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Transnational Corporations as Engines of Growth

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Chapter VI

TRANSNATIONAL CORPORATIONS, TECHNOLOGY AND GROWTH

Technology plays an undisputed role in economic growth by increasing the productivity potential of all factors of production, both tangibles such as labour and capital and intangibles such as organization and quality control. As the economies of the world are becoming increasingly globalized, technology emerges as the most decisive factor in determining international competitiveness and hence growth prospects. The present chapter provides a brief overview of the relationship between technology and growth, evaluates the role of TNCs in that relationship and draws some policy implications relevant to strengthening the contribution of TNCs to growth through technology transfer.

A. Technology as a determinant of growth

1. Linkage between technology and growth

The concepts of technology and technological change encompass many dimensions. Technological progress in some cases involves process innovation, implying that new ways are found to produce existing goods and services, often involving less use of resources. In others, it involves product innovation, implying the introduction of new products or the improvement of quality. Technology comprises more than machinery and other forms of hardware embodied in physical goods. It can be considered as "the stock of knowledge (technical or management)" [1] used in production and marketing. A part of that knowledge is embodied in machines, but much of it is also embodied in human skills, management methods, organizational structures and work routines. Technology, therefore, takes different forms: "hardware", such as machinery and equipment; "software", such as blue prints and process specifications; and the "services" of technicians and professionals for tasks such as quality improvements, management and marketing know-how and process and product design. The software and service components of technology are becoming increasingly important in the international economy, with the emergence of information technology as the central element in the production of many goods and services.

The pervasive nature of the concept of technology, as indicated above, raises several problems in relating technology to growth. There is no single measure of the level of technology and the rate of technological change; it is not easy to separate the independent contribution of technology from other factors of production, particularly capital and labour, in which technology often becomes embodied; [2] and the impact of technology on growth depends on complex interactions between technological change, the structure of incentives confronting enterprises to apply, adapt and innovate upon available technologies, as well as institutional arrangements regarding, among other things, the flow of information and the functioning of markets. [3]

Despite those problems, analysts generally agree on the importance of technology as a determinant of growth. At the conceptual level, technology is considered to promote growth in several ways. First, advancements in technology enable a country to obtain a greater output from any given combination of inputs, which means that the productivity of factors of production is enhanced by technology. Second, technology can promote and sustain growth through the production of new products (including qualitatively superior products), with higher value-added and greater income elasticity. Third (related to the above but deserving of special mention), technology can foster growth through improved export performance, which often requires a shift in the composition of exports from primary commodities to manufactures, and within manufactures to more technology-intensive products.

2. Some empirical evidence on technology and growth

A substantial body of empirical evidence drawn from developed countries provides empirical support for the conceptual links between technology and growth. Empirical evidence for the central importance of product innovations in long-term growth was provided by S. Kuznets as early as 1930. [4] Based on the premise that old consumer goods typically suffer from low long-term income and price elasticity, he argued that a cost-reducing impact of technological change in old goods would have a small aggregative impact on growth. The long-term growth impulse, therefore, came from new products. Similarly, J. Schumpeter emphasized the role of "creative destruction" of old products and their replacement by new ones in the dynamics of growth. [5] Many subsequent studies at both the aggregate and sectoral levels have provided empirical evidence for the beneficial impact of technology on growth through increased productivity of factors of production. [6]

Recent empirical studies on developing countries also demonstrate a significant impact of technology on growth through higher factor productivity. According to one study on Latin America, for example, nearly 20 per cent of growth in output for that region for the period 1940-1970 was accounted for by growth in total factor productivity.[7] The findings of several studies on countries/territories in Asia are presented in table VI.1. Very recently, furthermore, one study based on a sample of 25 countries, comprising developed countries as well as six newly industrializing economies (Argentina, Brazil, Hong Kong, Mexico, Republic of Korea and Taiwan Province of China), has found that innovation and diffusion of technology exerted a significant impact on growth of GDP and productivity for the period 1960-1985.[8]

As was noted earlier, technology can promote growth through improved export performance, which often requires a change in the composition of exports in favour of manufactures. Available evidence shows that, within the manufactures group of exports, R&D intensive industries have been the most rapidly growing exporters. Thus, over the period 1980-1987, the rate of growth of imports into developed countries averaged 10 per cent for high R&D intensive industries, while that of low R&D intensive industries was only 5 per cent.[9] It follows that, in so far as exports exert an influence on growth, the technological content will determine the strength of (export-led) growth.

The studies cited above provide convincing empirical evidence of the significant contribution of technology to growth, which in recent decades appears to have assumed an even greater importance for growth. For example, from about the mid-1970s, per capita use of commodity materials (such as, energy, steel, copper, cement) declined or levelled off, while per capita world GDP continued its upward trend; the difference between the growth in the use of materials and the growth of GDP can be largely attributed to growth in the use of knowledge-intensive new technologies such as electronics, computers and new materials.[10] Consistent with that assertion, data show a generally declining trend in the intensity of raw materials per unit of GDP in developed countries (figures VI.1 and VI.2).

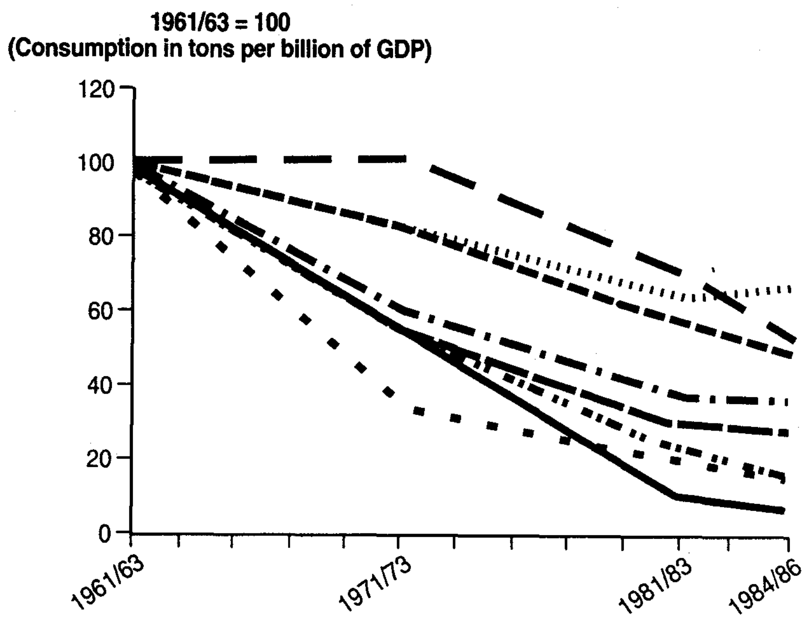
Table VI.1. Selected developing economies in Asia: growth of output and contribution of total factor productivity

(Percentage)

Economy	*Period*	*Growth rate in output*	*Contribution of total factor productivity*
Hong Kong	1955-70	9.3	46.5
	1970-80	9.6	21.3
India	1950-80	3.5	39.1
	1970-80	3.0	0.2
Indonesia	1970-80	7.7	31.5
Korea, Republic of	1955-70	8.8	56.4
	1970-80	8.5	41.2
Malaysia	1970-80	7.8	21.7
Philippines	1957-62	4.9	0.0
	1963-69	5.2	15.4
	1970-74	6.3	19.0
	1970-80	6.2	20.6
Singapore	1957-70	6.6	55.2
	1966-72	12.5	4.8
	1972-80	8.0	- 11.3
	1970-80	9.1	19.7
Taiwan Province of China	1955-77	8.0	53.6
	1970-80	8.5	50.0
Thailand	1970-80	6.9	19.7

Source: Yukio Ikemoto, "Technical progress and level of technology in 1970-1980: a translog index approach", *The Developing Economies,* vol. XXIV, No. 4 (December 1986), pp. 368-390.

Figure VI.1. Intensity of use of selected agricultural raw materials in developed countries



Source: UNCTAD, "Impact of technological change in patterns of international trade" TD/B(XXXV)/SC.I/CPR.2 (March 1989), p. 4.

Key: Rubber, Cotton, Jute, Sisal, Abaca, Wool, Wood, Sugar

B. Transnational corporations and technology development

As mentioned earlier, the common denominator linking technology to growth is that it permits production of a greater amount of, or new output from, a given amount of resources. That production requires new technological development that normally involves R&D efforts. Results of R&D, in turn, are often reflected in patents. The present section, therefore, deals with the role of TNCs in technology development, as indicated by R&D and patents.

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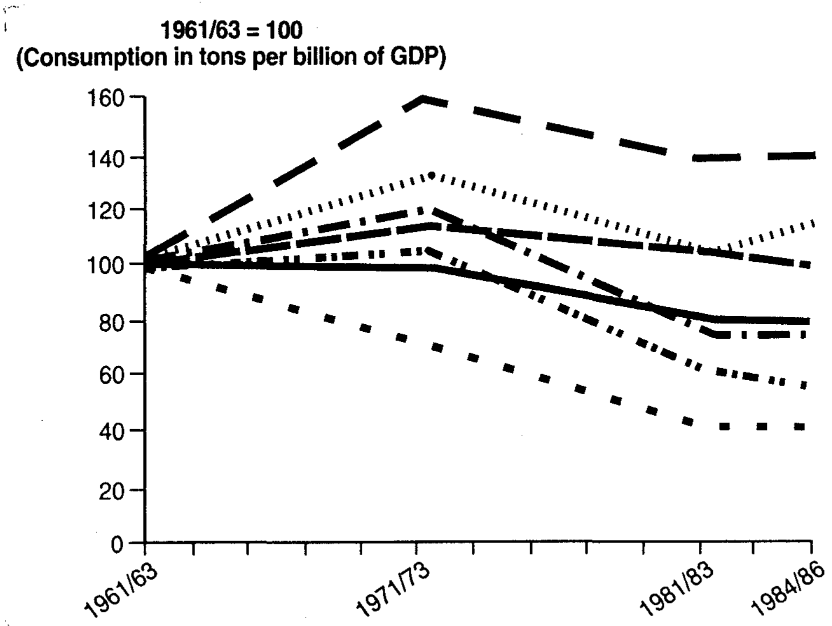
[34]See, for example, Richard Caves, "Multinational firms, competition and productivity in host country markets", *Economica*, vol. 14, No. 162 (1974), pp. 176-183; S. Globerman, "Foreign direct investment and 'spill-over' efficiency benefits in Canadian manufacturing industries", *Canadian Journal of Economics*, vol. 12, No. 1 (1980), pp. 24-52.

[35]Magnus Blomström and Edward N. Wolf, "Multinational corporations and productivity convergence in Mexico" (1989), mimeo.

Figure VI.2. Intensity of use of selected minerals, ores and metals in developed countries



Source: UNCTAD, "Impact of technological change in patterns of international trade" TD/B(XXXV)/SC.I/CPR.2 (March 1989), p. 4.

Key: Manganese, Aluminium, Copper, Iron ore, Nickel, Phosphate, Tin

tional market place, science and technology have become more and more linked. It is being increasingly recognized that a large part of technological development occurs because of actions taken by enterprises.[11] Indeed, TNCs devote substantial resources to R&D, in addition to having a variety of institutional arrangements with universities, research institutions and other enterprises.

The role of private companies in R&D relative to overall national expenditure on R&D by major home countries of TNCs is illustrated in table VI.2. It is interesting to observe that the proportion of sales spent by these companies on R&D far exceeds the proportion of total national expenditure as a proportion of GDP. Furthermore, R&D expenditures of the limited number of companies for which data are presented in table VI.2 account for a significant share of total national expenditures. And most of these firms, in turn, are TNCs, which, recognizing the key importance of technologies, have undertaken extensive research programmes. Such TNCs as IBM, General Electric, Hitachi, General Motors and Siemens have allocated funds amounting to billions of dollars annually for R&D (table VI.3).

Research-and-development expenditures capture the resources devoted to technological development. They are, therefore, an *input* indicator. Results of R&D often find expression in patents, which can be viewed as an *output* indicator of technological development. Here, again, available data on patents registered in the United States clearly show the dominant role of corporations. Foreign-owned corporations together with those of United States origin account for over three-fourths of patents registered in the United States; the share of foreign-owned corporations has increased from the mid-1980s and is now larger than that of domestic firms (table VI.4). The top 50 TNCs accounted for more than one-fourth of all patents granted to corporations during the 1980s. Overall, the development of technologies appears to be increasingly undertaken by TNCs.

2. The internationalization of technological development and transnational corporations

Historically, TNCs have undertaken technological development mostly in their home countries. Foreign affiliates generally undertook modifications and adaptations to innovations, emanating mainly from the R&D establishments of their parent firms in home countries. That is still the predominant pattern. In recent times, however, there has been a marked growth in the internationalization of R&D. As TNCs become progressively more global and acquire a world orientation for their inputs, products and markets, a number of them are establishing

Table VI.2. Research-and-development expenditure of selected countries and top companies [a]

A. National R&D expenditure, latest available years

Country	R&D expenditure (Million dollars)	Share of R&d expenditure in GDP	
		Per cent	Year
Canada	7 250.6	1.3	1989
France	22 241.0	2.3	1989
Germany, Federal Republic of	34 234.0	2.6	1989
Italy	11 189.6	1.3	1989
Japan	82 853.1	2.7	1989
Netherlands	4 792.3	2.1	1989
Sweden	5 459.5	2.9	1989
Switzerland	3 899.6	2.9	1986
United Kingdom	18 356.3	2.4	1988
United States	144 867.0	2.7	1989

B. R&D expenditure of top companies

Country	R&D expenditure of top companies (Million dollars)	R&D expenditure as percentage of sales	Number of companies
Canada	2 069	4.6	6
France	6 997	4.2	17
Germany, Federal Republic of	14 086	6.1	19
Italy	2 640	4.2	8
Japan	27 295	4.9	74
Netherlands	4 208	3.0	7
Sweden	3 454	6.5	10
Switzerland	4 426	5.9	10
United Kingdom	7 570	2.1	33
United States	37 569	4.7	28

Sources: Calculations of the Transnational Corporations and Management Division, based on OECD, *Basic Science and Technology Statistics* (Paris, 1991), table 3; United Nations, *National Accounts Statistics: Analysis of Main Aggregates,* various issues; and *Business Week;* Quality 1991, pp. 171-172 and 176-208.

a Companies with the highest absolute amount of R&D expenditures.

integrated R&D systems, with overseas laboratories playing a significant role. The increasing importance of economies of scope, shorter product cycles and rapid obsolescence, all of which require closer interaction with customers, have necessitated such an internationalization. In some cases, internationalization has been motivated by the desire to take advantage of scarce scientific and technical personnel, in which particular host countries possess a comparative advantage. At the same time, the process has been facilitated by the development of transnational computer-communication networks and on-line systems that permit the smooth flow of data and information among remote sites and, indeed, the on-line conduct of R&D. [12]

Table VI.3. Research-and-development expenditure by top 20 transnational corporations, 1990
(Millions of dollars)

Ten non-United States TNCs	*R&D expenditure*	*Ten United States TNCs*	*R&D expenditure*
Siemens	4 132	General Motors	5 342
Hitachi	3 011	IBM	4 914
Matsushita Electrical Industrial	2 423	Ford Motor	3 558
Philips Electronics	2 411	AT&T	2 433
Alcatel Alsthom	2 237	Digital Equipment	1 614
Fujitsu	2 097	General Electric	1 479
Toshiba	1 864	Du Pont	1 428
Nippon Telegraph & Telephone	1 739	Hewlett-Packard	1 367
NEC	1 728	Eastman Kodak	1 329
Bayer	1 699	Dow Chemical	1 136

Source: Business Week, Quality 1991, p. 176.

No comprehensive data exist on the geographical distribution of the R&D efforts of TNCs by country of origin. But the sketchy evidence available from limited survey data lends support to a growing internationalization. In the case of United States TNCs, the proportion of R&D expenditure accounted for by foreign affiliates increased to 10 per cent in 1989, from seven per cent in 1966. [13] The data seem to indicate that European TNCs have reached a considerably higher degree of internationalization of their R&D expenditures. Some 23 per cent of the R&D expenditures by 20 Swedish TNCs were undertaken abroad in 1987, compared with 21 per cent in 1980. [14] In the case of TNCs from the Federal Republic of Germany, it has been noted that the growth of R&D employment abroad has risen much faster than the growth of total employment abroad. A survey of 33 major firms showed that 18 per cent of their total R&D employees in 1989 were employed in affiliates abroad. [15] In contrast, a survey of 11 large TNCs from the Federal Republic of Germany at the end of the 1970s revealed that 15 per cent of their R&D personnel were employed abroad. [16] Some of the leading European TNCs, such as Ciba Geigy, Royal Dutch Shell, Bull, Philips, Olivetti, ABB and Norsk Hydro, each spend more than a third of their total R&D expenditure in foreign locations. [17]

Available data on patents also generally indicate a rising importance of R&D in foreign locations (table VI.5). Between the early 1970s and mid-1980s, the share of patents filed in the United States by TNCs that are credited to research undertaken outside the home country of the parent company has increased in 7 of the 11 countries included in the table.

Table VI.4. Number of United States patents, by type of grantee, [a] 1980-1991

(Thousands)

	Year											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991 [b]
United States-owned												
Individuals	11.4	12.0	10.3	9.2	10.4	10.7	11.0	10.9	11.7	14.7	14.9	7.7
Corporations [c]	27.6	29.4	25.8	25.7	29.9	30.9	29.3	33.5	31.3	37.9	36.0	18.6
Top 50 United States-based TNCs [d]	9.2	10.1	8.7	8.8	10.1	10.3	9.6	10.8	9.5	11.2	10.5	9.2
Government	1.2	1.1	1.0	1.0	1.2	1.1	1.0	1.0	0.7	0.8	1.0	0.6
Foreign-owned												
Individuals	4.1	4.2	3.4	3.3	3.7	4.0	4.3	4.9	4.8	5.4	5.3	2.7
Corporations [e]	19.2	21.3	19.6	19.9	24.0	26.8	27.6	33.5	32.1	38.7	37.3	19.1
Top 50 non-United States-based TNCs [d]	6.3	7.2	6.9	7.0	8.6	9.5	9.4	11.6	11.3	13.6	12.5	6.2
Government	0.3	0.3	0.4	0.3	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.8
All corporations c	46.8	50.7	45.4	45.6	53.9	57.7	56.9	67.0	63.4	76.7	73.3	37.7
Top 50 TNCs [d]	11.6	13.2	11.8	12.1	14.2	15.3	14.8	17.6	16.5	20.2	19.1	10.0
All corporations as a percentage of total	73.4	74.2	75.2	76.8	77.4	78.0	77.2	79.4	78.2	78.3	77.3	76.2
Foreign corporations as a percentage of all corporations [e]	41.0	42.0	43.2	43.6	44.5	46.4	48.5	50.0	50.6	50.5	50.9	50.7
Top 50 TNCs [e] as a percentage of all corporations [e]	24.7	26.0	26.0	26.5	26.3	26.5	26.0	26.3	26.0	26.3	26.0	26.5

Sources: United States Patent and Trademark Office, OEIPS/TAF Program within the Office of Information Systems, *All Technologies Report, January 1963-June 1991* (Washington, November 1991), *Design Patents Report, January 1977-June 1991* (Washington, November 1991) and OEIPS/TAF Program Database (Washington, June 1991).

a Utility and design patents only.
b Figures up to June 1991.
c May also include non-corporate organizations.
d Inventor patents only.
e May exclude subsidiaries identified separately from parent organizations.

In sum, TNCs account for the bulk of R&D expenditures in their home countries, which, in turn, are the global leaders of technological development. A small but increasing share of those expenditures is being shifted to host countries, albeit primarily to developed ones.

Obviously, technology development is the pre-requisite for improved factor productivity and product innovations which, in turn, fuel growth. By virtue of their dominance in technological development, TNCs play a major role in the growth process, a role that is likely to become of greater importance in the future because of the increasing importance of technology as a determinant of growth.

C. Transnational corporations and the transfer of technology to developing countries

The preceding section has demonstrated the importance of TNCs in the development of technology at the global level. The focus of analysis in the present section is on their role in technology transfer to developing countries. [18] The rationale is that, as demonstrated in the preceding section, technology development by TNCs mostly takes place in the home countries of those firms or in other developed host countries. [19] Therefore, access to technologies for developing countries is largely a matter of acquiring technologies from TNCs in developed countries. The impact of technology transfer from TNCs on the

Table VI.5. The share of United States patents of the largest firms world-wide attributable to research in foreign locations (outside the home country of the parent company), organized by the nationality of parent firms, 1969-1986

(Percentage)

Country	*1969-72*	*1973-77*	*1978-82*	*1983-86*
Belgium	49.6	54.2	56.1	71.3
Canada	42.0	40.0	39.8	35.5
France	10.2	9.4	8.8	10.9
Germany, Federal Republic of	13.6	11.5	12.3	14.4
Italy	20.1	18.3	13.7	11.7
Japan	2.9		1.9	1.3
Netherlands	63.9	68.8	64.1	70.0
Sweden	20.9	17.8	25.9	31.3
Switzerland	45.0	44.3	44.1	42.6
United Kingdom	43.3	40.5	38.7	45.0
United States	4.3	5.5	6.0	7.4

Source: John H. Dunning, "Multinational enterprises and the globalization of innovatory capacity", Rutgers University GSM working paper No. 91-03 (January 1991), table 7, p. 18.

growth of the host economy, however, depends on how the various modes of technology transfer interact with the local technological capabilities, incentive structures and institutional arrangements.

The principal sources of technology acquisition are scientific and technical publications (typically widely accessible at low costs); trade (through the import of machinery and equipment); FDI (through both wholly-owned foreign affiliates and joint ventures); and non-equity links with TNCs through mechanisms such as patents, licenses, technical assistance agreements and other contractual arrangements, as well as strategic alliances. Transnational corporations play a major role in all those modes of transferring technology, particularly so in the latter three.

1. Transnational corporations and the supply of capital goods

The import of capital goods is a prime determinant of the productive capacities of developing countries. As table VI.6 shows, developing countries in Africa recorded a significant decline in the absolute value of capital-goods imports during the decade of 1980s; those in Latin America and the Caribbean achieved only a marginal increase; and those in Asia and the Pacific raised their imports by nearly three-fourths. That is undoubtedly a significant explanatory variable in the differential growth performance of those groups of countries.

Table VI.6. Capital goods [a] imports by developing countries, 1980-1989

(Billions of dollars)

Country group	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*
All developing countries	115.3	130.5	122.4	106.2	105.9	101.4	112.4	126.1	143.9	155.2
Africa	23.5	26.3	22.5	18.2	17.6	16.7	16.5	16.5	17.2	18.2
Asia and the Pacific	56.7	65.1	68.2	65.3	62.4	56.7	63.7	74.0	87.2	95.8
Latin America and the Caribbean	31.1	35.8	29.0	20.3	23.6	25.3	28.5	31.8	35.0	36.3

Source: UNCTAD Secretariat.

a Includes SITC Rev. 1, Section 7, machinery and transport equipment, except 7194 domestic appliances non-electrical; 7241 television receivers; 7242 radio receivers; 7250 domestic electrical equipment; 7321 passenger motor cars; 7326 chasis for passenger motor cars; 7329 motor cycles; and 7331 bicycles.

The key issue in the present context is the role of TNCs in capital-goods imports. The non-availability of data does not permit a disaggregation of imports of capital goods from TNCs as compared with imports from other entities. Indirect evidence suggests, however, a major role of TNCs in the supply of capital goods. For example, in 1989, at least 80 per cent of United States foreign trade was undertaken by those corporations, including parent companies in the United States, foreign affiliates of United States TNCs and United States affiliates of foreign TNCs. It is, therefore, not unrealistic to assume that the proportion of capital-goods imports of developing countries from the United States accounted for by TNCs is quite high. The importance of TNCs in the supply of capital goods is also underscored by the high proportion of intra-firm trade in some capital goods items. For example, exports of non-electrical machinery by United States TNCs are substantially intra-firm; in 1989, 60 per cent of such exports were represented by intra-firm transactions. [20] The importance of intra-affiliate transactions in total capital goods imports of developing countries, however, would be considerably less (see chapter VIII).

2. Technology transfer through foreign direct investment

A TNC normally undertakes FDI when it possesses certain technological or other economic advantages over its competitors, which it finds in its best interest to exploit internally from a foreign location. [21] Technology forms an important part of the competitive advantage of a TNC, and many firms choose to service their foreign markets through FDI, not only to exploit that advantage but also to retain company control over their technology. Transnational corporations generally transfer their most recent technology to their affiliates, while selling or licensing older technology to locally-owned firms and joint ventures. [22] Hence, FDI may be the only way for many developing countries to gain access to the latest technology and especially to certain key technologies.

Foreign direct investment can promote technological change in developing countries—and, as box VI.1 shows, in developed countries as well—in a number of ways. The direct impact may occur through its contribution to higher factor productivity, changes in product and export composition, R&D undertaken by foreign affiliates, the introduction of organizational innovation and improved management practices, and employment and training (the last of these aspects is being dealt with in chapter VII). Indirect impacts occur through collaboration with local R&D institutions, technology transfer to local downstream and upstream producers, the effects of the presence of foreign affiliates on competition and on the efficiency of local producers and the turn-over of trained personnel.

(a) Direct effects

(i) Transnational corporations and factor productivity

An important contribution of technology to growth is through increased factor productivity. An evaluation of the contribution of TNCs to that process would require highly disaggregated data on the

Box VI.1. Foreign direct investment in developed countries and technology transfer

A good part of the discussion of FDI and technology transfer in developed countries focuses on the possibility that FDI may, in fact, reduce the technological capacity of the host economy and, hence, impair its growth prospects. For example, it has been argued that Japanese TNCs in the United States cause a drain of United States technology to Japan. More specifically, it is feared that, when Japanese companies acquire United States firms, especially in high-technology industries, they do so in order to capture innovative products and their technologies for the parent firm in Japan. [1] It is argued that, in the longer run, foreign investors will shift the bulk of R&D activities from the United States to their home countries and denude the United States of its innovative capacity by making the results of R&D unavailable to firms in the United States.

It is very difficult to assess the longer run impact of foreign investors acquiring or displacing United States firms on the development of technological capacity in the United States. However, if the concern is that foreign investors will shift R&D activities from their United States affiliates back to headquarters, the data show that, in fact, foreign affiliates in all industries taken together in the United States perform twice as much R&D per worker than United States firms (table 1). In the manufacturing sector, however, the differential is less pronounced and the amount of company-funded R&D expenditure per worker for United States firms is marginally lower than for foreign affiliates. Those figures do not give any indication of the type or quality of R&D undertaken by the two categories of firms, but they do not support the view that foreign firms are transferring large amounts of R&D from their United States affiliates to headquarters. Similarly, a study of royalties and licence fees found that transfer of foreign technology into the United States by foreign affiliates was more than five times larger than technology transferred out by them. [2] In fact, measured by royalties and licence fees, the largest proportion of technology transfer from the United States was accounted for by United States parents of foreign affiliates.

Many foreign investors may locate their R&D activities in the United States in order to take advantage of the technology centres in that country. [3] A study of Japanese entries into 297 United States industries showed that Japanese FDI predominated in R&D intensive industries in respect of establishment of new plants, but there is no indication that Japanese acquisitions are more frequent in high-technology industries. [4] Many Japanese companies pursue a strategy of vertical integration for their overseas activities. Fujitsu, for example, has constructed a $100 million R&D, manufacturing and service facility in Texas for the development of fiber optic transmission systems for the United States market, jointly by United States and Japanese engineers. [5]

Table 1. Research and development by United States affiliates of foreign firms, 1988

		United States firms	
	Foreign affiliates [a]	*Total* [b]	*Company-funded*
All industries			
R&D (millions of dollars)	7 382	97 889	65 583
Employment (thousands of workers)	3 682	91 076	...
R&D per worker (thousands of dollars)	2.00	1.07	0.72
Manufacturing			
R&D (millions of dollars)	6 402	89 776	60 223
Employment (thousands of workers)	1 762	19 341	...
R&D per worker (thousands of dollars)	3.63	4.64	3.11

Source: Edward M. Graham and Paul R. Krugman, *Foreign Direct Investment in the United States* (Washington, D.C., Institute for International Economics, 1991), table 3.3, p. 73.

a Data are preliminary

b Includes federally funded as well as company-funded expenditure.

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(Box VI.1, continued)

Likewise, in 1985, Honda established an R&D facility in Ohio, now employing 200 persons. Honda's goal is to employ 500 people in R&D centres in the United States by 1995. The strategy of the company is to develop and build cars in the areas in which they are sold. [6]

Foreign affiliates in the United States may also be helping to increase United States factor productivity by introducing new technology and management methods. This may particularly be the case in industries in which the United States is losing international competitiveness. In the automotive industry, the Japanese automakers in the United States are introducing new standards in the manufacturing and engineering of cars, which serve as models for United States automakers. For example, in 1990 the Ford Motor Company switched to the production of a new model without stopping the assembly line, by introducing reprogrammable machines that move on tracks. This is a practice Japanese automakers have developed, and used in the United States, to increase productivity. [7] In 1982, General Motors turned over a run down and inefficient auto plant in Fremont California to Toyota Motor Corp. as a part of a joint venture. By introducing new technology and a typical Toyota production system, with just-in-time delivery and a flexible assembly line, it only takes half of the previous work force to assemble the same number of cars. [8]

Japanese automakers in the United States also transfer technology indirectly, by providing technical assistance to United States suppliers. Since the surge of the yen made it more profitable for Japanese firms to source locally, they encourage United States car-part firms to adopt new methods to improve quality and lower production costs. [9]

In fact, Japanese FDI in the United States automotive industry has brought new investments and technology transfer to other declining industries in that country, like the steel and rubber industries. Faced with strong international competition and declining demand from the automotive industry, the United States steel industry verged on collapse at the beginning of the 1980s. However, many Japanese steel firms have invested heavily in the United States, building state-of-the-art plants for coating and preparing steel coils used by carmakers, and entering joint-ventures to modernize large integrated United States steel plants. [10] In this manner, the United States partners gain access to state-of-the-art Japanese technology, as well as the new market of Japanese automakers.

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1 Marjorie Sun, "Investors' yen for U.S. technology", *Science*, vol. 246 (8 December 1988), pp. 1238-1241; Eduardo Lachicha, "Japanese firms the most active investors in U.S. high-tech concerns, study says", *The Wall Street Journal*, 14 May 1991; and Georgio Gilder, "American technology at fire-sale prices", *Forbes* (22 January 1990), pp. 60-64.

2 See Kan H. Young and Charles Steigerwald, "Is foreign investment in the U.S. transferring U.S. technology abroad?", *Business Economics*, vol. XXV, No. 4 (October 1990), pp. 28-30.

3 See Edward M. Graham and Paul R. Krugman, *Foreign Direct Investment in the United States* (Washington D.C., Institute for International Economics, 1991).

4 See Bruce Kogut and Sea Jin Chang, "Technological capabilities and Japanese foreign direct investment in the United States", *Review of Economics and Statistics*, vol. 73, No. 3 (August 1991), pp. 401-413.

5 In 1989, Fujitsu had seven R&D centres in the United States, mainly devoted to software and development of data storage equipment. See *Business International*, 23 October 1989.

6 See Martin Kenney and Richard Florida, "How Japanese industry is rebuilding the Rust Belt", *Technology Review*, vol. 94 (February/March 1991), pp. 24-33. Toyota also announced a major expansion of research facilities in the United States in 1991 (see *The Wall Street Journal*, 3 June 1991).

7 See *The New York Times*, 14 March 1990.

8 See *Business Week*, 14 July 1986.

9 See *The Wall Street Journal*, 12 April 1988.

10 See Kenney and Florida, op. cit.

use of factors of production and value-added, differentiated by ownership in different industries. Such data are not readily available.

There are case studies, however, that provide some evidence of the relative efficiency of the use of factors of production, as between foreign affiliates and domestic enterprises. For example, an analysis of 282 pairs of foreign and domestic firms of similar size drawn from 80 manufacturing industries in Brazil concluded that foreign firms have a significantly higher ratio of value-added to output than domestic ones. [23] A study on Thailand found that foreign firms had higher average productivity of both capital and labour in the manufacturing sector compared with domestic firms, and the difference was owing to the higher efficiency of foreign firms as measured by a technology co-efficient derived from production-function estimations. [24] Similarly, a study on the Republic of Korea observed that the marginal product of both capital and labour was higher in foreign firms compared with domestic firms, but the differential was much greater for capital than labour. [25]

All these studies, therefore, support the view that foreign firms can contribute to growth through the provision of technologies that make more efficient use of capital and labour.

Table VI.7. Shares of high and medium research-intensive industries [a] in total sales and manufacturing sales of foreign affiliates, 1982 and 1989

(Percentage)

	1982		*1989*	
Developing region	*Share in total sales*	*Share in manufacturing sales*	*Share in total sales*	*Share in manufacturing sales*
United States majority-owned affiliates				
Africa	3.5 [b]	59.2 [b]	3.1 [b]	23.0 [b]
Asia and the Pacific	15.7	..	50.7 [b]	..
Latin America	21.8	57.3	33.1	60.9
Japanese affiliates				
Africa [c]	17.1	42.4	10.8	40.9
Asia and the Pacific [d]	29.0	74.5	25.9	79.8
Latin America	20.1	66.0	19.4	74.3

Sources: United States, Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey,* (Washington, D.C., United States Government Printing Office, 1985), table III.D.3, and *1989 Benchmark Survey,* Preliminary Results (Washington, D.C., United States Government Printing Office, 1991), table 32; Japan, Ministry of International Trade and Industry, *The Fourth Basic Survey on Japanese Business Activities Abroad* (Tokyo, Okurasho Insatsu-Kyoku, 1991), p. 12, and *Survey on the Overseas Activities of Japanese Companies,* No. 12-13 (Tokyo, Toyo Hoki Shuppan, 1984), p. 43.

a High and medium research-intensive industries include chemicals, machinery (except electrical), electrical machinery and domestic equipment, and transportation equipment.

b Part of data are suppressed by the source to avoid disclosure.

c Includes South Africa.

d Includes Australia and New Zealand.

(ii) Transnational corporations and product composition

As noted earlier, the introduction of new products or qualitatively superior old products is one of the ways by which technology promotes growth. Transnational corporations can play a role in this process. One way of assessing the role is to examine the performance of TNCs in the production of relatively more research-intensive products (table VI.7). The table shows that, for United States

TNCs, the expansion of the share of sales of high and medium research-intensive industries primarily occurred in Asia and the Pacific. In that region, United States affiliates also had the largest increase of R&D expenditure as percentage of sales, as noted later. Latin America shows a much slower growth in sales of high and medium research-intensive industries and Africa shows a decline. For Japanese TNCs, the picture is similar as far as Africa is concerned. And, again, there has been an increase in the share of sales of high and medium research-intensive industries in manufacturing sales in Asia and the Pacific as well as Latin America, with a slightly more pronounced growth in the latter region in terms of the share of manufacturing sales.

The creation of production facilities by TNCs in high and medium research-intensive industries can imply technology transfer not merely through a changing product composition, but also through the training of host country personnel in new technical skills and the introduction of new management methods and new ways of organizing the production process. The impact of FDI on the transfer of skills from host-country personnel, however, does not depend only on the degree of complexity of the technology employed; it is also a function of the methods used for transferring skills, the quality of in-house training programmes, the promotion policy for nationals through exposure to progressively higher levels of responsibility and the provision of off-the-job training.

As a note of caution, it should also be mentioned that the data in table VI.7 do not provide information on the value-added activities of the foreign affiliates. It could be that some TNCs locate only relatively labour-intensive, low value-added operations of those research-intensive outputs in the host country, and that the high value-added operations are located in the home country.

(iii) Transnational corporations and export composition

The technological content of exports can be an important determinant of growth performance. It is well known that R&D intensive exports generally have higher income elasticities; therefore, the growth of those exports is more sustainable over the long run. Besides, a rising share of such exports also carries the implication that the country concerned is in a position to take advantage of shifts in international demand (manifested in the growth of internationally competitive R&D intensive industries), rather than to rely exclusively on traditional exports based on natural-resource endowments or low labour costs. The role of TNCs in the export of R&D intensive products, therefore, deserves scrutiny.

The relevant data are presented in table VI.8. They show that, in the case of Japanese affiliates, the share of R&D intensive exports in total manufactured exports increased between 1982 and 1989 in Latin America and Asia, but declined in Africa, where an absolute decline of R&D intensive exports also occurred. In the case of United States affiliates, their share of R&D intensive exports increased somewhat in Latin America, declined slightly in Asia (though the share is still much higher than in Latin America) and remained very small in Africa. On the whole, affiliates have significantly increased R&D intensive exports.

Again, it is difficult to estimate the local value-added in the host country from export-oriented production. It should also be noted that the performance of TNCs in respect of R&D intensive exports is not necessarily better than that of local enterprises. In particular, local enterprises in certain Asian countries have clearly outperformed foreign affiliates. Total R&D intensive exports from Asia in 1989 were more than four times those recorded in 1982; [26] but the increase in R&D intensive exports by both United States and Japanese affiliates over the same period, though significant, did not reach a similar proportion. (See also the discussion on structural change of exports in chapter VIII.)

(iv) *Research and development by affiliates*

The evidence that an overwhelming proportion of the *foreign* R&D of TNCs is located in developed countries does not necessarily imply that such R&D is insignificant from a host-country perspective. In countries such as India, the Republic of Korea and Singapore, the share of aggregate R&D expenditure attributable to foreign firms exceeded 15 per cent in the 1970s. [27] Moreover, some evidence indicates that foreign affiliates may now be devoting more of their resources than before to R&D. In the case of the majority-owned foreign affiliates of United States TNCs, there has been a noticeable increase in their R&D expenditures as a proportion of sales in a number of developing countries (table VI.9). But there are some noticeable regional differences. Research-and-development expenditure by United States affiliates as a percentage of sales increased four times between 1982 and 1989 in Asia and the Pacific, while it stagnated in Latin America and remained insignificant for the developing countries in Africa.

The location of R&D activities in developing countries can be explained by locational advantages and the corporate

Table VI.8. Manufactured exports and research-and-development intensive [a] exports of foreign affiliates, 1982 and 1989

(Millions of dollars)

	United States majority- owned affiliates		*Japanese affiliates [b]*	
Developing region	*Manufactured exports*	*R&D intensive exports*	*Manufactured exports*	*R&D intensive exports*
Latin America				
1982	4 692	2 908	971	84
1989	10 176	6 794	815	165
Percentage increase	117	134	- 19	96
Asia				
1982	5 954 c	5 453 c	5 950	3 027
1989	13 861	12 176	11 560	7 230
Percentage increase	133	123	94	139
Africa				
1982	169 c	3 c	23	9
1989	566	9 c	30	5
Percentage increase	235	200	30	- 44

Sources: United States, Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey,* op. cit., tables III.E.4. and III.E.5, and *1989 Benchmark Survey* tables 42 and 44; Japan, Ministry of International Trade and Industry, *Survey on the Overseas Activities of Japanese Companies,* No. 12-13, op. cit., pp. 90, 91 and 95 and No. 18-19, (Tokyo, Okurasho Insatsu-kyoku, March 1990), pp. 74-75, 78-79 and 82-83.

a Definition same as in table VI.7.

b The values may be substantially understated because of incomplete coverage of firms in the surveys.

c Part of the data is suppressed by the source to avoid disclosure.

strategies of TNCs. The decisions of corporations to locate R&D activities in certain host countries are very much dependent on factors, such as the availability of R&D facilities and of trained scientific and engineering personnel. Generally, countries with high expenditures for R&D are also the countries in which United States affiliates have a high proportion of R&D expenditure compared to sales.

Very little is known of the type of research undertaken by foreign affiliates. The R&D activities taking place within foreign affiliates are, most likely, typically confined to adapting the technology of the parent company to local conditions. In a sample of 218 Japanese TNCs, 57 per cent expressed the view that the main objective of their foreign R&D facilities was to develop products tailored to meet local demand. [28] The effect of TNCs on deeper indigenous research-and-innovation capabilities ("know-why") in developing countries is less evident. As TNCs can import all their "know-why" and need to perform only adaptive research in host countries, local firms may well conduct more research (as opposed to development) than do foreign affiliates.

Table VI.9. Research and development expenditures of selected developing economies as a percentage of GNP and research and development expenditures for United States majority-owned affiliates as percentage of sales

	R&D expenditure of countries as percentage of GNP				*R&D expenditure of United States majority-owned affiliates as percentage of sales*	
Developing regions/economy	*Percentage*	*Year*	*Percentage*	*Year*	*1982*	*1989*
Latin America					0.2	0.2
Argentina	0.2	1982	0.5	1988	0.4	0.25
Brazil	0.7	1982	0.4	1985	0.4	0.3
Mexico	..	..	0.6	1984	0.3	0.2
Africa					0.01	0.02
Middle East					0.1	0.4
Asia and the Pacific					0.04	0.2
Hong Kong	..	..	..	..	..	0.1
India	0.7	1982	0.9	1986	0.5	0.6
Indonesia	0.4	1983	0.2	1988	0.02	0.03
Republic of Korea	0.9	1982	1.9	1988	..	0.3
Malaysia			..	..	..	0.1
Singapore	0.3	1981	0.9	1987	..	0.3
Thailand	0.3	1985	0.2	1987	0.03	0.02
Taiwan Province of China	..	..	..	..	0.3	0.4

Source: UNESCO, *Statistical Yearbook*, various issues; United States, Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey*, op. cit., tables III.H.3 and III.E.1; and *1989 Benchmark Survey*, op. cit., tables 40 and 76.

It may also be that a strong presence of TNCs can inhibit the development of an indigenous technological base beyond adaptive research.[29] When TNCs penetrate a host-country market, indigenous firms may be forced to cut back on research or to narrow their field of specialization, as they are confronted with declining market shares caused by competition with TNCs that possess much greater technological capacities. On the other hand, foreign competition could also induce domestic firms producing similar products to undertake R&D that otherwise would not have taken place, in order to improve their competitive advantage. In that case, FDI could advance local innovatory capacity in areas in which the host country and its firms are strongest and have a competitive market structure. In the case of greenfield investments, which do not compete with local industry, there is no displacement of local enterprises, and FDI will most likely lead to a net increase in the innovatory capacity of a host country, even through adaptive research.[30]

(v) Organizational innovation and management practices

Organizational innovation and improved managerial practices are being increasingly viewed as a major aspect of technological development for enhancing productivity and accelerating growth. The principal components of these aspects that have evolved over the last two decades or so can be summarized as follows:[31]

- The underlying philosophy of production has been altered: instead of producing to stock, goods are produced to order. That necessitates a demand-driven system capable of producing a variety of product types in much smaller volumes. Hence, lot sizes have been reduced dramatically.
- The efficient production of different products in small lot sizes requires minimizing downtime. That, in turn, requires quick line changeovers and tool setups. Machinery redesign becomes necessary but, more importantly, production-line workers must be trained to do changeovers rather than having them done by separate teams as in mass production.
- Production layouts need to be restructured, and changes made in the use and management of machines in order to create a smooth flow of smaller lot sizes.
- Inventories have to be reduced to a minimum "just-in-time" level rather than being stocked "just-in-case", so that the increased number of different product types can be accommodated without large carrying costs.
- Maintaining a smooth flow of production without inventories requires that components have zero defects or be of perfect quality, whether they come from suppliers or from in-house sources further back in the production line.
- Skill and craft demarcations among workers are eliminated and workers are trained to be multi-skilled; they are paid according to their skill level and the quality of their work.

The organizational changes involved extend throughout the firm: from design to marketing to production; from senior management to the shop floor; and from management's relations with its workforce to the firm's relations with its suppliers.

Transnational corporations from Japan, particularly those in the automobile industry, have been the pioneers of these developments. It was during the 1980s that these organizational techniques began to be introduced outside of Japan. In some cases this was a direct result of the operations of the Japanese affiliates themselves, especially in the electronics, automobiles, component and machine tool industries that had been established in North America and Europe. In other cases, non-Japanese suppliers of these Japanese foreign investors began to restructure to incorporate new patterns of organization in order to meet the requirements of their Japanese customers. A third source of innovation were the practices of those firms that had subsidiaries or joint ventures in Japan and which were learning through the operations of these subsidiaries - Bendix's production of auto components and Xerox's restructuring of the mid 1980s are cases in point. By the late 1990s, the central tenets of the new organizational paradigm had filtered through to the major non-Japanese TNCs and were being implemented at the plant level in various industrialized countries.

More recently, TNCs from Japan and elsewhere have started implementing organizational changes in developing countries. No systematic data are as yet available to document the extent of such technology transfer. However, available case studies show that some developing country firms have adopted these changes either as joint venture partners of TNCs or under licensing agreements (box VI.2); in other cases, similar changes have been introduced in TNC affiliates or subsidiaries in developing countries. Examples of the adoption of these technological changes can be found in such diverse countries as Brazil, the Dominican Republic, India, Mexico and Zimbabwe. [32]

(b) Indirect effects

Foreign direct investment can promote growth through several indirect mechanisms of technology transfer. For example, backward linkages to local firms, in the form of subcontracting the supply of parts, components and services, create additional demand for intermediate products. A supplier firm in a developing country that is in a subcontracting relationship with a foreign subsidiary can receive technical assistance to improve its product quality and production process or to undertake new product development. When upgrading the technological level of supplier industries, FDI often increases the local value-added and generates growth. The presence of foreign affiliates can increase competition and thereby force domestic enterprises to improve productive efficiency, which is growth-enhancing.

An earlier chapter has provided evidence that TNCs may be increasing their use of inputs from local sources. Local sourcing of inputs, particularly when done under subcontracting arrangements, is often associated with technological assistance to the local suppliers by TNCs. In a survey of the largest foreign affiliates operating in Mexico, for example, it was found that almost two thirds of them had local subcontracting relationships. Almost all of the foreign affiliates that subcontracted locally imparted some kind of training to their national subcontractors: 87 per cent provided training in quality control, 68 per cent gave technical assistance and 22 per cent offered financial assistance to their subcontractors. [33]

As to the spillover impact of TNCs on the technological capacity and productive efficiency of indigenous enterprises, several studies on developed countries provided mixed evidence. [34] The same is true of developing countries. A recent study on Mexico showed that the rate of productivity growth of local firms and their ability to reach the productivity standards of TNCs were positively related to the degree of foreign ownership of an industry. [35] That estimate was interpreted to imply that competition from foreign affiliates forced Mexican firms to increase productivity by investing in human capital and new technology. The study could not exclude, however, the possibility that the competitive pressure from foreign affiliates had simply forced out inefficient local firms, thus improving the average productivity performance of Mexican firms. In contrast, a study on Morocco did not provide any evidence that the presence of foreign firms resulted in increased productivity of domestically-owned firms. [36] Although

Box VI. 2. Transfer of organizational technology: the case of Escorts Ltd. in India

Escorts Ltd. is a large Indian firm which grew to prominence since the mid-1950s. It began by producing motorcycles, and diversified into tractors and automobile components. In 1985, following the general opening-up of the Indian automobile industry to TNCs, Escorts entered into a licensing agreement to manufacture Yamaha motorcycles in a new plant in Surajpur. This commenced production in 1986, manufacturing 100 cc motorcycles predominantly designed by Yamaha. Escorts' older Faridabad plant producing motorcycles of wholly Escorts design remained in operation. In early 1990, the two Escort plants accounted for 40 per cent of the Indian motorcycle market.

A key strategic decision was taken to build a new plant and to employ a young and skilled labour-force rather than to attempt a turnaround of the existing plant. The youth of the labour-force (average age of 25 years in 1990) was intended to facilitate training in radically new forms of work-organization; it was also designed to reduce pressure from workers and trades unions to "impose traditional workpractices".

Training has therefore been a priority for Escorts in its new plant. It began with senior managers, senior technical personnel and supervisors. Yamaha organized extensive training for these groups, including spells in Japan—from two weeks to six months, depending upon the tasks involved. Thereafter, training was extended to the direct work-force by teams of 10 Japanese and 10 Indian trainers. Workers received two weeks initial training before going on to the shop-floor. After approximately one month, they received training in new skills (off the shop-floor), with this cycle being repeated for a period of approximately six months, until workers were deemed to have reached a minimum acceptable standard. Thereafter, additional training was provided at regular intervals as the average skills of the labour-force were gradually increased, especially in the acquisition of multiple skills. This is reflected in the payments system, where basic wages are supplemented by increments for skill acquisition and are thus partly paid on the principle of what the workers can do, rather than what they actually do.

The plant is laid out on a cellular basis, with kanban carts moving work-in-progress between various stages of stamping, machining and assembly. Typically, each operator is responsible for a number of machines, unlike Faridabad where each machine tends to have a dedicated operator. Work-teams are responsible for each

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foreign firms had higher levels of productivity, domestic firms showed faster productivity growth; but that could not be attributed to dynamic externalities from FDI.

In some cases, TNCs stimulate technology development by local R&D institutions. In India, for example, one TNC recently signed a letter of intent with a Government-funded telecommunications R&D facility—the Centre for the Development of Telematics—to use switches designed by the Centre in a new open-architecture cellular system. In addition, the TNC intends to sponsor research at nine leading engineering colleges. [37]

(Box VI.2, continued)

cell, and workers within each team are generally cross-trained to perform all the tasks in the cell (as well, in many cases, as tasks in other cells). Just-in-time production on work-in-progress is carefully observed. The result, as can be seen from table 1, is that changeover time in the Surajpur press shop is eight to sixteen times quicker than at Faridabad. Batch-sizes were less than half, and inventory components and raw materials were generally six times greater than at the sister plant.

Table 1. Comparison between the Surajpur and Faridabad plants of Escorts Ltd., 1990

Plant	*Annual output (Number of motor-cycles)*	*Number of workers*	*Output per worker (Number)*	*Change-over time*	*Batch size*	*Inventory inputs*
Surajpur	77 500	625	124	30-60 minutes	4 000	15-30 days
Faridabad	96 000	4 000	24	8 hours	8 000-10 000	3-6 months

The Surajpur plant has thus experienced considerable progress and is considerably more efficient than its sister-plant at Faridabad. Labour productivity was almost five times higher, with 625 workers producing 77,500 motorcycles (124 motorcycles per worker), compared with the 4,000 workers manufacturing 96,000 units at Faridabad (24 motorcycles per worker). Most of this superiority in performance was due to organizational factors, although the product design by Yamaha also played a role. The decidedly superior performance of the Surajpur plant clearly illustrates how transfer of organizational technology by TNCs can bring about major improvements in productivity.

Source: Transnational Corporations and Management Division, *Transnational Corporations and the Transfer of New Management Practices to Developing Countries* (New York, United Nations, forthcoming).

3. Transnational corporations and technology transfer through non-equity forms

Apart from wholly- or majority-owned FDI (usually known as internalized forms of transfer), TNCs also transfer technologies through a variety of externalized (primarily non-equity) forms, which include minority joint ventures, licensing, management and marketing contracts and international subcontracting. (Box VI.3 discusses transfer of technology through joint ventures in developed countries.) But data on such technology transactions between developing countries and TNCs are sketchy and difficult to interpret. Few developed countries disaggregate their technology receipts by country, type of transaction (for example, licensing or management contracts) or relationship between the receiving and the paying enterprise (an affiliate or an unrelated enterprise). Similar comments also apply to developing country-data on technology payments. Hence, it is a formidable task to assess the role of TNCs in technology transfer through such forms, and it is harder still to assess their impact on growth.

An earlier study by United Nations Centre on Transnational Corporations concluded that, during the 1970s, and up until the mid-1980s, the incidence of externalized forms of technology transfer seems to have increased. [38] Data on United States TNCs suggest a weak corroboration of that trend (table VI.10). Attention should be drawn, however, to the fact that technology receipts from unaffiliated enterprises in developing countries account for a very small proportion of total receipts.

Data for host countries tell a similar story. In the Republic of Korea, for example, payments for foreign licensing and technology contracts increased their share in total technology-transfer transactions (defined as FDI inflows plus payments for foreign licensing and technical consultancy plus capital-goods imports) from 1.2 per cent in 1972-1976 to 1.6 per cent in 1982-1986. [39] In Thailand, technology payments (comprising payments for royalties, trademarks, technical and management fees) increased from around 0.1 per cent of GDP during the 1972-1976 period to 0.2 per cent during the 1984-1987 period. [40]

Several points need to be considered to put the pattern into perspective:

- The first concerns the potential of non-equity forms for the future. It is well known that many factors—such as the age and sophistication of a technology, industry characteristics, corporate strategies within particular industries as well as the level of host-country entrepreneurial, technological and human-resources development—affect the choice of particular TNCs regarding externalized technology transfer. That form of transfer, however, may be even less favoured in the future than it was in the past. For one, recent developments in information technologies tend to increase the internalization advantages of TNCs. Those developments facilitate and cheapen the cost of intra-firm communication, coordination and control. The high costs of development and rapid obsolescence are likely to reinforce efforts of TNCs to secure a quicker pay-back through internalization. Furthermore, the internalization of the R&D expenditure noted earlier and the trend towards strategic alliances among TNCs in respect of the development and transfer of technologies limit the plurality of sources in the technology market. The

Box VI.3. Joint ventures in developed countries and technology transfer

A study of Japanese FDI in the United States showed that joint ventures were the preferred entry mode for Japanese firms in industries with high United States R&D expenditure, while Japanese R&D expenditures had no significant influence on the mode of entry. [1] However, before any conclusions can be drawn on the role of Japanese-United States joint ventures in technology transfer from the United States, it is necessary to distinguish between different types of joint ventures. [2] One type is related to barriers in the form of Governments encouraging joint ventures in disadvantaged national industries to maximize the gains for domestic partners. A second type involves voluntary joint ventures between partners with mutually beneficial strengths. Again, voluntary joint ventures can occur between a strong firm in a national declining industry and a relatively weaker firm from a foreign firm with a strong competitive advantage or between equally strong partners with specialized advantages.

It can be assumed that technology transfer between the partners will be highest within voluntary joint ventures, and that a strong firm in a declining industry will receive relatively more technology than the partner with the competitive advantage. The well known joint ventures in the automotive industry, like Chrysler's joint venture with Mitsubishi, General Motors' investment in Isuzu and Ford's joint venture with Mazda, are examples of firms in a declining industry gaining access to new technology (among other things, the production of compact cars). The relatively smaller Japanese firms with the competitive advantage gain access to the United States market. The reverse example is Fujitsu's joint venture with Amdahl, a small and innovative computer firm. [3] Fujitsu gained United States technology while Amdahl received financial support.

Joint ventures of the type were the partners have mutual beneficial strengths are also numerous between United States and Japanese firms. One such joint venture is the Toshiba-Motorola venture to manufacture microprocessors (Motorola's competitive advantage) and large memory chips (Toshiba's competitive advantage). The joint venture with Toshiba has allowed Motorola to gain access to technology in order to compete in advanced dynamic random access memory (DRAM) chips. [4]

It is difficult to determine who has benefited the most from technology-related joint ventures between Japanese and United States firms. However, a study of the industry distribution of joint ventures between Japanese and United States firms in 1987 showed that industries in which Japan has a clear competitive advantage (measured by market share in the OECD countries) account for the largest share of joint venture assets. [5] This indicates that the existing joint ventures in manufacturing presumably provide more opportunities for the transfer of technology from Japan to the United States than from the United States to Japan.

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1 Bruce Kogut and Sea Jin Chang, "Technological capabilities and Japanese foreign direct investment in the United States", *Review of Economics and Statistics*, vol. 73, No. 3 (August 1991), pp. 401-413.

2 See Dorothy B. Christelow, "U.S.-Japan joint ventures: who gains?", *Challenge*, vol. 32, No. 6 (November-December, 1989), pp. 29-38.

3. Ibid.

4 See *Asian Business*, January 1991.

5 See Christelow, op. cit.

deceleration in the growth of external resource inflows through official development assistance and private flows other than FDI would limit the ability of developing countries to acquire unpackaged technology. Finally, recent policy changes in developing countries in favour of FDI tend to reduce the cost of internalization. Those factors are likely to increase the importance of FDI as an instrument of technology transfer.

- The second observation relates to the interrelationship between FDI and externalized technology transfer. With the exceptions of India and the Republic of Korea, the bulk of technology receipts of United States TNCs from unaffiliated enterprises in developing economies originates precisely in economies such as Argentina, Brazil, Hong Kong, Indonesia, Malaysia, Mexico, Philippines, Singapore, Taiwan Province of China and Venezuela, which are also among the largest FDI host economies. Thus, familiarity with the enterprises of a country and their capabilities gained through FDI may be a pre-condition for (or at least a facilitator of) externalized forms of technology transfer. In the case of India and the Republic of Korea, a combination of restrictive policies towards FDI, the availability of a substantial pool of well-trained human resources and the large market size encouraged externalized forms of technology transfer despite comparatively less FDI.

- Third, the growth impact of technologies transferred through externalized forms depends, as in the case of capital-goods imports, largely on the capacity of domestic entrepreneurs to make the right selection, use the acquired technologies effectively and adapt and innovate continuously. Relevant also to the growth-promoting im-

Table VI.10. United States and the Federal Republic of Germany: technology receipts, 1986-1990

(Millions of national currencies)

		Receipts from all unaffiliated enterprises		*Receipts from unaffiliated enterprises in developing countries*	
Year	*Receipts from all countries*	*Value*	*Percentage*	*Value*	*Percentage*
United States [a]					
1986	7 531	1 842	24.5	296	3.9
1987	9 419	2 171	23.1	364	3.9
1988	11 211	2 513	22.4	443	4.0
1989	12 404	2 814	22.7	563	4.5
1990	15 840	3 445	21.7	690	4.4
Germany, Federal Republic of [b]					
1986	1 690	134	7.9	10	0.6
1987	1 670	163	9.8	7	0.4
1988	1 892	129	6.8	9	0.5
1989	2 166	189	8.7	7	0.3
1990	2 360	157	6.7	..	..

Sources: United States, Department of Commerce, *Survey of Current Business*, vol. 71, No. 9 (September 1991), tables 4.1-4.5, pp. 74-78; and *Monthly Report of the Deutsche Bundesbank*, various issues.

a Includes royalties and licence fees.
b Includes receipts from patents, inventions and processes.

pact of technologies acquired through externalized forms is the capacity to negotiate reasonable terms. The many imperfections in technology markets give rise to a considerable scope for bargaining. If technology purchasers are not equipped with adequate knowledge concerning the availability of alternative sources of the same or similar technologies and their costs, transactions are very likely to be settled in terms more favourable to the sellers. In the case of Thailand, for example, it has been observed that no correlation existed between licensing fees and the complexity of technologies; fees were paid for technologies no longer covered by patents; and technical fees paid for similar technologies in the pharmaceutical industry ranged from 0.4 per cent to 20 per cent of sales. Even though many of the buyers were aware that the terms were disadvantageous, they did not have adequate information on alternative sources. [41]

4. Strategic alliances and technology transfer

High risks and rising R&D costs (especially in the area of new technologies) and the rapid obsolescence of new products have forced many TNCs to form technology-related strategic alliances to share development costs, acquire new technologies and make better use of scarce qualified personnel. [42] The substantial number of strategic alliances in existence now is a relatively new phenomenon, and it is very difficult to obtain precise data on its frequency and purpose. There are indications, however, of an emerging trend towards a very high proportion of agreements involving the development of and access to technologies. [43] The alliances of IBM with several other corporations for the purpose of developing its personal computer are an example: the Lotus Corporation provided the application software, and Microsoft wrote the operating system, for a micro-processor that was produced by Intel. [44] IBM (traditionally reluctant to conclude alliances) has now created alliances with more than 40 partners around the world, pooling technology and customer bases in the telecommunications and related fields. As a response to competition from IBM, the Japanese computer firm Fujitsu formed alliances with Texas Instruments, Siemens and Hitachi. Such alliances are often undertaken for the joint development of new generations of products and to set industry standards. Table VI.11 illustrates the geographical and industry breakdown of technology alliances among TNCs from the Triad. Transnational corporations from the United States and Europe are clearly the most active participants in strategic alliances, most of which take place in information technologies.

Technological alliances can be viewed as a way of providing collective protection to technological advances among a few partners. The increasing incidence of such alliances combined with the current pace and cost of technological development makes it more difficult for developing countries to acquire technology through traditional non-equity arrangements. Many alliances also involve common actions for setting international standards that increase the barriers to entry (including, for new products from developing countries) in the international market. Some developing countries, particularly the newly industrializing ones, have the potential and capability, however, to become partners in technology alliances. In the information-technology industry, for example, Taiwan Province of China, has made extensive use of alliances with TNCs to acquire technological capabilities. A typical example of that use is in the area of computer software, where the Government has set up two software engineering firms in cooperation with IBM.[45] Taiwan Province of China, provides good quality engineers at a relatively low cost while IBM provides experience in software research and development. Similarly, the Sony Group is to transfer advanced technology to the electronics industry in Taiwan Province of China. Sony has announced that it has entered into alliances with 130 electronics companies from that country working with a "technology development centre" to create a production base for export to Japan and affiliated companies of Sony world-wide.[46] Similarly, several firms in the automobile industry in the Republic of Korea have entered into alliances with TNCs from the Triad. Examples are those of Hunday with Mitsubishi and Chrysler; Daewoo with General Motors, Suzuki and Isuzu; and Kia with Ford and Mazda.[47]

These examples, however, represent only a small number of alliances that include developing countries. Indeed, only 2 to 3 per cent of technology alliances in the 1980s were between companies from the Triad and firms from newly industrializing economies, and less than two per cent included firms from other developing countries.[48] For most developing countries, then, the acquisition of new technologies is likely to rely—at least for the present—on intra-firm transfers by TNCs, rather than on inter-firm alliances between independent firms.

Table VI.11. International distribution of technology cooperation agreements in biotechnology, information technologies and new materials, cumulative 1989

(Number and percentage)

	Biotechnology		*Information technologies*		*New materials*	
Area	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
Japan	58	5	95	4	88	13
United States	428	35	707	26	139	20
United States-Japan	155	13	406	15	94	14
United States-Western Europe	245	20	599	22	133	19
Western Europe	223	18	509	19	118	17
Western Europe-Japan	38	3	177	7	49	7
Other	66	5	225	8	67	10
Total	1 213	100	2 718	100	688	100

Source: John Hagedoorn and Luc Soete, "The internationalization of science and technology (policy): how do 'national' systems cope?" in H. Inose, M. Kawasaki and F. Kodama, eds., *Science and Technology Policy Research: What Should be Done? What Could be Done?* (Tokyo, Mita Press, 1991), pp. 201-216.

D. Assessment

The present chapter has shown that technology is a key determinant of growth. It promotes growth by increasing factor productivity, enabling the introduction of new products with greater long-run income elasticities and bringing about shifts in the export composition in favour of research-intensive exports with higher growth potential. In recent decades, the importance of technology as a determinant of growth has been increasing.

Transnational corporations are responsible for the bulk of technological development. Therefore, in so far as growth is driven by technology, the growth and development of developing countries are closely linked to a variety of equity and non-equity links with TNCs that permit access to technologies.

One channel of access to technology is through the import of capital goods, in the supply of which TNCs play a dominant role. Because the choice of technologies acquired through that mechanism largely rests with domestic importers, the contribution of TNCs to growth through this mechanism is essentially indirect.

Foreign affiliates can promote technological change in developing countries—and thereby growth—through their own R&D. During the past decade, data for United States majority-owned affiliates in developing countries show that the share of R&D expenditures in sales, though small, has increased. The net impact on growth arising from increased R&D expenditure by foreign affiliates also depends on what effects such an increase has on the R&D capabilities of indigenous firms. In general, it appears that the effect is likely to be more beneficial where domestic firms are capable of undertaking R&D to meet the challenge of competition from foreign affiliates. Foreign affiliates generally appear to exhibit higher factor productivity, which contributes to growth. They also appear to have contributed to the growth of developing countries through increasing the share of R&D intensive products in their total sales and their manufactured exports, over the past decade. Domestic enterprises in Asia, however, outperformed TNCs in respect of R&D intensive manufactured exports.

Foreign affiliates also have contributed to the growth of developing countries indirectly by increasing their purchase of local inputs; but the level and nature of such purchases is conditioned by the level of the industrial development of the host country (see chapter V). In some cases, foreign affiliates have stimulated R&D by local institutions through collaborative arrangements. Sparse information on that aspect does not allow any conclusion of the overall effect of such a stimulation on growth.

In some cases, a growth stimulus has also been generated through significant technology transfer by TNCs via such non-equity channels as licensing and subcontracting. The countries that have benefited most from such transfers appear to be typically the largest host countries; but, sometimes, those forms involved unfavourable terms that imply an avoidable drain on domestic resources.

In recent times, there has been an upsurge of technological alliances among TNCs, particularly in respect of new technologies. The upsurge raises the concern that reduced competition in the international technology market and restrained access for developing countries could limit the contribution that the dissemination of new technologies can make to growth.

In sum, TNCs are making a worthwhile direct contribution to the growth and technological development of host developing countries through the R&D expenditure of affiliates, changes in their product and export composition and higher factor productivity. As to the indirect stimuli to growth through non-equity forms of technology transfer, integration with domestic economies, the stimulation of local R&D and technological alliances with developing country enterprises, the evidence is rather mixed. The beneficial impact of those mechanisms appears to be largely contingent on, among other things, the domestic capacity of the host country to generate and adapt acquired technologies; the competitive ability of domestic enterprises; and the availability of well-trained human resources. It can be concluded, therefore, that, as regards indirect stimuli to growth through a wider dissemination of technologies, TNCs can strengthen a national technological base where the above conditions already exist; but they are unlikely to create them.

E. Some policy implications

Several policy implications emerge from the findings in the present chapter. For one, R&D by foreign affiliates in developing countries appears to be mainly located in those countries that already possess some domestic technological competence and a reasonable supply of trained scientific and technical personnel. Policy measures directed towards inducing TNCs to undertake greater R&D in host economies should, therefore, be conceived in the broader context of the indigenous technological development policy of a country, encompassing, among other things, the creation of an adequate human-resources base for technological activities.

As noted earlier, FDI has made a notable contribution to technology transfer and thereby growth through changes in the composition of products and exports in favour of greater technological intensity. Here, again, performance variations of TNCs appear to be related to indigenous technological capacities of host economies; hence, the conclusion noted above with regard to inducing TNCs to undertake greater R&D in host economies is applicable here as well. In addition, it should be pointed out that, while FDI may be a useful means of quickly benefiting from the results of new innovations abroad through the transfer of production, it does not necessarily imply a dissemination of technological knowledge to domestic producers. That raises the question of the choice of mode of transfer as between FDI and externalized forms. There are contrasting experiences in respect of that choice, even though national-growth performances have been quite comparable. Singapore can be easily cited as a case of high reliance on FDI, while the Republic of Korea represents a greater reliance on externalized forms. That was facilitated in the Republic of Korea both by the creation of an ample entrepreneurial skill base and by governmental assistance to local enterprises that provides information and support in bargaining. Any country seeking to pursue a similar strategy would be well advised to evaluate carefully the level of human resources development of the country, the entrepreneurial capacity of domestic producers and the ability of the Government to provide appropriate information and guidance to domestic firms. Besides, it should be pointed out that restrictive policies towards FDI may severely limit access to sophisticated technology, as amply demonstrated by the experience of India. Furthermore, even the Republic of Korea chose to liberalize its FDI policy progressively since the early 1980s, as more modern technologies were needed to sustain international competitiveness and, as noted in chapter V, FDI contributed almost one half of the new capital in technology-intensive industries such as electrical machinery and transportation equipment.

In the context of the varying performance of TNCs in respect of linkages with the domestic economy, the question of performance requirements assumes relevance. Quite obviously, for example, if the objective is to promote efficiency in the use of resources in order to promote faster growth, the imposition of a local content requirement, in the absence of an internationally competitive supplier industry, would be counterproductive, at least in the short run. There may be a case for a highly selective use of such requirements, however, in cases with a high probability that local producers would be able to achieve quickly international standards with assured demand for their products. [49]

Even where TNCs are willing to transfer technologies in externalized forms, the terms of transfer may leave something to be desired, as the experience of Thailand (cited earlier) demonstrates. Excessive payments imply a drain on domestic resources and thus may inhibit growth. Technology purchasers should, therefore, be provided with adequate information regarding available alternatives, to enable them to make informed choices. An arbitrary imposition of limits on royalty payments or licence fees is likely to limit access to desired technologies.

A correlation appears to exist between FDI and access to externalized forms of transfer in most cases. Hence, highly restrictive policies towards FDI may also limit the scope to acquire technology through other channels, unless the country concerned has a strong bargaining position because of its large market size or its capacity to develop technologies independent of an association with TNCs. The link between FDI and externalized forms also raises a formidable technology barrier for the vast majority of developing countries that attract little FDI because of their structural constraints, no matter how liberal their national policies towards such investment.

The present chapter has also demonstrated that there is a marked tendency among TNCs to hold new technologies closely among themselves through strategic alliances. There have been, at the same time, some instances of such alliances with developing-country enterprises. Local enterprises, therefore, deserve encouragement to enter into such arrangements with TNCs from advanced countries, wherever possible, in order to gain access to new technologies, or to be able to apply them more widely in the interest of sustaining competitiveness and growth.

Finally, it should be emphasized that the growth-promoting impact of technologies acquired through FDI as well as other forms of association with TNCs ultimately depends on the incentive structure faced by both foreign and domestic enterprises in acquiring, adapting, innovating upon and diffusing technologies. The incentive structure is conditioned by a host of public policies, concerning physical infrastructure, human resources development, R&D, technology and FDI, competition, international

trade, factor pricing, venture capital, subsidies etc. The formulation of such a holistic approach is, no doubt, immensely complex; but without such an approach the contribution of TNCs to growth through technology transfer will fall short of its potential.

Notes

[1]Francois Chesnais, "Science, technology and competitiveness", *STI Review,* No. 1 (Autumn 1986), pp. 85-129.

[2]OECD has published a major work dealing with these issues: *Technology and Productivity: The Challenge for Economic Policy* (Paris, OECD, 1991).

[3]Sanjaya Lall and George Kell "Industrial development in developing countries and the role of government intervention", *Banca Nazionale del Lavoro Quarterly Review,* No. 178 (September 1991), pp. 271-292.

[4]S. Kuznets, *Secular Movements in Production and Prices* (Boston, Houghton Mifflin, 1930).

[5]J. Schumpeter, *Capitalism, Socialism and Democracy* (New York, Harper and Row, 1942).

[6]See, for example, Robert M. Solow, "Technical change and the aggregate production function", *Review of Economics and Statistics,* vol. XXXIX, No. 3 (August 1957), pp. 312-320; Edward Denison, *The Sources of Economic Growth in the United States* (New York, Committee for Economic Development, 1962) and *Why Growth Rates Differ?* (Washington, D.C., The Brookings Institution, 1967); M. Abramowitz "Resource and output trends in the United States since 1870", *American Economic Review: Papers and Proceedings,* vol. XLVI, No. 2 (May, 1956), pp. 5-24; J. Kendrick, "Productivity trends: capital and labour", *Review of Economics and Statistics,* vol. XXXVIII, No. 3 (August 1956), pp. 248-257; Z. Griliches, "Hybrid corn: explanation in the economics of technological change, *Econometrica,* vol. 25, No. 4 (October 1957), pp. 501-522; W. Parker and J. Klein, "Productivity growth in grain production in the United States, 1840-60 and 1900-10", in Brady Dorothy, ed., *Output, Employment and Productivity in the United States after 1800* (New York, National Bureau of Economic Research, 1966).

[7]V. J. Elias, "Sources of economic growth in Latin American countries", *Review of Economics and Statistics,* vol. 60, No. 3 (August 1978), pp. 362-371.

[8]J. Fagerberg, "Innovation, catching up and growth", in OECD, *Technology and Productivity: The Challenge for Economic Policy* (Paris, OECD, 1991), pp. 37-43.

[9]UNCTAD, "Impact of technological change on patterns of international trade", TD/B(XXXV)/SC.1/CRP.2 (March 1989), table 3, pp. 8-9.

[10]William F. Miller, "Europe 1992: regionalism and globalism", *The International Executive,* vol. 33, No. 2 (September-October 1991), pp. 28-35.

[11]Paul M. Romer, "Endogenous technological change", *Journal of Political Economy,* vol. 98, No. 5 (1990) pp. S71-S102. For a state-of-the-art review of the role of TNCs in innovatory activity, and a collection of major writings in this respect, see J. Cantwell, ed., *Transnational Corporations and Innovatory Activities. United Nations Library on Transnational Corporations* (London, Routledge, forthcoming).

[12]Jeremy Howells, "The location and organization of research and development: new horizons", *Research Policy,* vol. 19, No. 2 (1990), pp. 133-146 and Karl P. Sauvant, *International Transactions in Services: The Policies of Transborder Data Flows* (Boulder, Colorado, Westview Press, 1986).

[13]John H. Dunning, "Multinational enterprises and the globalization of innovatory capacity", Rutgers University GSM working paper No. 91-03 (January 1991), mimeo., and United States Department of Commerce, *U.S. Direct Investment Abroad:*

1989 Benchmark Survey Preliminary Results (Washington, D.C., United States Government Printing Office, 1991), tables 76 and 91.

[14]Dunning, "Multinational enterprises", op. cit.

[15]Christoph Doerenbacher and Michael Wortmann, "The internationalization of corporate research and development", *Intereconomics,* vol. 26, No. 3 (May/June 1991), pp. 139-144.

[16]Quoted in Michael Wortmann, "Multinationals and the internationalization of R&D: new development in German companies", *Research Policy,* vol. 19, No. 2 (1990), pp. 175-183.

[17]John H. Dunning, *Multinational Enterprises and the Global Economy* (Reading, Massachusetts, Addison Wesley, forthcoming), chap. 11.

[18]For a recent state-of-the-art review of the subject and a collection of major writings in this respect, see E. Chen, ed., *Transnational Corporations and Technology Transfer. United Nations Library on Transnational Corporations* (London, Routledge, forthcoming).

[19]In this context, it should be noted that only 2 per cent of total R&D expenditures of 11 TNCs of the Federal Republic of Germany surveyed at the end of the 1970s were in developing countries (see Wortmann, op. cit.). In the case of United States TNCs, 5 per cent of foreign R&D expenditures were in developing countries in 1982, and that proportion declined to 4 per cent in 1989 (see United States, Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey* (Washington D.C., United States Government Printing Office, 1985), tables III.H.3 and III.E.1, and *1989 Benchmark Survey,* op. cit., tables 40 and 76.

[20]United States, Department of Commerce, *U.S. Direct Investment Abroad: 1989 Benchmark Survey,* op. cit., table 85. For electrical machinery, 32 per cent of the exports were intra-firm. There are no separate data on the industrial distribution of exports by United States TNCs to developing countries. However, the intra-firm portion of exports to developing countries is generally lower than it is for developed countries.

[21]John H. Dunning, *Explaining International Production* (London, Unwin Hyman, 1988), p. 10.

[22]Magnus Blomström, "Host country benefits of foreign investment", Working Paper No. 3615 (Cambridge, National Bureau of Economic Research, 1991), mimeo.

[23]Larry N. Wilmore, "The comparative performance of foreign and domestic firms in Brazil", *World Development,* vol. 14, No. 4 (April 1986), pp. 489-502.

[24]Somsak Tambunlertchai and Eric D. Ramstetter, "Foreign firms in promoted industries and structural change in Thailand", in Eric D. Ramstetter, ed., *Direct Foreign Investment in Asia's Developing Economies and Structural Change in the Asia-Pacific Region* (Boulder, Colorado, Westview Press, 1991), pp. 65-102.

[25]Chung H. Lee and Eric D. Ramstetter, "Direct investment and structural change in Korean manufacturing", in ibid, pp. 105-141.

[26]Calculations of the Transnational Corporations and Management Division, based on United Nations Statistical Office, *Monthly Bulletin of Statistics,* various issues.

[27]John H. Dunning, "Multinational enterprises", op. cit., p. 16.

[28]Dunning, *Multinational Enterprises and the Global Economy,* op. cit., chap. 11.

[29]J. Cantwell, *Technological Innovation and Multinational Corporations* (London, Basil Blackwell, 1989), p. 178.

[30]John H. Dunning, "Multinational enterprises", op. cit.

[31]UNCTC, *New Approaches to Best-Practice Manufacturing: The Role of Transnational Corporations and Implications for Developing Countries* (United Nations publication, Sales No. E.90.II.A.13).

[32]Transnational Corporations and Management Division, *Transnational Corporations and the Transfer of New Management Practices to Developing Countries* (New York, United Nations, forthcoming).

[33]UNCTC, *Foreign Direct Investment and Industrial Restructuring in Mexico* (United Nations publication, Sales No. E.92.II.A.9).

[34]See, for example, Richard Caves, "Multinational firms, competition and productivity in host country markets", *Economica*, vol. 14, No. 162 (1974), pp. 176-183; S. Globerman, "Foreign direct investment and 'spill-over' efficiency benefits in Canadian manufacturing industries", *Canadian Journal of Economics*, vol. 12, No. 1 (1980), pp. 24-52.

[35]Magnus Blomström and Edward N. Wolf, "Multinational corporations and productivity convergence in Mexico" (1989), mimeo.

[36]Mona Haddad and Ann Harrison, "Are there dynamic externalities from foreign direct investment? Evidence from Morocco", in R. Newfarmer and C. Frischtak, eds., *Transnational Corporations, Market Structure and Industrial Performance. United Nations Library on Transnational Corporations* (London, Routledge, forthcoming).

[37]*Business Asia*, vol. XXIII No. 46 (18 November 1991), p. 14.

[38]UNCTC, *Transnational Corporations and Technology Transfer: Effects and Policy Issues* (United Nations publication, Sales No. E.87.11.A.4), p. 14.

[39]Calculated from table 2 in Lim Su Kim, "Technological transformation in Korea and its implications for other developing countries", *Development and South-South Cooperation*, vol. IV No. 7 (December 1988), pp. 19-29.

[40]The World Bank, Industry and Energy Department, *Technology Strategy and Policy for Industrial Competitiveness: A Case Study of Thailand* (Washington, D.C., The World Bank, April 1990), p. 16.

[41]Ibid.

[42]See Jonathan B. Tucker, "Partners and rivals: a model of international collaboration in advanced technology", *International Organization*, vol. 45, No. 1 (Winter 1991), pp. 83-120.

[43]See Lynn Krieger Mytelka, ed., *Strategic Partnerships: States Firms and International Competition* (London, Pinter Publishers, 1991), pp. 7-35.

[44]See Kenichi Ohmae, "The global logic of strategic alliances", *Harvard Business Review*, vol. 89, No. 2 (March-April 1989), pp. 143-154.

[45]See Gee San, "Technology, investment and trade under economic globalization: the case of Taiwan", in OECD, *Trade, Investment and Technology in the 1990s* (Paris, OECD, 1991), pp. 57-97.

[46]See *Financial Times*, 20 November 1991.

[47]*Asian Business* (January 1991), p. 26.

[48]The numbers are based on a total of 4,192 strategic technology alliances contained in the MERIT data bank, University of Limburg, Maastricht.

[49]For a discussion of issues related to performance requirements, see UNCTC and UNCTAD, *The Impact of Trade-related Investment Measures on Trade and Development* (United Nations publication, Sales No. E.91.II.A.19).