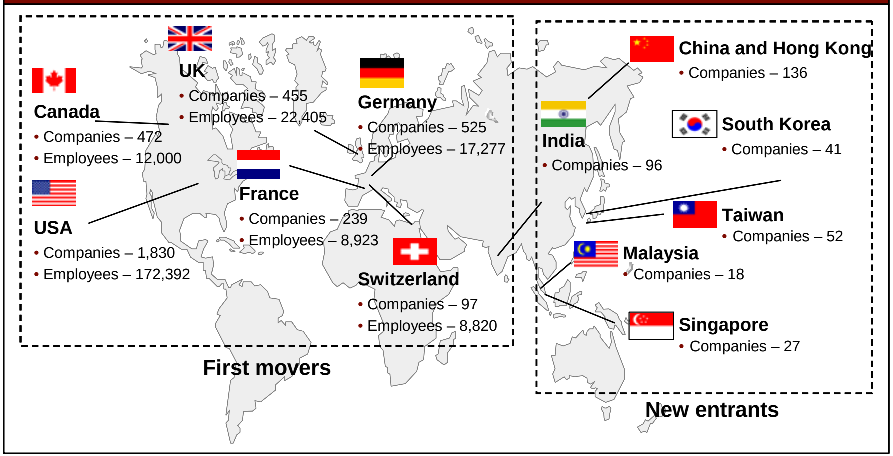
The interviewed companies apply for 40% of all pharmaceutical patents

Worldwide, the interviewed companies combined to receive 15,000 or 45 percent of the granted patents for pharmaceutical and biotech innovations from 1998 to 2003.[30] At the European Patent Office, they combined to apply for 10,000 or 43 percent of all pharmaceutical patents from 1999 to 2003. Of the European patents, about half represent active substances. The other half represents process or application patents.

It takes a lot of money and time to develop a medication. On average, only one out of 10,000 examined substances will reach a patient as a medication—and that will be 10 to 15 years after it was first examined. When you factor in failures and opportunity costs, each medication introduced to the market costs an average of several hundred million US$—over the last 25 years, medication development costs have increased by a factor of eight.[31] Two trends characterize R&D activities in the pharmaceutical industry:

- Pharmaceutical industry R&D budgets are increasing continuously. As late as in the early 1990s, R&D expenditures was about 25 billion US$; in 2004, it was already more than 50 billion US$.[32]
- In recent years, R&D has become increasingly globalized—international companies do R&D worldwide, exchanging knowledge among various locations. With globalization, not only do pharmaceutical companies increasingly compete with each other to innovate, but locations in North America and Europe are also confronted with growing competition. Asian countries including China, India, and Singapore have made multiple efforts to become world-class research locations (see Figure 5.2).

Fig. 5.2: Globalization in life science industry exemplified by biotechnology



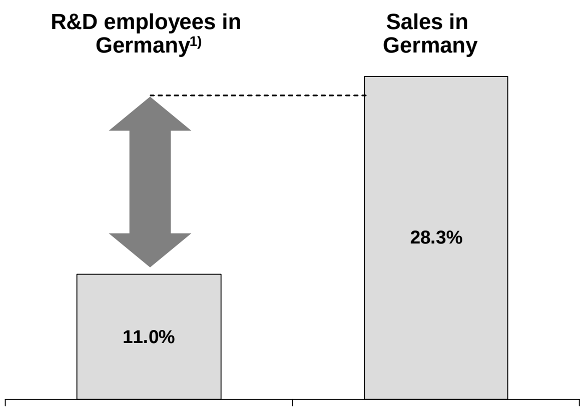
Source: dti (2005): Comparative statistics for the U.K., European and U.S. biotechnology sectors; A.T. Kearney Research (2005)

In this framework, Germany must stand its ground as an R&D location, even though it has struggled to do so in the past. Of course, Germany remains as always an important location for R&D on new medications, but its significance amongst its global competitors for R&D investments is decreasing. Where the United States increased R&D expenditures on an average of 12 percent per year from 1980 to 1997, Germany's annual growth in the same period was merely 6 percent.[33] Thus Germany's share of worldwide R&D expenditures dropped from 13 percent in the early 1970s to 7 percent in 1997 (see Chapter 3).

Interviewed companies with R&D activities in Germany under-represented

The interviewed companies account for approximately 11 percent of the R&D personnel of all research-based pharmaceutical companies in Germany, and approximately 10 percent of R&D expenditures. Yet their sales share is 28 percent—so R&D is clearly underrepresented (see Figure 5.3).

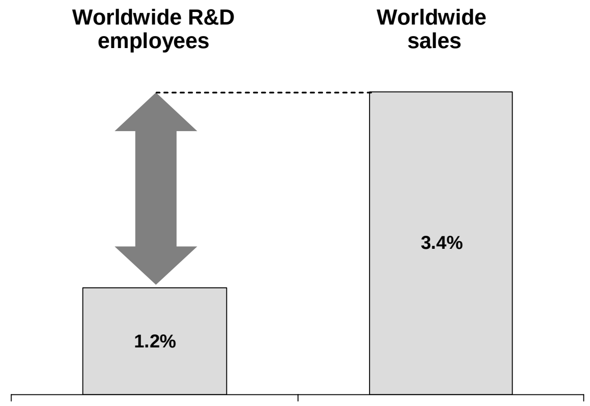
Fig. 5.3: R&D is underrepresented in Germany



1) Companies in the Verband der forschenden Arzneimittelhersteller (VfA)
Source: results of studies, VfA (2004a): Statistics, A.T. Kearney Research (2005)

The same principle holds when we look at the interviewed companies' R&D spending done in Germany compared to worldwide. Whereas Germany accounts for 4 percent of worldwide sales, it accounts for just 1.2 percent of worldwide R&D spending (see Figure 5.4).

Fig. 5.4: Germany's share of R&D worldwide spend



Source: results of studies, business reports, A.T. Kearney Research (2005)

When we consider this result against the background of potential measures to improve German competitiveness, it is clear that we must examine two pieces of the value chain: "basic research" and "clinical development."

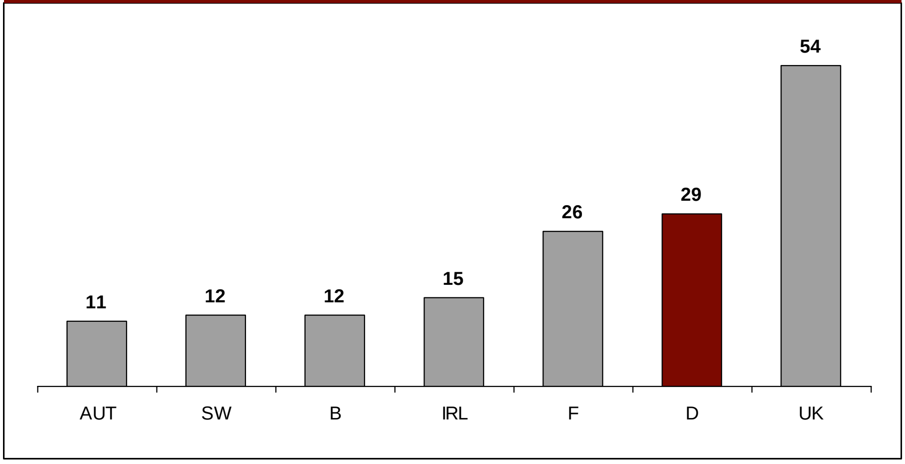
5.1.2 Basic Research

Basic research sets the stage for innovations that change life fundamentally. So, for example, six years after Jonas Salk developed the poliomyelitis serum in 1955, polio could be reduced by 90 percent in the United States. The generic term "basic research" includes three crucial phases: "Discovery," "Target," and "Lead," finally resulting in a "Lead Drug Candidate." Approximately 25 percent of total R&D spending is allotted to basic research.[34]

Interviewed companies do little basic research in Germany—USA and UK leading

For the interviewed companies, Germany plays only a secondary role as a location for basic research. Only three of them have their own research sites—whereas some of the large-scale pharmaceutical companies have closed their research facilities in Germany and transferred that function to the UK, USA, and/or India. This corresponds to a European analysis of foreign R&D investments in life sciences (Foreign Direct Investments – FDI), which showed that for 1997 to 2002, the UK garnered 54 investment projects from foreign countries, and clearly outpacing Germany, with just 29 such projects (see Figure 5.5). The analysis did not break down these R&D projects into basic research vs. clinical development.

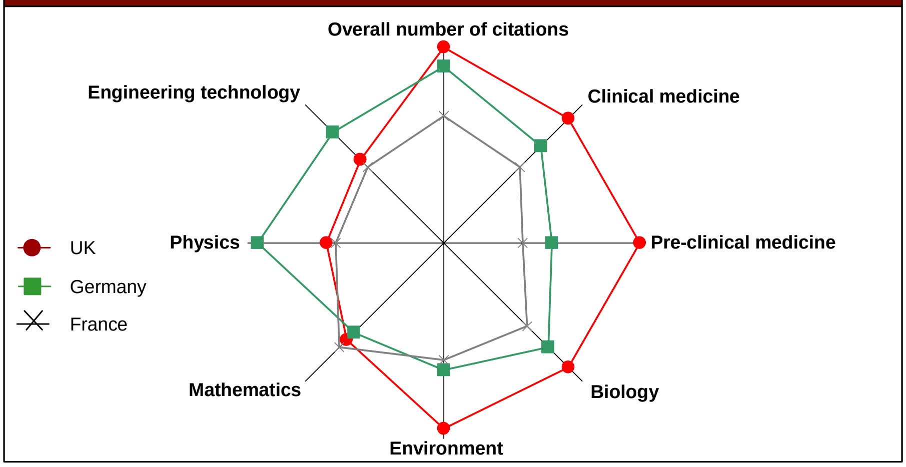
Fig. 5.5: R&D related Foreign Direct Investments in life science industry
(number of projects between 1997-2002)



Source: CGE&Y (2004): EU Enlargement: Driving Change in the European Life Science Industry

Why? Probably because the UK dominates important research areas for the pharmaceutical industry: pre-clinical medicine, clinical medicine, and biology. Based on the quotation rate of scientific publications of these departments, British scientists are far ahead of German scientists (see Figure 5.6).[35]

Fig. 5.6: Country ranking per field of research
(basis: number of citations in scientific publications between 1993 and 2002)



Note: Due to size, the United States has far more mentions in scientific publications than the United Kingdom, France or Germany and therefore is not included.

Source: Nature (2004): The scientific impact of nations.

The framework for research in Germany has improved – but further efforts are necessary

In recent years, Germany has begun making important efforts to improve its framework for conducting basic research. These efforts have included public promotion of innovative technologies such as nano- and biotechnology and the "Brain Gain instead of Brain Drain" initiative to enhance Germany's attractiveness even to the most brilliant scientists. A positive example for R&D investments in Germany came in 1998 when the pharmaceutical company Eli Lilly decided to build a new research and development center in Hamburg (see Figure 5.7).

**Abb. 5.7: Case study Eli Lilly –
Decision to build an R&D center in Germany**

With more than 40,000 employees worldwide – of which 8,700 are in research and development – Eli Lilly ranks among the largest pharmaceutical companies in the world. Eli Lilly has developed treatments for diabetes mellitus and other metabolic anomalies, cancer, infections, and diseases of the central nervous and heart circulation systems.

In 1992, Lilly acquired Beiersdorf research in Hamburg, Germany. In 1998, the company decided to invest in a new research and development center to pursue new approaches for the treatment of diabetes mellitus, and develop new ways to apply pharmaceutical products. The decision to locate the facility in Hamburg was determined by the following factors:

- **Research excellence:** Germany and Scandinavia have an excellent reputation in diabetes research. From Hamburg, Lilly could cultivate relationships and network with local and Scandanavian research groups.
- **Attractiveness of Hamburg**: The city of Hamburg offers an attractive lifestyle and appealing surroundings for scientists from around the world.
- **Political support**: The city government is focused on innovation and highly supportive of research and development work.

In 2000, Lilly opened a 10,200 square meter research and development center. Today, approximately 170 highly qualified scientists from 16 countries work there.

Source: Eli Lilly Company Information (2005)

Nevertheless, despite the increases of the past years, Germany's public research spending in the Life Sciences as measured against gross domestic product lags far behind its competitors (2002: Germany 0.16%; UK 0.16%, France 0.17%; Japan 0.18%, Finland 0.19%, USA 0.27%).[36] At current levels, funding lacks the volume, allocation, and duration for Germany to take over thematic leadership in an area. Funding does not focus on defined crucial areas of research where Germany is already strong and potentially able to take over international leadership.[37]

In addition, at 1.0 percent of gross domestic product, Germany invests a smaller portion of funds into university education (public and private) than its competitors (2001: USA 2.7%, Korea 2.7%, Canada 2.5%, Sweden 1.7%, France 1.1%, UK 1.1%; OECD average 1.8%).[38] Germany's 4.3% annual growth rate in this funding from 1992 to 2000 falls below the OECD average of 4.5%.[39] At present, no German university ranks among the top 10 universities worldwide. The first German universities in the worldwide rankings are the Technische Universität München (45th) and the Universität München (51st). By comparison, the worldwide top 10 includes two British universities (Cambridge and Oxford).[40]

Therefore, Germany must make further efforts to increase its attractiveness for international pharmaceutical companies' basic research. A permanent exodus of researchers would be an especially grave loss for Germany because pharmaceutical companies seek to locate near successful academic institutions. Currently, approximately 25 percent of all medication innovations occur in co-operation with academic research organizations.[41]

5.1.3 Clinical Development

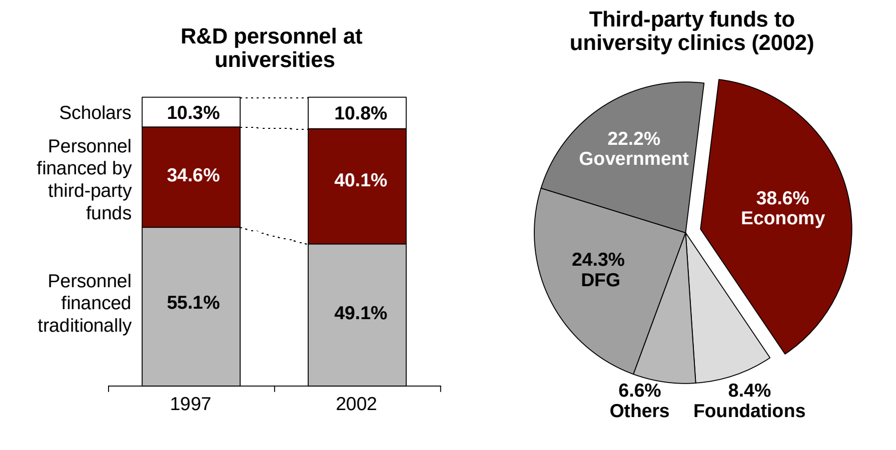
The pharmaceutical R&D process clearly differentiates between basic research on the one hand, and the development of a medication on the other hand. This development starts as clinical research with the first application to human beings. Without clinical research, innovations could not be put into practice, and thus would not be available to the general public. "In the past, clinical research contributed demonstrably to improving medical care. In the future as well, it will be of central importance for the development of new medications, and the introduction of improved or new therapy methods."[42] Pharmaceutical companies allot 45 percent of their R&D spending to clinical development, in which hundreds of patients participate in studies. (More specifically, the R&D allotment includes Phase I studies: 9 percentage points, Phase II studies: 7 percentage points, Phase III studies: 29 percentage points.)[43]

The pharmaceutical industry's clinical research is important from a medical as well as an economic point of view. Medically, it offers new or enlarged treatment possibilities, provides patients with earlier access to innovative medications, and offers physicians early opportunities to study new treatments under controlled conditions, assessing the risks and benefits of a new product before its market introduction. Additionally, university clinics get the chance to improve the strength of their qualitative and quantitative research.

Clinical research contributes an important share of the financing of universities

From the economic point of view, clinical research offers university clinics burdened with high cost pressures the opportunity to raise additional funds for top-notch research. Currently, German universities and university clinics receive approximately 800 million EUR annually from corporate sources. This corresponds to 38.6 percent of their total third-party funds. These funds finance 40.1 percent of universities' R&D personnel (see Figure 5.8), and thus, as shown in chapter 7.2, can create thousands of jobs.

Fig. 5.8: Significance of third-party funds in financing universities and university clinics



Source: Statistisches Bundesamt (2004): Im Fokus: Drittmitteleinnahmen der Hochschulen im Jahr 2002.

The significance of private sources, and especially the pharmaceutical industry, in financing clinical research in university clinics and medical schools will only intensify in the future.[44] Between 1997 and 2002, funds from the German Research Foundation (DFG, the central public funding organization for academic research in Germany) increased by just 8.4 percent annually, whereas in the same period funds from corporate sources and private foundations increased by 11.5 percent annually. This increased the share of private financing (economy and private foundations) from 44 percent to 47 percent.[45]

The interviewed companies' clinical research plays an important role worldwide as well as in Germany:

Interviewed companies account for 45% of all medications in clinical research worldwide

- Currently, the interviewed companies do clinical research on more than 540 medications worldwide. This represents about 45 percent of all clinical research on medications done by the 40 largest companies in 2003.[46]
- The interviewed companies' clinical studies executed in Germany strengthen the domestic research economy. In 2003, the interviewed companies notified BfARM (Bundesinstitut für Arzneimittel und Medizinprodukte, the Federal Institute for Drugs and Medical Devices) and Paul-Ehrlich-Institut (the Federal Agency for Sera and Vaccines) of approximately 260 clinical studies.
- In 2003, the interviewed companies executed more than 650 clinical studies of phases I to III with approximately 45,000 patients at German university clinics and medical universities.

At Hanover Medical University, 22% of all third-party funds are from clinical studies

Further evidence of the economic significance of the pharmaceutical industry's clinical studies in financing university clinics and medical schools comes from a current A.T. Kearney study conducted with Hanover Medical University (Medizinische Hochschule Hannover), which finds that 25 percent of all third-party funds involve clinical studies. At 90 percent, the pharmaceutical industry contributes the dominant share of these funds.

As a location for clinical development, Germany is in the center of the pack internationally

Despite many fears, clinical development in Germany is at least part of the international concerto—although not playing a leading role. Among other accomplishments, Germany takes an internationally leading position in the treatment of leukemia and lymphomas.[47] An A.T. Kearney analysis of the location distribution of clinical studies shows that compared to France and the UK, Germany should be able to house a comparable number of clinical studies. We evaluated the U.S. National Institutes of Health's database at www.clinicaltrials.gov listing all clinical studies on the treatment of serious or life-threatening diseases in the U.S., financed publicly or privately, and including information on other countries participating in those studies (see Table 5.1).

Table 5.2: Clinical studies in Eastern Europe					
	Country	**Number of studies**	**Percentage of studies located outside U.S. (total = 728)**	**Phase**	**Number per phase**
Eastern Europe	**Poland**	106	15%	I	1
				II	19
				III	80
				IV	6
	Hungary	70	11%	I	0
				II	16
				III	57
				IV	6
	Russia	62	9%	I	3
				II	11
				III	46
				IV	2
	Czech Republic	43	6%	I	1
				II	5
				III	35
				IV	2

Source: www.clinicaltrials.gov, A.T. Kearney Research (2005)

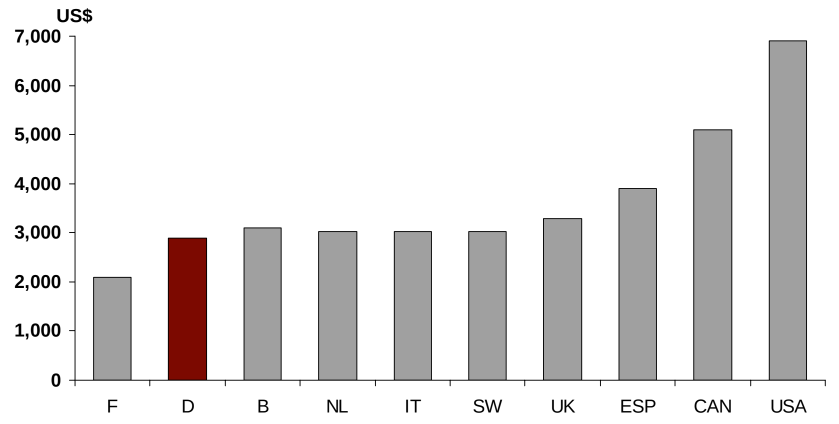
The pharmaceutical industry spent approximately 1.5 billion EUR for clinical development in Germany in 2003. This amounts to about 45 percent of total R&D spending.[48] Due to continually more complex licensing requirements, these costs are increasing annually.[49] Both the absolute size and the percentage of total R&D spending demonstrate clinical development's importance to German R&D. The number of clinical studies is comparable to those of France and the UK, though with Germany's larger population there is still room for improvement on a per capita basis.

Germany is an important clinical development location for the interviewed companies, as demonstrated by the fact that they conducted approximately 650 clinical studies in Germany in 2003—roughly 20–25 percent of the total clinical studies they did worldwide.[50]

Germany has important location advantages for clinical development

Germany can keep this strong competitive position because it has some important advantages over other industrial countries. Among other factors, Germany has a high population density[51] that puts a large number of patients near university clinics, good specialized scientific know-how in some areas (including diabetes and lung research), many universities and non-university research organizations, a high quality of studies that have strongly closed the gap in the last ten years, and an outstanding reputation today with regard to reliability and quality of data.[52] Furthermore, Germany's cost position is quite competitive with other industrial countries. In the United States, the costs for Phase III clinical studies average more than 50 percent higher per patient than costs in Western Europe (see Figure 5.9).[53]

Fig. 5.9: Per patient costs for clinical studies in phase III



Source: CRA (2004): Innovation in the pharmaceutical sector

Germany must stand its ground: International competition for clinical studies will increase massively

However, Germany must fight to keep its position in international competition because many other countries are actively promoting clinical research. Pharmaceutical companies often give preference to the northern countries, and increasingly also the new EU member countries (where the number of clinical studies is up 30 percent annually),[54] because they produce good quality data with less bureaucracy and thus better speed. Recently, Asia and Latin America (where spending on clinical studies is up 45 percent annually each)[55] have leaped forward in the quality and quantity of their clinical examinations—in the future, India, especially, could become a key player in this area.[56] In general, Eastern European countries have the advantage of faster patient recruitment. Already today, 15 percent of all listed studies at the U.S. National Institutes of Health are executed in Poland, 11 percent in Hungary, and 9 percent in Russia (see Table 5.2).

Table 5.2: Clinical studies in Eastern Europe

	Country	Number of studies	Percentage of studies located outside U.S. (total = 728)	Phase	Number per phase
Eastern Europe	**Poland**	106	15%	I	1
				II	19
				III	80
				IV	6
	Hungary	70	11%	I	0
				II	16
				III	57
				IV	6
	Russia	62	9%	I	3
				II	11
				III	46
				IV	2
	Czech Republic	43	6%	I	1
				II	5
				III	35
				IV	2

Source: www.clinicaltrials.gov, A.T. Kearney Research, 2005

As a result, Germany shows good potential in the area of clinical research, but it must be maintained and extended. Recent debates in Germany, saying that health insurance funds should not cover treatment costs for patients participating in clinical examinations, are potentially harmful. Such initiatives give the researching companies a feeling of uncertainty. Of course the costs of the clinical examination as such must be borne by the sponsor. But if the study also had to cover complete treatment costs, its price would rise dramatically, and Germany would no longer be able to resist cost competition with other countries.

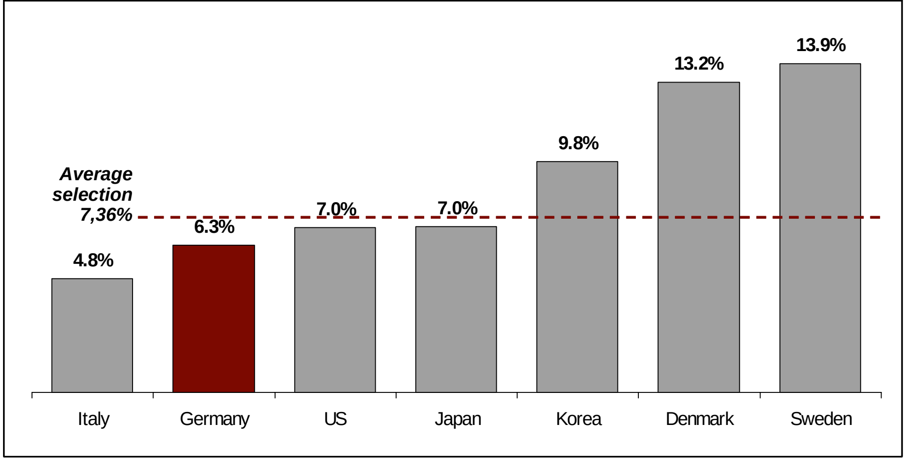
With the establishment of the Koordinierungszentren für Klinische Studien (KKS, the Coordination Center for Clinical Studies), the Interdisziplinäre Zentren für Klinische Forschung (IZKF, the Interdisciplinary Center for Clinical Research), the national genome research law, and promotion programs in biotechnology and health research, first steps towards the promotion of clinical research are complete.

5.2 Production

Germany loses significance as a production location

Germany has lost its attractiveness and significance for pharmaceutical production in recent years. During the 1980s the country was still the world's third-largest pharmaceutical producer, (measured by production value) behind the United States and Japan. Today, Germany ranks just fifth.[57] In contrast, for example, Sweden and Denmark increased their production levels by double-digit annual growth rates of 13.9 percent and 13.2 percent, respectively, between 1992 and 2000. Asian countries such as Korea have also achieved comparable growth rates (see Figure 5.10). In many cases, this development was driven by special national industrial promotion programs (see chapter 7).

Fig. 5.10: Development of pharmaceutical production
(selection, CAGR 1990-2000)



Source: OECD, A.T. Kearney Research (2005)

Even interviewed companies reduced production in Germany

In our study, the interviewed companies generally noted that Germany was losing significance as a production location. Only 6 of the 15 interviewed companies operated a German production site in 2003. By comparison, at the beginning of the 1980s, 9 of those 15 produced in Germany. Especially since the beginning of the 1990s, international companies have increasingly decided not to build or expand production capacity in Germany. The case study in Figure 5.11 provides an example of such a decision.

Fig. 5.11: Case study – Investment decision regarding production facilities in Germany

In the late 1990s, one of the world's largest pharmaceutical companies faced a decision -- whether to keep four production locations (with a total of 1,000 employees) in Germany, or transfer production to other countries.

Executives at the company's U.S.-based headquarters decided to close all four German production facilities, and transfer production to Ireland and the United Kingdom. The reasons for the decision were attributed to constantly deteriorating conditions in Germany, including:

- A political framework that put undue burden on the pharmaceutical industry, making it difficult to plan for future investments.
- Labor costs and labor extra costs as well as the increasing demand for time off made work in Germany far more expensive than in competitor countries such as the United Kingdom.
- Corporate tax rates in Germany were less appealing than in countries such as Ireland

Based on these conditions, even production locations that required a high degree of technological expertise could not withstand the comparison with other locations. As maintenance investments dried up, manufacturing plants became obsolete and were no longer competitive.

Source: A.T. Kearney Research (2005)

In general, Germany suffers from the same weaknesses regarding pharmaceutical production that it does for other industries. Investments are especially hindered by high enterprise taxes and the labor market. An international comparative assessment showed the German labor market decreasing: on a scale of 1 (bad) to 10 (good), Germany scored 2.9 in 1997 but just 1.5 in 2003. Comparative figures for 2003 included United States 7.3, UK 5.8, and France 2.1.[58]

Some recent investment decisions have favored Germany, highlighting two success factors:

- Increasingly, local location partners are willing to be flexible in their bureaucratic procedures (such as licensing procedures) and timeframes. So for example in mid-2005 the pharmaceutical company GlaxoSmithKline decided to enlarge its vaccine production site in Dresden with a 94.3 million EUR investment that doubled the site's annual production of influenza vaccines. Dresden won out over Singapore and South Korea. The decision's determining factors involved not just the site's excellent infrastructure and location synergies, but the employees' competence and flexibility as well as the Saxon government's support through fast and unbureaucratic licensing procedures.

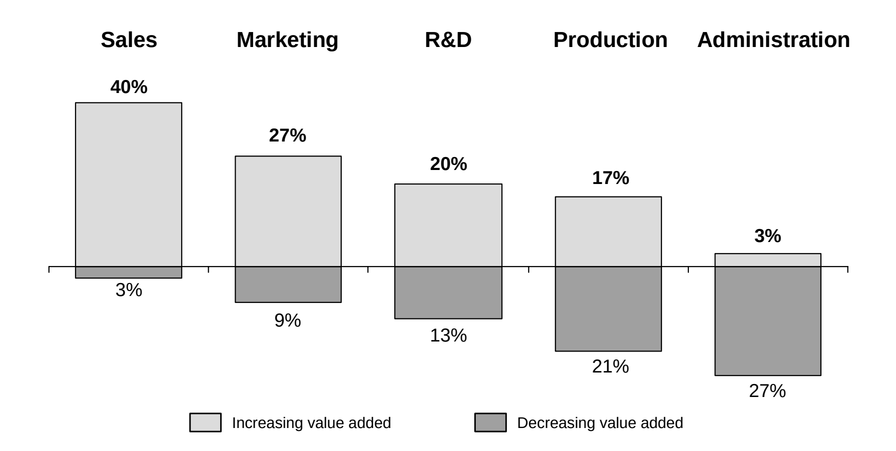
Germany should further strengthen its competitive position in bio-pharmaceutical production

- Though Germany, as demonstrated above, lacks broad competitiveness, it does boast location advantages in fast-growing innovative production areas such as biopharmaceutical production. These production processes are more complex, and require a differentiated infrastructure and the availability of specific resources. Groups like Roche and Boehringer Ingelheim recognized these German advantages, and invested heavily in building modern biotech production plants (Roche 420 million EUR, Boehringer Ingelheim 255 million EUR). Abbott and Aventis also operate biotech labs in Germany. Altogether, Germany's biopharmaceutical production capacity in 2003 ranked behind only that of the United States.[59]

5.3 Marketing and Sales

Because of the huge size of its market, Germany is a leading choice for marketing and sales for multinational corporations in all industries. In the coming years, nearly half of all multinational corporations expect to increase their German sales activities.[60] On the other hand, one-third of all companies expect that the role of personnel-intensive administrative functions will diminish in the German economy, due to its locational weaknesses as opposed to the potential productivity increases that can be achieved through outsourcing, cross linking, and electronic media (see Figure 5.12).[61]

Fig. 5.12: Expected change in value added in Germany



Source: AmCham Germany (2005): Perspektiven zum Wirtschaftsstandort Deutschland

Sales and marketing are very important for pharmaceu-tical companies

In the coming years, the pharmaceutical companies expect to further increase their sales and marketing activities. This expectation is based on several factors:

- Companies need to account for medications' high complexity and short innovation cycles through detailed and intensive communications.

- An ever-shortening *time-to-market* also increases demands on pharmaceutical companies' distribution.

- In the near-term, the physician will continue to be the pharmaceutical companies' central partner (despite the mail-order business). This communication requires significant field services.

High communication demands lead to above-average sales and marketing costs

Pharmaceutical companies' spending on sales and marketing amounts to approximately 25–30 percent of sales.[62] At the same time, commercializing innovative medications requires special employee qualifications: 30 percent of the sales and marketing employees of the interviewed companies are higher-education graduates. Only the pharmaceutical industry has legal regulations covering special duties of sales personnel. The law holds the sales representative responsible for having specialized knowledge in medical and pharmaceutical science.

The outlook for the future development of sales and marketing—as it relates to the economic performance and employment capability of the German pharmaceutical industry—is non-uniform:

- On the one hand, pharmaceutical companies will be forced to squeeze out savings due to expected sales losses through patent terminations and new firm amount regulations. Experts believe this will also impact field service. Even now, competing pharmaceutical companies co-operate, complementing each other in the sale of non-competing medications.
- On the other hand, decreasing product differentiation and shorter exclusivity periods will emphasize the importance of comprehensive market coverage and differentiated control of distribution channels. Sales will depend on highly qualified distribution teams advising specialists, for example oncologists for cancer, and neurologists for multiple sclerosis and Parkinson's disease. Here, Germany can look forward to high employment potential for very well trained employees.

Simply because of its size, Germany will remain an important location for sales and marketing activities. If political changes force international pharmaceutical companies to seek further savings, this would also have an impact on sales and marketing employees in the medium-term.

Sidebar: Why Foreign Companies Choose to Invest in Germany

Example: General Electric builds a new research center in Garching near Munich

In October 2002, General Electric surprisingly announced that it would build a new research center near Munich. Garching beat out eight locations vying for the center. The 10,000-square-meter GE Global Research Center officially opened on June 28, 2004. In a first phase, the American company invested 52 million EUR in the location. A second phase is planned with a comparable investment. The new research center offers jobs to 150 highly qualified researchers; the second phase will add another 150 researchers. GE chose Garching because of its existing specialists, its proximity to customers, and the Munich area's reputation for high-quality research (see Figure 5.13).

Munich attracts even international groups as a research location for medical engineering

Fig. 5.13: Why GE located the Research Center in Germany

1. **Researchers:** Garching is located near Munich that boasts German scientists who are leaders in all areas of research
2. **Research should be near the customer:** General Electric has large-scale customers in Germany especially in medical engineering and the automobile industry
3. **Quality of research:** The prestigious Technische Universität München is located in Munich and has close links with other high-quality research organizations

"By focusing on core themes like research and technology, it is possible now as ever to create growth and jobs in Germany."

Thomas Limberger, Chief Executive Officer

GE Central Europe

Source: A.T. Kearney Research (2005)

The new center is the third-largest research location worldwide for GE, the largest company in the world based on market capitalization. Each center concentrates on a certain development focus. While Bangalore, India, focuses on information technology, for example, the employees in Garching research new sources of power (such as photovoltaic and fuel cells), medicine, plastics, and sensor techniques.

Germany's higher costs did not affect the decision: "If you want to engage top people in research, they are expensive all over the world today." A researcher's workplace—including not just the scientist but the lab, access to university research organizations, assistants, and other infrastructure—is no more expensive in Germany than, say, the United States.[63]

Example: Roche Diagnostics builds a biotechnology production site in Penzberg (Bavaria)

In July 2004, the Swiss company Roche announced it would enlarge its biotechnology production in Bavarian Penzberg. To that end, the company will invest 290 million EUR into expanding Europe's largest biotech production location. Thus, 150 new highly qualified employees will join the existing 3,600 employees on location. The location prevailed over seven other Roche locations in the company's internal competition (see Figure 5.14). In 2007, the new plants will be up and running, and according to company information, will start production after 2009 depending on the establishment of processes and the execution of licensing procedures.

Bavaria attracts investments into biopharmaceutical production

Fig. 5.14: Why Roche decided to locate in Penzberg, Germany

1. **Specialists and scientific expertise:** Excellent location to train employees
2. **Regulation:** Acceleration of relevant licensing processes
3. **Infrastructure:** Innovative and highly-qualified infrastructure allows Roche to continually optimize production and supporting processes

"I still consider Germany to be one of the best locations."
Dr. Jürgen Schwiezer, Chairman of the Executive Board
Roche Diagnostics

Source: A.T. Kearney Research (2005)

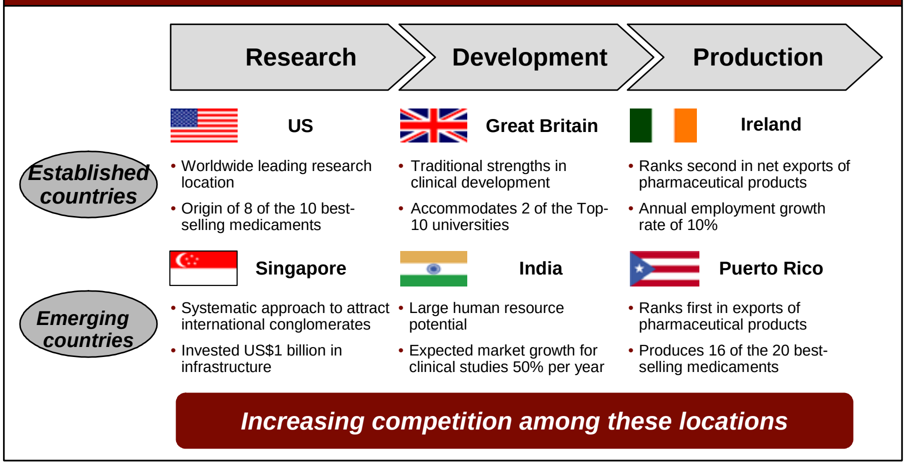
6 Effective Policies to Promote Innovation

6.1 Promoting the Research-Based Pharmaceutical Industry in Other Countries

Germany must compete with other countries, which in past years have made numerous efforts to keep the pharmaceutical industry within their borders, or offer it incentives for new investments.

It's important to note that Germany competes against established countries in R&D as well as production. Yet in recent years other countries, especially from the Asia-Pacific region, have entered this competition. In both R&D and production, the globalization trend sends competencies and resources worldwide, and the new entrants grab an increasing portion of the value chain (see Figure 6.1).

Fig. 6.1: Successful countries along the pharmaceutical value added



Source: A.T. Kearney Research (2005)

Let's take a tour of countries across the various phases of the pharmaceutical innovation process, focusing on value-added sections.

6.1.1 Established Countries

6.1.1.1 USA

Since the early 1980s, the USA has become the world leader in pharmaceutical research. The main reasons have been the following mutually strengthening factors:

- **Science and technology leadership:** The USA clearly leads the world in biomedical research—eight of the ten best universities in the world are American.[64] Furthermore, pharmaceutical companies benefit from the use and promotion of new technologies: In 2001, the US biotech industry alone spent 15.6 billion US$ on R&D, far outpacing the entire European biotech industry.[65]

Clustering and public promotion made the USA the leading research nation

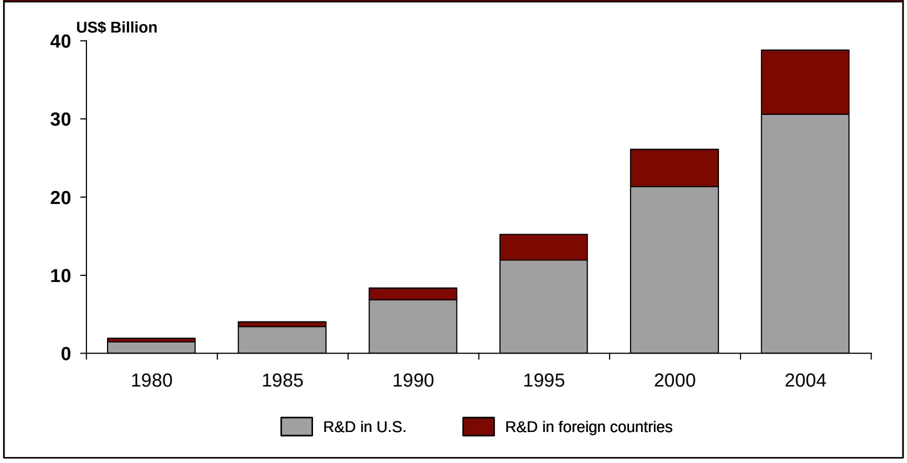
- **High public research spend:** The size of research spending by the National Institutes of Health (NIH) eclipses all comparable European institutions. In 2003, the NIH R&D budget amounted to approximately US$24 billion. By comparison, the same year the UK's National Health Service (NHS) spent approximately US$750 million for R&D. In 2005, BMBF has approximately US$8 billion at its disposal for total spending on education, science, research, and development.

- **Promotion of technology transfer:** By the 1980s, the USA recognized the necessity of a strong link between academic and industrial research. The Bayh-Dole Act of 1980 gave research universities the right to apply for a patent for their inventions, and to make use of the patent through corporate licensing contracts. From 1993 to 2000 alone, U.S. universities received 20,000 patents, some of which brought several million dollars in licensing fees, and led to the establishment of more than 3,000 new companies.[66]

- **Market size and pricing**: With a volume of approximately US$220 billion, and a share of approximately 47 percent, the USA is the largest pharmaceutical market in the world.[67] As in recent years, double-digit annual sales growth is forecast for the American pharmaceutical market in the future, increasing the USA's share of the world's pharmaceutical market to 61 percent.[68] Even during R&D, pharmaceutical companies value good co-operation with key opinion leaders in the largest markets.[69] Moreover, in contrast to Europe and Japan, the USA lacks price controls, a distinct value for the U.S. pharmaceutical industry.[70]

The following numbers demonstrate the phenomenal success of pharmaceutical research in the USA: In 2004, U.S. pharmaceutical and biotech companies invested a record US$38.8 billion in R&D on new medications. This capped over 20 years of continual increases in R&D spending, dating back to a value of US$2 billion in 1980 (see Figure 6.2). Thus, U.S. R&D spending increased about twice as much as Europe's, and in the 1990s, the USA passed Europe as the world's leading research location. Whereas European pharmaceutical companies in 1990 spent 73 percent of their research budget in Europe, by 1999 that figure was down to 59 percent.[71]

Fig. 6.2: R&D spend of U.S. pharmaceutical companies



Source: PhRMA (2005): Pharmaceutical Industry Profile, 2005

Currently, the U.S. pharmaceutical industry directly employs approximately 223,000 people.[72]

6.1.1.2 UK

Traditionally, the UK has played a leading role in the area of clinical research, building an excellent international reputation. The cornerstones of British success are access to know-how and capabilities, increasing public investments in R&D, and the promotion of private R&D spending through the price regulating system (PPRS).[73] An additional important advantage, especially for clinical research, is the fact that licensing need go through just a single commission. In addition, until recently medical institutions like the Wellcome Trust or the publicly-financed Medical Research Center secured financing.[74] The UK has developed many methodologies for broadly designed studies, meta-analyses, etc., in patient-oriented clinical research.

Whereas the other countries of Europe have to fight for their positions as locations for research and development, the UK increased its share of worldwide R&D spending from an average of 10.0 percent in 1973–1977 to an average of 13.1 percent in 1996–2000.[75]

In recent years, however, the UK's framework conditions for clinical research deteriorated significantly, and the country now faces obstacles similar to Germany's. Companies criticize long initial waiting periods, a difficulty in recruiting patients, high costs, and regulatory barriers.[76] At the same time the UK lacks some required infrastructure and trained clinical researchers.[77]

Therefore, the UK has recently made strong efforts to revitalize its clinical research capabilities. These efforts are based on recommendations of the Academy of Medical Sciences and the

Bioscience Innovation and Growth Team, among others.[78] Concrete results have included:

The UK has taken measures to maintain its traditionally strong role in clinical research

- **UK Clinical Research Collaboration (UKCRC):** Founded in 2004, this institute seeks to shorten the timeframe of the clinical development process from lab to patient. In particular it seeks to more effectively harness the potential of the NHS as one of the world's largest healthcare providers. To do this, it has brought together all parties participating in clinical research: medical universities, the NHS, regulatory boards, industry, and patients. It seeks to build the necessary NHS infrastructure and research personnel, create incentives for NHS research, and simplify and standardize regulatory processes.[79]

- **Public financing**: The government budgeted 24 million pounds to build up five new NHS research networks: for Alzheimer's disease, strokes, diabetes, mental health, and children's diseases. In addition, the NHS R&D budget will increase by 100 million pounds per year by 2008.

Industry welcomed this development, expecting that it will benefit clinical development in UK. Industrial representatives assess the UK as a leader in improving the framework conditions for pharmaceutical R&D.[80]

6.1.1.3 Ireland

During the 1980s and '90s, Ireland became an important production center for the international pharmaceutical industry. Most multinational pharmaceutical companies operate production sites in Ireland. The reasons:

Attractive tax policy promotes Ireland's pharmaceutical production – employment grows by 10% annually

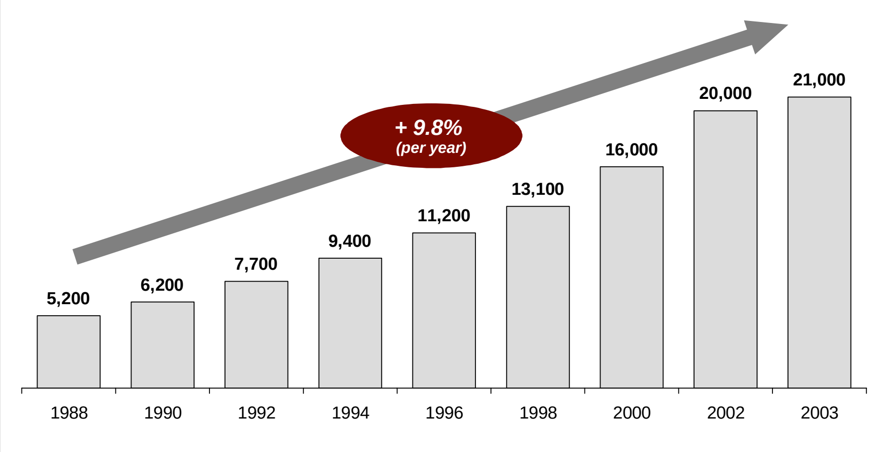
- **Tax easements**: Ireland has lowered its corporate tax rate to a flat 12.5 percent, which the government has pledged to continue, making long-term investment attractive.

- **Infrastructure**: Local companies provide excellent infrastructure. In particular, they offer a broad range of services and technological competencies.

- **Availability of resources**: Early on, Ireland invested in education, meaning that it can offer employers an array of scientific and medical specialists and graduates.

As a result, Ireland is increasingly becoming a net exporter of pharmaceutical products. At approximately 7 billion EUR, the balance of trade in the pharmaceutical sector was strongly positive in 2001. This had beneficial effects on employment. From 1988 to 2003, employment in the pharmaceutical industry grew by 10 percent annually (see Figure 6.3). In 2003, approximately 2 percent of all Irish employees worked in the pharmaceutical industry.[81]

Fig. 6.3: Employees in pharmaceutical industry in Ireland



Source: IPHA (2004): Statistics

These examples show how individual countries can successfully position themselves to add value in the worldwide pharmaceutical industry, and how a well-aimed public effort to improve business conditions can support this. However, during recent years Asian countries, especially, have also sought a strategic position in the pharmaceutical industry. In some countries, the pharmaceutical industry is already far developed, and creates attractive opportunities for international companies. Likewise, a selection of those countries can be characterized through orientation by value added.

6.1.2 Developing Countries

6.1.2.1 Singapore

Singapore's Biomedical Sciences Initiative: A systematic approach to make the country a center of life sciences

As a newly industrializing nation, Singapore has successfully launched efforts to compete for high-grade pharmaceutical R&D activities. Its starting point came when the government set a goal to develop the city-state as a center for pharmaceutical, biotech, and medical engineering industries. To this end, in 2000 Singapore initiated a Biomedical Sciences Initiative (BMS), whose systematic activities are coordinated by the Agency for Science, Technology and Research (A*STAR):

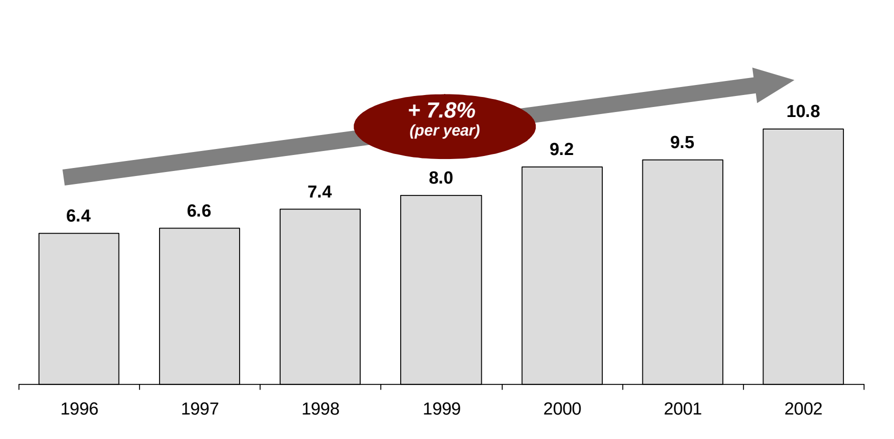
- **Building excellent infrastructures**: Singapore's showpiece is a science park called "Biopolis" – a 200-hectare area serving as the workplace for approximately 2,000 researchers in both public and private sectors. Biopolis makes available many companies' commonly-used resources such as modern laboratories, animal testing facilities, and incubators for start-up businesses. Singapore also has a Center for Drug Evaluation that carries out the same functions as the U.S. Food and Drug Administration (FDA). Altogether, Singapore invested approximately US$1 billion to build an outstanding infrastructure (including an additional science park in the west of the city-state). Additional components of this infrastructure include the availability of world-class telecommunication technologies and a residential park designed especially for scientists.

- **Financial incentives**: Singapore's government currently promotes about 30 venture capital companies that invest in life science companies. In addition, it fosters foreign investment in life sciences companies through measures including, for example, subsidizing investments in research centers, offering 5 to 10 year tax holidays, and providing liberal exemptions for expatriate staff. Foreign investors are given preferential treatment according to three dimensions of status: Distinguished Partners in Progress, Distinguished Friends of Singapore, and Business Friends of Singapore.

- **Securing well-educated resources:** Singapore's government promotes student interest in life sciences through various measures that are expected to increase new students by 50 percent within three years. Some of the more exemplary programs include scholarships for life sciences students and the "National Science Talent Search" competition.

Five years after starting BMS, Singapore is an up-and-coming player in biomedical research, and an attractive investment location for international pharmaceutical, biotech, and medical engineering companies. For example, GlaxoSmithKline announced an investment of approximately US$40 million to build a pre-clinical research facility where 30–35 scientists will examine diseases of the central nervous system. We can also see Singapore's increasing attractiveness as an R&D location through the growth of its R&D employees. From 1996 to 2002, the R&D employment rate increased from 6.4 per 1,000 total employees to 10.8 (see Figure 6.4).[82] By comparison, the EU average is 10.7.

Fig. 6.4: R&D employees in Singapore
(per thousand total employees)



Source: OECD (2003a): Science, Technology and Industry Scoreboard, 2003

6.1.2.2 India

Clinical research in India benefits from natural location factors and public promotion

India is on its way to becoming a key cog in the worldwide pharmaceutical industry value chain. It has promoted itself as a production location, and, more recently, as a location for clinical studies. India's strong points include the following location advantages, which in combination with public promotion will allow it to compete vigorously with established countries:

- **Patient recruiting**: The Indian population represents a very large pool of patients—participants are available for studies on almost all treatable diseases (40 million asthma patients, 34 million diabetes patients, 8 million epilepsy patients, 3 million cancer patients, etc.). Furthermore, patient recruiting can be extremely fast: Contract research organizations (CROs) can recruit patients for a phase III study in India within two months—in the UK this takes up to one year.[83]

- **Cost advantages:** India offers cost advantages estimated at 50–70 percent below that of the USA. For example, a three-month pre-clinical toxicological study with one active substance in the USA costs approximately US$850,000, but less than US$250,000 in India.[84]

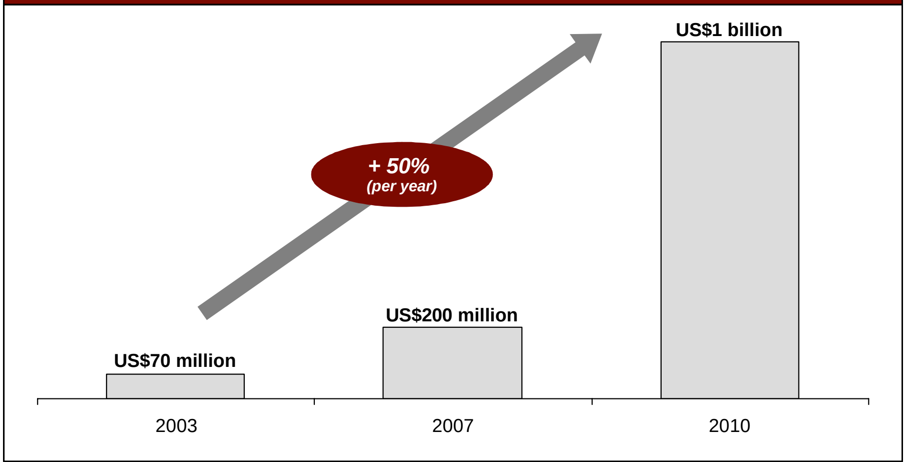
- **R&D personnel:** One of the most important advantages of Asia is the large number of scientists and well trained technical personnel earning far less than R&D personnel in the USA (approximately 25 percent), all of whom speak fluent English.

The government is also contributing to India's jump-start into the global competition for clinical studies, and is expected to play an important future role through:

- **Improved patent law**: Until recently, growth of India's pharmaceutical industry was hindered by a gap in medication patent laws as well as a generally bad business climate. But India now reformed the patent law to World Trade Organization (WTO) standards; since the beginning of 2005 innovations are protected and foreign companies can sell their products in India without fear of being ripped off by cheap copies.
- **Liberalization of FDI regulations**: Since 2001, the government has sought to make foreign direct investments more attractive by allowing complete ownership of pharmaceutical businesses. In general, the government is striving to reduce or remove bureaucratic barriers to foreign companies that want to produce in India.
- **Public financing***:* In May 2005, the government established a US$34 million public fund to support the risky medication development. In addition, it plans to increase spending on R&D from 1 percent to 2 percent of gross domestic product.

Based on these factors, we can expect annual growth rates of approximately 50 percent, with India's share of the worldwide market for clinical studies increasing from 0.7 percent today to 20 percent in 2010 (see Figure 6.5).

Fig. 6.5: Expected market growth for clinical studies in India



Source: Organization of Pharmaceutical Producers of India, India Business and Investment (2004), A.T. Kearney Research (2005)

6.1.2.3 Puerto Rico

Tax policy draws pharmaceutical production to Puerto Rico

With nearly one-quarter of the market, Puerto Rico is the world's largest exporter of pharmaceutical products. At present, around 30,000 people work in pharmaceutical production; this is one-quarter of all employees in the manufacturing sector. Furthermore, such employment creates an additional 90,000 jobs in upstream and downstream industries.[85] According to the pharmaceutical industry, 16 of the 20 most popular U.S. medications are produced on the island—nine of them world exclusives.

The main reasons for Puerto Rico's success are:

- **Tax policy**: Because of Puerto Rico's standing as a U.S. jurisdiction with foreign tax benefits, there is no customs frontier. The Dollar is the national currency. Companies such as Pfizer, Merck, Bristol-Myers Squibb, and Schering-Plough pay a low corporate tax rate of just 5–7 percent; in the USA they pay 35 percent. American biotech companies even enjoy exemption from taxation, as well as numerous other government incentive programs.

- **Labor cost level**: Employees' salaries are as low as 65 percent below U.S. levels.

Amgen, Eli Lilly, Abbott Laboratories, and others have invested approximately US$2.5 billion into new production plants on the island since 2001. With an export volume of US$37 billion in 2003, the pharmaceutical industry accounts for 26 percent of Puerto Rico's gross domestic product, and 67 percent of all exports.

The Puerto Rican pharmaceutical industry's development in coming years will be of great interest. On December 31st, 2005, the public investment subsidy will expire. Nevertheless, experts do not expect an exodus of pharmaceutical companies. Whereas the public subsidy was an important factor in drawing new investments to Puerto Rico, now that they have already been made, the advantageous labor costs and customs regulations should motivate the companies to stay.[86]

6.2 Promoting Innovative Industries in Germany

Germany can also successfully promote innovative industries, as the examples of optical technologies and medical engineering prove. The growth achieved in these industries, and the related job creation, is largely the result of effective government policies. This could be a standard for well-aimed support of the research-based pharmaceutical industry.

6.2.1 Optical Technologies

Clustering as a success component for the promotion of optical technologies

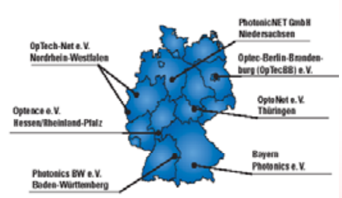
Industry groups forecast annual growth rates of 10 to 20 percent for optical technologies. This would represent a tenfold increase in the market through the year 2013. Research shows that optical technologies will even surpass electronics in significance.[87] Even today, the presence of this key technology in Germany has influenced approximately 15 percent of manufacturing jobs, which means approximately one million jobs.[88] At the same time, optical technologies are pacesetters for other technological developments and utilizations such as communication and production techniques, biotechnology, and nano-electronics. Japan and especially the USA are working to conquer this future market, also with remarkable public support.

This prognosis has been taken into account by the industry as well as by policy in Germany. Industry and the public combined to support a strategic process encapsulated in “Germany’s 21st Century Agenda for Optical Technologies“ (“Deutsche Agenda Optische Technologien für das 21. Jahrhundert”) in 1999/2000. In February 2002, the BMBF launched a promotional program called “Optical Technologies – Made in Germany,“ providing 280 million EUR in funding over a period of five years.[89] This financial support was linked to other efforts to optimize the business climate (see Figure 6.6).

Fig. 6.6: Ensuring favorable launch and framework conditions

The federal government is pursuing several measures to improve Germany’s attractiveness as a location for optical technologies. These measures include:

1. **Cross-linking resources – competency nets and optical technologies:** Build-up seven “Kompetenznetze Optische Technologien" to create “optical valleys.” The BMBF is using public-private partnerships to support these valleys.

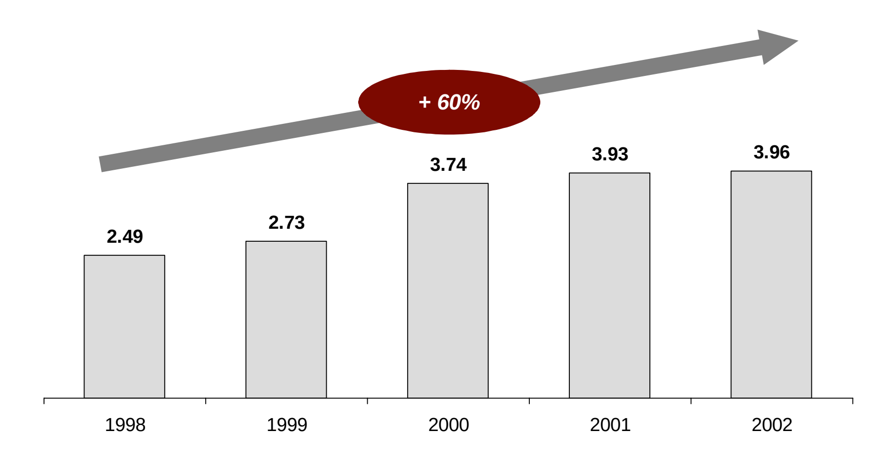


2. **Education and training**: Secure the required specialists by offering continuation of coursework, improved training programs, and the "Faszination Licht“campaign, which is designed to improve awareness of these technologies among new graduates
3. **Encourage small- and medium-scale companies**: Support the participation of small- and medium-scale companies through the use of grants and bonuses to promote various projects. The goal is to achieve a desired percentage (40% to 50%) participation.

Source: A.T. Kearney Research (2005)

This well-aimed promotion strategy helped propel Germany to lead the world in many optical technology utilization areas. Thus, worldwide about 40 percent of the laser beam sources for treatment of materials are produced in Germany. Between 1998 and 2002, German companies increased their sales by 12.3 percent annually (see Figure 6.7).[90]

Fig. 6.7: Revenue development of „Optical Technologies" in Germany (in bn. Euro)



Source: Spectaris (2005): Fortschrittsbericht Neuausrichtung.

According to the BMWA (Federal Ministry of Economics and Labor, or Bundesministerium für Wirtschaft und Arbeit), optical technologies directly employ 110,000 people. The number of employees has increased by an average of 15 percent per year—doubling since 1996. Optical technologies influence 16 percent of the jobs in manufacturing industries. It is forecasted that 15,000 additional jobs will develop by 2010 in medium-scale companies alone. In 2004, the export quota ranked at a remarkable 66.8 percent—proof of German products' strong international competitive position in this industry. Already in 2004, the R&D quota averaged nearly 10 percent.[91]

6.2.2 Medical Engineering

Medical engineering is one of the most attractive growth markets in the world. The market is growing 5 to 7 percent annually in industrial countries, and more than 12 percent annually in Asia (excluding Japan) and Latin America. By 2010, medical engineering spending is expected to increase from 6.8 to 7.1 percent of total health spending. Reasons for this growth include the continual aging Western industrial populations, increasing life expectancy, and technological progress. Above-average growth is also expected in regions such as Central Europe and China where there is a strong backlog demand. Decreasing hospital in-patient stays are leading to more ambulatory operations and after-treatment, thus also causing demand for devices and instruments in ambulatory practices and clinics. This presents long-term growth opportunities for German companies, which at the same time secures German R&D jobs.

Promotion of medical engineering through competency centers

Until 1999, the BMBF promoted medical engineering mainly as part of other technical measures. Since 1999, its research promotion has focused more on utilization- and patient-oriented aspects. To that end, BMBF designed a framework to promote medical engineering (see Figure 6.8). In 2004, the medical engineering promotion budget totaled 35 million EUR. An overview of publicly-supported research shows more than 1,100 projects, supported directly through EU, DFG, and BMBF, or indirectly by various research associations.[92]

Fig. 6.8: Framework to promote medical engineering

Through its "Rahmenkonzept Medizintechnik,"the BMBF plans to strengthen and further extend the growth market in medical engineering:

1. **Innovation competition to promote medical engineering:** The BMBF offers an innovation prize of 1.7 million EUR to encourage researchers to develop and push innovative projects in medical engineering through to completion.

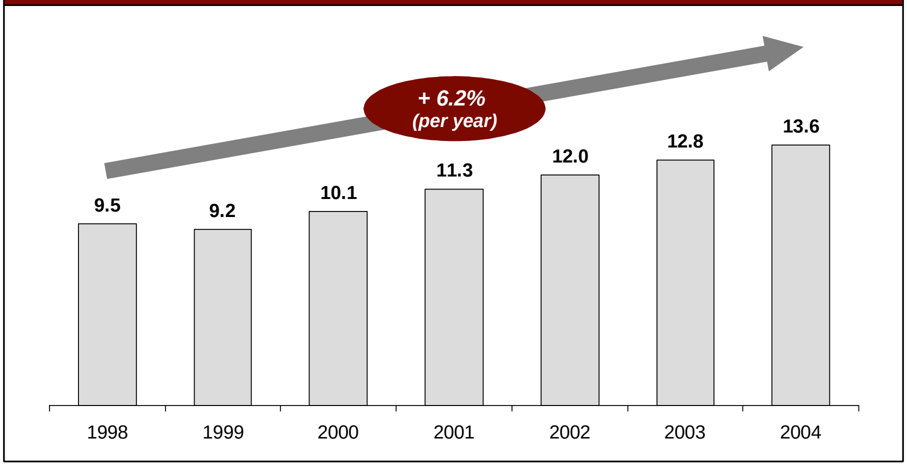
2. **Competency centers for medical engineering:** Since March 1999, the BMBF has been supporting competency centers for medical engineering. To date, the eight selected centers have received a total of 30 million EUR.

3. **Innovative singular approaches**: The BMBF also supports innovative singular approaches in medical engineering such as research on compound retina implants. For patients suffering from retinopathia pigmentosa, an electronic retina prosthesis replaces the degenerated retina, thus providing the patient with limited sight.

Source: A.T. Kearney Research (2005)

Germany is the world's third-largest producer of medical engineering products, behind only the USA and Japan. The USA is generally seen as the worldwide technology leader in all areas; in Europe, most see Germany or the UK as leaders. The German medical engineering industry excels particularly at X-ray apparatuses as well as dental materials, instruments, and systems. The German medical engineering industry has had a great deal of recent success, with total sales increasing by an average of 6.2 percent annually (see Figure 6.9).

Fig. 6.9: Development of market for medical engineering
(in billion EUR)



Source: Spectaris (2004): industry report 2004

The industry's competitiveness is linked to its high innovation potential. Nearly 25 percent of sales come from products less than two years old. New technologies in micro system techniques, laser techniques, and nano-technology are continually replacing outdated products.

Employment figures are also quite positive, with an increase of 1.2 percent to 90,000 employees in 2004. Since 2000, the number of employees increased continually from 79,000 to 90,000 (an annual growth rate of 3.3 percent).

On the other hand, the looks quite different. Even today, growth comes almost entirely from foreign markets, while the domestic market has stagnated for many years due to German Public Health's reforms and investment blocking. According to the industry association Spectaris, the German medical engineering industry's foreign sales increased by 33 percent from 2000 to 2003—twice as fast as domestic sales. This meant that the industry's average export share rose to 58 percent in 2004. In the future, the legislation's increasing rationing decisions will require medical products to prove their effectiveness and cost efficiency as do medications. Growth of German medical engineering companies could be slowed because while success in domestic markets is generally a prerequisite for success in international ones, they face increasing difficulties in overcoming the reimbursement barrier.[93] Already today, industry associations are concerned about the ability of compensation systems to recognize innovations—a deficit that could be intensified with the introduction of DRGs (Diagnostic Related Groups—a prospective payment system that pays a set amount for a given diagnosis).[94]

7 Conclusions

7.1 Increasing Employment at Various Steps in the Pharmaceutical Industry

Increasing employment opportunities in the German pharmaceutical industry must be assessed differently for the various steps of the value chain.

Very large employment potentials within the R&D area

The preceding discussions have clearly shown that Germany has lost ground to its competitors as an R&D location. Furthermore, German R&D spending and employment are comparatively underrepresented. This trend is the most alarming, since as an exceedingly innovative industry, pharmaceuticals can make a huge contribution to the German economy's knowledge and innovation capabilities. For Germany to catch up to world leaders, garnering an increasingly large share of worldwide R&D spending (with its associated employment), Germany must further improve its business framework. Recent years have seen positive developments, especially in the area of clinical research, but they must be broadened.

Despite some rather negative portrayals, German clinical research today ranks at least on a middling level in international competition, and thus in the medium term Germany should seek to optimize the framework for clinical research. However, Germany's attractiveness as a location for basic research can be improved only on a longer-term basis, because the current competitive advantage of other countries, especially the U.S. and the U.K., is simply too large. What's more, because most investment decisions regarding new research centers are made on a long-term basis, such centers could lead to additional employment only within a longer period.

When it comes to production, it will be difficult to make Germany broadly competitive, especially compared to Asian countries such as India and Korea, because of cost factors. Therefore, Germany must concentrate on further establishing itself as a location for innovative production processes such as biopharmaceutical production, thus creating a niche competitive advantage. This could also be a way to realize medium- to long-term positive employment effects in production.

The pharmaceutical industry's sales and marketing activities currently provide important, highly qualified jobs. Communication of scientific results will continue to play an important role. It is not yet clear whether this can lead to additional employment potential.

In conclusion, the largest employment opportunities are expected to be in R&D; furthermore these types of jobs will prove valuable to the development of Germany's science-based economy. But even in the area of production, well-aimed promotion of Germany's strengths at innovative processes can create jobs for well-trained specialists.

In the area of clinical research specifically, we see the following starting points to improve the German framework. These starting points are the result of interviews and written assessments of the participating companies. The companies believe that they could further strengthen Germany's competitive position, and thus in the medium term create incentives for greater R&D spending and employment in Germany.

In the area of basic research, extensive recommendations have already been given elsewhere on ways to improve. We'll mention two examples here: The recommendations of the Wissenschaftsrat "Strategic research promotion regarding communication, co-operation and competition in the science system" ("Strategische Forschungsförderung – Empfehlungen zu Kommunikation, Kooperation und Wettbewerb im Wissenschaftssystem") and the current report and action plan of the Task Force for the improvement of local conditions and innovation possibilities for the German pharmaceutical industry ("Verbesserung der Standortbedingungen und der Innovationsmöglichkeiten der pharmazeutischen Industrie in Deutschland").

7.2 Starting Points to Strengthen Clinical Research

The most important starting points: improve co-operation with university clinics, and reduce bureaucratic barriers

In the area of clinical research, progress has been made in improving conditions. Among these, for example, are the EU-wide standardization for submitting forms and the introduction of one ethical vote within the scope of the Clinical Trial Directive. According to the interviewed companies, set dates are observed without exception, which has improved the future planning process. From the view of the pharmaceutical industry, two main levers could create opportunities for more clinical studies to Germany:

- **Creation of efficient infrastructures**

  Despite various efforts, industry and university clinics are not yet fully cooperating. Although institutions such as IZKF and KKS were created in an effort to build more efficient clinical research structures, they have not yet completely fulfilled this mission. For the interviewed companies, the largest barriers to executing clinical studies in Germany are the complex and occasionally protracted administration of university clinics and the inability to directly and exclusively allocate personnel and resources to clinical studies.

  Because of the lack of an effective incentive structure, clinical research does not rise to the required level of importance especially at the university clinics. The considerable third-party funds made available for clinical studies for the most part become incorporated into the total budget of the institution. In principle, research teams may not decide how the money is used. Because departments benefit from research performance, they should have larger decision-making authority so as to strengthen their research capabilities through investments in their technical equipment or in education and training for study personnel.

The academic community does not value clinical studies like it does basic research, as measured by publications in respected specialized periodicals. This is primarily due to the long terms of studies and the large number of potential authors. Because clinical research does not lead to academic promotions the same way basic research does, academics lack the motivation to execute and support clinical studies.

Realigning the universities' infrastructure could improve the situation, the interviewed companies say. This could be done by developing professional study centers comparable to the General Clinic Research Centers (GCRC) in the USA. These are wards at university clinics with their own beds, exclusively treating study patients. The study personnel, such as nurses, are not tied up in general daily nursing care activities. Setting up these study centers in their own organizational structure would dramatically improve both the transparency of financing structures and the professional execution of studies.

- **Reduction of bureaucratic barriers**

  During the past years, a spreading bureaucracy was quoted again and again as Germany's disadvantage in terms of location. A typical example is the especially complex procedure to license multi-centric processes with ethical commissions. Examples for impediments are clinical studies with X-ray and/or nuclear medical examinations. They need special licensing for radiation protection (Strahlenschutz-ordnung) or X-ray ordinances (Röntgenverordnung) through the Federal Office of Radiation Protection (Bundesamt für Strahlenschutz). This affects many studies because often X-ray examinations are required to document the results of medical treatments. In some cases, these types of studies have licensing periods of 12 months. For that reason, some of the interviewed companies shift these activities to Austria or Switzerland.

Bureaucratic barriers should be reduced wherever possible—the most important starting point is the legal licensing procedure for radiation protection. The responsibility for licensing clinical studies should lie with a single institution, which if necessary can consult other experts. The duration of licensing procedures must be limited through deadlines. While the interviewed companies believe these are the most important initiatives, there are other starting points that could improve the Germany's framework conditions for clinical research. Among those are:

- Improved educational opportunities for clinical researchers in Germany, for example by firmly anchoring clinical medications development in medical education and clinical practice,

- A stronger interconnection among economic, research, and health policies, with different departments adjusting to a joint target.

7.3 Future Employment Potential in Pharmaceutical R&D

In part 1 of this study we saw how much additional employment could have developed if Germany's share of worldwide R&D spending had not decreased significantly during the past three decades. Going into the future, the government's goal must be to reverse this development, to strengthen Germany as an R&D location, and thus to create employment. In that, Germany should rival the UK and USA as shown in chapter 7.2. From 1999 to 2003, these countries have managed—thanks to a well-aimed industrial policy, and despite new competitors like the new EU members and the Asian countries—to increase pharmaceutical R&D employees at annual rates of 6.5 percent and 2.7 percent respectively (while Germany is at 0.4 percent).[95] The UK's growth has been especially remarkable because it was achieved from an already high level (number of pharmaceutical R&D employees per 1 million inhabitants: UK: 447, USA: 262, Germany: 188).

In calculating future employment potential in the German pharmaceutical industry, the following assumptions are made:

- In clinical research, Germany's good starting position will already lead to medium-term positive employment effects if conditions are optimized. Therefore, concrete starting points can be found in this study as well as in many other analyses. As an example, the recommendations of the Wissenschaftsrat should be mentioned.[96]

  For that purpose, it is assumed that during the first five years, the growth rate will resemble that of the USA (2.7 percent annually). Only after that can Germany achieve the higher growth rate of the UK (6.5 percent annually) because then, the measures will have completely taken effect, improving Germany's image (especially among decision committees of multinational companies) as an excellent R&D location.

- In basic research, an additional employment effect can be gained only in the long term due to Germany's rather weak current position. Therefore, it is assumed that improving the business climate today will have effects only after five years. From this point on, the UK's growth rate (6.5 percent annually) is assumed.

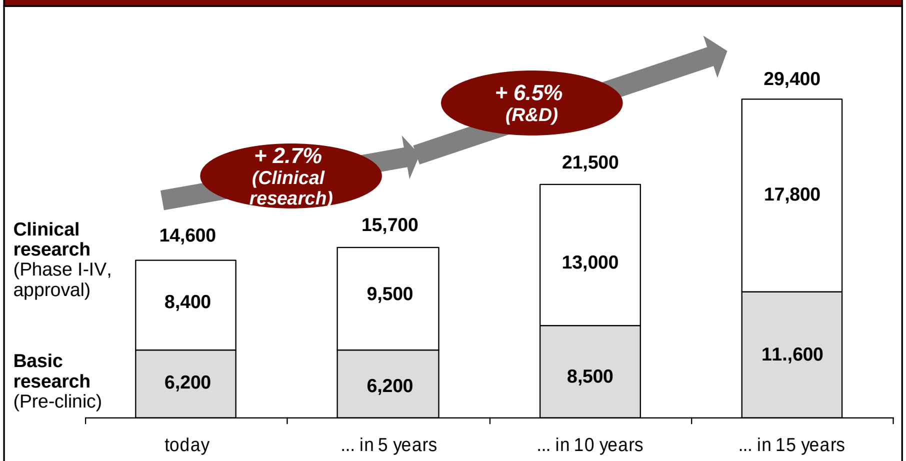
- The 15,500 German pharmaceutical R&D employees are distributed as follows: 40 percent in basic research and 54 percent in clinical research (phases I to IV as well as licensing).[97] The remaining 6 percent are allotted to technical personnel. For this allotment, because specific data for Germany is lacking, structural data on U.S. R&D personnel has been used.[98]

Given those assumptions, the following future direct R&D employment potential emerges (see Figure 7.1):

A doubling of today's R&D jobs is possible in the long term

- Based upon an A.T. Kearney simulation, improving the conditions for clinical research should generate an additional 1,100 R&D jobs within the next five years. A longer period of 15 years sees an additional employment potential of 9,400 jobs—for the most part very highly qualified jobs.
- The number of employees working in basic research could increase during the next ten years from today's 6,200 up to 8,500, and further within the next fifteen years up to 11,600.
- In the long term we thus see total potential direct employment in R&D of 14,800 jobs, which is a doubling of today's level.

Fig. 7.1: Future direct employment potential in Research & Development of the pharmaceutical industry in Germany



Source: Stifterverband (2004): Forschung und Entwicklung in der deutschen Wirtschaft, A.T. Kearney analysis (2005)

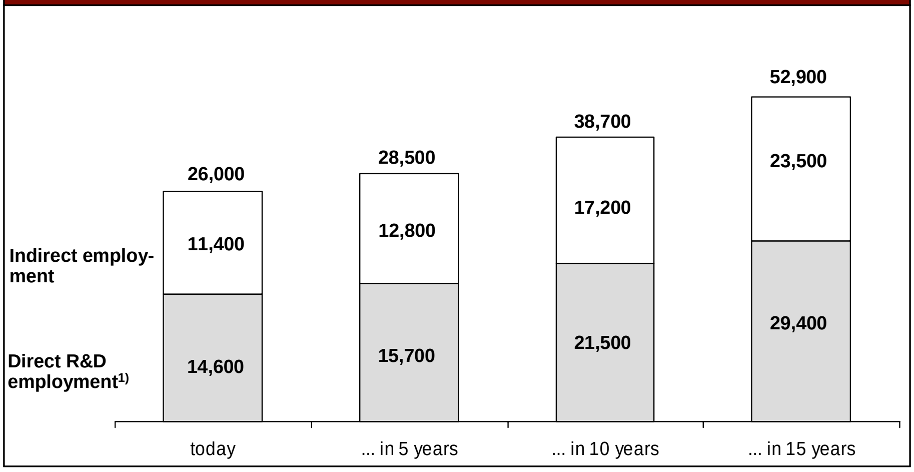
Assuming that increases in R&D personnel will be matched by increases in R&D spending on clinical research in Germany, this would also mean a significant increase in financing for German universities and university clinics.

With this medium- to long-term employment potential in pharmaceutical R&D comes an indirect employment effect: 0.8 jobs in upstream industries for every direct R&D job (see Figure 3.4). This means for example that 1,000 additional employees in clinical research would create an additional 800 jobs in upstream industries. To simplify matters, the 0.8 multiplier is maintained as a constant for the next fifteen years, i.e., ignoring any potential effects from productivity or structural changes. From that emerges the following total employment effect (see Figure 7.2):

In total, additional employment of 2,500 jobs in the medium term and 26,900 in the long term

- In a five-year period, 1,400 indirect jobs will be induced in upstream industries due to the additional employment in clinical research. The total employment effect thus amounts to 2,500 jobs after five years.
- After 10 years, there is an indirect employment potential of 5,800 jobs. The total employment effect thus amounts to 12,700 jobs after ten years.
- After 15 years, there is an indirect employment effect of 12,100 jobs. The total employment effect thus amounts to 26,900 jobs, about doubling today's direct and indirect R&D employment.

Fig. 7.2: Future direct and indirect employment potential of the pharmaceutical industry in Germany



Source: A.T. Kearney analysis (2005)

8 Summary of Results Part 2

Chapter 5 evaluates additional employment opportunities in the pharmaceutical industry in Germany. The most important aspects include:

- In terms of research and development, Germany must be assessed in both basic research and clinical research. Interviewed companies do a small degree of basic research in Germany – the U.S. and U.K. are clearly more attractive locations. Although an improved framework may lead to additional employment opportunities, these opportunities will only be realized over the long-term as investment decisions regarding new research centers are made based on longer-term analysis. In clinical research, companies rank Germany in the medium-to-good category. An improved framework could bring more short-term, clinical studies positions to Germany.

- In production, Germany should concentrate on creating innovative production processes and increasing competitive advantage. Over the longer-term, the focus should turn to realizing additional employment opportunities.

- In distribution and marketing, Germany is among the most important locations in the world due to its market size. Yet, size does not necessarily mean there will be additional jobs in the future. Revenue pressures will likely continue to force companies to manage costs, and shorter product life cycles will require more and better communication.

- Germany can be a very attractive location for foreign companies especially in research and development—this is further illustrated by examples of General Electric and Roche.

Chapter 6 discusses successful industry policies. The most important include:

- Various established countries (U.S., U.K., Ireland) as well as upcoming countries (Singapore, India, Puerto Rico) are actively promoting the pharmaceutical industry using targeted promotions. For all components of the value chain, examples show how other countries appreciate and support the pharmaceutical industry as an innovative and economically strong industry.

- Germany successfully promotes its location attractiveness using examples of companies in the optical technologies and medical engineering fields that have flourished in Germany.

Chapter 7 uses the results from chapters 5 and 6 to demonstrate the future employment potential of the pharmaceutical industry in Germany:

- To increase employment opportunities, Germany must first improve conditions within the R&D area. For example, in clinical research, university clinics must expand their infrastructures and reduce or eliminate bureaucratic barriers.

- Given the tough competition from the U.S. and U.K., Germany could see an increase of 2,500 jobs in the R&D over the medium-term. An additional 26,900 jobs could be created over the longer term.

9 Appendix

Michael Nusser, Rainer Walz (Fraunhofer ISI)

9.1 Appendix 1: Description of the Fraunhofer ISIS Input-Output Model

The Fraunhofer ISIS (Integrated Sustainability Assessment System) model was developed to analyze how economic and technological changes and the related demand factors affect the different dimensions of sustainability (structural changes, production, jobs, employee qualifications and working conditions, regional effects and environmental effects).

Among other things, the Fraunhofer ISIS model can be used to analyze how employment in the pharmaceutical industry affects employment in up- and downstream sectors. An input-output (IO) model forms the framework for analyzing how the flow of goods between economic sectors affects indirect employment in Germany. This is a static, open Leontief model based on the most recent IO tables of the German Statistisches Bundesamt for 2000.

In the IO tables, the German economy is split into 71 economic sectors and different final demand sectors *(see table A-1 for an overview of the 71 economic sectors)*. The core of this IO model is the matrix showing the interrelationships of goods and services among 71 economic sectors *(see figure A-1)*.

The rows of the tables show the supply of goods and services among the manufacturing and service sectors (intermediate demand) as well as the supply from those sectors to the final demand sectors. The columns indicate which intermediate inputs the sectors require from other sectors to manufacture their products and services. The tables also show the demand for primary inputs, corresponding to the sectors' gross value added (import inputs are excluded). This constitutes the depreciation, the difference between production taxes and subsidies, income from business activity and assets, and income from employment.

Figure A-1: Scheme of an input-output table (including employment coefficients)

		Producing and service sectors	Final demand sector				Gross production value
		Sectors 1 – 71	Consumption by households	Consumption by government	Investments	Exports	
Producing and service sectors	Sectors 1 – 71	Interrelation matrix: Supplies of goods and services among the sectors (intermediate demand) (in million euros)					
Import preliminaries							
Gross value added	Depreciation						
	Operating surplus						
	Compensation of employees						
Gross production value							

Employment coefficients	Volume of work per million euros

The following abbreviations are used in the input-output model:

$i = 1,..., n$; $j = 1,..., n$	Indices for producing and service sectors, where n = 71
$k = 1,.....,m$	Index for final demand aggregates, where m = 6
x_i	Production value for sector i
$X = (x_i)$	Vector of the sectoral production values
$y_{i,k}$	Demand for good i over final demand aggregate k
$Y = (y_i) = (\sum_{k=1}^{m} y_{i,k})$	Vector of the total final demand for good i
$Z = (z_{i,j})$	Matrix of the inter-sectoral flow of goods
$A = (a_{i,j}) = Z\hat{X}^{-1}$	Interrelation matrix standardized on production values whose elements $a_{i,j}$ indicate how many value units of good i are needed to produce one value unit of good j. In this, $\hat{X}$ represents a diagonal matrix with the sectoral production values as the main diagonal elements.

Since the production value of each sector is made up of the sum of supplies to intermediate and final demand, it is true that:

$X = AX + Y$.

Then, the correlation between final demand and production can be formulated within this static input-output model as follows:

$X = (I – A)^{-1} * Y$.

The term $(I – A)^{-1}$ is also referred to as the Leontief-Inverse C. Each element $c_{i,j}$ of this matrix reflects the directly and indirect (upstream) production needed in sector i in order to produce one unit of good j for final demand. The production effects of any demand for goods can thus be determined using this correlation.

New technologies, certain economic activities (such as the creation of a technology park) and partial segments of sectors (such as research-based international pharmaceutical companies) can be incorporated into the IO model by quantifying the preliminary goods supply on the input side from other sectors (including imports), the components of gross value added, the supplies to the other sectors on the output side, and the final demand.

The Fraunhofer ISIS model uses modules beyond those in the standard IO model. It can analyze the impact of various economic conditions on the level of employment, on the qualifications required and working conditions, on the regional structure as well as on the environment, all within a consistent framework. The employment and qualification modules are particularly relevant to this study. The latter is based on the data from Eurostat Labour Force Survey, based on the projected data of the German micro-census.

Assuming a roughly linear correlation between the level of employment in a sector and the level of production in a sector, the following employment effects result:

$L = l * X$

where l stands for the sectoral employment coefficient l_i (shown as gainfully employed persons per unit of gross production value). When strong interrelations exist among these sectors, the higher the employment intensities are (for instance, in service sectors), the higher the indirect employment effects.

Within the scope of this study, the Fraunhofer ISIS model has been incorporated into the design and adjusted as follows:

- To adjust the model to the specifications of the 15 companies we interviewed, we created a specific sector made up of the members of the Local American Working Group of PhRMA. This new “LAWG sector” was integrated into the Fraunhofer ISIS model.

- We used a questionnaire to LAWG members as the main data basis for the modeling of the LAWG sector. Their spending and investment behavior in 2003 was measured along the 71 economic sectors. To guarantee high-quality results, the questionnaire was discussed with the company representatives in a preparatory workshop. We also used telephone interviews and a glossary on important terms and definitions to ensure answers were complete and standardized.
- Within the present study, about 85 percent of the inter-sectoral interrelation could be numbered “exactly and of high quality” among the different economic sectors through collection of primary data (expenditures and investments) at the companies. Only about 15 percent have been numbered by means of adequate ratio formulas (e.g., pharmaceutical industry average or sample average).
- Although expenditures affect all sectors according to the respectively modeled preliminary interrelations, the investments were modeled separately because they are mainly interrelated with other sectors rather than the current expenditures.
- The employment coefficients used in the Fraunhofer ISIS model for 2003 are based on productivity assumptions developed within the EU study, “Impact of Technological and Structural Change on Employment: Prospective Analysis 2020; Background Report,” available at: http://www.jrc.es/home/pages/detail.cfm?prs=969

Table A-1: Sector classification of Fraunhofer ISI input-output model (ISIS) (version disaggregated into 71 economic sectors)

No.	Sectors
1-3	**Agriculture, hunting, forestry, a fishing**
1	Agriculture, hunting
2	Forestry and logging
3	Fishing, operation of fish hatcheries and fish farms
4-42	**Producing Industry** ("produzierendes Gewerbe" (including total manufacturing, electricity, gas, steam, and hot water supply; excluding construction)
	Extraction of …
4	Coal and lignite
5	Crude petroleum and natural gas (incl. related services)
6	Uranium and thorium ores
7	Metal ores
8	Stone, sand, clay, and other mining
9-39	***Total Manufacturing***
	Production of …
9	Food products and feed
10	Beverages
11	Tobacco products
12	Textiles
13	Wearing apparel, dressing and dyeing fur
14	Leather and leather products
15	Wood and wood products
16	Pulp, paper, and paper products
17	Articles of paper and paperboard
18	Publishing
19	Printing, reproduction of recorded media
20	Coke, refined petroleum products, and nuclear fuel
21	Pharmaceuticals
22	Chemicals and chemical products
23	Rubber products
24	Plastic products
25	Glass and glass products
26	Ceramic products, processed stone and clay
27	Basic iron, steel, and tubes
28	Basic precious and non-ferrous metals (e.g. aluminum, zinc, copper)
29	Casting of metals
30	Fabricated metal products
31	Machinery and equipment
32	Office machinery and apparatuses, data processing equipment
33	Electrical machinery and apparatus

No.	Sectors
34	Radio, television, and communication equipment
35	Instruments with regard to medical, control and measurement techniques
36	Motor vehicles, trailers, and semi-trailers
37	Other transport vehicles and equipment
38	Furniture, jewelry, musical instruments, sports articles, toys
39	Recycling
40	Production and distribution of electricity and long-distance heating
41	Extraction of gas, distribution of gaseous fuels through mains
42	Collection, purification, and distribution of water
43-44	**Construction**
43	Site preparation, complete constructions and parts thereof
44	Building installations and completion
45-71	**Service sectors**
45	Sales, maintenance, and repair of motor vehicles; retail sale of automotive fuel
46	Wholesale trade and commission trade
47	Retail trade, repair of personal and household goods
48	Hotels and restaurants
49	Transport via railways
50	Other land transport, transport via pipelines
51	Water transport
52	Air transport
53	Supporting and auxiliary transport activities; travel agencies
54	Post and telecommunications
55	Financial intermediation
56	Insurance and pension funding
57	Activities auxiliary to financial intermediation
58	Real estate activities
59	Renting of machinery and equipment without operator
60	Computer and related activities
61	Research and development
62	Company / business related activities
63	Administration of the state and the economic and social policy of the community, provision of services to the community as a whole
64	Compulsory social insurance activities
65	Education
66	Health and social work, and veterinary medicine
67	Sewage and refuse disposal, sanitation, and similar activities
68	Activities of membership organizations
69	Recreational, cultural, and sporting activities
70	Other service activities
71	Private households with employed persons

9.2 Appendix 2: Calculation of the Incorporated R&D

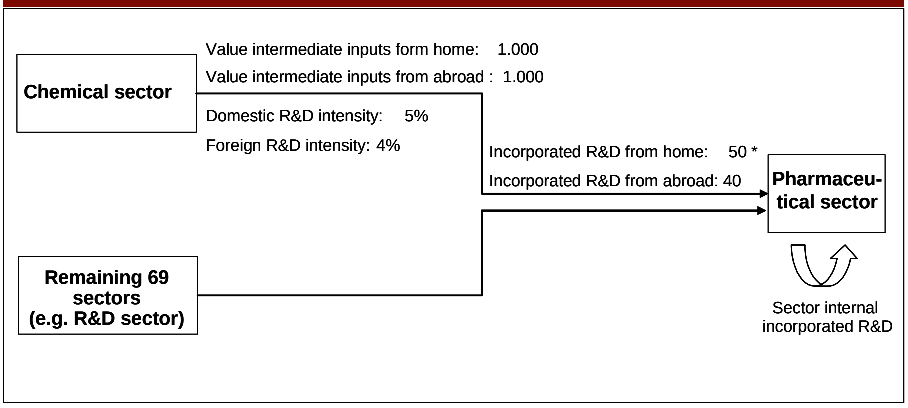
The significance of a sector as purchaser of innovative intermediate inputs can be determined through the size of R&D expenditures contained by the intermediate inputs from upstream economic sectors. These R&D expenditures contained in intermediate inputs are defined as “incorporated” R&D.

Incorporated R&D from home: Per sector we calculated with an average domestic R&D intensity (R&D expenditures/production value). In some cases, the R&D intensity of export products could be higher than that of products supplied to domestic downstream sectors; this is not taken into account in our calculations. Per sector, the average domestic R&D intensity (as a percentage) is multiplied by the domestic value of intermediate inputs (in euros) to arrive at the incorporated R&D from home.

Incorporated R&D from abroad: Per sector we calculated with an average foreign R&D intensity using a weighted average of the most important OECD countries. For the most important sectors representing more than 80 percent of the incorporated R&D from abroad, however, we calculated the exact import structure. We multiplied the average “foreign R&D intensity” per sector (and per import country) by the import value of the intermediate inputs from abroad (in euros) to arrive at the incorporated R&D from abroad.

We calculated the size of the intermediate inputs with the Fraunhofer input-output model ISIS, including sector internal supplies (for example, pharmaceutical industry to pharmaceutical industry). The R&D intensities are taken from the Organization for Economic Cooperation and Development (OECD) STAN Indicators database. The calculation logic is illustrated in Figure A-2, using the chemical sector and illustrative numbers.

Fig. A-2: Calculation incorporated R&D (e.g., chemical sector)



* Logic: 1.000 * 5% = 50

Quoted Literature

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