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Technology Generation and Technology Transfers in the World Economy: Recent Trends and Implications for Developing Countries

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Abstract

This paper puts together new data on the technology generation and technology transfers in the world economy over the 1975-1995 period to examine the emerging trends and patterns. In particular we examine the trends in the country and corporate concentration in the technology generation in terms of indicators of R&D activity, patent ownership and receipts of technology fees and royalties against the background of emergence of new core technologies and the recent trend of corporate restructuring. It then examines trends and patterns in international technology transfers as represented by royalty and technology receipts by major source countries of technology and contrasts these trends with those in FDI inflows. Then trends with respect to the mode of technology transfer are discussed. The paper is concluded with a few observations for technology import policies of developing countries.

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Technology Generation and International Technology Transfers in the World Economy: Recent Trends and Implications for Developing Countries

1. INTRODUCTION

Technology is a crucial input in the industrialization and development of countries. In the current era of liberalization of international trade regimes worldwide and increasing emphasis attached to international competitiveness, the importance of technology as a factor determining the growth prospects of nations has gone up even further. A considerable proportion of technological inputs is sourced from abroad especially in the early stages of a country's development. Technology is perceived as an intangible assets and is traded internationally either in embodied or in disembodied form. The former includes the transfer of knowledge incorporated in the designs of machinery or that embodied in the skills of migrating experts. The disembodied knowledge is transferred under contracts under which process know-how, product designs, rights to use patented knowledge or copyrighted designs or drawings are transferred by their owner to another party for a fee. The international technology markets are known to be dominated by a handful of industrialised countries. The technological activity within these countries is also concentrated among a smaller set of bigger corporations dominating different branches of industries.

A number of changes have taken place over the past two decades or so which might have important implications for the patterns of technology generation and its transfer abroad. These developments include evolution of new core technologies e.g. ICT (information and communication technologies), biotechnologies and advanced materials and their widespread application in different industries highlighted their commercial potential prompted a wave of technonationalism and technological protectionism in the industrialised world. The institutional framework for technology generation changed with the adoption of the Agreement on Trade Related Intellectual Property Rights (TRIPs) as a part of the Uruguay Round of multilateral trade negotiations providing for the harmonization and strengthening of the intellectual property system. The deep economic integration in the Europe and North America led to worldwide corporate restructuring. Finally, internationalization of R&D activity by multinational enterprises (MNEs) became an established trend. All these developments are likely to have implications for the international technology markets and hence technology transfers.

A large volume of literature had addressed itself to the examination and analysis of trends and patterns in the international technology transfer activity and their implications in the late 1970s and early 1980s [see, for instance, Stewart, 1979; Lall, 1980; Madeuf, 1984; OECD, 1982; Rosenberg and Frischtak, eds., 1985; Vickery, 1986, 1988; and Reddy and Zhao, 1990 for a review]. However, a relatively little information and analysis on the emerging trends in international technology transfers in the more recent period is available despite increasing importance of cross-border transactions in technology and their role in development. An examination of trends and analysis of their implications for technology acquisition could prove to be valuable for policy making in developing countries which substantially depend on the imports for fulfilling the technological requirements in the process of their industrialization.

This paper pieces together information and data from diverse national and international sources to generate a rough picture of emerging trends in the global technology market and in international transfers of disembodied technology. We use technological payments data to capture disembodied technology transfers, assuming that any significant international transfers of knowledge are paid for. These data are contrasted with those on FDI inflows. It helps to examine the trends and patterns emerging in these transfers. These cover trends in concentration of sources of technology as well as pattern of distribution, relative importance of internal and external channels of transfer, among others. It would appear from this analysis that the triad nations consisting of USA, European Economic Area and Japan account for the bulk of origin as well as destination of technology flows. The importance of FDI or internal sources of technology transfer as a channel of technology transfer seems to have gone up in the recent years. The global flows of technology fees and global magnitudes of FDI inflows show a great degree of correspondence. Yet it becomes apparent that it may be hazardous to use inflow of FDI as an indicator of technology transfer.

The structure of the paper is as follows. Section 2 discusses the trends in technology generation especially in country and corporate concentration. Section 3 examines the trends in international transfers of disembodied technology and contrasts the patterns observed with those in FDI inflows. Section 4 looks at the trends and patterns in the mode of technology transfers over time, across sectors and countries. Finally, the paper is concluded with a few policy remarks.

2. TRENDS IN TECHNOLOGY GENERATION

The innovative activity which is the source of technology generation has been highly concentrated in a handful of industrialised countries. Besides being concentrated in a few countries, the innovative activity is dominated by a small number of larger corporations. In what follows, the trends pertaining to country as well as corporate concentration in technology generation are examined.

2.1 Country Concentration in Technology Generation

Table 1 compiles a few indicators of technological activity for the ten largest sources of technologies in the world. These cover indicators of both technological ‘inputs’ as well as ‘output’. R&D expenditure is considered as the most important input indicator of the technological activity. One of the technology output indicator considered is patents obtained by inventors from different countries at the US Patents and Trademarks Office over the past 20 years period (1977-1996). Since inventors from anywhere in the world like to register a patent in the US, the world’s biggest market and one providing most stringent and longest duration of patents (20 years), US patents are widely considered as surrogates of technological output especially for the purposes of international comparisons. However, it is important to keep in mind that this measure may be biased in favour of industrialised countries as much of the innovative activity in developing countries is of adaptive type and may not yield patentable inventions. Secondly, considerable administrative costs of obtaining a US patent may discourage some inventors especially those in developing countries from applying for them. Another indicator of technological activity is the actual receipts of royalties and technological fees which indicate the amount of disembodied technology exported and hence measure the importance of a nation as a supplier of technology. The final column also summarises the figures on FDI outflows which are also governed to a large extent by the strength of created assets of their enterprises with ownership of technology being the most important source of the firms’ created assets.

The data summarised in Table 1 reveal an extreme form of concentration with just ten countries accounting for the bulk of all technological activity in the world. It is evident that the top ten countries account for as much as 84 per cent of global resources spent on R&D activity annually, they control 95 per cent of the technological output in terms of patents taken out in the US, and receive 91 per cent of global cross-border royalties and technological fees. Hence,

Table 1: Major Source Countries of Technologies

Countries	R&D Expenditure, 1993 ¹		US Patents taken, 1977-96 ²		Technology Fees Received, 1993 ³		FDI Outflows, 1995 ⁴	
	(billion PPP \$)	% in total	in '000	% in total	billion \$	% in total	billion \$	% in total
USA	166.3	39	985.3	57	20.4	40	95.5	30
Japan	74.4	17	307.6	18	3.6	7	21.3	7
Germany	37.1	9	136.2	8	7.3	14	35.3	11
France	26.4	6	52.7	3	2	4	17.5	6
UK	21.6	5	52.8	3	2.9	6	37.8	12
Italy	13.2	3	22.1	1	0.9	2	5.1	2
Canada	8.4	2	34.4	2	0.9	2	4.8	2
Netherlands	5.1	1	16.9	1	6.2	12	12.4	4
Sweden	4.8	1	17.3	1	0.4	1	10.4	3
Switzerland	4.2	1	25.5	1	2 [@]	4	8.6	3
subtotal 10	361.5	84	1650.8	95	46.6	91	248.7	79
World	428.58 [#]	100	1732	100	51 [*]	100	315	100

Source: Kumar on the basis of

¹OECD (1996) *OECD in Figures - Statistics on the Member Countries: 1996 Edition*, Paris: OECD, pp 56-7.

²US Patents and Trademarks Office (1997) *TAF Special Report: All Patents, All Types - January 1977-December 1996*, Washington, DC,

³OECD (1993) op. cit. p. 60-1.

⁴UNCTAD (1996) *World Investment Report 1996*, Geneva: United Nations.

[#]UNESCO (1996) *World Science Report 1996*, Paris: UNESCO.

[@] Own estimates based on mirroring of payments by major OECD countries.

^{*}Own estimate providing for non-reporting countries.

the concentration in terms of technological output is even more uneven than for technological inputs. The control over technology is reflected in their nearly 80 per cent share of global FDI outflows.

The relative position of countries in terms of different indicators varies. It is curious to find, for instance, that Japan accounts for 17-18 per cent of global R&D expenditure and US patents, but shares only 7 per cent of global technological receipts (and FDI outflows). Similarly, Netherlands and Switzerland command a much higher proportion of global royalties than their share of R&D expenditure or patents. The discrepancy between the share in technological activity and returns in terms of royalties could be on account of different focus of the technological effort of different countries. The technological effort of Japanese corporations seems to be geared towards obtaining competitiveness of their products in domestic and export markets more than for supporting the transfer of technology and production. Audretsch and Yamawaki (1988) reached a similar inference from their detailed empirical study of R&D rivalry and trade balance between US and Japan.

Has the concentration in generation or ownership of technology declined over time? An over time examination of trends is possible in terms of US patents ownership and royalty receipts as reliable data on R&D expenditure on a long term comparable basis in constant prices is difficult to be found. Table 2 summarises the pattern of ownership of US patents over the 1977-1996 period. It would appear from it that although the share of patents owned by US inventors has gone down over time, the share of top ten patent owning countries has not declined much. Japan has emerged strongly as a leading holder of US patents improving her share from 11 per cent in pre-1983 patents steadily to nearly 21 per cent in the nineties. The share of top ten countries in total patents has declined slightly from 96.2 per cent during the 1977-82 period to 96.0 during 1983-89 and to 94.4 per cent during the 1990-96 period suggesting a slight decline in the overall concentration. However, there is some tendency of a higher concentration among the top three innovating countries viz. the US, Japan and Germany with their combined share rising from 82 % in the first period to 83 % in the latest period.

Table 2: Trends in Ownership of US Patents, 1977-96

	Patents Granted During					
Year	1977-82	share	1983-89	share	1990-96	share
US	244507	62.1	556267	58.0	429052	55.5
Japan	43977	11.2	147441	15.4	160167	20.7
Germany	34237	8.7	84545	8.8	51625	6.7
United Kingdom	15002	3.8	33753	3.5	19043	2.5
France	12551	3.2	30959	3.2	21790	2.8
Canada	7223	1.8	18089	1.9	16305	2.1
Switzerland	7581	1.9	16564	1.7	8910	1.2
Italy	4757	1.2	12311	1.3	9773	1.3
Sweden	5035	1.3	11455	1.2	5870	0.8
Netherlands	3955	1.0	10072	1.0	6817	0.9
share top 10	378825	96.2	921456	96.0	729352	94.4
share top 3	322721	82.0	788253	82.2	640844	82.9
Total	393629	100.0	959368	100.0	772927	100.0

Source: Kumar based on data presented in US Patents and Trademarks Office (1997) *TAF Special Report: All Patents, All Types - January 1977-December 1996*, Washington, DC.

The trends in terms of receipts of royalty and technological fees reveal more changes. Figure 1 summarises the composition of the receipts of royalties received by major OECD countries (excluding Switzerland for lack of data) in 1976 and 1993. It also suggests the decline in the relative position of the US as a source of technology with her share going down from 53 to 43 per cent between 1976-93. Another thing which is apparent from the figure is the decline of the UK as a second most important source of technology in 1976 with 23 per cent share to the fifth place in 1993 accompanied by emergence of Germany, Japan, and Netherlands as major sources of

technology. On the whole the concentration would appear to have loosened a bit with top five sources accounting for 84 per cent share in 1993 in place of 89 per cent earlier. Also it is a bit more evenly distributed now than in 1970s when two dominant sources accounted for 76 per cent of all royalties received.

Emerging Sources of Technology

The above discussion would tend to suggest a slight trend of loosening of concentration of technology generation activity in terms of countries with the emergence of Japan and Germany as leading sources of innovation and technology transfer. Are some more countries emerging as significant sources of technology outside the OECD members?

The US patent ownership data as summarised in Table 3 suggests that a few countries are beginning to obtain US patents in increasing numbers over the years. These countries which include Taiwan, South Korea, Israel, Hong Kong, South Africa, Mexico, Brazil, Mainland China, Argentina, Singapore, Venezuela, India and a few East and Central European countries collectively account for 3 per cent of US patents granted during 1990-1996 compared to 1.5 per cent during the 1977-82, with much of the increase coming about since 1990. However, the bulk of this 3 per cent share is accounted for Taiwan (which accounts for 1.4 %) and South Korea (with 0.77 %), although a few countries e.g. Israel, China, Singapore, India are showing an increasing trend of patenting in the US. The Latin American countries such as Brazil, Mexico, Argentina, and Venezuela also own significant number of US patents. However, their share does not show a rising trend. The East and Central European countries also have lagged behind in technology generation and their combined share has actually fallen from 0.8 per cent during 1977-82 period steadily to 0.17 per cent in the 1990s.

Figure 1: Breakdown of Receipts of Technology Transfer Fees by Reporting OECD Countries, 1976 and 1993

Source: Kumar based on OECD data.

Table 3: Emerging Sources of Technology in Terms of Ownership of US Patents

Year	Patents granted during					
	1977-82	share	1983-89	share	1990-96	share
Taiwan	382	0.10	2292	0.24	11040	1.43
South Korea	70	0.02	580	0.06	5970	0.77
Israel	641	0.16	1507	0.16	2685	0.35
Hong Kong	272	0.07	633	0.07	1416	0.18
S. Africa	491	0.12	699	0.07	787	0.10
Mexico	245	0.06	289	0.03	314	0.04
Brazil	144	0.04	212	0.02	413	0.05
China P. Rep.	7	0.00	142	0.01	353	0.05
Argentina	130	0.03	135	0.01	187	0.02
Singapore	17	0.00	65	0.01	337	0.04
Venezuela	51	0.01	122	0.01	192	0.02
India	56	0.01	96	0.01	204	0.03
East and Central Europe	3444	0.87	2417	0.25	1317	0.17
Sub-total	5950	1.51	9189	0.96	25215	3.26
Others	731	0.19	902	0.09	1494	0.19
Total	393629	100.00	959368	100.00	772927	100.00

Source: Kumar based on data presented in US Patents and Trademarks Office (1997) *TAF Special Report: All Patents, All Types - January 1977-December 1996*, Washington, DC.

The rise of innovative activity in Taiwan and Korea is not only reflected in increasing number of US patents owned but also in emerging technology exports which are as yet small in value terms but have grown rapidly over the past few years as shown in Table 4. The technology exports of South Korea and Taiwan are concentrated largely in the South and Southeast Asian countries. The gradual build up of technological effort of Asian newly industrialising countries, in particular, of South Korea and Taiwan as reflected in rising expenditures on R&D and rising number of overseas patents owned is expected to result into increase in their importance as technology exporters in the future [see Lall, 1997, for a discussion of Korean and Taiwanese technological effort]. We have elsewhere documented the evolution of FDI outflows from some of these countries which is but a reflection of the growing technological capability and created assets of enterprises based in these countries [see Kumar, 1997].

Developing countries, other than the Asian NIEs, play a negligible role in global innovative activity and appear to have lagged behind. Their share in global R&D expenditure or as a proportion of their domestic product has declined over the past decade [Freeman and Hagedoorn, 1992; Kumar and Siddharthan, 1997]. The share of developing countries in global R&D expenditures has come down from nearly 6 per cent in 1980 to nearly 4 per cent in early 1990s

[UNESCO figures]. This is despite the fact that Asian newly industrialising countries like Korea and Taiwan have greatly expanded national R&D expenditures over the past years. The recent decline in R&D activity in developing countries has been on account of a combination of several factors. These include the need to balance budgets as a part of the structural adjustment programmes undertaken by them which has adversely affected the public funded R&D activity. The R&D activity by industry has been discouraged by the lack of protection from technology imports, heightened entry barriers, and declining opportunities of adaptive R&D because of tightening patent protection [see Kumar & Siddharthan 1997 for a more detailed discussion].

The growing internationalization of R&D activity of MNEs has attracted attention in the recent years. The R&D activities of MNE affiliates now account for a considerable proportion of

Table 4: Technology Exports from South Korea and Taiwan, 1987-93

Year	South Korea		Taiwan	
	Numbers	Royalty Received in million US\$	Numbers	Values in million NT\$
1987	n.a.	n.a.	n.a.	390
1988	15	9	1	353
1989	27	10	5	344
1990	50	35	3	785
1991	39	35	4	n.a.
1992	80	33	2	2117
1993	105	45	2	1269
Total	409	260	17	4868

Sources: Kumar on the basis of: OECD, 1996, *Reviews of National Science and Technology Policy: Republic of Korea*, Paris; and ROC, 1995, *Indicators of Science and Technology: Republic of China 1995*, Taipei.

national R&D expenditure in a number of host countries, for instance, over 15 per cent in Australia, Belgium, Canada, the UK, the USA, Germany, South Korea and Singapore in the 1980s [Dunning, 1994]. However, the prospects of overseas R&D activity making a significant difference to the developing world's share of R&D activity are small. This is because the bulk of the overseas R&D activity of MNEs is concentrated in the industrialised host countries. The developing countries together account for only about 5 per cent of all overseas R&D activity of US and Japanese MNEs. Furthermore, even that R&D activity is concentrated in a few countries endowed with relatively superior technological infrastructure and resources among the developing countries. In an empirical analysis of the factors determining the location of overseas R&D activity of MNEs elsewhere, we found the importance of availability of technological resources and infrastructure and of host country

market size [Kumar 1996]. The R&D activity conducted in developing countries seemed to be more of an adaptive nature while the more creative and innovative activity was confined to industrialised countries. Therefore, we had concluded that the overseas R&D activity of MNEs tends to widen the gap between technologically richer and technologically poorer nations by concentrating their R&D investments in the countries already ahead in this respect.

The growing neglect of R&D activity by developing countries is going to have serious consequences for their ability to efficiently apply new technologies in their development. A considerable volume of literature has argued the importance of local technological capability even for importing technology and applying it effectively in view of imperfections in the technology markets, need for adaptations to local conditions and absorption for keeping it updated and avoid technological obsolescence [see for instance, Pack and Westphal (1986:121)]. The trend of developing countries losing share in both R&D expenditure as well as in the global distribution of technology flows would have serious implications for their growth prospects and competitiveness. Although a few Southeast Asian countries have managed to grow in the past by depending upon on FDI for technological inputs for upgradation and diversification, they are becoming increasingly conscious of the constraints of this strategy and are making an effort to strengthen local technological activity [see Lall, 1997].

2.2 Trends in Corporate Concentration

Much of the innovative activity within each country is dominated by a small number of larger corporations. Tuldar and Junne (1988) have, for instance, observed a high concentration of national R&D expenditure in a few large corporations in most of the industrialized countries. As much as 81 per cent of all Swiss national R&D expenditure in 1983 was accounted for by four companies viz. Ciba-Geigy, Hoffman-La Roche, BBC and Sandoz. Similarly, Philips, Shell, Akzo, and Unilever accounted for 69 per cent of Dutch R&D expenditure; Siemens, Bayer, Hoechst, Daimler, and VW accounted for 22 per cent of German R&D expenditure; GM, IBM, AT&T, Ford, and United Technologies accounted for 12 per cent of all the US R&D expenditure; and so on (op. cit. Table 6.5).

An examination of the trends in corporate concentration in technology generation can be had from the trends in ownership of US patents by the largest corporations. Table 5 summarises the distribution of ownership of US patents owned by organizations and corporation by the period of grant. It is evident that top 165 US and foreign companies and other organizations (each owning more than a 1000 patents at the end of 1996) own 38 per cent of all patents owned by organizations. The rest of 62 per

cent patents were shared by 130,431 corporations/ organizations. Within the group of 165 corporations, top 50 corporations account for as many as 65 per cent patents belonging to the 165 companies and 25 per cent of all organizational patents. The corporations included have not been regrouped according to the change in the ownership subsequent to the grant of patent due to mergers/ acquisitions. Therefore, the actual level of concentration could be higher than that indicated by these figures on account of recent spate of mergers among larger corporations and takeovers of smaller enterprises by them. The share of these corporations in the patents granted during 1977-82, 1983-89, and 1990-96 has been compared. It appears that their share, whether in the patents owned by top 165 or all corporations, declined between 1977-82 and 1983-89 period slightly from 65.15 per cent to 64.68 per cent but increased in the 1983-89 to 1990-96 period from 64.68 per cent to 68.45 per cent.

Table 5: Trends in the Ownership of US Patents owned by Organizations, 1977-96

Category	Patents granted during		
	1977-82	1983-89	1990-96
Patents owned by organizations/ corporations	303096	453836	621815
Patents owned by top 165 Companies/Organizations	117189	175981	232280
Patents owned by rest 130431 organizations	185907	277855	389535
Patents owned by top 50 corporations	76345	113828	158999
Share of top 50 in patents owned by 165 organizations, %	65.15	64.68	68.45
Share of top 50 in all organizational patents, %	25.19	25.08	25.57

Source: Kumar based on data presented in US Patents and Trademarks Office (1997) *TAF Special Report: All Patents, All Types - January 1977-December 1996*, Washington, DC.: US PTO.

The rise in concentration of patents in the top corporations in the recent period could be on account of a number of mutually reinforcing trends. The first is the rapid evolution of core technologies and their commercial potential for businesses and hence scramble for their control. This has led to corporate restructuring worldwide as companies increasingly indulged in strategic assets seeking acquisitions. For illustration, mergers between Ciba-Geigy and Sandoz, Glaxo's with Wellcome, Pharmacia and Upjohn, among others have been inspired by the need to strengthen capabilities in biotechnology related research, the takeover of Lotus by IBM, of Word Perfect by Correl Ventura, of Intuit by Microsoft, the merger between BT and MCI, among others, have been inspired by the need to strengthen competencies in the ICT technologies. In addition, larger food, chemicals and pharmaceutical corporations have acquired a host of specialist biotechnology firms as the commercial prospects of their R&D became clearer in the recent years [see Kumar and Siddharthan, chap. 3, for illustrations].

The corporate restructuring has in part been provoked by recent trends of deep economic integration at the regional level undertaken in EU and North America which prompted the national champions in the member states to restructure their operations on pan-regional basis. It has provoked outsiders to take over insider companies to acquire an insider status and thus evade the threat of discrimination against extra-regional goods [see Kumar, 1994].

Table 6 summarises the sales, R&D expenditure, US patents and multinationality index for the largest 50 corporations owning the US patents. It is apparent that all of these are giant corporations with sales in the multibillion dollar or sterling range (the largest among them being GM with a sales turnover of 93 billion pounds); all of them have large R&D budgets often spending more a billion pounds a year on R&D; all of them originated in either US, Japan, Germany, the UK, Switzerland, or Netherlands. Finally, in terms of the multinationality index which measures the importance of foreign operations in total assets, foreign affiliate sales and employment, all are multinational. Except for AT&T, General Electric, and NEC, foreign operations accounted for upwards of 25 per cent of their global operations other than exports from their home bases. Many of the corporations had more than half of their operations outside their home country e.g. IBM, Philips, Bayer, Sony, Ciba-Geigy, BASF, Mobil, Hoechst, Shell, Exxon, P&G. A strong interaction between firm size, R&D activity, patent ownership and multinationality is thus obvious from the data presented in Table 6.

Multinational corporations thus own a substantial chunk of technologies in the world. The larger corporations also have a right of prior access over a large volume of technologies generated in the public funded institutions, universities and small specialist small firms because of research contracts. Finally, the new technology revolution has sparked off a wave of strategic alliances which enables corporations to exploit synergies in competencies of unrelated corporations, cross license technologies and patents, and engage in joint R&D. Alliance formation in joint R&D has been encouraged by the Framework Programmes of the EU which subsidize joint corporate R&D activity in new technologies of EU enterprises. Freeman and Hagedoorn's (1992)

Table 6: Largest Fifty Corporations Owning US Patents, 1977-96

Rank Based on Total Patents	Company	Home Country	Sales 1994 in million £	Multinatio nality Index 1994*	R&D Spending 1994 million £	US Patents Granted During			
						1977-82	1983-89	1990-96	Cumulative
1	General Electric	US	38420	16.7	751.7	4807	5288	6111	16206
2	IBM	US	40940	56.4	2161.7	2703	4199	8123	15025
3	Hitachi	Japan	47408	27.7	3102.3	2425	5387	6688	14500
4	Canon	Japan	12383	33.5	776.9	1259	4443	8095	13797
5	Toshiba	Japan	30815	20.0	1995.2	1217	5032	7164	13413
6	Mitsubishi	Japan	15728	31.0	430.2	473	3043	6676	10192
7	Philips	NL	22460	85.0	1370.2	2175	3936	3832	9943
8	Kodak	US	8665	43.0	549.1	1524	2309	5896	9729
9	AT&T	US	47998	10.8	1987.9	2394	3313	3673	9380
10	Motorola	US	14218	43.6	1188.9	1057	2316	5770	9143
11	Fuji	Japan	6835	n.a.	473.5	1067	3284	4494	8845
12	Siemens	Germany	34885	47.3	3096.1	2418	3399	2994	8811
13	Du Pont	US	21759	42.0	669.2	1990	2608	3608	8206
14	Bayer	Germany	17905	72.5	1310.1	2556	2741	2908	8205
15	Matsushita	Japan	6752	39.8	300.1	1164	2039	4843	8046
16	Westinghouse	US	5998	n.a.	116.9	2444	2927	2064	7435
17	NEC	Japan	22935	19.3	1676.3	539	1876	4945	7360
18	Sony	Japan	23922	58.5	1472.7	889	1879	4221	6989
19	Xerox	US	11401	36.7	572.1	1764	1692	3522	6978
20	GM	US	99041	25.7	4497.2	1650	2342	2581	6573
21	Dow Chemicals	US	12793	45.3	806.0	1653	2628	2084	6365
22	Ciba-Geigy	Swiss	10769	64.6	1050.6	1889	2001	2330	6220
23	3M	US	9638	48.9	673.7	1020	1795	3268	6083
24	BASF	Germany	18009	51.5	790.2	1383	1911	2483	5777
25	Fujitsu	Japan	20110	n.a.	2113.6	340	1503	3704	5547
26	Texas Instr.	US	6593	n.a.	440.4	880	1550	3047	5477
27	Mobil	US	42669	58.7	175.8	1144	2332	1985	5461
28	Hoechst AG	Germany	20468	64.6	1389.3	1543	1652	2252	5447
29	Sharp	Japan	9725	41.6	709.1	487	1726	3152	5365
30	Robert Bosch	Germany	13389	47.2	913.4	1268	1792	2042	5102
31	Nissan Motor	Japan	43733	32.2	n.a.	1237	2188	1634	5059
32	RCA	US	n.a.	n.a.	n.a.	2469	2468	1	4938
33	Honda	Japan	24748	41.0	1209.7	405	2145	1932	4492
34	Phillips Petroleum	US	n.a.	n.a.	n.a.	1644	1568	997	4209
35	Allied Signal	US	7993	n.a.	211.6	745	1673	1726	4144
36	Ricoh	Japan	6201	n.a.	349.7	620	1327	2195	4142
37	Toyota	Japan	60667	28.1	n.a.	1102	1927	1067	4096
38	Shell	NL/UK	61929	63.6	437.0	906	1505	1603	4014
39	Hughes Aircraft	US	n.a.	n.a.	n.a.	583	1056	2235	3874
40	Hewlett Packard	US	15973	41.4	1295.6	321	766	2705	3792
41	Ford Motor	US	82095	28.6	3332.7	668	1093	1915	3676
42	United Technologies	US	13548	42.5	625.1	900	1347	1340	3587
43	Exxon Research	US	72805	63.8	356.7	1402	1394	774	3570
44	Olympus	Japan	1537	n.a.	178.7	759	1300	1444	3503
45	Unisys	US	4729	n.a.	309.0	1499	1328	646	3473
46	ICI	UK	9189	n.a.	184.0	1141	952	1083	3176
47	Minolta	Japan	n.a.	n.a.	n.a.	445	953	1664	3062
48	Rockwell	US	7162	n.a.	380.5	931	1186	922	3039
49	Procter & Gamble	US	19364	50.0	676.9	643	772	1472	2887
50	American Cynamid	US	2890	n.a.	402.6	1188	811	883	2882

Sources: Kumar based on the following sources: Sales and R&D expenditure from DTI Innovation Survey reproduced in *Financial Times*, 17 June 1995; Multinationality Index from UNCTAD 1996, *World Investment Report 1996*, Table I.12; US Patent from USPTO, 1997, *TAF Special Report: All Patents, All Types - January 1977-December 1996*, Washington, Patent and Trademark Office. *defined to be the average ratio of foreign component of total assets, sales and employment.

examination of strategic alliances compiled in the MERIT-CATI database reveals that the bulk of the technological alliances have been entered into between corporations based in industrialised countries in new core technologies. In other words, the larger corporations based in major industrialised countries may be commanding a stronger control over technology than indicated by their share of patents.

To sum up this section, the technology generation activity in the world continues to be highly concentrated in a handful of countries and a small number of relatively larger corporations play a disproportionately larger role. While the country concentration seems to have declined slightly over the years, the corporate concentration at the top level seems to have gone up in the recent years as a result of corporate restructuring provoked by new core technologies and regional economic integration in Europe and North America. The rising dominance of larger corporations on new technologies may have some adverse implications for their access for developing countries on reasonable terms. Furthermore, the new norms of patent protection under the TRIPs agreement dilute the compulsory licensing provisions and treat importing as working of patents. Thus they give to the potential technology suppliers more freedom to select the ways of internationalization of their operations, and in particular, use exports as a main means of exploitation of innovation [Correa, 1993]. The adequate anti-trust provisions for dealing with potential abuse of monopoly power granted by the strengthened patent system do not exist in most developing countries.

3. TRENDS IN INTERNATIONAL TECHNOLOGY TRANSFERS

The data on global transfers of technology are relatively scarce. Very few countries outside the OECD group report expenditures on technology purchases abroad on an internationally comparable basis. That leaves only supplier countries data as a potential source for examining the trends. OECD secretariat compiles the receipts and payments of technology fees by its member states to examine the trends in technological balance of payments of the member states. However, the trends in the global distribution of the flows are not clear from it because the origin of the receipts is not provided. Hence, the trends in the technology flows are usually deduced in the literature from the trends in the inflows of FDI. This is in part because while FDI flow data are relatively easy to get from IMF, UNCTAD and OECD sources. Although FDI is a major channel of technology transfer, it is by no means the only channel. In some situations such as transfer of process technologies, arm's length licensing could be an important channel as will be seen later.

An attempt has been made here to compile some data on global flows of technology as represented by the technology, license fees and royalty payments by technology receiving nations

to the technology supplying nations for the past two decades [see Madeuf, 1984; OECD, 1995, Box 12.1, for a discussion of definitions, concepts and problems involved in using this data source to measure technology transactions]. The fees and royalties paid by developing countries have been estimated here by subtracting total payments by OECD countries out of their total receipts. This helps to gather an idea of the global distribution of technologies.

Table 7 summarises the trends in global technology transfer payments and FDI inflows over the past two decades. It is evident that both of these flows have registered an explosive growth over the past years especially since the mid-1980s (see Figures 2 and 3). The annual technology transfer payments rose from \$ 6.8 billion in 1976 to an estimated \$ 64.4 billion in 1995. Providing for the OECD countries not reporting the technology receipts especially Switzerland's and emerging NIEs, the global magnitude of technology related fees crossing national borders could be of the order of \$ 68 billion. Similarly, the annual global FDI inflows rose from \$ 22 billions in 1975 to a peak of \$ 315 billion in 1995. However, the growth rates recorded by FDI inflows have been more impressive than those by technology transfer payments over the whole period or any of the sub-periods (see Table 7). This suggests that a recent spurt of FDI inflows may not have been accompanied by technology transfers in the same proportion.

A number of reasons may be responsible for the trend observed that transfers of technology may not be keeping pace with inflows of FDI. A considerable proportion of FDI inflows in the recent period have been on account of mergers and acquisitions (M&A) of existing enterprises [UNCTAD 1996]. Technology transfer in these M&As could be restricted to transfer of some organizational and managerial skills. The M&As especially those in the industrialised countries were led by the restructuring of businesses prompted by regional

Table 7: Global Technology Flows and Foreign Direct Investments, 1975-95
(in billion US \$)

Years	Technology Transfer Payments			FDI Inflows		
	By All Countries ¹	Estimated payments by Developing Countries ²	Share of Developing Countries, %	World ³	To Developing Countries ³	Share of Developing Countries, %
1975	n.a.	n.a.	n.a.	21.509	6.286	29.223
1976	6.82	1.80	26.40	27.648	7.050	25.497
1977	7.88	2.34	29.76	33.788	7.814	23.125
1978	9.65	2.67	27.63	39.928	8.578	21.483
1979	10.36	2.47	23.88	46.067	9.342	20.278
1980	12.48	3.36	26.93	52.207	10.106	19.357
1981	12.60	4.19	33.25	56.817	15.015	26.426
1982	10.60	2.16	20.40	44.472	13.454	30.252
1983	11.23	2.74	24.42	44.094	10.265	23.281
1984	12.01	3.02	25.17	48.984	10.500	21.435
1985	12.39	2.85	22.99	49.312	11.475	23.270
1986	16.55	3.52	21.29	78.283	14.184	18.119
1987	20.72	3.80	18.35	132.949	25.021	18.820
1988	24.43	4.20	17.21	158.289	29.718	18.775
1989	27.36	5.43	19.84	200.612	29.756	14.833
1990	33.46	6.70	20.02	211.425	31.776	15.029
1991	36.47	6.38	17.49	158.428	40.889	25.809
1992	47.30	7.11	15.04	170.398	54.750	32.131
1993	48.41	10.12	20.90	208.388	73.350	35.199
1994	56.42 ^P	14.08 ^P	24.96 ^P	225.660	87.024	38.564
1995	64.44 ^P	18.05 ^P	28.01 ^P	314.933	99.670	31.648
average annual growth rate, 1975-95	13.14	15.33		16.40	16.57	
average annual growth rate, 1975-85	7.44	8.93		9.56	7.59	
average annual growth rate, 1985-95	18.99*	17.95*		21.19	24.06	

Source: Kumar, on the basis of following sources and definitions:

¹represents total technological receipts of OECD member countries (except Denmark, Portugal, Switzerland, Ireland, Iceland, Turkey, and Greece, for which data are not available for all the years); compiled from OECD's *Basic Science and Technology Statistics*, various editions in national currencies and converted into US dollars with exchange rates for the respective years provided in World Bank's *World Data 1995*, CD-ROM.

²Our estimates of technological payments by non-OECD countries to OECD countries. Estimated to be equal to the difference between technological receipts and technological payments by OECD countries.

³UNCTC and UNCTAD.

^POur projections on the basis of actual growth of royalty receipts of US, UK, Japan, France and Germany between 1993-95.

*Based on the actual figures for the 1985-93 period.

Figure 2: Global Technology Transfer Payments, 1976-95

Source: based on Table 7.

Figure 3: Global FDI Inflows, 1975-95

Source: based on Table 7.

economic integration in Europe and North America and responses of outside enterprises to consolidate their market positions within these trade blocs as observed earlier. Significant proportion of FDI inflows in the recent years also represents debt-equity conversions in Latin America and large scale privatisation of public sector enterprises in different parts of the world which also may have been accompanied by relatively little transfers of technology. The circular flow of overseas Chinese capital in the Southeast and East Asia is responsible for some of the recent buoyancy in FDI inflow figures which may represent flow of largely financial capital unaccompanied by considerable amount of knowledge. Finally, an increasing proportion of FDI flows in recent years have gone into services which may not be as technology intensive as the manufacturing.

The share of Developing Countries

Technology transfers as well as FDI inflows to developing countries have also grown over the period. Comparing the rate of growth for flows to developing countries compared to global growth is higher in the 1985-95 (1985-93 in the case of technology flows) period one notes that technology transfers to developing countries have grown at a slower rate than overall inflows, FDI inflows reveal a reverse pattern. This has meant that while the share of developing countries as recipients of FDI has gone up, their share in global technology transfers has come down. The share of developing countries in the two related types of flows over the years plotted in Figure 4 suggests that except for the 1990s, the two have followed each other quite closely. In the early years developing countries' share in technology payments generally exceeded their share in FDI inflows but a inverse tendency is apparent in the more recent years. However, the recent sharp rise in the share of developing countries in global distribution of FDI inflows has to a large extent been on account of a rather heavy concentration of FDI inflows in China which has emerged to be the largest host country of FDI among developing countries. The bulk of the FDI inflows attracted by China is associated with the Chinese business community in the East Asian newly industrializing countries such as Hong Kong, Macau, Singapore, Taiwan. A substantial proportion of these flows are believed to represent roundtripping of Chinese capital rerouting itself via Hong Kong to claim the fiscal benefits

Figure 4: Share of Developing Countries in Global FDI Inflows and Technology Transfer Payments

Source: based on Table 7.

meant for foreign investors and hence may not bring new knowledge to China. Excluding the inflows to China, the share of developing countries looks comparable to those prevailing in the late 1970s and early 1980s. The long term trend in share of technology transfers to developing countries vis-à-vis global transfers (as well as FDI inflows excluding the Chinese inflows) appears from Figure 4 to be one of decline.

The intercountry distribution of technology transfers appears to be highly concentrated in the triad nations viz. USA, the European Economic Area (EEA, comprising EU and EFTA members), and Japan. These countries are not only major sources of technology but also share the bulk of all technology inflows. Figure 5 depicts this phenomenon. UNCTAD studies have reported a similar importance of triad nations in the global distribution of FDI inflows (see, for instance, UNCTAD,1995, Figure I.6). A domination by triad countries of even greater extent in the international distribution of strategic technology alliances has been noted by Freeman and Hagedoorn (1992). As many as 95 per cent of these alliances entered into by corporations in the 1980-89 period were reportedly entered into between enterprises from the industrialised countries, with the triad countries alone accounting for nearly 92 per cent share. The alliances between triad and newly industrialising countries

Figure 5: Triad Nations in Global Technology Transfers,

Estimated Total Transfers in 1995, \$ 68 Billions#

* Distribution of technology transfers made by the European countries is based on the actual distribution of Technology receipts by Germany, France and the UK. Europe covers both EU members and EFTA members

Estimated value of transfers made by industrialised countries arrived by projecting the 1993 values to 1995 at the actual growth rate achieved by the US, France, Germany, Japan and the UK in this period, and providing for the countries for which data is not available.

Source: Kumar based on US, Department of Commerce; Japan, Management and Coordination Agency; France, INPI; Deutsche Bundesbank; UK, National Statistical Office; OECD.

accounted for 2.3 per cent of the alliances and enterprises from all other developing countries share only 1.5 per cent.

Furthermore, it would appear that the importance of the triad countries is increasing in the global distribution of technologies originating in most of the source countries. Table 8 shows that the share of triad countries in technology transferred by France and Japan increased over the past decade. Developing countries (non-OECD countries) received about 26 per cent of France's technology in 1985 but their share declined to 17 per cent a decade later. In the case of Japan, developing countries received nearly half of technology transfers, their share also declined with increasing concentration of Japanese technology transfers to the OECD countries.

The data for UK and Germany also reveal a trend similar to that observed for France viz. that of increasing concentration in the triad especially in the European countries. The share of developing countries has increased only within the technologies transferred by the US corporations from a rather small base at 10 per cent in 1986 to 16 per cent by 1995. Dahlman et al. (1995) have also noted the relative slowdown in technology transfers to developing countries. UNDP (1992:66) similarly observed a declining share of developing countries in the capital goods trade which is the channel of international trade of embodied technology. It noted that while most developing countries are being left out of a flow that carries technological innovations and substantial scope for adaptation to local needs and conditions, technological exchanges among industrialised countries strengthen their competitiveness and makes it increasingly difficult for developing countries to share the fruits of technological advance.

Even among the developing countries as a group, the distribution of technology transfers is highly concentrated in a few countries which account for a large share of technologies received from most of the source countries. Table 8 shows that top 5 recipients accounted for more than half of all technologies received by developing countries from the US and Japan. Only in the case of France, the distribution among developing countries is more even because of technology transfers to a number of Francophone African countries. Furthermore, for all the three source countries, the share of largest 5 recipients has increased over the past decade. This pattern is close to that obtained in the distribution of FDI inflows with the top ten countries accounting for 81 per cent of developing countries' inflow in 1993 as compared to 66 per cent in the 1970s and 1980s. The patterns of regional focus again like those in FDI, emerge too. Japan's technology transfers have focused on Asian NIEs. French companies have considerable proportion of their technologies going to former French colonies in Francophone Africa. The US companies have favoured a few Latin American countries viz. Mexico, Brazil and Argentina, and Asian NIEs like Korea, Singapore, Taiwan, Hong Kong, Thailand.

Table 8: Intercountry Distribution of Technological Receipts of US, France and Japan, 1985/95

	Receipts by USA in million dollars		Receipts by France in million francs		Receipts by Japan in 100 million Yen	
	1986	1995	1985	1995	1986	1992
All Countries	7,511	25,456	8,523	10,833	2,241	3,777
Developed Countries	6,797	21,327	6,271	8,987	1,081	1,882
<i>share in total</i>	<i>90</i>	<i>84</i>	<i>74</i>	<i>83</i>	<i>48</i>	<i>50</i>
USA			2,333	2,376	577	1,119
Canada	737	1,235	150	138	20	80
Belgium-Luxembourg	286	713	131	308	9	21
France	608	1,942			59	113
Germany	864	2,699	597	1,095	78	99
Italy	486	1,105	545	850	72	62
Netherlands	493	1,858	318	361	25	19
Norway	53	87	127	45	1	1
Spain	90	654	331	589	45	30
Sweden	91	287	82	126	2	3
Switzerland	271	571	245	871	38	21
United Kingdom	885	2,333	706	634	76	248
Other Europe	291	1,904	275	459	14	13
Australia	218	553	92	116	58	50
New Zealand	64	41	4	4	8	1
Japan	1,360	5,345	437	1,015		
Developing Countries	714	4,129	2,253	1,846	1,160	1,895
<i>share in total</i>	<i>10</i>	<i>16</i>	<i>26</i>	<i>17</i>	<i>52</i>	<i>50</i>
<i>subtotal top 5</i>	<i>368</i>	<i>2,773</i>	<i>259</i>	<i>393</i>	<i>699</i>	<i>1,263</i>
<i>share in developing countries</i>	<i>52</i>	<i>67</i>	<i>11</i>	<i>21</i>	<i>60</i>	<i>67</i>
Argentina	26	128	25	42	3	9
Brazil	25	311	17	18	38	22
Chile		26	8	9		
Mexico	109	414	42	52	13	24
Venezuela	15	93	65	25		
Other South and Western Hemisphere	96	184	6	2	11	12
South Africa	71	112	24	74	17	27
Other Africa	9	31	652	469	171	170
Israel	6	29	9	21		
Saudi Arabia	10	45	26	14	6	2
Other Middle East	14	12	266	101		
China		85	28	144	197	165
Hong Kong	33	289				
India	54	48	65	57	44	50
Indonesia	8	56	55	23	152	131
Korea, Republic of	74	766	32	66	211	394
Malaysia	7	95	9	8	32	167
Philippines	19	77	3	3	6	19
Singapore	60	993	5	14	48	240
Taiwan	33	208	1	18	85	217
Thailand		116	3	43	54	245
Other Asia	45	11	37	13	37	35

Source: Kumar based on: US Department of Commerce (Bureau of Economic Analysis), Washington, DC; France, Institut National De la Propriete Industrielle (Bureaux des Transferts Techniques Internationaux), Paris; Japan, Management and Coordination Agency (Statistics Bureau), Tokyo.

Therefore, a bulk of international technology transfers are mutually shared by the industrialised countries in the triad. The bulk of the transactions with developing countries are actually received by a few relatively more dynamic countries and over time the concentration seems to be increasing. The recent growth in the annual flows of technology across countries, like FDI flows, appears to have benefited a handful of countries.

4. MARKETS VERSUS INTRA-FIRM TRANSACTIONS OF TECHNOLOGY: THEORY, EMPIRICAL EVIDENCE AND RECENT TRENDS

The theory of international operations of firms as evolved over time with contributions of Hymer (1960), Caves (1971), Buckley and Casson (1976), and Dunning (1981), among others, considers FDI and arm's length contracts as alternative modes of foreign production. A firm exploits the revenue productivity of her intangible assets (ownership advantages) e.g. knowledge, technology, brand names etc., abroad through FDI or within the firm (internally) if the market transactions are difficult to be set up and governed. In other cases contracts are used to license the intangible assets. Thus the choice between FDI and licensing is determined by the transaction or governance costs. The higher the transaction costs, the higher the incentive to internalise the transaction (internalisation incentives) and likelihood of FDI being chosen as a mode of foreign production or technology transfer. The transaction costs are generally high for market transactions because of market failures due to 'public good like' nature of technology, difficulty in making a convincing disclosure and buyer's uncertainty, problems with codification of knowledge, and risk of dissipation of brand goodwill. It must be pointed out, however, that external markets for all intangible assets are not subject to the same degree of market failure, and hence transaction costs vary. Some intangible assets such as proprietary process technologies can be profitably licensed at arm's length [Kumar, 1987]. Product technologies and those process technologies that can not be codified easily or embodied in capital goods because of a high tacit component are more difficult to be licensed. Therefore, the relative importance of licensing as a channel of technology or knowledge transfers varies across industries.

Besides the characteristics of intangible assets or technology to be transferred as predicted by theory, a number of other factors may affect the choice between FDI and licensing in practice. For instance, licensing is preferred when FDI is not profitable or possible. This could be because of small size of the market or government restrictions on FDI. Licensing is encouraged when the licensor lacks experience in managing manufacturing plants abroad [Caves, 1996].

Some empirical studies have confirmed these propositions. Davidson and McFetridge (1985) in an empirical study of the choice of mode of foreign participation found certain firm- and technology-specific factors also playing a role such as age, size, past experience in technology transfer, extent of product and geographical diversification of the firm, the degree of sophistication of technological advance, among others. An OECD survey [Vickery, 1988] of licensing has shown that smaller enterprises engaged in licensing activity unaccompanied by equity ownership more than larger corporations. Local absorptive capacity and entrepreneurship are also important for licensing as the survey showed that most licensing deals arose from requests from host enterprises and that they concentrated in industrialised countries and in the developing countries in Asia. Process technologies were found to be transferred on licensing basis more often than product technologies. Finally, most licensing agreements included restrictive clauses such as territorial limits, exclusivity provisions and market limitations. Kumar (1987) found FDI to be predominating the advertising and human skill intensive industries in an analysis of determinants of FDI and licensing across 49 Indian manufacturing industries. Licensing was important in industries where knowledge could be embodied in capital goods and those with relatively simpler technologies.

In the period since the mid-1960s a growing proportion of international transfer of disembodied technology has taken place under arm's length contracts or licensing arrangements. This was because maturing and standardisation of a wide range of technologies led to widening of technology markets as alternative sources emerged and competition increased. A large number of host governments evolved foreign investment codes during the 1960s and 1970s and started restricting FDI inflows in an effort to reduce remittances of dividends and or to protect domestic enterprises. Thus arm's length licensing emerged as an alternative channel of international technology transfer. This trend of rising importance of arm's length contracts as an alternative to FDI continued till the mid-1980s. It is evident from the distribution of technology receipts by major technology exporting countries reported in Table 9. The share of technology receipts by US corporations from their affiliates in their total technology receipts (those in which they retained a controlling stake), for instance, declined from 71.36 per cent in 1975 to 68.97 per cent in 1985. Since the mid-1980s, the share of receipts from affiliates, however, has constantly improved from nearly 69 per cent to over 80 per cent in 1995. The relative importance of receipts from affiliates in total receipts of technology payments varies across countries. In general, the German companies tend to transfer a greater proportion of technology internally compared to American and British corporations. However, increasing importance of affiliated receipts in the more recent

period is visible for the UK and Germany as well. Comparable figures for Japanese corporations are not available. However, the proportion of intra-firm transactions in all technology transactions made by Japanese corporations in number terms is available [see Urata, 1997]. These numbers summarised in Table 10 suggest that the proportion of intra-firm licensing has gone up over the 1986-92 period. In 1992 as many as 37 per cent of contracts were entered into by related firms compared to 28 per cent in 1986.

Table 9: Composition of Technology Receipts, 1975-1995

Years	United States			United Kingdom			Germany		
	Total Receipts of Royalties \$ million	from affiliates (per cent)	from unaffiliated licensees (per cent)	total receipts, million pounds	from affiliates (per cent)	from unaffiliated licensees (per cent)	total receipts (for patents, innovation and processes) million DM	from affiliates (per cent)	from unaffiliated licensees (per cent)
1975	2643	1886 (71.36)	757 (28.64)						
1980	4998	3693 (73.89)	1305 (26.11)						
1985	6121	4222 (68.97)	1899 (31.03)	969	500 (51.60)	469 (48.40)	1693	1559 (92.08)	134 (7.91)
1988	10968	8455 (77.09)	2513 (22.91)	1098	656 (59.74)	442 (40.25)	1898	1769 (93.20)	129 (6.79)
1990	15507	12062 (77.78)	3445 (22.22)	1420	1001 (70.5)	419 (29.5)	2499	2336 (93.5)	163 (6.5)
1992	20238	16109 (79.6)	4129 (20.4)	1990	1518 (76.3)	472 (23.7)	2419	2281* (94.3)	138 (5.7)
1995	26953	21699 (80.21)	5333 (19.78)	3339	n.a.	n.a.	3116	2947 (94.6)	168 (5.4)

Sources: Kumar, on the basis of US Department of Commerce, *Survey of Current Business*, and *Monthly Report of the Deutsche Bundesbank*, various issues; UN-TCMD (1993); UNCTAD (1994). * belongs to 1991

Table 10: Share of Intrafirm Contracts in Total Technology Licensing by Japanese Corporations, Industry by Regions (percentages)

	1986						1992					
	Asia	Latin America	North America	Europe	World	Total N° of cases	Asia	Latin America	North America	Europe	World	Total N° of cases
Total industry	35.9	26.2	30.5	13.8	28.1	2076	46.3	25.4	34.3	20.6	37.0	3608
Manufacturing	36.1	25.8	30.0	12.9	27.8	1992	46.9	26.1	33.6	20.3	37.4	3442
Food	25.0	--	--	--	25.0	4	12.0	0.0	14.3	7.5	9.0	233
Textiles	67.9	0.0	0.0	0.0	58.3	127	52.9	40.0	22.2	12.1	34.5	110
Wood and pulp	0.0	0.0	0.0	0.0	0.0	44	0.0	--	25.0	16.7	18.2	11
Chemical products	26.3	7.4	3.5	9.3	12.3	325	27.9	40.0	13.8	6.1	15.8	606
Iron and steel	22.7	22.2	13.3	0.0	10.8	83	10.0	0.0	33.3	5.1	13.2	106
Non-ferrous metals	22.9	50.0	58.3	8.3	28.1	64	42.9	0.0	35.9	18.8	34.8	204
General machinery	28.2	0.0	47.4	5.1	19.2	182	33.9	60.0	54.3	61.3	42.6	183
Electric machinery	38.8	55.9	44.2	24.4	38.7	511	71.3	65.0	26.1	32.4	58.8	949
Transport machinery	31.1	8.3	21.4	7.3	20.8	385	35.7	23.5	56.3	30.6	37.1	709
Precision instruments	50.0	0.0	61.5	77.8	53.5	43	42.9	100.0	71.4	63.6	55.9	34
Petro and coal products	0.0	--	--	--	0.0	1	0.0	0.0	37.5	25.0	19.0	21
Other manufacturing	28.8	54.5	39.6	32.1	33.6	223	46.5	30.0	43.1	54.5	44.6	276

Source: Urata (1997) based on MITI, Kaigai Toshi Tokei Soran [Comprehensive Statistics of Foreign Investment], nos. 3 and 5.

The explanation for the decline in the importance of contractual or non-equity modes of technology transfer can be found in terms of a number of factors. These include liberalisation of foreign investment policy regimes world-wide which removed the restrictions on FDI vis-à-vis licensing since the mid-1980s. The emergence of new core technologies viz., microelectronics, biotechnologies and new materials as observed earlier, has also contributed to this trend. Because these technologies are still evolving and have pervasive application in a wide range of sectors, they are seen by their owners as key instruments of technological competitiveness. This has prompted a wave of technological protectionism in the industrialised countries. Hence, companies owning them are wary of transferring them to unaffiliated parties.

The relative importance of arm's length licensing as a channel of international technology transfer is also expected to vary across industries, as observed earlier, depending upon the characteristics of technology e.g. a high tacit component. Table 11 shows that the proportion of technology transferred internally has varied from just 44% for primary and fabricated metals to 97% for non-electrical machinery in the case of technology transferred by the US corporations. In the case of German companies too, primary and fabricated metals industry had least transfers internally (36%). However, the tendency of internalization also varies across the source countries. The US companies, for instance, transferred 55 per cent of technology in electric and electronic equipment and 46 per cent in transportation equipment on internal basis, the corresponding percentages for German corporations were 98 and 97 per cent. As observed earlier, German companies, in general, have a much higher proportion of technologies transferred internally. The Japanese technology transfers as summarised in Table 10 also reveal inter-sectoral differences. As expected engineering industries viz. general machinery, electrical machinery, transport equipment, and precision instruments, which have a higher component of product technology have a higher than average proportion of internal transfers in 1992. In the Japanese case, a relatively high proportion of transfers in textiles and non ferrous metals industries are also conducted on internal basis, presumably on account of their home market feeding nature. In the case of food processing industry the proportion of internal transfers is very low compared to rather high ratios for US and Germany. While the overseas expansion of Western food processing enterprises is strongly based on their brand reputations, Japanese enterprises may be transferring process technologies in this area not having built up wellknown brand names as yet.

Table 11: Sectoral Composition of Technology Fees Received by US and German Corporations

Industry	USA: Receipts 1989 (Millions of Dollars)			Germany: Receipts 1991 (million DM)		
	Total	From affiliates (% Share)	From unaffiliated foreigners (% Share)	Total	From affiliates (% Share)	From unaffiliated foreigners (% Share)
All Industries	12,800	10,281 (80)	2,519 (20)	2,419	2,281 (94)	138 (6)
Manufacturing	11,212	9,376 (84)	1,836 (16)	2,284	2,201 (96)	83 (4)
Food and kindred products*	567	511 (90)	55 (10)	33	28 (85)	5 (15)
Chemicals and allied products#	2,183	1,707 (78)	475 (22)	1,232	1,207 (98)	25 (2)
Primary and fabricated metals	135	59 (44)	76 (56)	11	4 (36)	7 (64)
Machinery, except electrical	5,803	5,624 (97)	179 (3)	188	168 (89)	20 (11)
Electric and electronic equipment	699	382 (55)	317 (45)	508	497 (98)	11 (2)
Transportation equipment	250	114 (46)	136 (54)	115	111 (97)	4 (3)
Other manufacturing	1,576	978 (62)	598 (38)	197	185 (94)	12 (6)

* includes tobacco products in the case of Germany. # includes mineral oil refining in the case of Germany.

Source: Kumar on the basis of US Department of Commerce (1992), *US Direct Investment Abroad, 1989 Benchmark Survey*, Washington DC: GPO; Deutsche Bundesbank, *Monthly Report*, May 1992.

Finally, the relative importance of internal modes of technology transfer vis-à-vis arm's length licensing is expected to vary across the host or receiving countries depending upon among other factors the local absorptive capacity and technological capability in the host country, quality of local entrepreneurship, the relative level of sophistication and complexity of economic activity, government's attitude towards FDI, and more crucially on the risk perceptions of corporations with respect to the potential host markets. Table 12 summarises the patterns in terms of modes in transfer of technology by the US corporations in 1986 and 1995. Some countries such as Japan, South Korea, Israel, India, Taiwan, are known to have promoted the arm's length route of technology acquisition through selective technology imports and FDI policies in order to pursue a more autonomous path to building local technological capabilities. All of these countries have been successful in acquiring a greater proportion of technology imports on arm's length basis as evident from the Table 12. The proportion of external or unaffiliated imports is also high for Sweden, Chile, South Africa, Saudi Arabia, Indonesia and Thailand. Brazil, Argentina and Venezuela also imported the bulk of technology under contractual modes in 1986. Subsequently, however, they seem to have placed emphasis on internal transfers through liberalization of FDI policies as clear from the sharp changes in the share of unaffiliated receipts in 1995. The Japanese data summarised in Table 10 enables a comparison of the proportion of internal modes across different host regions within the broadly defined industries. For instance, in the electric machinery

industry which involved 949 technology transfers in 1992 more than any other branch of manufacturing, the proportion of internal transfers was much lower for the industrialised countries in North America and Europe than developing countries in Asia and Latin America. One possible explanation for this is the lower local absorptive capacity in developing countries may make arm's length licensing as an inappropriate mode. It is also possible that the nature of operations, e.g. in terms of market-orientation, varies across these regions.

Table 12: Origin of Technology Fees Received by US Corporations, 1986-95
(Millions of Dollars)

	1986					1995				
	Total	From Affiliates	Share	From others	Share	Total	From Affiliates	Share	From others	Share
All Countries	7,927	5,988	(76)	1,939	(24)	26,953	21,619	(80)	5,333	(20)
Canada	737	593	(80)	145	(20)	1,235	1,094	(89)	141	(11)
Japan	1,360	728	(54)	632	(46)	5,345	3,444	(64)	1,903	(36)
Australia	218	184	(84)	34	(16)	553	466	(84)	86	(16)
New Zealand	64	47	(73)	17	(27)	41	31	(76)	10	(24)
Belgium-Luxembourg	286	251	(88)	35	(12)	713	615	(86)	99	(14)
France	608	503	(83)	105	(17)	1,942	1,779	(92)	161	(8)
Germany	864	747	(86)	117	(14)	2,699	2,366	(88)	334	(12)
Italy	486	422	(87)	64	(13)	1,105	968	(88)	137	(12)
Netherlands	493	423	(86)	70	(14)	1,858	1,799	(97)	58	(3)
Norway	53	36	(68)	17	(32)	87	66	(76)	21	(24)
Spain	90	73	(81)	17	(19)	654	576	(88)	79	(12)
Sweden	91	68	(75)	23	(25)	287	198	(69)	89	(31)
Switzerland	271	236	(87)	35	(13)	571	507	(89)	64	(11)
United Kingdom	885	773	(87)	113	(13)	2,333	2,094	(90)	239	(10)
Argentina	26	13	(50)	13	(50)	128	91	(71)	37	(29)
Brazil	25	5	(20)	19	(76)	311	267	(86)	45	(14)
Chile						26	10	(38)	16	(62)
Mexico	109	81	(74)	28	(26)	414	340	(82)	74	(18)
Venezuela	15	4	(27)	11	(73)	93	75	(81)	18	(19)
South Africa	71	56	(79)	15	(21)	112	77	(69)	35	(31)
Israel	6	3	(50)	3	(50)	29	12	(41)	18	(62)
Saudi Arabia	10	3	(30)	7	(70)	45	6	(13)	39	(87)
Hong Kong	33	30	(91)	3	(9)	289	232	(80)	57	(20)
India	54	5	(9)	49	(91)	48	9	(19)	39	(81)
Indonesia	8	3	(38)	5	(63)	56	22	(39)	34	(61)
Korea, Republic of	74	(^D)		(^D)		766	162	(21)	605	(79)
Malaysia	7	5	(71)	2	(29)	95	63	(66)	32	(34)
Singapore	60	40	(67)	20	(33)	993	(^D)		(^D)	
Taiwan	33	16	(48)	17	(52)	208	125	(60)	83	(40)
Thailand						116	71	(61)	45	(39)

(^D) Suppressed to avoid disclosure of data of individual companies

Source: Kumar on the basis of US Department of Commerce, *Survey of Current Business*, respective issues.

It would appear from the above that FDI inflows seem to have been accompanied by transfers of technology in varying degrees. Some countries seem to have managed to acquire a large proportion of their technology requirements under contractual modes giving them independence of decision making crucial for charting an independent path for building local capabilities and have rapidly emerged as technology exporters in their own right on the global scene. The prominent examples are the East Asian countries. There may be others which despite relatively large inflows of FDI may have not been able to acquire technology and knowledge necessary to industrialise themselves and move upwards in terms of levels of competence among the leagues of nations. How far a nation can utilize the imported knowledge whether as a part of the FDI package or under contractual arrangements for augmenting the local capability to respond to the challenges of competitive industrialization seems to depend on the quality of local entrepreneurship. Selective policies towards technology imports and other policies supportive of local technological and industrial development are most effective in the presence of a receptive local entrepreneurship as demonstrated by the experiences of Japan, Korea and Taiwan. Too selective or restrictive policies towards technology imports in the absence of responsive local entrepreneurship may lead to growing technological obsolescence as witnessed in the case of India during the 1970s and 1980s. We have discussed the conceptual and empirical issues concerning the interaction between technology imports and local technological development at length elsewhere [Kumar and Siddharthan, 1997].

5. CONCLUDING REMARKS

The above examination of trends in technology generation and transfer in the world economy over the past two decades has shown that technology generation activity continues to be highly concentrated in a handful of advanced industrialised countries although the extent of concentration has slightly declined overtime. Barring a couple of newly industrializing countries such as Taiwan and South Korea, there does not seem to be a prospect of a developing country emerging as a serious contender in technology generation. In fact the technological effort in developing countries as a group has declined and the technology gap between them and industrialised countries has widened overtime rather than narrowed. The neglect of building local technological capability by developing countries will seriously affect their ability to employ even the imported technologies effectively and efficiently. The policy makers in developing countries need to urgently restore the importance that technology deserves in their developmental policy and programmes.

The hold of larger corporations on the generation of new technologies seems to have intensified with growing scale of R&D activity, recent trend of corporate consolidation and restructuring, different forms of inter-firm cooperation arrangements and strategic alliances, and growing industry-university links especially in the new core technologies. Furthermore, the evolution of new core technologies and growing awareness of their commercial potential, and a general appreciation of technology in determining the international competitiveness in the current age of globalization has led the governments in industrialised countries adopt policies supporting, subsidising, and protecting their national champions as a part of strategic trade policies. The increased domination of technologies by fewer corporations coupled by the tendency of technoprotectionism may have implications for the access and terms of transfer of technologies to developing countries especially in view of the recently strengthened and harmonized international regime of intellectual property protection. The new norms of patent protection treat importing as working of patents and provide to the patent holders greater freedom to opt for exporting to particular markets and choosing not to transfer technology. While most industrialised countries are equipped with effective anti-trust regulations to deal with possible abuse of monopoly power of patent holders, most developing countries lack effective competition policy instruments. International initiatives to evolve codes of conduct for transfer of technology and on activities of transnational corporations have failed to evolve any effective norms. Adoption of effective competition policy instruments either at national levels or collectively at regional levels (à la European Union) to minimise the adverse impact of the possible resort to restrictive business practices by patent holders and (other anti-competitive practices especially in the context of liberalization of national economies and hence greater exposure to outside businesses) is also a possible item on the policy agenda of developing countries.

The annual magnitude of international transfers of disembodied technology in terms of royalty and technical payments has grown rapidly especially since the mid-1980s. However, their growth has not kept pace with that of FDI inflows, suggesting that recent expansion of FDI inflows has not been accompanied by technology flows in the same proportion. The intercountry distribution of global technology flows reveals that the triad nations viz. USA, European countries and Japan not only generate most of technology but also share among themselves the bulk of technologies transferred across countries. The technology transfers from Europe and Japan reveal also a strong regional focus. Although the share of developing countries in global technology transfers has gone up in recent years, the long term trend has been one of decline. Finally, the bulk of technology transfers to developing countries are actually received by a handful of relatively more developed

and technologically more dynamic countries and this concentration is increasing. From this, the local absorptive capacity would appear to be one of the determinants of a country's ability to receive technologies from abroad. The local absorptive capacity is in turn accumulated with technological effort sustained over the years, thus reemphasizing our earlier observation regarding the importance of local technological capability for utilising even the imported technologies.

In terms of the mode of technology transfer, the trends suggest a reversal of the growing popularity of arm's length licensing in the period since mid-1970s till mid-1980s. Since the mid-1980s, market or arm's length transactions have steadily lost their importance and intra-firm transfers have regained their prominence as mode of technology transfers. Although, FDI or intrafirm transfers emerge to be the most important mode of technology transfer, arm's length licensing is still quite popular mode of technology transfer in a number of sectors especially those involving process technologies. It also appears that countries with lower absorptive capacity may find it more difficult to obtain technologies on arm's length basis. Finally, there is a considerable variation across countries in the relative importance of internal modes of technology acquired. Some countries especially East Asian newly industrialising economies have sought technology as much as possible unaccompanied by ownership consciously with selective policy. As documented very well in the literature [see for instance, Kim, 1997; Kumar and Siddharthan, 1997], such policy has allowed the technology importing domestic firms independence of decision making so important for pursuing an autonomous path of expansion. The emergence of Japanese, and of late, Korean and Taiwanese corporations as multinational enterprises in their own right would not have been possible with technology acquisition under FDI route. It must be emphasized, however, that market transfers alone do not guarantee such outcomes. They only provide necessary conditions and are effective only in the presence of responsive (and perhaps aggressive) local entrepreneurship willing to complement imported knowledge with extensive in-house technological effort on absorption, adaptation, continuous updating and eventually on innovation. In the absence of such effort, technology imports through markets may lead to, as the experience of India has shown, technological obsolescence.

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