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Christoph Dörrenbächer and Michael Wortmann*

The Internationalization of Corporate Research and Development

Foreign direct investment has grown rapidly in recent decades and, along with it, foreign research and development activities. The following article analyzes the reasons for the internationalization of R&D, examines its patterns in relationship to Germany and discusses the implications for future policy.

During the last two decades, maintaining or increasing the competitiveness of their national economies has become an important goal of economic and other policies in all OECD countries. National science and technology (S&T) policies are paying growing subsidies to companies in order to help make them more competitive on world markets.¹

But at the same time, the big firms, the multinational corporations (MNCs) who are performing the major part of research and development (R&D) and receiving the largest share of national R&D subsidies, are internationalizing their activities.² In recent decades, foreign direct investment has grown much faster than most other international economic indicators like world production or international trade.

MNCs have not only internationalized production, foreign R&D activities have also become more and more important, not only in quantity but also in quality. An increasing amount of innovative R&D and, in some cases, even R&D of strategic importance to the corporations is being carried out abroad.

This article will attempt to assess the quantity and quality of the internationalization of corporate R&D, i.e. of German companies abroad and of foreign companies in the Federal Republic of Germany (FRG). It will also show the possible implications of this for the competitiveness of the national economy and for national S&T policy. First, we will examine the reasons behind the internationalization of R&D.

Analyzing the motives of MNCs in creating new R&D facilities abroad or enlarging already existing R&D units,

two different levels should be distinguished. We could speak of R&D related motives if the introduction or expansion of R&D is done at the location which is most efficient within the framework of the corporate R&D system. In addition to these motives, the carrying out of R&D abroad may serve other purposes not related to an improvement of the company's R&D system. In these cases we might speak of R&D unrelated motives.

There are basically two kinds of R&D related motives. Traditionally most important is R&D abroad which supports local production. Technology transferred from the parent company to the subsidiary has to be adapted to local market and production requirements.³ Another kind of R&D abroad is aimed at the generation of new technologies that will be used throughout the whole company. Especially in those technologies where a

¹ Cf. A. J. M. Roobeek: Beyond the technology race, Amsterdam 1990; and R. van Tulder, G. Junne: European multinationals in core technologies, Chichester 1988.

² In the USA, Robert Reich recently posed the question, "Who is us?" He suggests that the government should no longer support the US based MNCs, but rather all companies with sound economic activities in the USA. Cf. R. Reich: Who is us?, in: Harvard Business Review, No. 1, 1990, pp. 53-64. In other words: the slogan "What's good for General Motors is good for America" is heavily questioned.

³ A study undertaken by Pausenberger found that at the end of the 70s more than 50% of the R&D personnel of German affiliates abroad were concerned with the adaption of technology. Various American studies conducted in the 70s confirmed this result for US MNCs. Cf. E. Pausenberger: Technologiepolitik internationaler Unternehmen, in: Zeitschrift für die Betriebswirtschaftliche Forschung, 1982, p. 1031; D. Craemer: Overseas research and development by United States multinationals 1966-75, New York 1976; R. C. Hirschey, R. E. Caves: Internationalization of research and transfer of technology by multinational enterprises, in: Oxford Bulletin of Economics and Statistics, Vol. 42, No. 2, 1981, pp. 115-130; R. Ronstadt: International R&D: The establishment and evolution of research and development abroad by seven U.S. multinationals, in: Journal of International Business Studies, Vol. 9, No. 1, pp. 7-24. A good compilation of these studies is given by R. Pearce: The internationalization of research and development by multinational enterprises, Houndmills 1990.

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certain foreign region has a particular innovative potential, it may be important for a company to participate through a local R&D unit. The participation mainly takes place through the recruitment of R&D personnel and the integration in the scientific community. The innovative potential in the foreign country does not necessarily have to be more advanced than the potential in the home country. Technological expertise can also be complementary, so that foreign R&D and R&D at home would complement one another. Additionally, foreign R&D units often serve as so-called "listening posts" which monitor technological developments for their parent companies. A combination of both motives – R&D supporting local production as well as R&D aiming at the creation of new technologies – is given in the case of a product mandate. Here, a subsidiary has the full responsibility for all entrepreneurial functions – R&D, production and marketing – in a specific product area.

Very often, the carrying out of R&D abroad is determined by R&D unrelated motives. There could be requirements of national governments aiming at the preservation of R&D potential in their countries. Such provisions are often made by technologically weak nations.⁴ Very often national procurement will favour companies which are performing R&D in the country. For instance, this is the case in telecommunications where a significant degree of national presence, including R&D, is considered necessary in order to participate in the markets of industrialized countries. In other areas, such as pharmaceuticals, local R&D (clinical testing) is a precondition for market approval. Another motive might be to improve the image of the company not only vis-à-vis the government or other customers, but in view of attracting qualified personnel who want to work for "interesting" companies who provide career opportunities.

Finally there is another very important reason behind the growth of R&D abroad. Growth of MNCs is increasingly taking place through acquisitions of already existing companies, which, in many cases, have their own R&D

facilities. In many cases, it might be desirable for the MNC to take over these R&D units and their innovative potential. In some cases, this might even be one of the main motives behind the take-over. But, in other cases, the growth of R&D abroad might just be an unintended side-effect.⁵

Internationalization

In Germany, just like in other countries,⁶ R&D is concentrated at large corporations. About three quarters of the R&D personnel in manufacturing industry works for companies which have more than 1,000 employees, while those companies only account for less than 50% of total employment. The R&D intensity (share of R&D personnel in total employment) of these companies is 6.4% while in smaller companies it is below 2%.⁷

More than 50% of the R&D personnel works in companies with more than 10,000 employees. Still, these figures obviously underestimate the importance of the big corporations because they include a large number of smaller companies which are their affiliates. The domestic R&D personnel of the seven largest German MNCs⁸ alone makes up one third of total R&D employment in German manufacturing industry.

While domestic German manufacturing industry employed about 300,000 people in R&D in 1989,⁹ we estimate that more than 40,000 were working in R&D units of German MNCs abroad.¹⁰ As the total workforce of German manufacturing MNCs abroad numbers around 1,600,000, the average R&D intensity abroad is somewhat more than 2.5%. If we consider only the manufacturing affiliates in developed countries, where the majority of foreign R&D personnel is concentrated, then the R&D intensity is considerably higher. A total workforce of less than 1,000,000 people shows an average R&D intensity of over 4%. This is about the same as the average in domestic German manufacturing industry.

R&D abroad has grown tremendously in recent decades. Overall employment has grown by two thirds since 1976.¹¹ But, the growth of R&D employment abroad was much faster, and R&D intensity abroad grew even faster than in the FRG.¹² The quantitative growth is to a

⁴ Examples can be found e.g. in Canada or in Spain.

⁵ While managers from the MNCs usually stress the expected synergy effects through the integration of the acquired companies, business literature points out that foreign R&D has grown "opportunisticly". Cf. T. J. Gerpott: Globales F&E Management, in: Die Unternehmung, Vol. 44, 1990, pp. 226-246.

⁶ Cf. P. Wiltgen: Research and development for high technology by European multinationals, Universiteit van Amsterdam, Vakgroep Internationale Betrekkingen en Volkenrecht, Amsterdam (manuscript) 1987, p. 127.

⁷ For details of the calculation cf. C. Dörrenbächer, M. Wortmann: Die Internationalisierung von Forschung und Entwicklung – Stand, Perspektiven, Folgen, FAST Study No. 15, Berlin 1991, pp. 31-32.

⁸ These companies, each of which has over 8,000 employees in domestic R&D, are BASF, Bayer, Bosch, Daimler Benz, Hoechst, Siemens and Volkswagen. Cf. *ibid.*, pp. 32-33.

⁹ The latest data available (for 1987) record 282,831 R&D personnel. Cf. Stifterverband für die Deutsche Wissenschaft (ed.): Forschung und Entwicklung in der Wirtschaft 1987, Essen 1990, p. 62.

¹⁰ This estimation is based on company data presented in Table 1, taking into account the regional and industrial structure of German foreign direct investment.

¹¹ This is the first year for which data are available from the Deutsche Bundesbank.

¹² Cf. M. Wortmann: Multinationals and the internationalization of R&D: New developments in German companies, in: Research Policy, No. 2, 1990, pp. 176 f.

large extent the result of the increasing importance of take-overs of companies in other industrialized countries. We estimate that German MNCs acquired at least 10,000 R&D employees abroad in the five years between 1985 and 1989.¹³

Today, about half of total foreign R&D employment is concentrated in Europe¹⁴ and almost the other half is located in North America. The strongest growth took place in the USA, where German – and other – MNCs were only weakly represented until the mid 70s. Today, the US affiliates of German MNCs show a somewhat higher R&D intensity than those of British, French or Japanese MNCs.¹⁵ R&D in Japan is, in quantitative terms, still negligible, even though the R&D intensity of many German affiliates is very high. Some MNCs are entering the complicated Japanese market with R&D facilities set up simultaneously to, or even before, production.

Data from a recent survey¹⁶ (see Table 1) shows that the R&D intensity abroad for the whole sample (33 companies) as well as for the chemical and electrical industries make up about half of the R&D intensity in the FRG. Only in the automotive industry (including suppliers) is the R&D intensity abroad considerably lower.¹⁷

The chemical industry has a very high R&D intensity abroad (5.5%). This is to a large extent due to pharmaceuticals, which require sizable R&D efforts at home as well as abroad; in many foreign countries, clinical testing is a condition for market approval. But foreign R&D in many other fields can be found, too – among them in the important field of new materials.

An area not so much of quantitative as of qualitative importance is modern biotechnology, especially recombinant DNA. Several German companies have concentrated the most important part of their R&D in this field in the USA.¹⁸ Some have used the experience of their US affiliates in more traditional biotechnology as a starting-point for developing R&D units for modern biotechnology, whereas others have set up completely new, small companies for this purpose.¹⁹

In the electrical industry, R&D intensity abroad is also high, even though the figure from our sample (5.9%), due to the dominance of one single very big company, is probably an overestimation for the industry as a whole. In the 80s, the quantitative growth of R&D intensity abroad has probably been strongest in this industry, due to the growing importance of special software development for

¹³ For detailed descriptions of over 600 take-overs by German MNCs cf. FAST (ed.): *International Investment Monitor '90*, Berlin 1990.

¹⁴ Here, R&D intensity in more peripheral countries is much lower than in the core countries. For Spanish manufacturing affiliates, data from a sample of 39 companies indicate R&D intensity is only about 2%.

¹⁵ Calculated from data published in US Department of Commerce: *Foreign direct investment in the United States, 1987 benchmark survey*, Washington DC 1990.

¹⁶ This inquiry was part of a research project conducted for the MONITOR programme of the EC.

¹⁷ Further information on the strategies of companies from different industries can be found in W. Oesterheld, M. Wortmann: *Die Internationalisierung von Forschung und Entwicklung durch bundesdeutsche multinationale Unternehmen*, FAST Study No. 6, Berlin 1988; and C. Dörrenbächer, M. Wortmann, *op. cit.*

¹⁸ This strategy is followed by MNCs from other European countries, too, as the take-over of Genetech by Hoffmann – La Roche shows.

¹⁹ Another way to participate in the technological developments in the USA is co-operation with US companies. Cf. M. Wortmann, *op. cit.*, pp. 180 f.

Table 1
Employment, R&D-employment and R&D-intensity at 33 German Multinationals (1989)

		world	domestic	foreign	foreign/world (%)
chemicals (n = 8)	employment	436,485	243,851	192,634	44
	R&D-empl.	38,234	27,683	10,551	28
	R&D-intens. (%)	8.8	11.1	5.5	
vehicles ¹ (n = 9)	employment	913,558	667,352	246,206	27
	R&D-empl.	58,763	52,618	6,145	10
	R&D-intens. (%)	6.4	7.9	2.5	
electrical (n = 3)	employment	391,575	248,143	143,204	37
	R&D-empl.	42,605	34,120	8,485	20
	R&D-intens. (%)	10.9	13.8	5.9	
other (n = 13)	employment	217,639	185,144	32,495	15
	R&D-empl.	6,955	6,450	505	7
	R&D-intens. (%)	3.2	3.5	1.6	
total (n = 33)	employment	1,959,257	1,344,718	614,539	31
	R&D-empl.	146,557	120,871	25,686	18
	R&D-intens. (%)	7.5	9.0	4.2	

¹ Vehicles includes all suppliers plus all Daimler Benz activities.

Source: Own survey.

foreign markets. But innovative foreign R&D, occasionally within the framework of product mandates, can be found in almost all areas of the electrical industry. Comparing this industry with the chemical industry, it is interesting to note that R&D in the key technology of this industry, i.e. semiconductor technology, in contrast to modern biotechnology, is still concentrated in the FRG, while R&D in the USA is only in highly specialized areas of lesser strategic importance.

The comparatively low foreign R&D intensity in the automotive industry is mainly the result of the fact that foreign employment by German MNCs in this industry is concentrated in less developed countries, especially in Latin America, and in the European periphery. R&D abroad primarily supports local production. After the take-over of SEAT by Volkswagen, the continuation of R&D there was a result of requirements set by the Spanish government.

Other industries, including mechanical engineering and plant construction, show a considerably low R&D intensity at home as well as abroad.

²⁰ Three of these companies have more than 4,000 R&D employees in the FRG: ABB, Opel/GM and Philips.

Foreign Affiliates in the FRG

The internationalization of R&D is not a one-way process. Thus, the substantial R&D activities of affiliates of foreign MNCs in the FRG also have to be considered. According to our estimation, well over 40,000 people out of more than 1,000,000 employed in foreign affiliates in the manufacturing sector work in R&D. Ranking at about 4%, the R&D intensity of foreign manufacturing affiliates in the FRG is as high as the average R&D intensity of German manufacturing affiliates abroad, as well as of the entire manufacturing industry in the FRG.

Some of the foreign affiliates in the FRG show a very high R&D intensity, especially in the electrical industry (including computers) and in the automotive industry. Data from 8 important foreign affiliates in the FRG show that R&D intensity in most of these companies is as high as the R&D intensity of comparable German companies.²⁰ And the quality of foreign R&D in the FRG is not restricted to adaptive tasks.

This is not surprising in cases where the German company has been taken over only recently. Large R&D facilities at affiliates of MNCs based in small neighbouring countries, like Switzerland or the Netherlands, might be

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The number of developing countries with which the IMF and the World Bank have made structural adjustment agreements has increased rapidly in the eighties. At the same time the discussion on the conflicts arising from such adjustment programmes has been greatly intensified. On the premise that the success or failure of the programmes, the way in which they are conducted and the period for which they can be politically supported, is determined decisively by the activity of interest groups, an empirical analysis of Mauritius was conducted. The example of this small island economy can serve to elaborate the relevance of a broad social consensus for the success of adjustment programmes. (Only available in German).

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explained by the lack of overall R&D resources (e.g. trained personnel) in these countries.

But affiliates of US MNCs are performing a high amount of R&D, too. In the automotive industry, German affiliates are developing models for the whole European market which are also manufactured in other European countries. In the computer industry, too, German affiliates are performing R&D with more than just regional importance.

Despite the high publicity which the first R&D efforts of Japanese companies in the FRG have received, these are still of very little importance.

MNCs' Strategies

In-depth studies of individual corporations²¹ reveal that the composition of international R&D systems of MNCs is a result of a mix of the above-mentioned processes and motives. Even though the internationalization strategies differ due to industry and even company specific conditions, it is clear that the importance of foreign R&D that is using local innovation potential is growing.

Since the mid 80s, it has almost become a commonplace among management consultants and managers²² that the future belongs to triadic MNCs, i.e. corporations which have a strong local presence via foreign direct investment in all three important regions of the world (USA, Europe, Japan). Against the background of an increasing economic interlacing within and between the triadic regions and taking into consideration the levelling of the technological capacities of the three regions, company strategies which concentrate business activity in the home country seem less promising. The traditional model of an MNC, i.e. first testing new products at home, next exporting those products and finally producing them in foreign markets, seems to be outdated. Simultaneous presence in all three regions with locally adapted products seems to be a decisive requirement of future business. According to a recent study,²³ this also necessitates a new structure of the R&D system:

Table 2
Employment, R&D-employment and
R&D-intensity at 8 Foreign Affiliates in the FRG
(1989)

	employment	R&D empl.	R&D intensity (%)
electrical ¹ (n = 6)	137,057	16,188	11.8
automotive (n = 2)	102,836	9,800	9.5
total (n = 8)	239,893	25,988	10.8

¹ Electrical industry includes computer manufacturers.

Source: Annual reports and other company information.

"What we have called the 'global network' model of technology management is clearly the 'wave of the future' when it comes to competing globally. This model consists of a network of technology core groups in each major market – the U.S., Japan, and Europe – managed in a coordinated way for maximum impact. Only a handful of companies, including IBM, Ciba Geigy, Bayer and ICI are pursuing this approach. Since building a technology network can take from 10 to 20 years or more, the companies that move in this direction today will have a clear winning edge tomorrow."²⁴

Although it is doubtful that such a highly integrated network would be a realistic perspective even for large MNCs in the foreseeable future, the shift in quality of foreign R&D is evident. The traditional structure of unilaterally transferring technology from the parent company to affiliates abroad which only adapt delivered technology to local requirements, is becoming increasingly blurred. What can be expected for the future is the creation of polycentric companies with several innovation centres – some of them in foreign countries.

Implications for National Competitiveness

Again, it is important to point out that the growth of the foreign R&D of German companies is largely a result of the general growth of these companies through acquisitions. Beyond this, we could show that the affiliates of foreign companies in the FRG are pursuing R&D to about the same extent and with the same intensity as German companies abroad. We even assume that the FRG is a favoured location for R&D by foreign companies in Europe.²⁵ This clearly means that the quantitative increase in the foreign R&D of German companies cannot be interpreted as an "exodus of German R&D". There is no quantitative imbalance in the R&D internationalization process in the FRG.

A remaining question is whether the internationalization of R&D in qualitative terms has had any negative effects on the FRG. Of interest for the public

²¹ For in-depth studies of three companies which account for over one third of the foreign R&D of German MNCs cf. C. Dörrenbächer, M. Wortmann, op. cit., pp. 34-68.

²² Cf. especially K. Ohmae: Triad power, New York 1985.

²³ This study was carried out by Booz-Allan & Hamilton. The major results are published in A. C. Perrino, J. W. Tipping: Global management of technology, in: Research & Technology Management, No. 3, 1989, pp. 12-19.

²⁴ Ibid., pp. 13-14.

²⁵ The latest available data for 1982 show that the R&D intensity of US affiliates in the FRG is higher than in other European countries. Calculated from US Department of Commerce: U.S. direct investment abroad, 1982 benchmark survey data, Washington DC 1987.

discussion are especially those cases where single companies are increasing their R&D efforts in so-called key technology areas abroad more quickly than at home. Especially in modern biotechnology, some companies have located R&D of strategic importance in the USA in order to participate in the more advanced innovative potential in this area.

In assessing the consequences for Germany two principal views are possible.²⁶ The first view fears a weakening of the R&D landscape in Germany with disastrous long-term effects on German competitiveness. The other perceives the fast access to foreign technology potentials as the best way for German companies to increase their international competitiveness and to pull up on the leading companies of the world.

Long-term advantages and disadvantages for Germany will depend on whether a rapid transfer of technology from abroad leads to an increase in the competitiveness of the domestic parts of the MNC, including its domestic R&D, or whether R&D abroad is followed by production abroad and, in the long run, complete divisions of the company becoming concentrated abroad. There are no signs of such a tendency up to now, even though this question cannot be answered definitely on the basis of the knowledge we have so far on this topic.

It should be noted here that in the USA there is a somewhat complementary discussion of the advantages and disadvantages of inward direct investment in high tech areas. In the USA, acquisitions of high tech companies by foreign firms are regularly followed by protests warning against a "sell out" of US technology while others welcome the inflow of foreign capital and managerial skills.²⁷

But if it is true that the companies of the future – including their R&D systems – will be organized in a more triadic manner, the effects on "home countries" will be basically positive if "their" companies are strengthening their international competitiveness by increasing R&D in North America and in Japan.

Implications for S&T Policy

For policy, too, the internationalization of R&D has important consequences. The concept of international competitiveness, which was traditionally related to the competitiveness of countries or regions, has to be redefined if the most important actors – the MNCs – are increasingly acting across geographical borders.

The relationship between S&T policy and foreign R&D intensive companies includes a contradiction which is in principle insoluble. On the one hand, the innovative

potential of foreign firms should be utilized for the national R&D system. On the other hand, a transfer of results from domestic R&D abroad is to be prohibited. It is obviously impossible to reach both objectives at the same time.

This problem can be seen with the S&T policy of the European Community, which aims at increasing the competitiveness of Europe and "its" companies by building up European research networks. But how should it deal with IBM if this company wishes to participate in the JESSI programme. Even more difficult is the case of the British computer manufacturer ICL which was taken over by Fujitsu: should ICL now be excluded from the JESSI programme because there is the danger that technology which has been developed in Europe might be transferred immediately to Japan? In both of these cases, as in others, policy seems to follow a middle road by allowing the foreign owned companies to participate in more peripheral parts of the programmes.

At the same time, in the USA it has yet to be decided whether foreign companies will be allowed to participate e.g. in the Sematech programme. Finally, in Japan BASF has recently become the first foreign company to participate in a government supported R&D programme.

But not only the relationships of governments to foreign companies are becoming more complicated, relationships to their "own" companies are becoming more difficult, too. MNCs now can install new R&D facilities at home or abroad. A new international competition for the location of R&D is emerging. This puts increasing pressure on national S&T policies as well as on other policies which influence the national climate of innovation. In the FRG, this became obvious in recent years with the public controversy on legal regulations for modern biotechnology, when some MNCs were setting up new R&D as well as production units in this field in the USA arguing that legislation in the FRG was an impediment. We cannot answer here the question whether this really was the main reason for the MNCs' moves to the USA or whether the innovative potential at the new location was the main reason behind these decisions. The implication of these developments is obvious: it is becoming more difficult for governments to regulate the framework for R&D, and technological progress in general, on the basis of nationally defined priorities.

²⁶ The headlines of recent title stories in two German magazines were "Exodus der deutschen Forschung" (highTech No. 8/1990, pp. 54-63) and "Forschen für Deutschland" (manager magazin No. 9/1990, pp. 155-181).

²⁷ Compare e.g. R. Reich, E. Mankin: Joint ventures with Japan give away our future, in: Harvard Business Review, No. 2, 1986, pp. 78-86; and E. M. Graham, P. Krugman: Foreign direct investment in the United States, Washington DC 1989.