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# Transfer of Technology by German Firms

by Georg Koopmann, Klaus Matthies, Hamburg\*

**Outside the USA little empirical work has been done to assess the impact of technology transfers on the economic performance of transferring countries. The following considerations are concerned with the transfer of technology by German firms.**

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The United Nations Conference on Science and Technology for Development (UNCSTD) at the end of August has again demonstrated that transfer of technology is one of the most controversial issues in the North-South dialogue. The discussion gives, however, rise to considerable confusion, and it is not easy to define the front-lines. In official declarations, developing countries are accusing the advanced industrial economies of technological imperialism, i. e. transferring at monopolistic conditions technologies which are not appropriate to meet the real needs of the Third World. Practical policies in LDCs, however, reveal a different approach: advanced technologies geared to the markets in developed countries are warmly welcome also in developing areas, because they are expected (1) to call forth a bigger push to industrialization and growth than appropriate technologies requiring time-consuming R & D efforts could do and (2) to enable LDCs to compete effectively on international markets with products facing an elastic demand. Oddly enough, it is this pragmatic approach to technology transfer which causes more concern in industrialized countries than radical claims put forward in numerous conference documents. Apprehensions are growing that technological bases might become eroded, export markets get lost and domestic markets come under increasing pressure.

The new challenge arises primarily from the so-called new industrial countries (NICs), i. e. Brazil, Greece, Hong Kong, Mexico, Portugal, Singapore, South Korea, Spain, Taiwan, Turkey and Yugoslavia. These countries are in a comparatively good position

to incorporate foreign technology in an effective way and are increasingly adopting policy measures to guarantee a comprehensive transfer and unrestricted use of technology.

Outside the USA little empirical work has been done to assess the impact of technology transfers on the economic performance of transferring countries. The gap could only be filled by extensive primary research, which is beyond the scope of the present article. Rather, the following considerations, which are limited to the technology transfer by German firms, will have as their main objectives:

- to state the definitions and concepts required to understand the significance of technological outflows for the country of origin;
- to describe the dynamics and regional concentration of technology transfer by German firms;
- to characterize the industries, from which the bulk of technological transmissions originates;
- to point out the major factors determining the impact of technology transfers on the sending country; and
- to give first empirical evidence indicating the impact on the German economy by using Brazil as a case in point.

## Different Types of Technology

In order to determine the effects of technology transfer it is meaningful to distinguish between innovation technology and production technology, although the dividing line may sometimes be difficult to draw. Whereas production technology merely enables the recipient to produce a good which he could not

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**Table 1**  
**Technology Transfer and Performance in German Manufacturing**

Sector	Direct investment abroad		Receipts from foreign licensees		Domestic R & D expenditures		Output growth p. a.	RCA <sup>c</sup> in 1978 in world trade
	Stock <sup>a</sup> 1978 million DM	as % of domestic investment <sup>b</sup>	1975 million DM	as % of turnover (× 100)	1975 million DM	as % of turnover	1965 to 1977 %	Ratio
Chemical industry	11,251	14.4	304	38.5	3,818	4.8	6.4	1.65
Electrical engineering	5,930	13.9	147	20.3	3,671	6.7	5.5	1.66
Mechanical engineering	5,640	8.0	95	9.6	1,710	3.1	1.8	2.87
Iron, steel, non-ferrous metals	5,411	7.3	10	1.3	372	0.6	1.5	0.71
Transportation equipment	3,892	6.9	103	15.0	2,928	4.9	4.8	2.26
Food products	2,156	3.7	4	0.4	98	0.3	3.0	-1.11
Leather, textiles, clothing	1,398	4.5	11	2.1	59	1.0	-0.1	-1.43
Stone, clay, ceramics, glass	1,179	3.1	3	1.1	97	1.3	2.1	0.37
Oil processing	819	5.9	2	0.6	87	0.2	3.5	-3.44
Metal goods	598	2.7	2	0.7	40	1.0	2.7	0.93
Plastics, rubber and asbestos	590	2.7	9	3.9	120	2.1	7.0	1.05
Precision mechanics, optics	471	8.1	1	1.1	285	4.5	0.2	1.18

<sup>a</sup>Cumulated net capital outflows since 1952. <sup>b</sup>Capital outflows 1952 to 1977/gross investment in fixed assets 1960 to 1977.

<sup>c</sup>Revealed Comparative Advantage (RCA) =  $(Ex_i - Im_i / Ex_i + Im_i) : (Ex - Im / Ex + Im)$ .

Sources: Bundesanzeiger, various issues; Monatsberichte der Deutschen Bundesbank, Vol. 28, No. 4, April 1976; H. Echterhoff-Severitt: Forschung und Entwicklung (FuE) in der Wirtschaft 1975, supplement to: Wirtschaft und Wissenschaft, No. 4, 1977; R. Krenzel et al.: Produktionsvolumen und -potential, Produktionsfaktoren der Industrie im Gebiet der Bundesrepublik Deutschland, various issues; Statistisches Jahrbuch 1979 für die Bundesrepublik Deutschland, Stuttgart, Mainz 1979; authors' calculations.

manufacture before, innovation technology significantly adds to his technology capacity.

A transferred technology may be still in use in the country of origin. This technology-complementing transfer will have very different effects compared to the transfer of a technology that is no longer applied in the home country (technology-substituting transfer). An example frequently cited is the difference between Japanese and US investors. Whereas the USA invest abroad in high-technology industries and thus create production that is competitive with home country products, Japan transfers production to foreign countries in industries in which she has a comparative disadvantage, thus enabling her to supply the home market with cheaper products which do not compete with Japanese manufactures<sup>1</sup>. A similar reasoning lies behind the distinction between horizontal transfer, that will result in the production of the same (competing) good, and vertical transfer suggesting that different goods will be manufactured in home and host country.

### Measurement of Transfers

There are more meaningful classifications, but all have in common that up to now they cannot be filled with empirical evidence. The only indicators for the transfer of technology can be derived from statistics on licensing, direct investment and trade in knowledge-intensive goods<sup>2</sup>. To all figures applies that they do not represent technology transfer as such, as (1) it is

combined with the transfer of other resources, or (2) the value of the technology cannot be determined. The former is true of direct investment – designated by many authors as the most important vehicle of technology transfer – and foreign trade. The latter is the case with licensing. In theory, figures on licensing receipts represent a pure equivalent of (patented and licensed) technology transferred abroad. An important part of licensing, however, does not take place "at arm's length" but is intra-firm trade. There may also be transactions labelled licensing fees that more accurately would have to be called profit remittance. Even more important may be that a growing part of international licensing takes place as cross-licensing with partners exchanging their knowledge with no financial transaction involved.

### High Concentration on Industry Level

With these reservations in mind, the analysis of direct foreign investment and foreign licensing statistics shows that technology transfer by German firms has experienced a rapid growth for several years. Since 1967 industrial capital flows to foreign countries expanded by 9.5 % annually, i. e. more than twice as fast as domestic investment. In the same period licence receipts from abroad rose by 8.1 % annually. The third channel of technology transfer, highly knowledge-intensive exports, have been even more expansive with annual growth rates of 20 %.

A look at the structure of investments and licensing abroad (Table 1) reveals (1) a heavy concentration on

<sup>1</sup> Cf. J. H. Dunning: Towards a taxonomy of technology transfer and possible impacts on member countries, in: Technology transfer to developing countries, Paris (OECD), 1978, p. 30.

<sup>2</sup> Commodities with a high content of R & D (SITC items 711.4, 714, 724.9, 726, 729.3, 734, 861 minus 861.9, 862, 864).

## TECHNOLOGY TRANSFER

a small number of industrial sectors, and (2) a strong sectoral correspondence between foreign investment and foreign licensing. Only four sectors – chemical industry, electrical engineering, transportation equipment and mechanical engineering, in that order – account for the bulk of licensing abroad. 83 % of all receipts from foreign licensees registered by the Bundesbank in 1977 are credited to their account, compared to a share of 47 % in manufacturing net production. This sectoral concentration is paralleled by a similar concentration on firm level. In 1973 only 92 German firms (with receipts of at least DM 1 mn each) accounted for 84 % of all receipts.

Direct investment is more evenly distributed, but the four mentioned industries are also among the biggest foreign investors. 60 % of total industrial capital abroad up to 1978 has been transferred by them (a fifth major investor, metalworking, adds another 12 %). As the Bundesbank statistics on licence fees make no distinction between affiliated and non-affiliated transactions, it is not possible to state whether – as with US companies – investments and licenses relate in most cases to the same affiliated recipient.

The picture hardly changes when adjusting for different industry sizes. The said industries, led again by chemicals and electrical engineering, are the most

transfer-intensive of all industries, regarding licensing in relation to turnover. The same applies to the sectoral foreign investment intensity, except for transport equipment, which falls back behind the smaller but relatively more outward-oriented manufacturers of precision and optical goods.

### Regional Distribution of Transfers

Technology transfers from Germany are not only concentrated on industry and company levels, but also regionally biased towards industrialized countries (Table 2). More than 70 % of foreign investments and more than 80 % of licensing contracts are destined for developed countries. Major sources of licence fees are the EC countries and the United States, both regions being preferred host countries for German affiliates. Japan is next in licensing, but, as a result of her restrictive policy regarding foreign investors, has not become an important destination for German capital. As can be seen, the licensing pattern of German firms follows the familiar regional pattern of their economic ties. This applies not only to German activities abroad, but as well to the engagement of foreigners in Germany.

This pattern is quite different from the relations to developing countries, where foreign investment and

**Table 2**  
**German Direct Investment Abroad and Receipts from Foreign Licensees of German Companies, 1970, 1975 and 1978 (Millions of DM)**

Sector	Year	Developed countries		Developing countries		Brazil	
		Direct investment	Receipts from licensees	Direct investment	Receipts from licensees	Direct investment	Receipts from licensees
All sectors	1970	14,900.7	316.3	6,212.3	118.1	1,470.8	55.0
	1975	29,710.0	555.3	12,281.5	202.0	2,874.9	68.7
	1978 <sup>a</sup>	41,210.6	635.8	16,982.0	141.9	4,039.2	12.6
Chemical industry and oil processing	1970	4,451.0	142.0	1,046.9	32.0	248.8	1.3
	1975	6,831.2	244.3	1,590.2	61.2	452.6	1.7
	1978 <sup>a</sup>	8,942.5	239.4	2,245.9	62.3	639.6	0.4
Metal industries <sup>b</sup>	1970	4,643.4	71.4	1,639.4	71.1	778.8	51.8
	1975	8,138.3	118.8	2,601.9	101.1	1,339.4	63.3
	1978 <sup>a</sup>	11,119.7	142.9	3,676.1	36.9	1,941.7	8.7
Electrical engineering	1970	1,981.7	74.4	593.3	11.8	201.7	1.8
	1975	3,147.4	123.3	1,050.3	23.8	408.6	3.1
	1978 <sup>a</sup>	4,531.4	155.8	1,866.7	19.5	847.0	0.3
Precision mechanics, optics	1970	343.2	1.6	70.5	0.3	12.2	–
	1975	589.4	0.5	184.7	0.2	22.2	–
	1978 <sup>a</sup>	776.7	0.9	220.4	0.4	40.4	–
Food products	1970	544.6	4.7	240.3	0.1	43.7	–
	1975	858.8	3.6	360.3	0.5	152.0	–
	1978 <sup>a</sup>	1,094.3	2.7	389.9	0.6	152.7	–
Other sectors	1970	2,936.8	22.2	2,621.9	2.8	185.6	0.1
	1975	10,144.9	74.8	6,493.1	15.2	500.1	0.6
	1978 <sup>a</sup>	14,746.0	94.1	8,583.0	22.2	417.8	3.2

<sup>a</sup>Figures for licence fees refer to 1977. <sup>b</sup>Includes iron and steel, non-ferrous metals, mechanical engineering, transportation equipment and metal goods.

Sources: Bundesanzeiger, var. issues; Monatsberichte der Deutschen Bundesbank, Vol. 24, No. 5, May 1972 and Vol. 28, No. 4, April 1976; Supplement to Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank, Series 3, Balance-of-payments statistics, No. 8, August 1978; unpublished data from Deutsche Bundesbank.

licensing as well as knowledge-intensive trade almost exclusively originate in Germany. Again, within the large group of countries the transfer is predominantly geared towards the advanced economies. Brazil, Spain and Mexico received 47 % of German capital invested in developing countries until 1978, with an even higher share in metal industries (79 %), electrical engineering (68 %) and chemical industry and oil processing (54 %).

The contribution of these countries to Germany's licensing receipts is not quite as high, but still 30 % with a higher share in metal industries. Whereas the importance for direct investments increased during the 1970s, the three countries' weight in licensing fees is smaller now.

### **Impact on Sectoral Performance**

The dynamic development of technology transfer leads to the question of its impact on sectoral performance. Table 1 suggests that

- the different kinds of economic links with other countries are not substitutive; foreign investment, foreign licensing and foreign trade rather constitute complementing elements of growth abroad;
- industries with a strong outward orientation in investment and licensing are – with the exception of machinery – the growth sectors in the German economy. The overall performance of these sectors is obviously more stimulated than restrained;
- technology transfer-intensive industries show a strong international competitiveness, as measured by the concept of revealed comparative advantages;
- technology is transferred, above all, by sectors with high domestic R & D efforts. The chemical industry, electrical and mechanical engineering and transportation equipment together spent 84 % of total expenditures in 1975. Together with precision mechanics and optics they are the most R & D-intensive industries.

There is apparently a close relationship between R & D-intensity of a sector and its technology transfer, with technology transfer obviously being the by-product of a company's R & D efforts. But there may even exist a more planned interdependence between R & D and technology transfer, i. e. R & D efforts take place only under the precondition of international commercialization of its results. This distinction is important, as in the latter case the technology would not have been developed without the possibility of its transfer abroad.

For a sample of 30 US firms it has been calculated that, on the average, about one-fifth of R & D expenditures would not have been effected, if the firms had not set up foreign subsidiaries or transferred technology abroad in other ways. Moreover, nearly one-third of an average R & D project's returns were traceable to transfer of technology, and, not surprisingly, a statistically significant relationship between the contribution of technological outflows to volume and return of R & D efforts, on the one hand, and the overall importance of foreign sales (i. e. exports plus sales of manufacturing subsidiaries abroad in relation to total sales), on the other, has been established<sup>3</sup>. Given the traditionally strong export orientation of German firms and their overproportionately growing direct investment involvement, there is good reason to assume that extent and profitability of R & D activities in Germany are to a considerable degree explained by the exploitation of technological assets in foreign countries. This is the more true as only an insignificant share of R & D is carried out with foreign subsidiaries of German firms.

### **Determinants of Impacts**

In order to assess the significance of technology transfer for the German economy as a whole, however, the discussion must not be limited to the transferring industries. Above all, it must be extended to the sectors, which may possibly get hit by technological transmission abroad. The main determinants of impact to be considered in this context can be grouped under the following headings:

- structural characteristics of the countries, to which technology is transferred;
- structures, motives and strategies of the companies transmitting technology;
- legal and administrative regulations.

Perhaps the most important structural characteristic of host countries in this context derives from the domestic scientific and technological base, which is a crucial determinant of the recipient's ability to absorb, adapt and advance the technological knowledge received from abroad. As a consequence, the scientific and technological infrastructure, in conjunction with availability, qualification and remuneration of manpower as well as size and growth potential of domestic markets permitting (or not) economies of

<sup>3</sup> Cf. E. Mansfield et al.: Foreign trade and U.S. research and development, in: *The Review of Economics and Statistics*, Vol. 61, No. 1, pp.49 to 57.

scale to be exploited, determines to a considerable degree the international competitiveness of production activities which are based on imported technology. Moreover, volume, diversity and efficiency of domestic supplier industries must be taken into account, since the scope for exporting machinery, equipment and intermediate goods arising in the wake of technology transfers depends largely on these factors.

As far as structures, motives and strategies of technology transferring firms are concerned, a distinction has to be made between "offensive" actors adopting technology transfers as a measure to capture foreign markets, and "defensive" companies carrying technologies abroad which are no longer competitive at domestic locations. Defensive type technology transfers are also characteristic of oligopolistically-structured high-technology industries, where technological assets are exploited abroad in protected markets in order not to lose ground against competitors. Technology transfer in this context is assumed to bear, in a particular way, an inherent danger of eroding comparative advantages in the countries of origin<sup>4</sup>. In addition to this, the impact of technological transmissions on the sending countries' economies may vary considerably according to the organizational arrangement adopted. Of particular importance in this context is the distinction between external transfers at arm's length and internal transmissions within transnational corporations with the latter permitting the transferring firms a stricter control of technology use.

Among the legal and administrative regulations, which have a strong bearing on the significance of technological exports for the exporting countries, policies with a long-run impact, e. g. measures strengthening the national scientific and technological potential, are to be distinguished from provisions calling forth immediate results. To the latter group belong the establishment and modification of mechanisms to stimulate and control foreign capital and technology inflows as well as export promotion measures and import regulations regarding capital goods, parts and components employed for manufacturing the foreign technology-based products.

Given the poor statistical data base it is not possible to assess empirically for the German economy the above-listed factors determining the repercussions of technology transfers on the transmitting countries. As a consequence the brief empirical analysis which

follows will be confined to some evidence regarding technology transfers by German firms to Brazil.

### Brazil as a Case in Point

Brazil is by far the most important recipient of German technology among the countries of the Third World. As of yearend 1978, nearly one-third of total German direct investment in developing countries was accounted for by Brazil, and in 1976 more than 10 % of German exports of highly knowledge-intensive goods have been directed towards Brazil. As far as licence fees and similar payments are concerned, Brazil contributed, on an annual average, almost 60 % to all German receipts from LDCs between 1965 and 1975. It is true that in subsequent years the Brazilian share fell to about 15 %. This is, however, hardly indicative of a declining German technology transfer to Brazil, but may rather be explained by a stiffer legislation and administration concerning foreign technology enacted in 1975. In particular, explicit payments for technology received from related companies are still authorized only in a very limited number of cases.

The question then arises, whether the substantial German technological transmissions tend to narrow the scope for German exports to Brazil as well as third-country markets and turn out as a serious challenge even to the home market of German firms. Since empirical evidence conducive to assess the impact of knowledge-intensive trade and technology transfer via licenses to unrelated firms is lacking, the analysis will concentrate on direct investment, which is, however, the dominant vehicle of German technological exports to Brazil.

Starting manufacturing in Brazil is, as a rule, equivalent to limiting export possibilities for the products concerned. Efficiency considerations do not matter as long as local production can meet domestic demand. This does, however, not necessarily mean that German firms investing in Brazil are replacing German exports to this country. The attractiveness of the Brazilian market in conjunction with fierce import substitution policies followed by the Brazilian government suggest that investors from other countries or Brazilian companies would have seized the opportunity, if the German firms had refrained from establishing production facilities. In the wake of German investment activities in Brazil exports from Germany might even have increased, since local manufacturing opens the Brazilian market for other products of the investing companies and stimulates exports of machinery and intermediate goods, which otherwise would rather have been obtained from non-

<sup>4</sup> Cf. J. H. Dunning, *op. cit.*, p. 30.

**Table 3**  
**Exports of German-owned Companies in Brazil, 1971 to 1977**

Brazilian company	German parent	Main export products	1 000 \$							% of total sales		
			1971	1972	1973	1974	1975	1976	1977	1974	1975	1976
VW do Brasil	Volkswagen	Cars ckd; car engines	1,672	13,006	20,523	80,395	132,929	148,117	168,522	7.9	11.2	10.7
Mercedes Benz do Brasil	Daimler Benz	Trucks	3,382	16,892	7,869	29,715	59,312	76,454	83,449	6.3	10.1	12.0
Bosch do Brasil	Bosch	Pumps	3,997	4,920	5,753	5,793	6,017	3,846	6,267	n.a.	n.a.	n.a.
Icotron	Siemens	Condensators	1,010	1,522	2,144	4,041	4,235	2,867	4,084	23.0	23.9	14.0
Siemens SA	Siemens	Switchboards	628	911	1,159	2,594	2,784	3,109	4,082	3.6	2.6	2.7
Vitrofarna	Jenaer Glas-Werk	Glassware	690	698	628	1,051	1,762	1,428	1,706	17.0	27.3	15.4
Osram do Brasil	Siemens	Tungsten filaments	538	723	867	1,208	1,750	1,254	1,698	8.9	16.4	10.6
Krupp Metal-úrgica	Krupp	Crankshafts	1,010	1,096	1,587	1,483	1,509	2,653	3,952	-	1.6	2.9

Sources: Visão: Quem é quem na economia brasileira, var. issues; Interinvest: Guia Interinvest, Rio de Janeiro 1975/76; Banco do Brasil: Relatório Cacex, var. issues; authors' calculations.

German sources. For Siemens, one of the largest German investors in Brazil employing about 15,000 persons in 10 local plants, it has been estimated that about 7,000 jobs in Germany are due to the company's engagement in Brazil<sup>5</sup>.

#### Erosion of German Advantages?

German investment projects in Brazil are, however, no longer almost exclusively oriented towards the local market. Table 3, which contains figures for 8 major exporting subsidiaries of German firms combining about 50 % of total 1977 exports by German-owned companies in Brazil, demonstrates that exports from Brazil increased at an annual rate of more than 60 % between 1971 and 1977. Exports sales have also become significant in relation to total revenues. Moreover, the Brazilian subsidiaries of German firms are predominantly operating in industries, where Brazil has traditionally been at a comparative disadvantage vis-a-vis advanced industrial economies, e. g. automotive, chemical and electronic industries. If in addition to this it is considered that industrial exports from Brazil are stimulated by extensive subsidies, the activities of German-owned subsidiaries in Brazil may indeed contribute to eroding German competitive advantages.

<sup>5</sup> Cf. M. Gester: Die Siemens-Investitionen in Brasilien zahlen sich aus (Siemens' investments in Brazil are paying), in: Frankfurter Allgemeine Zeitung, No. 176, August 1, 1979. A positive relationship between export and technology transfer via direct investment is also suggested by the strong performance of German industrial exports to Brazil. Since the mid-sixties, when the stock of German direct investment in Brazil set out to grow by annual rates of above 10 %, exports of manufactures increased from less than US-\$ 100 to nearly US-\$ 1.5 bn.

A closer analysis of the figures does, however, little to substantiate this conclusion. About 40 % of Brazilian exports of those commodities, which are the main export products of German-owned subsidiaries, were allotted to other Latin American countries in 1977. These deliveries cannot be regarded as a serious threat to German export interests, since Brazil in a good number of cases enjoys preferential access to the markets concerned and other companies in Latin America would presumably have done the business instead of the German-owned firms in Brazil.

Less than 10 % of the exports under consideration were directed towards the German market. In relation to total German imports in the corresponding SITC-items, imports from Brazil accounted for only 0.5 %. In contrast to this the Brazilian share in total German imports of manufactures amounted to 1.2 %. In the years ahead the overall significance of imports from Brazilian subsidiaries of German firms may increase, but this will hardly occur to an extent overstraining structural adjustment capacities of the German economy.

To sum up, no conclusive evidence could be found to suggest harmful consequences for the German economy resulting from transfer of technology via direct investment of German firms in Brazil. On the contrary, given a positive impact of German investment for the Brazilian economy, technological transmissions assuming the form of direct investment appear to be a non-zero sum game with a favourable outcome for both the parties involved.