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Trends in the Internationalisation of R&D - the German Perspective

by
Marian Beise^a and Heike Belitz^b

^a Zentrum für Europäische Wirtschaftsforschung (ZEW) Mannheim,

^b Deutsches Institut für Wirtschaftsforschung (DIW), Berlin

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Deutsches Institut für Wirtschaftsforschung, Berlin
Königin-Luise-Str. 5, 14195 Berlin
Phone: +49-30-89789- 0
Fax: +49-30-89789- 200
Internet: <http://www.diw-berlin.de>

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Abstract

In this paper we present latest facts about the R&D activities of German multinational companies abroad and R&D activities of foreign companies in Germany. These results confirm that Germany is still an attractive location for R&D activities of multinational companies in many technological fields. However, the internationalisation of R&D is closely linked with the internationalisation of sales and production. In the commonly accepted eclectic theoretical approach by Dunning direct investment is pushed by companies that have advantages over their competitors in the host countries, where also attractive locational advantages exist. Since R&D is a source of both ownership and locational advantages, it was suggested earlier that instead of owning a technological advantage, companies with technological weaknesses start R&D in countries, which possess a technological advantage, to get access to new technologies. In contrast we found that German firms prefer to do R&D abroad in technological fields in which they hold a technological lead, e.g. in chemicals, pharmaceuticals and motor vehicles, but that they tend to perform R&D in countries which are also strong in these fields. Our results suggest that in most cases it is not the technological superiority of the host country itself which is the decisive locational advantage to attract multinationals' R&D but the lead-market function of that country or region.

JEL Classification: F23, O32

Keywords: Multinational company, R&D, Internationalisation

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1 Introduction

In Germany as in other developed industrial countries, multinational enterprises are stepping up research and development (R&D) in their affiliates abroad. Mostly by acquiring existing companies abroad that engage in R&D, they open up new markets and procure local know-how. In some new technologies, multinational enterprises obtain access to the technological resources of smaller technology firms abroad through co-operation or acquisition. In Germany, the tendency for multinational enterprises to internationalise research and development, is seen partly as a relocation of R&D resources abroad and therefore as a threat to the longer-term technological capacity of the German economy. The growing importance of foreign affiliates' research is sometimes adduced as evidence for weaknesses in domestic research. It has also been suggested that stagnating R&D expenditure in Germany and other industrial countries at the beginning of the nineties was due to many German multinationals increasing R&D spending only outside their home country. On the other hand the quantitative importance of foreign-owned companies in the manufacturing industry in Germany has on average remained constant over a long period. There is no substantial expansion of foreign companies' share in production and R&D activities in Germany in the recent years. It has been claimed that this stagnation is evidence of Germany's low attractiveness for foreign-owned R&D.

The technological performance of multinational companies' home and host countries is supposed to be affected by the internationalisation of their research and development activities and the resulting international technology flows, since a large share of R&D expenditure is invested by multinational companies (Patel and Pavitt 1992). The world-wide restructuring of R&D in multinational companies, mostly triggered by acquisitions, affects research resources in individual national locations. To assess the technological capacity of a national economy is to ask how this restructuring of R&D in multinational enterprises affects a country's R&D potential and productive potential. Is the R&D specialisation pattern of a country influenced by the internationalisation of R&D within multinational enterprises?

In this paper we present some results of our investigation of the extent and the sectoral structure of the R&D activities conducted by German firms abroad and by foreign firms in Germany, with the aim of coming closer to assessing what impact the internationalisation of R&D in multinational enterprises has on the technological resources and future technological performance of Germany.

2 Internationalisation of Multinational Companies' R&D and the Technological Performance of Countries

Internationalising corporate R&D in the product cycle

Any explication of production and R&D internationalisation in multinational enterprises must take account of Vernon's product cycle hypothesis, which has the innovation process as its point of departure (Vernon 1966). Innovations are triggered by special home-market conditions and come to fruition in close co-operation with customers. As soon as market volume is adequate, foreign demand is also served, initially through exports, then by means of local production in export markets. Earlier studies of the process of internationalisation add R&D activities to this cycle.¹ To improve a company's capacity to react to specific market conditions, R&D has to be conducted in the production entities located in the country concerned. As affiliates assume greater responsibility, the R&D capacities accumulating in other countries advance from technical adaptation to autonomous product and process development, and finally to the generation of technical knowledge that contributes to the knowledge stock of the overall enterprise. Nevertheless, in this framework research in multinational enterprises initially remains concentrated in the parent company, where all crucial innovations originate. In the early phase of internationalisation of corporate R&D knowledge is predominantly transferred from parent companies to foreign affiliates. Technology transfer appears to have a larger impact on newly established affiliates than on older ones (see e.g. Fors 1997a). R&D undertaken in the affiliates seems to facilitate technology transfer, suggesting that "absorption capacity" may be crucial in order to make productive use of the parent's technology. This may imply that affiliates become more self-reliant in terms of technology over time.

However, with multinational companies developing international networks of R&D facilities, the traditional product cycle concept needs to be broadened (Cantwell 1995). The more a multinational enterprise operating in different countries responds to regional impulses for innovation emanating from the local market and public and private research, the less the home country will be the sole source of corporate innovation. The internationalisation of R&D that followed the product cycle has modified the conditions for internationalisation. Foreign affiliates innovate and perform R&D like domestically-owned companies.² After periods of expansion, many multinational companies co-ordinate and restructure R&D units in various

¹ See earlier studies by Terpstra (1977), Ronstadt (1977), Behrmann and Fischer (1980).

locations. After a phase of decentralisation, the groups often begin to consolidate, to eliminate duplicate research and intensify intra-group technology transfer. In this phase, so-called competence centres are formed within the group, which assume responsibility for certain areas of business and the related regional markets. The corresponding R&D resources are often concentrated in these selected affiliated companies. Firms acquire product know-how by responding to stimuli from the market and from technological development in foreign locations. The formation of competence centres with sole responsibility for product or process development in foreign affiliates confirms the strong market relatedness of innovation and direct investment posited by product-lifecycle theory. What remains to be settled in this framework is the relationship between the two essential factors of the eclectic theory of Dunning (1979), which explains foreign direct investment. The propensity of a company to engage in direct investment abroad is seen to depend on the specific advantage of the company in serving the external market (ownership advantage), as well as on the higher attractiveness of foreign locations against the home country (locational advantage). In terms of R&D, which is said to be both the main input for both ownership and host country advantage, it is not clear what factor prevails.

New directions of technology transfers

The "classical" forms of internationalised research in multinational companies - central R&D for global markets and local development for local markets - are increasingly complemented by two new forms of international product and process development, which include technology transfer between associated companies (Bartlett, Ghosal 1990):

- The development of products that meet special market needs can, after adaptation, be successfully introduced in other markets as well (locally leveraged innovations). Innovations of a multinational enterprise are no longer only generated in the home country with its specific demand, but also in foreign markets in which affiliates develop products themselves.
- Globally co-ordinated research programmes which decentralised R&D units contribute their specific knowledge to and simultaneous research is conducted for in decentralised laboratories (globally linked innovations). In this case technology transfer is most intensive between research units distributed in different countries.

² In an analysis of an innovation survey Beise and Belitz (1997) found little differences between innovation activities of German-owned and foreign-owned firms in Germany, for similar results for R&D activities in the US see Graham and Krugmann (1989).

The research units of multinational companies thus have different tasks in intra-group research and development specialisation. To some extent R&D activities are tied closely to specific regional markets and the corresponding production, and to some extent they are independent of these factors. While market-related R&D units primarily strengthen the competitiveness of the company in a (sub-)market, science-oriented R&D units largely independent of specific markets and production develop knowledge that is in principle at the disposal of the entire, world-wide group of companies. In the second case especially it is not clear where the application of research results will enhance productivity and improve technological efficiency.

Changes of national specialisation patterns?

Newly emerged strategies of multinational enterprises' international R&D organisations could also have an impact on the R&D pattern of national economies. By acquiring R&D-performing companies abroad, multinational companies create intra-company research and production capacities in different locations. The growing liberty to separate R&D and production geographically gives companies new possibilities to divide labour internationally and distribute specialisation among different research locations. Groups are reorganising their world-wide research resources to avoid duplicating research and to exploit the specialisation advantages offered by particular locations.

Studies suggest that there are significant economies of agglomeration in the geographical location of innovation due to regional knowledge spillovers (see e.g. Porter 1990, Krugman 1991, Venables 1996). The role of supply-side factors has increasingly been emphasised as a reason for international decentralisation and reconcentration of R&D in multinational companies. MNE's could disperse their research geographically to gain access to new lines of innovation. If these strategies become predominant in a world shaped by multinational firms, what impact would this have on specialisation patterns of national innovation systems? Cantwell and Harding (1997) suggest that countries could have tended to narrow their technological specialisation, when multinational companies concentrate their research in countries with specialisation advantages. A country becomes therefore an attractive location for foreign-owned R&D in its sectors of specialisation. On the other hand, national firms build on their inherited national areas of technological strength to develop related ones abroad through internationally integrated strategies. The unique pattern of technological accumulation of these multinational firms influences both the host countries in which they operate, and their home country as well.

Patel and Vega (1997) provide some empirical observations for debate on the pattern of technological activities of multinational companies outside their home countries. Based on a systematic analysis of the US patenting activities of 220 of the most internationalised firms, they find that firms predominantly locate their R&D abroad in technological areas where they are strong at home. Their results suggest that adapting products and processes to suit foreign markets and providing technical support to foreign manufacturing plants remain major factors underlying the internationalisation of R&D. Despite the fact that large firms are increasingly engaging in small scale activities to monitor and scan new technological developments in centres of excellence in foreign countries within their areas of existing strength, there is little evidence to suggest that even these firms routinely go abroad to compensate for technological weaknesses at home.

Barré (1995) analyses the relation of international innovative networks of multinational companies to the R&D specialisation pattern of 11 countries in the European Union, measuring the technological specialisation of countries and multinational companies by their patent applications. The way national systems of innovation both as home countries and as host countries are related to international innovative networks in multinational companies differs widely among countries. He suggests that the internationalisation of R&D within multinational enterprises is in some cases significantly influenced by the national specialisation pattern. For Germany, Barré (1995) finds no correlation either between specialisation patterns of R&D activities of foreign companies and German companies in Germany, or between foreign R&D of German companies and domestic R&D of host countries, but strong correlations for countries with a large share of foreign-owned firms like Britain, Canada and Belgium as hosts and for small countries with well-known multinational companies like the Netherlands, Switzerland, and Sweden as home of MNU's R&D.

Trade, FDI and internationalisation of R&D

The internationalisation of R&D in multinational companies follows the internationalisation of trade and production and is closely related to foreign direct investment. To answer the question why multinational companies expand their R&D resources abroad one must start to explain foreign direct investment and its relationship with trade. There are a number of theoretical approaches to explaining foreign direct investment, but as yet no valid generalised theory has been advanced.

For globalising multinational enterprises market entry by means of trade and investment is essential. We might expect to see a gradual substitution of direct investment for trade, but

especially in high-tech sectors trade and direct investment are complements rather than substitutes (see e.g. Ostry 1996, Blomström et al. 1988, Jungnickel 1995). Empirical evidence from different countries indicates a positive relationship between domestic R&D intensity and direct investment abroad (Caves 1996, Dunning 1992). For both the United Kingdom and Germany, Barrell and Pain (1997) found that knowledge-based assets have a significant effect on the level of foreign direct investment, with innovating sectors investing more abroad than less innovative ones. This also suggests that new products and processes may be expected to come with inward foreign investment.

Internationalisation and productivity growth

The extent to which a country's total factor productivity depends not only on domestic R&D capital but also on foreign R&D capital, Coe and Helpman (1995) and other scholars point to significant effects of international R&D spillovers on productivity growth in industrialised countries through trade. Coe and Helpman suggest that direct investment could play a similar role. The effects of outward FDI on the home country have generally been believed to be positive, but the debate has revealed some concern about the consequences of the international division of labour taking place within multinational companies (Blomström and Kokko 1996). Instead, Lichtenberg and van Pottelsberghe de la Potterie (1996) find evidence for the hypothesis that outward foreign direct investment is indeed used for technology sourcing. It was also suggested that MNE activities have negative effects on host countries. If a country attracts foreign affiliates concentrated in low value added activities and without own substantial R&D activities, they may still be able to drive out their local competitors. In doing so, they may well reduce the technological capabilities of indigenous competitors and of their suppliers. This possibility has been labelled the "Trojan horse" effect (Dunning 1992).

Barrell and Pain (1997) on the other hand analyse the extent to which technology transfers and other spillovers from foreign-owned firms affect the pace of technical change and hence economic growth in the host economy. Using a model which is closely linked to that of Coe and Helpman (1995) they found significant effects from inward FDI to technical progress for Germany and the United Kingdom.

In their review of earlier studies on multinational corporations and spillovers Blomström and Kokko (1996) continue that such effects exist and that they may be substantial both within and between industries. However, recent research suggests that host country spillovers vary systematically between countries and industries and that the positive effects of FDI are likely to increase with the level of local capability and competition. A high level of local competence

and a competitive environment both contribute to raise the absorptive capacity of the host country. Adding R&D to foreign direct investment in the framework of the product-life-cycle, the thesis suggests that the technological capacity of a national economy is not only determined by R&D conducted within the country, but increasingly by R&D generated by foreign trade partners and associated companies abroad, e.g. the parent companies or affiliates.

The expectation of many multinationals is to get access to new technology through foreign direct investment. So far only Mansfield and Romeo (1984) found a positive effect of foreign affiliates' R&D of US companies on productivity at home. Fors (1997b), using the same model as Mansfield (1984) and data covering 1965-1990, could not find any impact of affiliates' R&D on the performance of home operations of Swedish MNEs. Only when the foreign investment is located in advanced industrial economies do minor productivity spillovers occur as a result of "reverse" technology transfer.

3 R&D conducted by German Companies Abroad

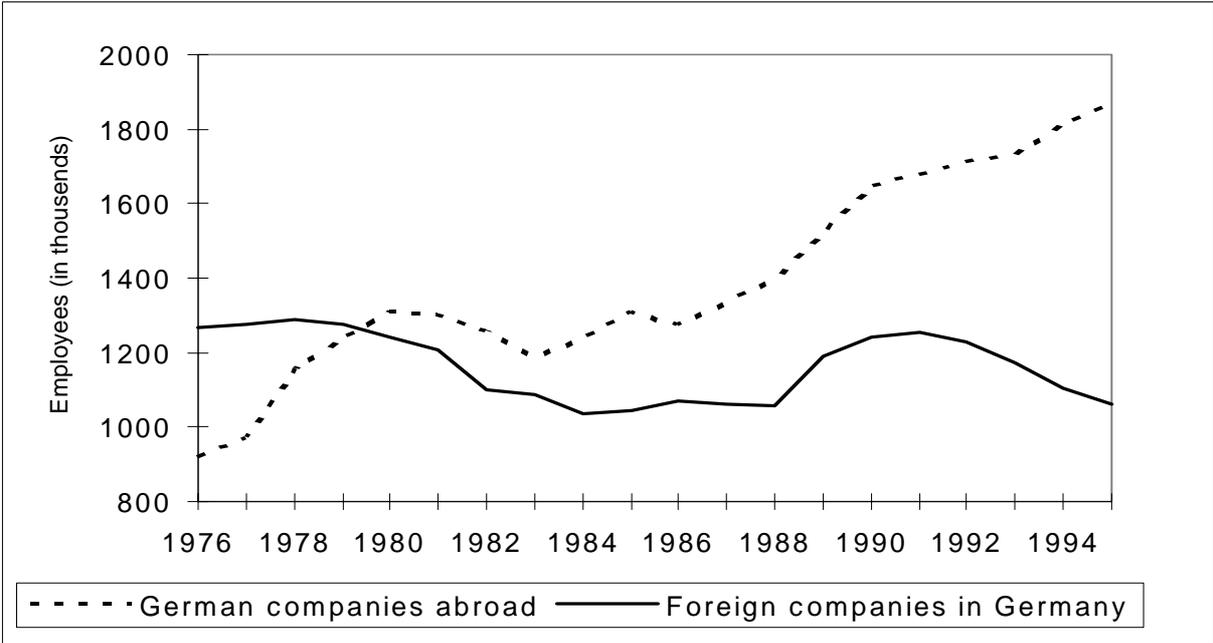
After losing all foreign assets in World War II, major German companies have once again joined the trend towards internationalisation, stepping up R&D abroad since the end of the sixties. For the post-war period, a close positive link between R&D intensity and direct investment by industries abroad has been demonstrated for Germany (Schreyger 1994), suggesting that German companies gain their ownership advantages mainly from technological innovations.

Since the start of the eighties German manufacturing companies have employed more people abroad than corresponding foreign companies in Germany (figure 1).³ The most important target regions for direct investment by German manufacturing firms are the industrialised countries of Europe and North America. More than 60 per cent of the stock of direct investment is located within the European Union and the USA. The stock of German direct investment in the Asian-Pacific countries (Asia and Oceania, Japan and China) is growing rapidly, but still accounts for less than 7 per cent of the overall stock of manufacturing direct investment in 1995. The Central and Eastern European Countries too are still of relatively minor importance for the activities of German companies abroad, despite

³ The statistics of the German Bundesbank on capital relations between Germany and the rest of the world cover all companies in which more than 20 per cent of equity capital or voting rights belong to German (or foreign) firms or individuals.

their advantages in terms of labour costs. In the industrialised countries German-owned companies grow largely by virtue of acquisition of companies or divisions of companies. In many cases existing R&D divisions are also acquired in this process. The proportion of the overall workforce of German companies working abroad rose from 17 per cent in 1980 to 25 per cent in 1995.

Figure 1
Employees of German Companies Abroad and of Foreign Companies in Germany in Manufacturing Industry¹⁾ 1976 to 1995



¹⁾ Until 1990 West Germany.

Source: Deutsche Bundesbank

The degree of internationalisation is highly developed in many R&D-intensive industries. In the case of German-based companies in the chemical industry, half of the overall work force is employed abroad; in the automobile industry the figure was around 40 per cent in 1995; (table 1). About three quarters of German direct investment in manufacturing abroad is in the research-intensive industries, particularly in the chemical, electrical engineering, and motor-vehicle industries (table 2).

Table 1
Employees of German MNEs abroad as a Proportion of all Employees of German Companies, 1980 and 1995

Industry	1980 ²⁾	1995
		%
Manufacturing	17.1	25.1
of which:		
Non-R&D-intensive	9.6 ³⁾	15.4
R&D-intensive	24.1 ⁴⁾	32.8
of which:		
Chemicals	42.1	48.8
Machinery	13.1	18.0
Office machinery and computers	24.4	22.4
Motor vehicles	25.2	40.5
Electrical machinery ¹⁾	22.7	–
Electrical machinery and apparatus ¹⁾	–	35.7
Radio, TV and communication equipment ¹⁾	–	29.6
Precision instruments ¹⁾	15.7	–
Medical, precision, and optical instruments ¹⁾	–	23.8
1) Not comparable due to changes of the sectoral classification in 1995. - 2) West Germany. - 3) 1982.		
Sources: Statistisches Bundesamt; Deutsche Bundesbank; Own calculations.		

Table 2
Share of Employment in Research-intensive Sectors in Total Employment 1995

Industry	Companies in Germany			German companies abroad
	total	of which:		
		German owned	Foreign owned	
Chemicals	8.3	7.0	15.2	19.9
Machinery	15.6	15.6	15.7	10.2
Office machinery and computers	0.9	0.8	1.6	0.7
Motor vehicles	10.4	9.8	14.0	19.9
Other transport equipment	2.2	2.4	1.0	1.4
Electrical machinery	8.8	9.3	5.7	15.5
Radio, TV, communication equip.	2.3	1.7	5.3	2.1
Medical, precision, and optical instruments	3.3	3.1	4.3	2.9
All R&D intensive industries	51.8	49.7	62.7	72.6
Sources: Statistisches Bundesamt; Deutsche Bundesbank; Own calculations.				

Table 3
R&D Expenditure by German Companies Abroad 1995

Industry	Subsidiaries abroad	Ratio of subsidiaries abroad to	
		Parent companies in Germany	All Companies in Germany
	in DM millions	in %	
Manufacturing	9 800	20	18
of which:			
Chemicals and pharmaceuticals	5 800	40	55
Metal products, machinery, transport equipment	2 200	10	8
Machinery	320	12	6
Electrical machinery, precision instruments, metal products	1 600	15	11
Electrical machinery	1 500	15	11
Total	10 000	20	17

1) WZ 79: classification of economic branches, 1979 edition.
Sources: SV-Wissenschaftsstatistik; Own estimations.

Earlier studies on the internationalisation of multinational enterprises' R&D are based on surveys and case studies in selected multinational companies.⁴ In 15 multinational companies in Germany in 1975/76, 21 per cent of production and 10 per cent of R&D were located abroad. Although individual firms had specialised in certain R&D fields within the framework of the overall group, the authors of the study came to the conclusion that, "the establishment of globally integrated research programmes including specialised foreign affiliates is not in sight" (Jungnickel et al., 1977, p. 120). Other studies record percentages of between 11 and 20 for the foreign share of R&D expenditure and R&D personnel in various groups of multinational companies in the eighties (Pausenberger 1982, Brockhoff and Boehmer 1993, Dörrenbächer and Wortmann 1991). Generally these analyses show that:

- German companies were already engaged in R&D abroad in the late sixties. The proportion of R&D conducted in other countries grew continually in the seventies and eighties, with almost constant growth rates and not much faster than the proportion of the workforce employed abroad.
- The volume of foreign research was concentrated in a few large companies.

⁴ See also Belitz and Beise (1995).

- The most important target regions for R&D commitment were the developed industrial countries in Europe (e.g. Britain and France) and North America, followed at some interval by Japan.
- The chemical and electrical machinery industries were particularly forward in conducting R&D abroad. The automobile industry was concentrated on less developed countries, e.g. Spain, South America, and just started doing R&D in the USA and Britain as well.
- The greater part of R&D resources abroad were acquired by taking over companies with R&D capacities.

On the basis of figures provided by German parent companies, it was possible to estimate current R&D expenditure by their foreign subsidiaries at around DM 10 billion (1995); (table 3).⁵ R&D expenditure by German companies abroad corresponds to around 17 per cent of the total R&D expenditure invested within Germany. The internationalisation of R&D has gone furthest in the chemical and pharmaceutical industries. With expenditure of around DM 5.8 billion in 1995, more than half of the R&D expenditure of all German-owned companies abroad is accounted for by these industries. The R&D expenditure of the subsidiaries abroad represented 40 per cent of the R&D expenditure by the German parent companies. German

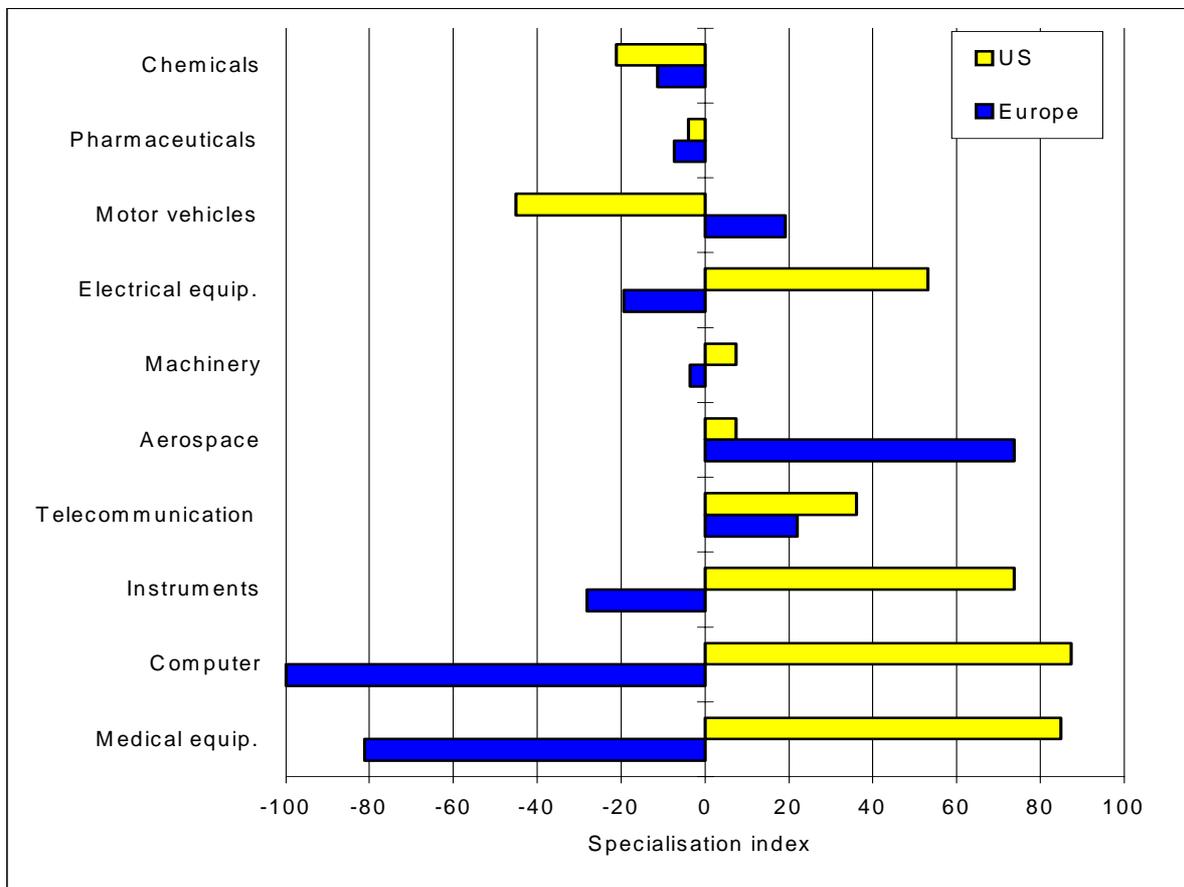
Table 4
Share of US Patents of Selected Large German Firms Attributable to Research Abroad, Classified by Technological Activity, 1969-1995

Technological Activity	1969-72	1973-77	1978-82	1983-86	1987-90	1991-95
Chemicals	16.22	13.36	14.35	14.93	16.85	20.77
Pharmaceuticals	31.62	20.83	23.69	28.00	28.02	30.19
Metal Products	16.05	12.59	9.65	11.59	10.53	17.42
Machinery	10.48	9.31	8.48	10.24	12.49	14.59
Electrical Equipment	5.02	6.00	9.69	14.77	19.87	21.44
Office Equipment	3.36	9.28	8.95	13.21	29.11	40.38
Motor Vehicles	7.69	3.17	7.99	19.84	15.20	8.80
Other Transport Equipment	18.45	8.82	4.00	4.17	7.28	7.19
Professional & Scientific Instruments	7.61	9.61	9.09	0.00	13.21	21.06
Total	12.77	11.05	12.07	14.47	17.05	20.72

Source: Cantwell, Harding (1997).

⁵ The first comprehensive survey of R&D expenditure by majority-owned German companies abroad has been conducted for 1995 by SV-Wissenschaftsstatistik GmbH.

Figure 2
Specialisation of Foreign R&D of German MNEs in the USA and in other European Countries 1995

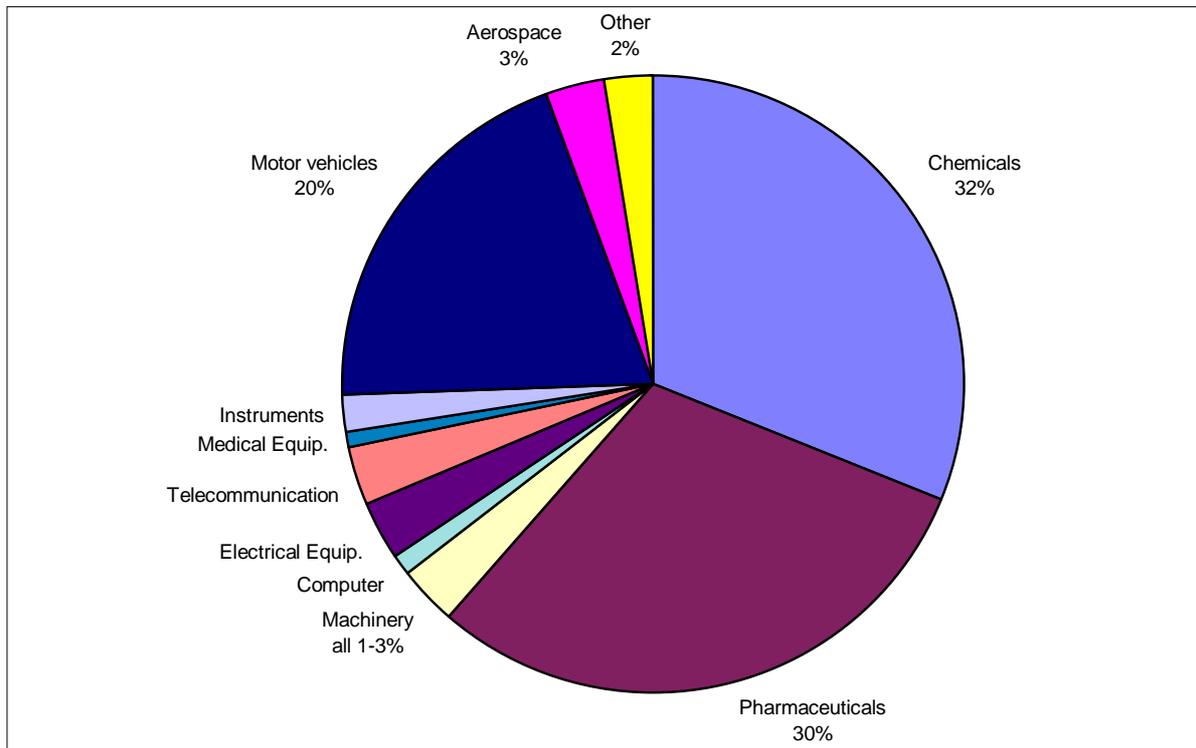


Source: SV-Wissenschaftsstatistik, Own calculations.

companies in the electrical machinery industry spent around DM 1.63 billion on R&D abroad in 1995, representing 15 per cent of their worldwide R&D expenditure.

The proportion of MNE's patent applications by location of inventor provides a further indication of the degree of R&D internationalisation. According to various studies, the share of patent applications by German-owned multinational companies with inventors living outside Germany was about 20 per cent in the early nineties (Cantwell and Harding 1997, Patel and Vega 1997). The share of patents is thus equivalent to the 20 per cent share of foreign research in German companies (see also table 3). The data derived by Cantwell and Harding (1997) show a generally increasing tendency for overseas research by German firms. The share of patents of large German firms attributable to research abroad was about 12 per cent in the seventies and then rose from the beginning of the eighties to 20 per cent in the early nineties. The proportion of the overall workforce of German manufacturing

Figure 3
Distribution of Foreign R&D of German MNEs



Source: SV-Wissenschaftsstatistik, Own calculations.

companies working abroad rose from 17 per cent in 1980 to 25 per cent in 1995. This is a further indication that the internationalisation of R&D in German companies follows the internationalisation of production.

The data for shares of US patents of large German firms with inventor country outside Germany classified by technological activity are given in table 4. German R&D has become more internationalised over the whole time period in chemicals, mechanical and electrical machinery and professional and scientific instruments. The R&D activities of German companies abroad are concentrated on the US and Europe. Analysing US patents of selected multinational companies attributable to research in foreign locations in 1990-1994 Patel and Vega (1997) found that the inventor country of nearly 70 per cent of patents of German firms was the US, the inventor region of 25 per cent of these patents was Europe and of only 3 per cent Japan. According to the survey by SV-Wissenschaftsstatistik, German companies in the US are specialised in electrical machinery, computers, professional and

medical instruments.⁶ In Europe they are specialised in aerospace, telecommunication and automobiles. The German chemical and pharmaceutical industry has a real global technological network with R&D units in all regions of the triad (see figure 2). Besides pharmaceutical and chemical products, R&D activities by German firms abroad are also conducted primarily for automobiles and auto components (figure 3). These are products in which Germany's foreign trade is also specialised, and they are produced in those industries accounting for the largest proportion of employment by German subsidiaries abroad. This serves to confirm the close relationship between conducting R&D and producing goods abroad.

Patel and Vega (1997) analyse the importance of different technical fields in foreign technological activities of 220 firms aggregated according their nationality (table 5). Process and machinery related technologies are important for firms of all nationalities. There is some evidence to suggest that firms tend to go abroad in their areas of strength: US firms in computers; German, UK and Swiss firms in organic chemicals and pharmaceuticals; and Japanese firms in computers, image and sound.

⁶ The specialisation index was constructed similarly to the RCA specialisation index in trade. Due to data constraints we use the relation of the share of firms with R&D in a Region in a technical field and the share of firms with R&D in that region however technical field.

Table 5
Main Fields of Patent Activity of MNEs in Foreign Locations by Nationality of Firm
1990-1996

Technical Field	All	US	UK	Germany	Switzerland	France	Japan
Cases	1130	336	155	132	122	106	78
				in %			
Process and Machinery ¹⁾	36.2	31.2	43.2	31.8	40.2	34.9	32.1
Organic Chemicals	9.7	12.5	9.0	9.1	12.5	5.7	3.8
Pharmaceuticals	7.5	5.7	6.5	13.6	13.4	5.7	1.3
Computers	7.3	11.0	1.9	3.8	0.9	9.4	16.7
Telecommunication Equip.	5.8	6.3	3.9	5.3	1.8	9.4	9.0
Electrical Devices	4.4	6.5	2.6	1.5	0.9	8.5	5.1
Image & Sound	4.0	3.9	0.6	3.8	0.0	5.7	12.8
Materials	3.7	3.3	5.8	4.5	2.7	5.7	2.6
Electrical Machinery	3.5	1.8	3.2	4.5	4.5	5.7	3.8
Medical	3.3	4.2	4.5	4.5	3.6	0.0	0.0

¹⁾ Chemical processes, metallurgical processes, chemical apparatus, non-electrical machinery, specialised machinery, metal-working equipment, assembling & material handling, instrument, misc. metal products.

Source: Patel and Vega (1997)

The US are the most important location for German R&D abroad in terms of R&D expenditure. In 1995 German companies invested US-\$ 3.9 billion in R&D in the US after US-\$ 2.5 billion in 1994. Measured in terms of purchasing power parities, this represented more than half of total R&D expenditure abroad by German firms and one tenth of total R&D expenditure in the domestic German economy. The steep rise in 1995 is due to mergers and acquisitions especially in the pharmaceutical sector.⁷ Three quarters, that is US-\$ 2.8 billion, of R&D expenditure by German manufacturing companies in the US is accounted for by the chemical and pharmaceutical industry.

⁷ For example the US company Marion Merrell Dow was acquired by Hoechst AG for US-\$ 7.1 billion. The R&D expenditure of Marion Merrell Dow accounted for US-\$ 462 million in 1994.

Table 6
R&D Expenditure of Foreign-owned Firms in the US

Majority ownership	Country-structure of R&D expenditure		Average annual real growth of R&D expenditure	R&D expenditure in the USA as a proportion of R&D in home country (BERD) ¹
	1980	1995	1980-1995	1995
	in %			
All countries	100.0	100.0	11.4	–
of which:				
Canada	6.9	7.5	12.3	23.4
France	7.5	9.3	13.0	9.7
Germany	19.5	22.5	12.4	16.4
Netherlands	15.4	4.7	3.0	27.7
Switzerland	17.4	17.5	11.4	80.0 ²
Great Britain	16.0	13.7	10.2	16.5
Japan	4.5	10.6	17.8	3.8
Other countries	10.9	12.1	12.1	–
¹ Measured at purchasing power parities. BERD: business enterprise expenditure on R&D. ² 1994.				
Sources: US Department of Commerce, OECD; own calculations.				

Since the end of the 1960s German firms have steadily expanded their R&D potential in the US. Between 1980 and 1995 their R&D expenditure there grew at an annual rate of 12 per cent in constant prices, slightly more than that by all foreign companies in the US (table 6). Germany has the largest R&D potential in the US of all the foreign companies, followed by Switzerland and Great Britain. With respect to R&D expenditure in the economy of the country of origin, however, R&D spending in the US by companies of smaller home countries like Swiss and Dutch firms is substantially greater than that of German companies. British firms' R&D spending in the US is the same proportion of that at home as German firms (table 6). Thus, compared to other European countries majority-owned German companies are in no way particularly active in expanding R&D abroad.

In leading new technological fields multinational companies conduct R&D in their own research centres, often situated in high-tech regions located near renowned universities. The aim of these centres is to follow technological developments in the US, to acquire technology and to open up markets. Many German pharmaceutical companies, for instance, maintain bio-technology laboratories in the US. Of a total of 95 research centres run by German companies identified in the US in a 1994 study, 28 were active in the fields of chemicals and new materials, 18 in the area of pharmaceuticals and bio-technology, 15 in electronics

(semiconductors, optical electronics and high-definition television), 11 in the automobile sector and 8 in the fields of computer hardware and software. German parent companies with the greatest number of research centres in the USA are Siemens (24), and the three large German chemical concerns Bayer (13), BASF (12) and Hoechst (10) (Dalton and Serapio 1995). A comparison of the fields of technology in which German companies conduct R&D in the USA and in Germany, weighted by the proportion of company employees, reveals a relatively high degree of similarity of focus (Belitz, Beise 1997). Overall it appears that German companies abroad are engaged primarily in fields of research that are strong in Germany as well. Ownership advantages and markets are thus the most important motive for direct investment abroad in research-intensive sectors too.

European countries - Great Britain and France, in some cases also Austria - represent additional important locations for R&D by German companies abroad. In Japan - as is evident from direct investment - German companies are only just beginning, in relatively small numbers, and largely concentrated in the chemical industry, to start up production and R&D activities. So far, countries offering lower labour costs for development activities, such as India and a number of Central and East European countries, have played only a subordinate role in the internationalisation of corporate R&D activities.

4 R&D Conducted by Foreign Companies in Germany

Germany itself has traditionally been an important industrial location for foreign investors. In assessing the technological capacity of the national economy, one must ask how foreign-owned firms have influenced R&D resources and specialisation patterns in Germany. In 1995 more than 3,000 industrial companies in Germany with a substantial foreign capital stake employed around one million people. The parent companies of these firms are largely based in the European countries and the US: slightly more than half the stock of direct investment in manufacturing industry was held by companies from the European Union, one third from the USA and just 2 per cent by firms based in Japan. Just under two thirds of all employees in foreign-owned industrial firms in Germany were employed in R&D-intensive industries in 1995, including around 15 per cent each in the chemical, the electrical machinery and instruments, the machinery and the automobile sectors.

Table 7
Share of Employees of Foreign-owned Companies in Germany, 1980 and 1995

Industry	1980 ¹⁾	1995
	in %	
Manufacturing industry	16.4	16.0
of which:		
Non-R&D-intensive branches	14.2	12.3
R&D-intensive branches	18.5	19.3
of which:		
Chemicals	23.7	29.2
Machinery	14.2	16.0
Office machinery and computers	49.2	27.4
Motor vehicles	19.0	21.3
Electrical machinery ²⁾	18.3	
Electrical machinery and apparatus ²⁾	–	10.3
Radio, TV and communication equipment ²⁾	–	37.1
Precision instruments ²⁾	15.7	–
Medical, precision, and optical instruments ²⁾	–	21.0
1) West Germany.		
2) Not comparable due to changes of the sectoral classification in 1995.		
Sources: Statistisches Bundesamt; Deutsche Bundesbank; Own calculations.		

The quantitative importance of foreign-owned companies in manufacturing industry in Germany has on average remained constant over a long period. Overall, since the start of the eighties, firms in which foreign companies and individuals hold a substantial capital stake, have accounted for around one quarter of turnover and about 16 per cent of employment (table 7). Total R&D expenditure by all majority-owned foreign companies in Germany can be estimated at DM 9.6 billion and R&D employment by such firms at 42,500.⁸ Thus in 1995 just under 17 per cent of total R&D expenditure and rather more than 15 per cent of the R&D staff in the German economy were accounted for by foreign firms. There has been no change in the relative importance of foreign firms for the R&D potential of Germany in 1993. Around half of the R&D personnel of foreign companies work for European and the other half for US firms. Japanese companies, which represent a very small proportion of the stock of direct investment, conduct only very limited R&D activities in Germany.

⁸ The estimation is based on a special evaluation for 1995 conducted by the SV-Wissenschaftsstatistik of its regular surveys of R&D expenditure. The estimation by the 500 most R&D-intensive companies, was disaggregated for German/foreign majority ownership. This covers around 83 per cent of the total R&D expenditure conducted in Germany. The foreign companies included in the

Table 8
Total R&D Expenditure of Large Companies in Germany, by Majority Ownership (1995)

Industry	All selected companies					All companies in Germany
	Domestic companies	of which:				with R&D
		German-owned	Foreign-owned	of which from:		
				USA	Europe	
	in DM millions					
Manufacturing	46,568	38,583	7,986	4,332	3,542	54,900
Chemicals	9,613	9,021	592	240	–	10,520
Machinery	2,869	2,351	518	–	443	5,490
Motor vehicles	12,745	9,990	2,754	2,607	–	13,100
Electrical machinery	11,470	8,739	2,731	465	2,118	13,180
Total	47,999	39,981	8,018	4,332	3,575	57,790
	%					
Manufacturing	100.0	82.9	17.1	9.3	7.6	84.8
Chemicals	100.0	93.8	6.2	2.5	–	91.4
Machinery	100.0	81.9	18.1	–	15.5	52.3
Motor Vehicles	100.0	78.4	21.6	20.5	–	97.3
Electrical machinery	100.0	76.2	23.8	4.1	18.5	87.0
Total	100.0	83.3	16.7	9.0	7.4	83.1
Sources: SV-Wissenschaftsstatistik; Own calculations.						

About one fifth of the R&D capacity in the motor vehicle industry and the electrical machinery sector in Germany is foreign-owned. The figure is slightly lower for machinery. In all these areas foreign-owned companies thus make an essential contribution to the technological resources of Germany.

In the electrical machinery and automobile industries there is no significant difference between the average R&D intensity of majority-owned German and foreign companies. In other industrialised countries, too, foreign companies adjust to the average R&D intensity of

special evaluation spent at least DM 8 billion on R&D in 1995, employing more than 32 000 people in R&D activities. However, almost all of foreign-owned firms in Germany are majority-owned.

comparable domestic companies of the host country (OECD 1994, Beise, Belitz 1997a). Therefore firms adapt their R&D behaviour to the respective national context and the local incentives to conduct R&D. In countries in which domestic companies perform little R&D, there is scarcely any incentive for foreign firms to conduct intensive R&D activities.

Table 9
R&D Intensity of Selected Major Companies in Germany by Predominant Ownership and Selected Industrial Sectors 1995

Industry	German owned companies	Foreign-owned companies	All firms in Germany engaged in R&D
	R&D intensity of workforce (%)		
Manufacturing	9.5	7.7	NA
Chemicals	11.5	7.4	NA
Machinery	5.6	5.9	5.2
Motor vehicles	8.3	8.4	7.9
Electrical machinery	10.9	11.1	11.0
	R&D intensity of turnover (%)		
Manufacturing	6.3	4.0	NA
Chemicals	6.2	1.8	NA
Machinery	3.7	3.8	3.5
Motor vehicles	5.8	5.7	5.4
Electrical machinery	7.2	6.0	6.9
Sources: SV-Wissenschaftsstatistik, 1995; Own calculations.			

Not only does the behaviour of foreign-owned companies in Germany show very little difference to that of German-owned companies, only a small proportion of their R&D activities is financed by the parent company. Many affiliates abroad finance R&D themselves and sell the results to their parent company and related companies. This is indicated by the low share of total R&D expenditure in Germany that is financed by foreign sources, and by the low share of external R&D expenditure abroad that is financed by German companies. In each case the figure is only about 2-3 per cent.

About one quarter of the American corporate R&D expenditure outside the United States is invested in Germany; in the manufacturing sector it is also around one quarter. From the US perspective this means that Germany has, for many years now, been the most important R&D locations abroad, followed by Great Britain. In terms of expenditure Germany is the most important location for transportation equipment and machinery R&D for US firms abroad. In 1995, US firms invested 60 per cent of their total motor-vehicle R&D expenditure

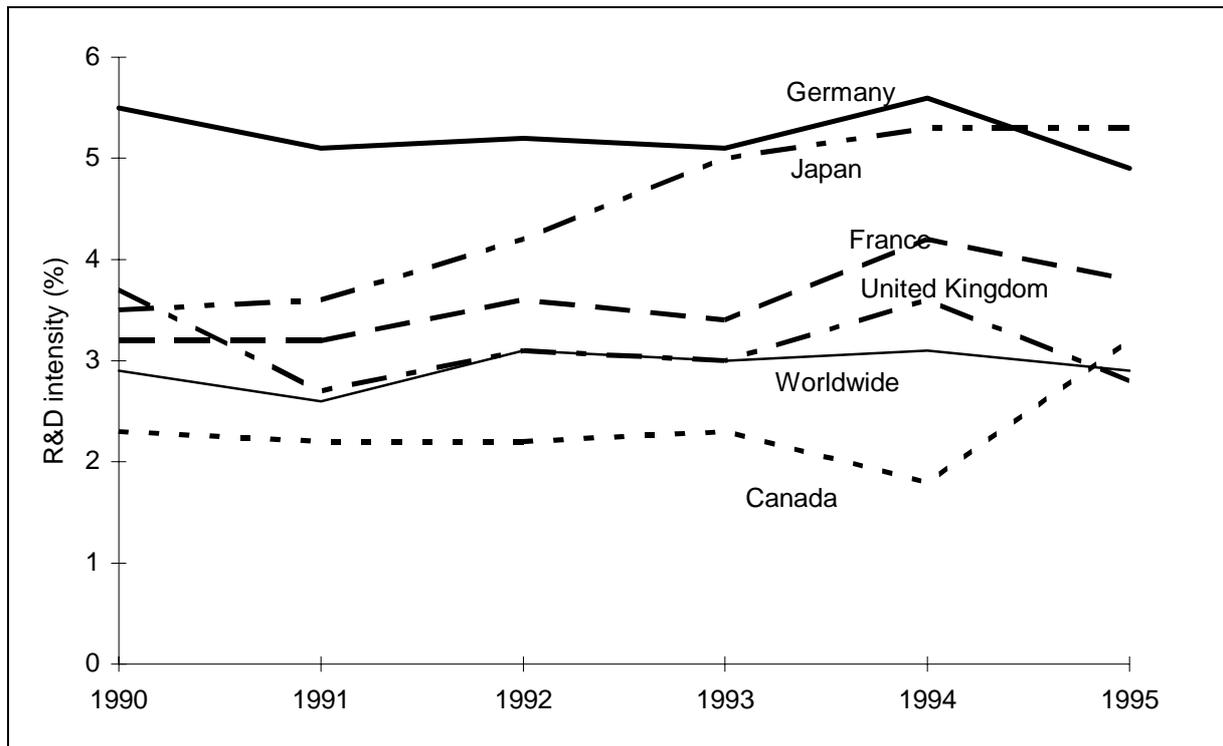
abroad in Germany. Alongside Japan and the Netherlands, Germany is also among the most important research locations for US firms abroad in the field of electronic and other electric equipment. The R&D intensity of US firms is second highest in Germany following Japan. The R&D intensity of US firms in Japan has increased rapidly in recent years, where research activities in the chemical industry, in particular, have been expanded (figure 4).

Table 10
Spending on R&D by US MNEs Abroad, Manufacturing 1966 - 1995

Host country	1966	1977	1982	1990	1995 ¹⁾
	in US-\$ million				
All countries	528	1785	3123	8468	11293
	share in selected countries (%)				
Germany	22.3	24.1	27.1	28.7	25.4
Britain	23.5	19.7	22.8	18.7	14.7
France	6.4	14.5	6.3	8.2	9.5
Japan	0.6	1.5	2.3	4.5	8.2
Canada	29.5	10.7	12.3	11.7	13.2
Total selected countries	82.4	70.5	70.7	71.7	71.0
¹⁾ Preliminary estimates.					
Sources: US Department of Commerce; Own calculations.					

Figure 4

R&D Intensity of US MNEs Abroad by Host Country, 1990 to 1995



1995: Preliminary estimates.

Source: US Department of Commerce, Own calculations.

According to the Japanese External Trade Organisation JETRO, Germany ranked third to Britain and France in Europe as host to Japanese manufacturers. The proportion of Japanese affiliates engaged in production that have their own research facilities is as high in Germany as in Britain (table 12). With 22 research centres independent of production, Germany was the second most important research location for Japanese companies in Europe after Britain. In proportion to the number of Japanese-owned producer affiliates, Germany even has the largest number of such research centres. The share of Japanese companies in domestic industrial R&D resources in Germany is determined by the share of Japanese firms in productive capacity.

Table 11**Share of R&D Expenditure Abroad by US MNEs in Germany 1977 - 1995**

Sector	1977	1982	1990	1995 ¹⁾
	%			
Total industry	22.3	24.5	25.1	22.8
Manufacturing industry	24.1	27.1	28.7	25.4
Food and kindred products	19.7	12.6	17.6	4.2
Chemicals and allied products	12.4	11.3	11.6	9.0
Primary and fabricated metals	26.2	22.4	28.2	28.8
Industrial machinery and equipment	18.3	21.2	27.7	22.2
Electronic and other electric equipment	28.0	34.5	16.6	11.9
Transport equipment	NA	46.1	55.8	59.2
Other manufacturing	NA	12.4	20.7	17.6

¹⁾ Preliminary estimates.
Sources: US Department of Commerce; Own calculations.

Table 12**Research and Development of Japanese MNEs in Europe 1996**

	Number of foreign affiliates	Number of independent R&D facilities	Share of foreign affiliates engaged in R&D (%)	Ratio: Independent R&D facilities to foreign affiliates
Europe of which based in:	738	78	34.3	10.6
Britain	223	28	40.4	12.6
France	114	13	27.2	11.4
Germany	101	22	40.6	21.8
Spain	60	1	45.0	1.7
Netherlands	52	3	28.8	5.8
Belgium/Luxembourg	45	3	33.3	6.7

Sources: JETRO (1997); Own calculations.

Technological specialisation pattern

While R&D resources of American companies in Germany are concentrated in the motor vehicle industry, European companies focus more strongly on electrical and mechanical machinery. A comparison of the fields of technology in which foreign and German companies conduct R&D in Germany on the basis of data from the Mannheim Innovation

Table 13**Specialisation Index of Foreign-owned Firms in Germany Compared to Foreign-owned Firms in all Foreign Locations (RTA)**

	1969-72	1973-77	1978-82	1983-86	1987-90	1991-95
Chemicals	-56.7	-34.5	-42.9	-46.1	-45.8	-38.3
Pharmaceuticals	-78.3	-94.0	-63.9	-59.1	-72.7	-68.8
Metal products	11.7	0.1	9.4	39.4	31.8	54.4
Machinery	12.7	30.1	34.5	27.9	25.9	33.7
Electrical Machinery	35.9	13.0	12.7	9.4	10.9	3.5
Motor Vehicles	-32.9	40.6	0.2	22.1	67.2	48.6
Other Transport Equipment	30.5	53.6	0.2	-9.8	38.9	72.7
Professional & Scientific Instruments	48.2	32.6	29.3	8.5	22.2	25.1

Source: Cantwell, Harding (1997), Own calculations.

Panel reveals a relatively high degree of similarity of focus. New materials, production engineering, environmental technology and software predominate in both foreign and domestic companies. Overall it appears that German and foreign companies are engaged primarily in the same fields of research. There are no substantial differences in the concentration of R&D activities on technology fields. This is an indication of the similarity of foreign and domestic companies in Germany (Beise, Belitz 1997a/b).

Patent data represent a powerful means of assessing the geographical and sectoral distribution of multinational companies' R&D. Cantwell and Harding (1997) have presented data on patenting activities of large German companies abroad and foreign companies in Germany during the period 1969-1995 as a proxy of their R&D activity. They analyse the technological specialisation across different fields of technological activity with the Revealed Technological Advantage (RTA) Index, which is similar to the well-known Revealed Comparative Advantage (RCA) used to measure comparative advantages of nations in trade.⁹ To measure a comparative advantage in R&D, if this exists, we have calculated the RTA indices of patenting by non-German companies in Germany comparatively to the patenting by non-German companies due to research in all foreign locations classified by main fields of technological activity on the basis of patent data derived by Cantwell and Harding (1997). Foreign companies in Germany exhibit technological specialisation (compared to their R&D in all foreign locations) in mechanical engineering, electrical equipment,

⁹ The index used here varies around 0, such that values greater than 0 suggest that a group of firms is comparatively specialised in the activity in question relative to the other firms, while values less than 0 are indicative of a position of a lack of specialisation.

motor vehicles, other transport equipment, and professional and scientific instruments. These are fields of relative technological strength for Germany with RTAs greater than 0 (BMBF 1998). Foreign-owned firms in Germany are not specialised in chemicals and pharmaceuticals. All companies in these sectors in Germany (German-owned and foreign-owned) exhibit a high specialisation index but a negative index in pharmaceuticals. Overall there is no correlation between the specialisation of foreign R&D in Germany and the specialisation of Germany in R&D, suggesting that comparative advantage in R&D could hardly be the sole explanation for patterns in foreign R&D.¹⁰

5 International Restructuring of Corporate R&D

The eighties can be characterised by a continuous growth of internationalisation of R&D by multinational companies fed mainly by mergers and acquisitions, but also by greenfield investments by foreign research facilities. In the nineties, the need to raise the efficiency of R&D by reducing development times, removing duplicated research, and exploiting economies of scale in R&D facilities called for a reconcentration of R&D within the largest multinational corporations with a high degree of internationalisation of production and R&D. Anecdotal evidence suggests that this reconcentration no longer merely takes place at the parent company in the "home country", but also at subsidiaries in the leading market regions. In a number of cases regional "centres of competence" have been formed within multinational corporations, in which responsibility for R&D, production and sales is brought together. It is here that technological advances are made - not least due to the access to the global R&D potential of the corporation - and it is often here that they are first translated into actual production. The development of such "centres of competence" requires the spatial coincidence of market impulses, and productive and research-related competence.

Although this international reconcentration of R&D takes place in some of the largest European and US firms, there is still an ongoing international expansion of R&D in many industries and companies, especially in Japanese firms. Both expansion and reconcentration leads to the question how a country can attract R&D activities of foreign companies or bind existing R&D capacities of MNEs at home. It was suggested that attracting corporate "centres of competence" and newly established R&D units of these companies will be determined by

- the lead-market function of the country or region

¹⁰ Barre (1995) also finds no correlation in Germany but positive correlation in the UK.

- the production potential of these companies in that country, and
- by the attractiveness of its research infrastructure.

In a recent analysis of the international R&D of selected German and foreign-owned companies we found different internationalisation patterns and a different importance of these factors in three high-tech fields: pharmaceuticals, semiconductors and telecommunication equipment (ISI, DIW, ZEW 1997).

The innovation dynamic in both semiconductors and telecommunications is driven by lead-markets. In semiconductor technology, production and process R&D are linked, while product development and other technologies are more free in selecting locations apart from production. While in pharmaceuticals the pre-clinic part of the R&D is pushed through progress in science, the clinical-phase of the R&D-process is also linked with lead-market functions (table 16). Here the clinic is the quasi-customer and progress in disease treatment is mainly influenced by the organisation and the sophistication of the medical system, i.e. of the cooperation between clinics and pharmaceutical companies or the approval of pharmaceutical treatments. Once a substance is found, incentives for R&D in different locations are derived from the time-to-market.

Table 16
Determinants of Internationalisation of Corporate R&D in High-tech Fields

Importance of proximity of R&D to ...	Pharmaceuticals		Semiconductors		Telecommunications	
	Pre-clinical research	Clinical research	Process developm.	Product-developm.	Hardware-developm.	Software-developm.
Lead-market	low	very high	low	very high	high	very high
National science system	very high	high	high	low	low	low
Production	low	low	high	low	high	low

Source: FhG-ISI/DIW/ZEW (1997).

Our case studies suggest: the importance of lead-markets for industrial R&D is growing. Lead-markets are characterised by more-than-average potential volume and growth rate, and a special technological dynamic and openness for innovations. The lead-function of a regional market attracts R&D activities of multinational companies for such innovations, with mature in close user-producer interaction. There are conditions that favour the technical-specific lead-function of a regional market, like the approval of new pharmaceutical

treatments or a competitive market structure and innovation supporting regulation in telecommunications.

For Germany it was shown that a lead-market function in semiconductors and telecommunications lured multinational companies to found R&D performing affiliates in Germany and to establish competence centres within the worldwide corporation. In pharmaceuticals the volume of the German market is a strong argument, but this was overcompensated by too-little opportunities for cooperations with research institutions in the pre-clinical phase and the too-restrictive admission process. Germany is therefore no preferred location for pharmaceutical R&D.

Clustering of R&D of multinational companies in regional centres of excellence?

The case-studies suggest that multinational companies locate their foreign R&D in large dynamic markets in mature, customer-driven technologies. Of course, within lead-markets, e.g. Western Europe or the USA, MNEs also select locations where infrastructure is most sophisticated and human capital is available. When technologies are still research-driven and the market is not established yet (e.g. genetic technology in the pharmaceutical industry), they tend to locate R&D solely in their home country or in leading research regions where they expect to participate in the excellent research infrastructure. By establishing research units in these centres of excellence abroad, German companies too will continue in their efforts to keep up with technological developments there, especially in new high-risk research fields where commercial exploitation is imminent.

6 Conclusions

On the basis of the available data, a close relationship between the scale and growth of production and R&D spending in German-owned companies in foreign industrialised countries as well as in foreign affiliates in Germany could be demonstrated. R&D conducted by multinational companies abroad is thus predominantly market and production related. In Germany, as in other industrial countries, the internationalisation of R&D by multinational enterprises has reached a relatively high level. In 1995, the share of foreign-owned companies in Germany in total industrial R&D spending in Germany was 17 per cent, in the United States the proportion was 14 per cent, in France 17 per cent in 1994 (OECD 1997). Industrial R&D in Germany is thus already comparatively highly "internationalised". Foreign companies in Germany have been conducting R&D in Germany on a relatively large scale for a considerable time. In Germany the R&D intensity of German-owned and foreign-owned

firms in the manufacturing industry, apart from the chemical industry, is approximately equal. The behaviour of foreign-owned companies in terms of innovation does not differ significantly from firms in majority German ownership. Germany as a research location occupies an outstanding position internationally from the perspective of multinational enterprises, even if other locations are gaining in attractiveness as production and research is progressively internationalised. In the mid-nineties R&D expenditure by German companies abroad reached that of foreign companies in Germany but since then it has exceeded it. Although German firms have "caught up" in terms of establishing an overseas presence in recent years, German direct investment remains modest in terms of the volume of foreign trade compared with such countries as the US, Great Britain and France. Multinational corporations are expanding their sales and production activities in all regions of the "triad" (North America, Europe, Japan). Given their need to "catch up" and the dynamic growth of foreign markets, an increase in activities by German firms abroad is to be expected.

Given that the development of the R&D potential of German firms abroad follows that of their productive capacity, R&D expenditure by German firms abroad is in the future expected to grow more rapidly than that by foreign firms in Germany. Yet the acquisition and expansion of research divisions by German firms abroad, in the course of a trend to increased internationalisation of capital interrelationships, does not, in itself, constitute evidence of a deterioration in the conditions for R&D by multinational corporations in Germany. Although sometimes R&D divisions are relocated abroad in the course of rationalisation and reconcentration processes within the international R&D networks of multinational corporations, there are no grounds, from a German perspective, for diagnosing a general trend towards an "emigration" of R&D potential abroad. As German firms expand abroad, their research potential grows to match their increased production potential, primarily as a result of acquisitions. That means in particular, that German companies in general do not add new R&D activities to a host country. In very internationalised industries like chemicals and pharmaceuticals, they also decrease R&D activities in the host and home countries due to the restructuring process after big mergers.

In our view there is no evidence that the German specialisation pattern is narrowing due to the internationalisation of R&D. First, German companies do not in general diversify their R&D activities by building up R&D capacities in research intensive international regions with excellent research expertise. Instead German firms largely perform R&D abroad in fields in which they are specialised in. This is mainly to strengthen their grip on international markets in these fields by complementing their firm's specific strength with local market dynamics

and closeness to leading customers. Second, innovation incentives are derived from interdependence of local market and research dynamics and are sometimes close to production. Emerging markets attract production and R&D activities by multinational companies, which aim to dominate these markets with innovations, that correspond most with local market dynamics. In this view Germany was attractive as a lead-market for motor vehicles and telecommunication equipment. In Germany foreign companies build extensive production and R&D facilities in these fields.

Yet, we conclude from the data available that multinational corporations do not concentrate their production and research in the so-called centres of excellence, where the research infrastructure is the sole attraction, but predominantly in markets they consider to be important for the future. Firms select sites as locations for newly established or restructured R&D centres, where over the longer-term a dynamic demand for new products and services - a lead-market - meets favourable conditions for research and production.

As a rule it is the domestic market that serves as a point of market entry for new products. In the wake of the process of internationalisation there is increasing scope for converting the results of research into actual production on a foreign market first, if demand conditions there are more favourable. This process has been observed in a number of cases. Firms failing to exploit a demand potential do not make full use of their growth potential at the location in question. In many cases government plays a role here that should not be underestimated: by setting the framework of conditions, and as an investor, it exerts influence on the market for high-tech products (environmental protection, infrastructure, the health service, technical standards and conditions of market entry for products, etc.). In many cases it is not so much costs or technological potential, but rather the regulatory conditions that determine the choices made by multinational corporations regarding locations for production and research. By strengthening its lead-market functions within Europe, Germany is in a position to raise its attractiveness as a location for global „centres of competence“.

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Marian Beise
Zentrum für Europäische Wirtschaftsforschung (ZEW)
L7,1
D-68161 Mannheim
Telefon: +49 621 1235 172/ Fax: -170
Email: beise@zew.de

Heike Belitz
Deutsches Institut für Wirtschaftsforschung (DIW)
Königin-Luise-Str. 5
D-14195 Berlin
Telefon: +49 30 89789 664/ Fax: - 200
Email: hbelitz@diw-berlin.de