Trends and Patterns of Technology Acquisition in Indian Organised Manufacturing : An Inter-Industry Exploration

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Abstract

With liberalization of foreign technology import policy in the 1990s, India has seen declining R&D intensity at national level. This has generated a general concern on how Indian industries are doing in technology accumulation under the new policy regime. The present study has made a preliminary attempt to analyze different modes of technology acquisition including R&D for Indian Manufacturing Industries by National Industrial Classification (NIC) Revision 1998 at 3-digit level. It has constructed a new technology indicators database for Indian Industries at NIC (1998) and also constructed a composite technology index for Indian manufacturing to examine how high-technology industries have performed during the period 1991-2002. The research revealed many interesting facts about the nature and character of technology accumulation in Indian manufacturing, which has important policy implications.

1. Introduction

In the area of globalising world economy, competitiveness of nations depend crucially on the speed of acquiring, absorbing and effectively utilising new technology vis-à-vis their global competitors. Technology in the form of creative application of existing technical knowledge or generation and application of new technical knowledge results in productivity improvements. In the process, it endows the nations a competitive advantage by infusing technical improvements in product or production process. The Indian Science and Technology Policy (ISTP)-2001 clearly recognizing this role of technology, aims 'to encourage in highest level of

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innovation and research and development in industry' and 'to integrate science and technology with all spheres of national activity in order to enhance India's global competitiveness'.

The present study attempts to examine how have Indian industries performed in acquiring and stengthening their technological capabilities during the reform period. The period between 1991 and 2001 has seen dramatic changes in the Indian technology policy as compared to prereform period. As a part of the import- substituting development strategy pursued by India, the pre-reform Indian technology policy was meant to reduce dependence on foreign technology and skills. The indigenisation of technological capacity building was to be achieved by :

(i) protecting local technology and skills from imported ones wherever local skills were available and

(ii) permitting foreign technology including investment in cases where local alternatives were inadequate or not available with strong emphasize on indigenisation and absorption of imported knowledge and skills.

The Technology policy regime was more selective and restrictive towards foreign technology imports during this phase (Panchamukhi et al. 1994). Foreign collaborations were barred for majority of industries and wherever permitted were subjected to complex approval procedures, policy-led ceilling on foreign investment, royalty payments, etc. Technology imports were required to demonstrate necessity of the importing technology and required to give a firm assurance on indigenisation and subsequent development of imported know-how through investment in in-house research and development (R&D). Further, it was required that the imported technology be open to sublicensing within the country without any minimum guaranteed royalty or restrictive clauses with respect to exports, source of capital goods, raw materials, or spares.

The policy further disallowed foreign brand-names for sales in Indian markets, emphasized on exclusive use of Indian consultancy relative to foreign consultancy, and insisted for a limit on renewals or extension of foreign collaboration. Technology import through foreign investment was restricted to relatively high technology and capital-intensive industries. Imports of capital goods were banned if locally available and a small list of others was allowed through Open General Licenses (OGL) subject to ceilling and the satisfaction of authorities regarding local unavailability.

The Indian technology policy has undergone sea change in character during 1990s when India adopted outward looking development strategy in 1991. Technology imports through foreign direct investment (FDI) are now freely permitted in all sectors including services, except a small negative list on environmental, small-scale sectors and security concerns. For faster approval of foreign investment Reserve Bank of India (RBI) based automatic route was created and limited on foreign ownership was raised or completely lifted for many industries. Foreign technological collaborations of US $ 2 million were also

accorded automatic approval route in the case of all industries if royalty involved is limited to a total payment of 8 per cent on sales. The period of royalty payment has been extended to 10 years from the date of agreement or 7 years from the date of commencement of commercial production, whichever is earlier. In the case of foreign financial collaboration (without technology transfer) a royalty payment up to 2 per cent for exports and 1 per cent for domestic sales on use of trademarks and brand name under automatic route is permitted. The wholly owned subsidiaries (WOS) are permitted under automatic route to make royalty payment up to 8 per cent on exports and 5 per cent on domestic sales to their parent companies without any restriction on the duration of royalty payments (Secretary of Industrial Approval, 2003).

Quantitative restrictions on import of capital goods intermediates were removed and tariff rates were significantly reduced during this phase. The average import coverage ratio for capital goods declined from 77 per cent in 1986-90 to 21 per cent in 1991-95 and further to 8 per cent in 1996-00. The average effective rate of protection was brought down by more than half to 33 per cent in 1996-00 from 79 per cent in 1986-90 (See Das, 2002, Table 3, pp. 18). The policy permits import of second-hand capital goods provided they have a minimum residual life of 5 years. Under the Export Promotion Capital Goods (EPCG) Scheme, exporters from manufacturing sector are allowed to import capital goods (including computer systems) at concessionary customs duty and service industries enjoy the facility of zero import duty.

As the technology policy of India has significantly liberalised foreign technology import, both embodied and disembodied, it may be interesting to examine the changes in the pattern of technology acquisition by Indian industries. One may presume that under a liberalising policy regime with increasing access to foreign technologies at a lower transaction costs, Indian industries might more rely on foreign technology (embodied and disembodied) vis-à-vis in-house R&D and domestic capital goods. However, the nature of relationship between different channels of technology acquisition is complex to make such a simplistic proposition (Basant, 2001). The exact nature of relationship between foreign and domestic technologies may not necessarily be a substituting type and it could even be a complementary or independent type. In the case the same competitive advantages can be derived from foreign and domestic technologies then they involve substitution as industries can substitute one against other depending on their relative costs and uncertainty consideration. If advantages are different then industries need to invest independently on them and if advantages obtained complement each other in strengthening industries' competitiveness then investment in such channels are complementary. However, the present study confined to trends and patterns of different ways of technology acquisition only and does not deal with issues of complex relationships among them[1].

The paper is structured in the following way : Section 2 conceptualizes technology and discusses about different modes of its acquisition. Section 3 deals with issues in preparation of the dataset. The next Section 4 provides trends and

patterns of different modes of technology acquisition. Section 5 outlines the methodology of constructing a composite technology index and presents the results obtained. Section 6 concludes the paper.

2. Technology and Modes of Acquisition

Technology can be defined as the application of knowledge, existing or newly created, in transforming factors of production into output. Technological change involves a new product development or relates to improvement of the product characteristics, modifications in production process or changes in existing organisational patterns.

In the neoclassical economics although technology is the main factor affecting long-run economic growth, it has been assigned with an exogenous role. It is assumed to occur effortlessly at some constant rate of time. The firm-the black box that transforms inputs of labour and capital into output of goods and services is assumed to possess free knowledge on available technology. Given the perfectly competitive situation prevailing in factor and product market, the black box select the best technology to produce output dictated by the market signals.

The neoclassical depiction of technology, however, has little resemblance to the real world situation. Firms operate in imperfectly competitive world. Let alone developing and assimilating new technology, even knowing the existing technology and using it in production is not cost-free. For accumulating technological capabilities, whether be in mastering the existing technology or infusing minor improvements in existing processes and products or developing entirely new products, firms are required to make intangible and tangible investments like research and development (R&D), technology licensing, capital goods accumulation etc. Technical change is a function of these investments and not a simple function of time as in the neoclassical framework. The endogenous growth models, which appeared since late 1980s, clearly recognised the fact production and or access to technology involves costs and it is not an exogenous phenomenon to firms and industries (Grossman and Helpman 1990; Romer 1990).

Given the fact that acquiring technology is costly, an Indian industry has to make conscious investment in improving its technological capabilities. This may involves different types of investment as required by different modes of technology acquisition. The source of technology can be internal to an industry or can be external (see Figure 1).

The sector can strengthen its technological prowess by indigenous technological efforts i.e., investing in in-house R&D for new product and process development, reverse engineering or absorbing and improving imported foreign technologies. The sector can also get technology externally from different sources, which can be through embodied or disembodied modes.

The embodied mode of technology acquisition takes place when the industry invests in acquiring new vintages of machinery and equipments. The assumption

here is that new innovation is embodied in these new capital goods. Depending upon the source of location, the embodied mode can be further divided into procuring capital goods domestically or importing from overseas. The disembodied channel includes investment in acquiring technology in the form of licenses, patents, knowhow, trademarks, designs, etc.

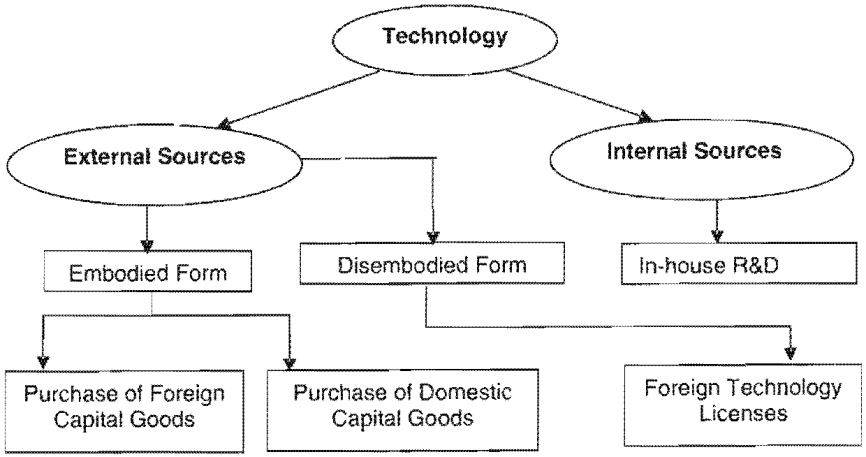

Fig. 1 : Modes of Technology Acquisition

For developing countries tagged as technology-laggards, import of foreign technology has been a major source of their technological capability building. However, given a restrictive technology policy followed by India in the pre-1990s period, this mode of technology accumulation was moderate for Indian manufacturing (Lall 1996).

3. Database Construction

For Indian manufacturing obtaining data on different modes of technology acquisition at sectoral level is hard to come by. The principal source of industrial statistics in India, the Annual Survey of Industries (ASI), published by Central Statistical Organisation (CSO) does not provide any information on the technological activities. The Department of Science and Technology (DST), Government of India in its annual publication 'R&D Statistics' provides R&D expenses at sectoral level. However, it suffers from sample bias as it includes only those R&D units, Which are recognised by the DST. Moreover, among the recognised in-house R&D units in private sector not all participate in the DST survey. For example, 1130 private sector units included in the survey for 1996-97 about 121 units did not responded and 19 units reported to have zero R&D expenditure[2].

Given the unavailability of data on all the indicators of technology acquisition, we had to rely on the Prowess database of the Centre for Monitoring

Table 1

Different Measures of Technology Acquisition in Indian Manufacturing, 1991-2001

Year	In Rs. Crore		As a Per Cent of Gross Value Added		In Rs. Crore		As a per cent of Gross Fixed Asset	
	R&D	Technology Payment Abroad	R&D	Technology Payment Abroad	Foreign Capital Goods	Domestic Capital Goods	Foreign Capital Goods	Domestic Capital Goods
1991	130	314	0.31	0.74	1676	13821	1.17	9.62
1992	285	435	0.58	0.89	2470	27349	1.45	16.09
1993	467	750	0.84	1.35	2983	20117	1.46	9.84
1994	591	834	0.91	1.29	3834	21426	1.58	8.82
1995	956	1391	1.11	1.62	11390	45149	3.67	14.56
1996	1393	2365	1.31	2.22	13027	35720	3.43	9.4
1997	1929	1935	1.76	1.77	12589	23979	2.89	5.51
1998	1727	1487	1.46	1.26	12372	45252	2.4	8.78
1999	1902	1795	1.55	1.46	12880	34559	2.25	6.04
2000	1904	3861	1.38	2.8	7599	23053	1.27	3.84
2001	2136	3173	1.47	2.18	5128	21431	0.85	3.54

Source: Authors' estimation based on Prowess Database, CMIE (2002).

Indian Economy (CMIE). This database provides firm-level financial indicators covering all the required technology indicators, on about 4000 manufacturing enterprises. The in-house R&D expenditure incurred is taken as a measure of the sector's indigenous technology acquisition. The technology payments made overseas for licenses, patents, knowhow, and technical assistance is used as the measure of disembodied technology acquisition. The import of capital goods is taken as sector's embodied technology acquisition from abroad. For obtaining the figure on domestic embodied technology accumulation, we have made use of the data on stock of plant and machinery reported in Prowess.

First, the sectoral investment in plant and machinery was obtained by subtracting last year's stock of plant and machinery to this year's stock.

Second, the obtained investment in plant and machinery was adjusted for the imported machinery to arrive at the domestic capital goods formation.

The Prowess has its own industrial classification markedly different from National Industrial Classification (NIC) 1998. To express Prowess database into standard industrial classification we developed an industrial concordance. Prowess for each firm provides 'activity' classification at a more detailed level of dis-aggregation. These activities were then mapped into NIC 1998 classification (which is same as International Standard Industrial Classification (ISIC) Revision 3) at 3-digit level. For some firms the activity classification was not reported in the Prowess and in that case we relied on the Prowess industrial category to group them into the appropriate NIC classification[3].

4. Trends and Patterns in Technology Acquisition

4.1 Overall Manufacturing : The investment of Indian manufacturing in different modes of technology accumulation has been summarized in Table 1 and shown in Figures 2 and 3. These investments are provided in absolute monetary terms as well as in intensity form (i.e., normalised by the size of sales or gross fixed asset) to know their strategic importance. In India there has been a general concern in both policy and academic circle on the declining trend of R&D. Between 1989-90 and 1999-00, although R&D has increased by 232 per cent in nominal term, as a percent of GNP declined by 22 basis points from 0.92 per cent to 0.70 per cent[4]. Given that public sector has been the main contributor to total R&D expenditure in India, this declining R&D intensity was inferred to have resulted from declining role of state in acquisition and application of scientific knowledge[5].

The trend in R&D intensity of Indian manufacturing seems to have defied the declining trend observed in the case of total economy. The R&D as a percent of gross value added (GVA) had increased steadily between 1991 and 1997 from a 0.31 per cent to 1.76 per cent and then hoover around 1.5 per cent during 1999-2001 (Table 1, Figure 2). The competitive pressures caused by the reform process in 1990s may explain partly this increasing intensity of Indian manufacturing firms to

undertake R & D. With opening up of the economy, many technologically advanced Indian firms have increased their R & D activities to keep their strength in domestic market as well to expand their position in global market, while many technologically less competent firms were forced to undertake R & D functions to survive in the growing competition. The strategic interventions by government in expanding scientific infrastructure, skill formation, provision of grants-in-aid and soft loan for R & D, and other fiscal incentives like enhanced depreciation allowance on plant and machinery, customs duty exemption on government funded research, tax deduction for sponsored research programmes in approved national laboratories and for donations for scientific research etc. also seemed to have played role in encouraging R & D intensity of the manufacturing sector. However, in comparison to developed countries' manufacturing sector like the United States which spend more than 3 per cent of sales, the R & D intensity performance of Indian manufacturing is not satisfactory[6]. As competition in internal and international market is becoming increasingly technology driven, Indian manufacturing has to increase its productive R & D in tandem with global competitors.

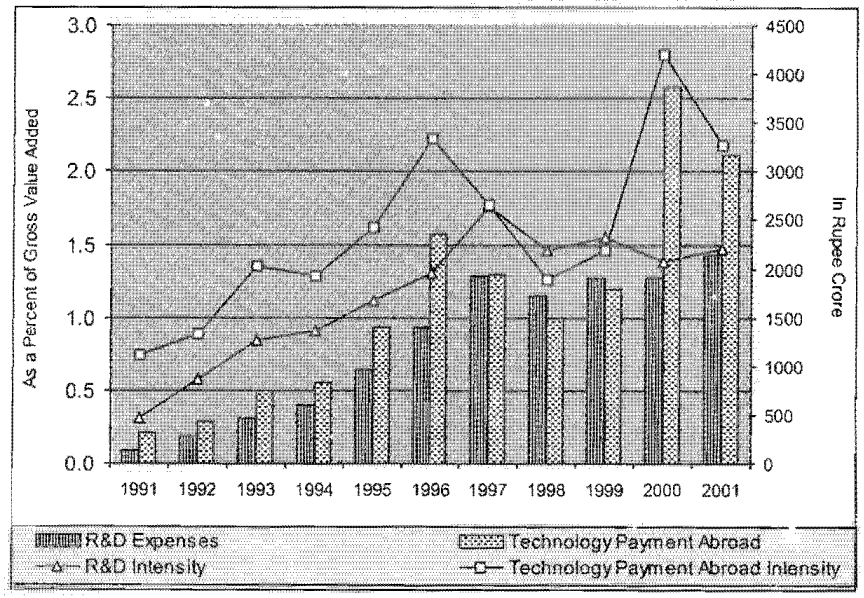

Fig. 2 : R&D and Technology Payment Abroad, 1991-2001

As observed in the case of R&D, the investment trend in acquiring foreign disembodied technology has also been quite encouraging. The investment of Indian manufacturing in foreign technology has been more or less growing in the 1990s. Technology payments made abroad as a percent of gross value added has increased by three-times from 0.74 per cent in 1990-91 to 2.22 per cent in 1995-96 (Table 1,

Figure 2). Another important point to note that Indian manufacturing seems to be relying more on foreign disembodied technology than in-house R&D as a way of technology acquisition. Over 1991-2001, except for two years, it had consistently invested more per unit of value added in acquiring foreign technology than in conducting in-house R & D. This disproportionate reliance on foreign technology by Indian manufacturing is in tune with the literature which emphasized that technology follower developing countries rely significantly on import of foreign technology to strengthen their technological capacity.

This simultaneously upward trend of investments in R & D and foreign disembodied technology per unit of value added also suggests that liberalisation of technology import policy has not resulted in the neglect of in-house R & D. It appears that Indian manufacturing is increasing its technological capability by investing more in R&D as well as in importing foreign technology in the 1990s. Katrak (2002) has also reached at the same conclusion for a sample of electrical and electronics and automobile industries where he found that in these industries, firms making products based on in-house R & D have achieved growth comparable to those enterprises using imported technologies over the period 1991 to 1998-99. This means that liberalisation has not generated any relative disadvantage to the enterprises that market products based on in-house R & D as compared to those based on imported technologies. Therefore, indigenous technological developments and foreign technology imports have moved together without harming each other.

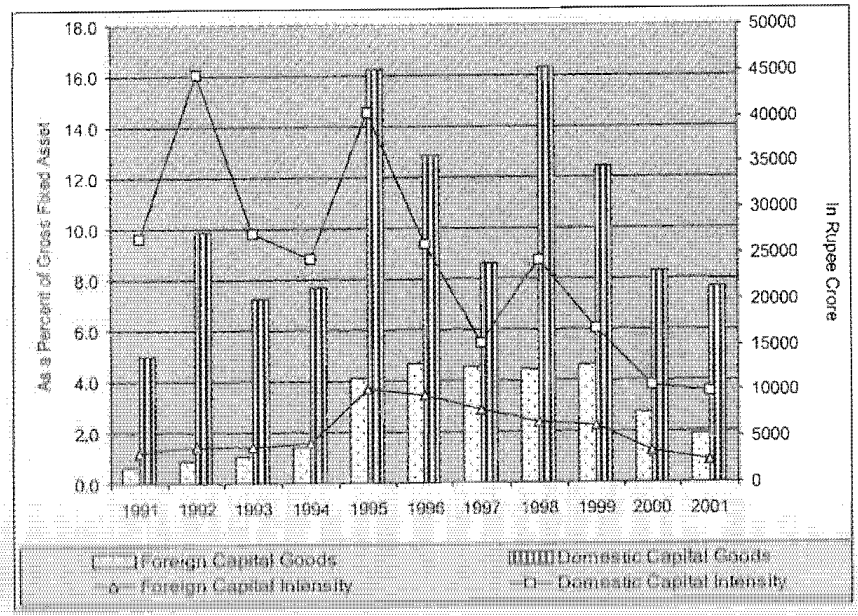

Fig. 3 : Investment in Foreign and Domestic Capital Goods, 1991-2001

Table 2

Industrial Composition of Cumulative R&D Investment in Indian Manufacturing, 1991-2001

Industry	NIC 1998	R&D (In Rs. Crore)			As a per cent of Total			As a per cent of Gross Value Added		
		1991-95	1996-01	1991-01	1991-95	1996-01	1991-01	1991-95	1996-01	1991-01
Production, processing and preservation of meat, fish, fruit ,vegetables, oils and	151	6	27	33	0.25	0.24	0.25	0.43	0.84	0.71
Manufacture of dairy products	152	5	21	26	0.19	0.19	0.19	0.32	0.42	0.39
Manufacture of grain mill products, starches and starch products, and prepared an	153	3	13	16	0.12	0.11	0.12	0.39	0.64	0.57
Manufacture of other food products	154	16	95	111	0.67	0.86	0.83	0.23	0.50	0.42
Manufacture of beverages	155	1	8	9	0.04	0.08	0.07	0.04	0.19	0.14
Manufacture of tobacco products	160	13	54	67	0.52	0.49	0.50	0.37	0.52	0.49
Spinning, weaving and finishing of textiles	171	46	474	520	1.90	4.31	3.87	0.25	1.33	0.96
Manufacture of other textiles	172	7	22	28	0.28	0.20	0.21	1.91	1.82	1.84
Manufacture of wearing apparel, except fur apparel	181	8	18	26	0.32	0.17	0.20	0.12	0.14	0.13
Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	191	0	0	0	0.00	0.00	0.00	0.02	0.13	0.08
Manufacture of footwear	192	3	16	19	0.12	0.14	0.14	0.37	0.72	0.63
Saw milling and planning of wood	201	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of products of food,cork,straw and plaiting materials	202	1	5	6	0.04	0.04	0.04	0.21	0.41	0.36

Table 2 (*contd.*)

Manufacture of paper and paper product	210	12	44	55	0.49	0.40	0.41	0.24	0.42	0.36
Publishing	221	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Printing and service activities related to printing	222	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Reproduction of recorded media	223	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of coke oven products	231	3	16	18	0.11	0.14	0.14	0.35	0.60	0.54
Manufacture of refined petroleum products	232	107	882	990	4.41	8.03	7.37	0.23	0.66	0.55
Manufacture of basic chemicals	241	173	533	706	7.13	4.85	5.26	0.61	0.84	0.77
Manufacture of other chemical products	242	444	2215	2658	18.27	20.15	19.81	3.01	4.99	4.50
Manufacture of manmade fibers	243	0	0	0	0.00	0.00	0.00	0.26	0.31	0.28
Manufacture of rubber products	251	90	186	276	3.70	1.69	2.06	1.85	1.80	1.82
Manufacture of plastic products	252	6	79	85	0.24	0.72	0.63	0.20	0.91	0.73
Manufacture of glass and glass products	261	2	8	10	0.10	0.07	0.07	0.27	0.35	0.33
Manufacture of non metallic mineral products n.e.c.	269	36	249	285	1.49	2.27	2.13	0.35	1.16	0.89
Manufacture of Basic Iron and steel	271	239	396	635	9.83	3.60	4.73	0.81	0.62	0.68
Manufacture of basic precious and non ferrous metals	272	28	125	154	1.16	1.14	1.14	0.26	0.49	0.42
Casting of metals	273	5	5	10	0.20	0.05	0.07	0.74	0.38	0.50
Manufacture of structural metal products, tanks, reservoirs and steam generators	281	15	51	65	0.60	0.46	0.49	0.50	0.68	0.63
Manufacture of other fabricated metal products; metal working	289	4	9	14	0.17	0.09	0.10	0.27	0.25	0.25

Table 2 (*contd.*)

service activities										
Manufacture of general purpose machinery	291	212	686	898	8.74	6.24	6.69	1.91	2.75	2.49
Manufacture of special purpose machinery	292	148	500	648	6.09	4.55	4.83	1.78	3.04	2.62
Manufacture of domestic appliances n.e.c	293	5	31	36	0.21	0.28	0.27	0.38	0.95	0.79
Manufacture of office, accounting and computing machinery	300	25	52	77	1.04	0.47	0.58	2.80	1.67	1.93
Manufacture of electric motors, generators and transformers	311	59	134	194	2.45	1.22	1.44	2.23	2.63	2.49
Manufacture of electricity distribution and control apparatus	312	4	6	10	0.17	0.05	0.07	2.08	1.76	1.89
Manufacture of insulated wire and cable	313	7	24	32	0.30	0.22	0.24	0.33	0.46	0.42
Manufacture of accumulators, primary cells and primary batteries	314	13	91	104	0.54	0.83	0.77	1.25	2.70	2.36
Manufacture of electric lamps and lighting equipment	315	0	0	0	0.01	0.00	0.00	0.25	0.29	0.26
Manufacture of other electrical equipment n.e.c.	319	66	169	235	2.72	1.54	1.75	2.35	2.62	2.54
Manufacture of electronic valves and tubes and other electronic components	321	48	561	609	1.97	5.11	4.54	0.88	5.98	4.11
Manufacture of television and radio transmitters and apparatus for line telephone	322	12	58	70	0.50	0.53	0.52	1.45	1.91	1.81

Table 2 (*contd.*)

Manufacture of television and radio receivers, sound or video recording or reprod	323	27	150	177	1.11	1.36	1.32	0.98	2.02	1.74
Manufacture of medical appliances and instruments and appliances for measuring	331	2	11	13	0.08	0.10	0.10	0.52	1.63	1.24
Manufacture of optical instruments and photographic equipment	332	0	0	1	0.02	0.00	0.00	1.47	0.09	0.30
Manufacture of watches and clocks	333	1	9	9	0.03	0.08	0.07	0.22	0.81	0.66
Motor vehicles	341	160	1242	1402	6.60	11.30	10.45	1.66	4.45	3.73
Manufacture of parts & accessories for motor vehicles and their engines	343	100	464	564	4.12	4.22	4.20	1.54	2.44	2.21
Building and repair of ships and boats	351	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of railway and tramway locomotives and rolling stock	352	1	2	3	0.03	0.02	0.02	0.14	0.41	0.28
Manufacture of aircraft and spacecraft	353	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of transport equipment n.e.c.	359	65	396	461	2.68	3.60	3.43	1.78	3.25	2.91
Manufacture of furniture	361	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing n.e.c	369	198	847	1044	8.14	7.70	7.78	0.71	1.05	0.96

Note: Due to rounding-off, the value of some of the variables is zero for certain industries. But it may not be in actual term.

Source: Authors' estimation based on Prowess Database, CMIE (2002).

The accumulation of technology through capita goods, both foreign and domestic, has been quite disappearing in 1990s. Leaving few sporadic jumps in the acquisition of domestic capital goods as a percent of gross fixed asset, a marked declining trend can be noted during 1991-2001. The investment of Indian manufacturing in domestic capital goods declined by 6-percentage point from 9.62 per cent in 1991 to 3.54 per cent in 2001 (Table 1, Figure 3). Likewise, investment in foreign capital goods that had marginally improved during 1991-1994, declined in the period 1995-2001. There have been hardly any changes in the import of capital goods as a percent of gross fixed asset between 1991 and 2001. Contrary to what was observed between R&D and importing foreign disembodied technology, among these two channels of embodied technology acquisition, the per unit investment of Indian manufacturing was consistently higher in the case of domestic capital goods than in foreign capital goods.

Overall these trends indicate that imports of disembodied technology followed by in-house R & D have emerged as the most preferred modes of technology acquisition for Indian manufacturing during 1991-2001 as compared to employing indigenous or foreign capital goods.

4.2 Inter-industry Patterns of Technology Acquisition : The industrial composition of R&D investment by Indian manufacturing threw a skewed distribution during 1991-2001 as over 75 per cent of aggregate R&D is concentrated in just 10 industries out of a total of 56 (3-digit) industries (Table 2).

Manufacture of other chemical products that include drugs and pharmaceutical products stood as the top contributor with 20 per cent of manufacturing R&D. It is followed by motor vehicles (10 per cent), manufacturing n.e.c. (8 per cent), refined petroleum products and general purpose machinery (7 per cent each), basic chemicals, special purpose machinery, basic iron and steel, and electronic components (5 per cent each), and parts and accessories for motor vehicles and their engines (4 per cent). About 11 industries had nearly zero percentage share indicating very little contribution or nothing to the total manufacturing R&D. Other industries' share ranges from 1 per cent to 4 per cent of the aggregate R&D investment.

In terms of R&D intensity the same skewed pattern of innovative activity in Indian manufacturing can be observed. There are about 40 industries out of total 56 which have either spend one per cent of value added or less during 1991-2001 (Table 2). Among others, 13 industries estimated to have invested about 2-3 per cent, 2 industries about 4 per cent and only one industry about 5 per cent. Therefore, it can be concluded that R&D activity as a means of technology accumulation in Indian manufacturing has not been widespread among industries and a few industries that do R&D spend very little in terms of value added. The observed R&D intensity of Indian industries is also very less in comparison to global level. For example, the R&D intensity of the best performing Indian industry, other chemical products including pharmaceutical, is only about 5 per cent where as the

U. S.pharmaceutical industry alone is investing more than 10 per cent of sales in R&D activities.

In Table 2, period-wise average R&D intensity between 1991-1995 and 1996-2001 also has been provided. Comparing the R&D intensities over these periods might capture the impact of liberalisation process. Between these periods, R&D investment per unit of value added has been markedly increased for a number of industries. There are about 26 industries out of 56 for whom R&D intensity has grown at least by twice. The highest growth has been noted for 2 industries, electronic valves, tubes and other electronic components and 'leather, luggage, handbags saddlery' where R&D intensity became seven-times in 1996-2001 as compared to 1991-95. It has grown five-times for 3 industries ('spinning, weaving and finishing of textiles, beverages, and plastic products), four-times for 1 industry (watches and clocks), three-times for 6 industries (non metallic mineral products n.e.c., medical appliances and instruments and appliances, railway and tramway locomotives and rolling stock, refined petroleum products, motor vehicles, and domestic appliances n.e.c.), two- times for another 14 industries[7]. For about 16 industries R&D intensity remained nearly at the same level in both the periods. The intensity has declined in the case of 7 industries where it became nearly half or even less for office, accounting and computing machinery, casting of metals and optical instruments and photographic equipment.

The highly concentrated character of Indian manufacturing in terms of technology accumulation has been further revealed by the inter-industry investment pattern of foreign disembodied technology. As summarized in Table 3, a sub-total of 6 industries accounted for about 77 per cent of investment devoted to acquire foreign disembodied technology during 1991-2001. The refined petroleum product has been the top acquirer of foreign technology with 30 per cent of aggregate technology payment made abroad. The other five industries in the pack are manufacturing n.e.c. with 16 per cent, basic chemicals with 11 per cent, basic iron and steel with 9 per cent, motor vehicles with 5 per cent, and other chemical products with 3 per cent. Another sub-total of 35 industries out of total 56 industries in Indian manufacturing have either spent less than 1 per cent of their value added in acquiring foreign technology or have spent nothing. The remaining 10 industries have spent in the range of about 1-2 per cent of their value added.

Expressing disembodied technology purchase by Indian industries as a per cent gross value added has shown some interesting observations. For instance, refined petroleum product, top purchaser of foreign technology by absolute amount of technology payment, now stands at seventh position in terms of intensity. Manmade fibers has emerged as the single largest importer of foreign technology in the Indian manufacturing investing about 15 per cent of its value added in acquiring foreign knowhow during 1991-2001 (Table 3). With investing 6 per cent of value added, electric lamps and lighting equipment has been the second largest foreign technology purchaser. Next industries in the order are coke oven products and electricity distribution and control apparatus with 4 per cent each, and dairy

Table 3

Industrial Composition of Cumulative Technology Payment Abroad by Indian Manufacturing 1991-2001

Industry	NIC 1998	Technology Payment (In Rs. Crore)			As a per cent of Total			As a per cent of Gross Value Added		
		1991-95	1996-01	1991-01	1991-95	1996-01	1991-01	1991-95	1996-01	1991-01
Production, processing and preservation of meat, fish, fruit , vegetables, oils and	151	5	7	12	0.13	0.05	0.07	0.35	0.23	0.27
Manufacture of dairy products	152	45	170	214	1.20	1.16	1.17	3.04	3.31	3.25
Manufacture of grain mill products, starches and starch products, and prepared an	153	8	12	20	0.22	0.08	0.11	1.07	0.59	0.72
Manufacture of other food products	154	8	27	35	0.21	0.19	0.19	0.11	0.14	0.13
Manufacture of beverages	155	4	1	5	0.10	0.01	0.03	0.16	0.03	0.07
Manufacture of tobacco products	160	13	20	33	0.35	0.14	0.18	0.39	0.19	0.24
Spinning, weaving and finishing of textiles	171	121	256	377	3.25	1.75	2.06	0.66	0.72	0.70
Manufacture of other textiles	172	4	4	8	0.09	0.03	0.04	0.97	0.37	0.51
Manufacture of knitted and crocheted fabrics and articles	173	12	13	25	0.33	0.09	0.14	1.93	0.54	0.83
Manufacture of wearing apparel, except fur apparel	181	10	47	57	0.26	0.32	0.31	0.15	0.37	0.29
Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	191	0	2	2	0.00	0.01	0.01	0.00	1.41	0.80
Manufacture of footwear	192	4	12	16	0.10	0.08	0.09	0.46	0.55	0.53
Saw milling and planning of wood	201	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00

Table 3 (*contd.*)

Manufacture of products of food, cork, straw and plaiting materials	202	1	0	1	0.02	0.00	0.01	0.12	0.04	0.06
Manufacture of paper and paper product	210	6	171	177	0.17	1.17	0.97	0.13	1.65	1.16
Publishing	221	0	5	5	0.01	0.03	0.03	0.03	0.16	0.12
Printing and service activities related to printing	222	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Reproduction of recorded media	223	0	4	4	0.00	0.03	0.02	0.00	1.05	1.03
Manufacture of coke oven products	231	15	126	141	0.40	0.86	0.77	1.94	4.81	4.16
Manufacture of refined petroleum products	232	59	5519	5578	1.58	37.76	30.41	0.13	4.14	3.11
Manufacture of basic chemicals	241	658	1377	2034	17.67	9.42	11.09	2.33	2.16	2.21
Manufacture of other chemical products	242	146	398	544	3.93	2.72	2.97	0.99	0.90	0.92
Manufacture of manmade fibers	243	2	0	2	0.06	0.00	0.01	26.65	1.09	15.07
Manufacture of rubber products	251	72	80	152	1.93	0.55	0.83	1.48	0.77	1.00
Manufacture of plastic products	252	21	63	83	0.55	0.43	0.45	0.70	0.72	0.71
Manufacture of glass and glass products	261	43	28	71	1.15	0.19	0.39	4.94	1.26	2.30
Manufacture of non metallic mineral products n.e.c.	269	39	102	140	1.04	0.70	0.77	0.37	0.47	0.44
Manufacture of Basic Iron and steel	271	670	956	1626	17.98	6.54	8.86	2.26	1.50	1.74
Manufacture of basic precious and non ferrous metals	272	107	276	384	2.88	1.89	2.09	0.98	1.07	1.05
Casting of metals	273	4	6	10	0.10	0.04	0.05	0.59	0.47	0.51
Manufacture of structural metal products, tanks, reservoirs and steam generators	281	44	24	67	1.17	0.16	0.37	1.49	0.32	0.65

Table 3 (*contd.*)

Manufacture of other fabricated metal products; metal working service activities	289	22	34	56	0.59	0.23	0.30	1.46	0.88	1.04
Manufacture of general purpose machinery	291	138	316	455	3.72	2.16	2.48	1.25	1.27	1.26
Manufacture of special purpose machinery	292	120	149	269	3.23	1.02	1.47	1.44	0.91	1.09
Manufacture of domestic appliances n.e.c	293	22	52	74	0.60	0.35	0.40	1.67	1.58	1.60
Manufacture of office, accounting and computing machinery	300	18	112	130	0.49	0.77	0.71	2.02	3.61	3.25
Manufacture of electric motors, generators and transformers	311	28	67	94	0.74	0.46	0.51	1.04	1.30	1.21
Manufacture of electricity distribution and control apparatus	312	17	1	18	0.45	0.01	0.10	8.38	0.47	3.54
Manufacture of insulated wire and cable	313	16	11	27	0.44	0.07	0.15	0.74	0.20	0.36
Manufacture of accumulators, primary cells and primary batteries	314	14	41	55	0.38	0.28	0.30	1.36	1.21	1.24
Manufacture of electric lamps and lighting equipment	315	6	1	7	0.15	0.01	0.04	8.25	2.18	5.74
Manufacture of other electrical equipment n.e.c.	319	38	46	83	1.01	0.31	0.45	1.34	0.71	0.90

Table 3 (*contd.*)

Manufacture of electronic valves and tubes and other electronic components	321	73	132	205	1.97	0.90	1.12	1.35	1.40	1.38
Manufacture of television and radio transmitters and apparatus for line telephone	322	15	24	39	0.40	0.16	0.21	1.78	0.78	1.00
Manufacture of television and radio receivers, sound or video recording or reprod	323	45	180	225	1.20	1.23	1.23	1.61	2.44	2.21
Manufacture of medical appliances and instruments and appliances for measuring	331	3	4	7	0.08	0.03	0.04	0.78	0.58	0.65
Manufacture of optical instruments and photographic equipment	332	1	4	4	0.02	0.03	0.02	2.44	2.59	2.56
Manufacture of watches and clocks	333	5	1	6	0.14	0.01	0.03	1.49	0.10	0.45
Motor vehicles	341	267	690	957	7.16	4.72	5.22	2.76	2.47	2.55
Manufacture of parts & accessories for motor vehicles and their engines	343	82	334	416	2.20	2.29	2.27	1.26	1.76	1.63
Building and repair of ships and boats	351	18	69	88	0.49	0.48	0.48	0.97	2.26	1.77
Manufacture of railway and tramway locomotives and rolling stock	352	1	1	2	0.03	0.01	0.01	0.20	0.22	0.21
Manufacture of aircraft and spacecraft	353	0	46	46	0.00	0.31	0.25	0.00	1.14	0.72
Manufacture of transport equipment n.e.c.	359	53	308	361	1.42	2.11	1.97	1.45	2.53	2.28
Manufacture of furniture	361	0	0	0	0.00	0.00	0.00	7.00	0.72	1.33
Manufacturing n.e.c	369	604	2286	2891	16.23	15.64	15.76	2.16	2.83	2.66

Note: Due to rounding-off, the value of some of the variables is zero for certain industries. But it may not be in actual term.

Source: Authors' estimation based on Prowess Database, CMIE (2002).

products, office, accounting and computing machinery, refined petroleum, manufacturing n.e.c., optical instruments and photographic equipments, and motor vehicles with 3 per cent each. Of the total 56 industries about 13 industries had a technology import intensity of less than 1 per cent, 25 had nearly 1 per cent, and another 8 about 2 per cent.

Between 1991-95 and 1996-2001, the disembodied technology intensity increased noticeably, at least two fold, for about 12 industries such as refined petroleum products, paper and paper product, publishing, coke oven products, wearing apparel, ships and boats, office, accounting and computing machinery, transport equipment n.e.c., television and radio receivers, sound or video recording, aircraft and spacecraft, reproduction of recorded media, and leather, luggage, handbags saddlery. For 30 industries it remained more or less same while declined for 14 industries[8]. Therefore, only a small sub-set of industries in Indian manufacturing were observed to have increased their foreign technology intensity during the reference period. As compared to R&D where 26 industries reported increased intensity, this further dismay the apprehension that liberalised technology import policy will lead to greater reliance on foreign technology vis-à-vis in-house R&D activities.

The industry wise investment made by Indian manufacturing in accumulating foreign capital goods has been presented in Table 4. As found in the case of R&D and disembodied foreign technology, purchase of foreign capital goods by Indian manufacturing has also been highly concentrated in a few industries as top ten industries accounted for as much as 78 per cent of the aggregate foreign capital purchase. From 1991 to 2001, refined petroleum products imported the largest amount of foreign capital goods accounting for about 21 per cent. While basic iron and steel accounted for 11 per cent, spinning, weaving and finishing of textiles, motor vehicles, manufacturing n.e.c., and basic chemicals, each imported about 9 per cent of the total foreign capital goods purchased. The share of 31 industries out of 56 was very negligible, less than 1 per cent of the total foreign capital goods. However, capital goods accumulation as a per cent of gross fixed asset shows that industries have added foreign capital goods to their capital stock worth at least 1 per cent of their gross fixed asset except 4 industries–saw milling and planning of wood, beverages, other food products, and railway and tramway locomotives and rolling stock.

Reproduction of recorded media had the highest intensity of foreign capital goods at 37 per cent, followed by electric lamps and lighting equipment with about 9 per cent, motor vehicles with 7 per cent, footwear with 6 per cent, knitted and crocheted fabrics and articles, printing and services other textiles, plastic products, wearing apparel, and transport equipment n.e.c. each with about 4 per cent.

The percentage distribution of total investment in purchasing domestic capital goods provides further evidence of skewed industrial concentration in technology acquisition. Table 5 shows that 81 per cent of total domestic capital goods acquisition during 1991-2001 has been accounted by top 10 industries alone.

Table 4

Industrial Composition of Cumulative Investment in Foreign Capital Goods in Indian Manufacturing 1991-2001

Industry	NIC 1998	Foreign Capital Goods Import (In Rs. Crore)			As a per cent of Total			As a per cent of Gross Fixed Asset		
		1991-95	1996-01	1991-01	1991-95	1996-01	1991-01	1991-95	1996-01	1991-01
Production, processing and preservation of meat, fish, fruit, vegetables, oils and	151	84	147	231	0.37	0.23	0.27	1.79	0.89	1.09
Manufacture of dairy products	152	75	86	160	0.33	0.13	0.19	1.88	0.72	1.01
Manufacture of grain mill products, starches and starch products, and prepared an	153	32	55	86	0.14	0.09	0.10	1.99	0.97	1.20
Manufacture of other food products	154	80	210	289	0.36	0.33	0.34	0.41	0.39	0.39
Manufacture of beverages	155	22	30	51	0.10	0.05	0.06	0.41	0.1	0.25
Manufacture of tobacco products	160	133	449	583	0.60	0.71	0.68	3.30	3.50	3.45
Spinning, weaving and finishing of textiles	171	2541	5471	8012	11.37	8.60	9.32	4.21	2.91	3.22
Manufacture of other textiles	172	56	140	196	0.25	0.22	0.23	6.41	3.44	3.97
Manufacture of knitted and crocheted fabrics and articles	173	273	367	640	1.22	0.58	0.74	9.51	3.10	4.35
Manufacture of wearing apparel, except fur apparel	181	654	1662	2316	2.93	2.61	2.69	4.73	3.30	3.61
Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	191	5	9	13	0.02	0.01	0.02	1.93	1.52	1.64
Manufacture of footwear	192	183	156	339	0.82	0.25	0.39	16.77	3.38	5.94

Table 4 (*contd.*)

Saw milling and planning of wood	201	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of products of food, cork, straw and plaiting materials	202	31	69	99	0.14	0.11	0.12	2.16	1.52	1.67
Manufacture of paper and paper product	210	458	858	1315	2.05	1.35	1.53	2.08	1.41	1.59
Publishing	221	51	112	162	0.23	0.18	0.19	3.43	1.34	1.65
Printing and service activities related to printing	222	7	2	9	0.03	0.00	0.01	11.22	1.19	4.00
Reproduction of recorded media	223	6	487	492	0.03	0.77	0.57	10.11	37.66	36.51
Manufacture of coke oven products	231	4	118	122	0.02	0.19	0.14	0.44	2.38	2.09
Manufacture of refined petroleum products	232	5049	12777	17826	22.59	20.09	20.74	2.51	1.95	2.08
Manufacture of basic chemicals	241	2188	5235	7423	9.79	8.23	8.64	1.60	1.54	1.56
Manufacture of other chemical products	242	399	1676	2075	1.78	2.64	2.41	1.37	1.54	1.50
Manufacture of manmade fibers	243	3	1	4	0.01	0.00	0.00	3.02	0.95	1.79
Manufacture of rubber products	251	291	548	839	1.30	0.86	0.98	1.86	1.63	1.70
Manufacture of plastic products	252	589	1592	2181	2.63	2.50	2.54	5.35	3.27	3.65
Manufacture of glass and glass products	261	197	270	466	0.88	0.42	0.54	5.14	1.90	2.58
Manufacture of non metallic mineral products n.e.c.	269	280	1452	1732	1.25	2.28	2.02	0.60	1.19	1.03
Manufacture of Basic Iron and steel	271	2545	6725	9271	11.39	10.58	10.79	1.30	1.44	1.40
Manufacture of basic precious and non ferrous metals	272	392	2200	2592	1.75	3.46	3.02	0.74	1.84	1.50
Casting of metals	273	37	89	125	0.16	0.14	0.15	1.89	1.24	1.37

Table 4 (*contd.*)

Manufacture of structural metal products, tanks, reservoirs and steam generators	281	194	269	463	0.87	0.42	0.54	2.00	0.85	1.12
Manufacture of other fabricated metal products; metal working service activities	289	134	266	400	0.60	0.42	0.47	3.71	1.74	2.12
Manufacture of general purpose machinery	291	561	1005	1566	2.51	1.58	1.82	2.84	2.25	2.43
Manufacture of special purpose machinery	292	239	516	755	1.07	0.81	0.88	1.43	1.39	1.40
Manufacture of domestic appliances n.e.c	293	62	247	309	0.28	0.39	0.36	2.02	2.10	2.08
Manufacture of office, accounting and computing machinery	300	34	81	115	0.15	0.13	0.13	3.16	2.05	2.28
Manufacture of electric motors, generators and transformers	311	49	195	244	0.22	0.31	0.28	1.21	1.77	1.62
Manufacture of electricity distribution and control apparatus	312	2	10	11	0.01	0.02	0.01	1.04	3.26	2.49
Manufacture of insulated wire and cable	313	210	411	621	0.94	0.65	0.72	3.42	2.39	2.66
Manufacture of accumulators, primary cells and primary batteries	314	48	225	273	0.22	0.35	0.32	2.32	2.08	2.12
Manufacture of electric lamps and lighting equipment	315	15	45	60	0.07	0.07	0.07	5.95	10.52	8.81
Manufacture of other electrical equipment n.e.c.	319	97	214	311	0.44	0.34	0.36	2.14	1.49	1.64
Manufacture of electronic valves and tubes and other electronic components	321	289	596	885	1.29	0.94	1.03	3.15	3.00	3.04

Table 4 (*contd.*)

Manufacture of television and radio transmitters and apparatus for line telephone	322	30	173	202	0.13	0.27	0.24	1.50	3.07	2.66
Manufacture of television and radio receivers, sound or video recording or reprod	323	202	681	883	0.90	1.07	1.03	3.13	2.54	2.65
Manufacture of medical appliances and instruments and appliances for measuring	331	1	26	27	0.00	0.04	0.03	0.18	1.92	1.46
Manufacture of optical instruments and photographic equipment	332	19	6	24	0.08	0.01	0.03	8.45	1.15	3.41
Manufacture of watches and clocks	333	65	70	135	0.29	0.11	0.16	5.57	2.27	3.18
Motor vehicles	341	1079	6936	8014	4.83	10.91	9.32	4.93	7.28	6.84
Manufacture of parts & accessories for motor vehicles and their engines	343	414	1616	2030	1.85	2.54	2.36	2.92	3.41	3.29
Building and repair of ships and boats	351	5	37	42	0.02	0.06	0.05	0.15	0.85	0.54
Manufacture of railway and tramway locomotives and rolling stock	352	4	3	8	0.02	0.01	0.01	0.62	0.33	0.45
Manufacture of aircraft and spacecraft	353	34	66	100	0.15	0.10	0.12	0.72	1.08	0.92
Manufacture of transport equipment n.e.c.	359	118	1028	1147	0.53	1.62	1.33	1.53	4.29	3.61
Manufacture of furniture	361	0	1	1	0.00	0.00	0.00	0.00	1.65	1.49
Manufacturing n.e.c	369	1788	5880	7668	8.00	9.25	8.92	1.98	1.94	1.95

Source: Authors' estimation based on Prowess Database, CMIE (2002).

Notably, 11 industries each had a share of about 1 per cent and another 33 industries had a share of less than 1 per cent. The domestic capital goods purchased as a per cent of gross fixed asset shows that almost all Indian industries had spent over 2 per cent of their fixed assets. In this sense investment in domestic capital goods as a channel of technology acquisition is broad-based in Indian manufacturing. This higher intensity of domestic capital goods observed in the case of several Indian industries might partly be explained by the government policy of self-reliance in developing domestic capital goods sector. For long time Indian capital goods sector was provided with high level of import protection compelling industries to use domestic capital goods. It seems that this trend has not changed to a large extent even in reform period as many industries continue to use Indian made capital goods. Another factor could be that the Indian made capital goods are relatively more suitable to the prevailing domestic factor price conditions than foreign capital goods and enterprises oriented towards domestic market might have preferred domestic capital goods.

5. Developing a Composite Technology Acquisition Index

From policy perspective it is useful to know how Indian industries have performed in overall technology accumulation taking all the different measures of acquisition into consideration. The increasing global competition requires Indian industries R&D to diversify, particularly towards more knowledge-based industries. These industries, known as strategic sectors, provide higher rates of return to domestic labour and capital than other industries, generate knowledge and productivity spillovers, create new markets and improve productivity growth in long-run. As a result industrial policies of advanced countries like the U.S., Japan, France, Germany and others are oriented towards these industries with heavy government interventions like cheap credit allocation, R&D subsidies, and other fiscal incentives. Hence, developing a composite index of technology acquisition can help us to understand the performance of technology-intensive sectors in India and to identify the sectors to be targeted by government policies for boosting technological activities.

For classifying Indian manufacturing industries according to technology intensity we have made use of technology classification developed by the Organisation for Economic Co-operation and Development (OECD) and provided in *OECD Science, Technology and Industry Scoreboard 2003*. The OECD[9] utilising average industry-level aggregate OECD R&D intensities over 1991 to 1999 had classified ISIC Revision 3 industries into four categories :

(i) high-technology,

(ii) medium-high-technology,

(iii) medium-low-technology and

(iv) low-technology industries.

Table 5

Industrial Composition of Cumulative Investment in Domestic Capital Goods in Indian Manufacturing 1991-2001

Industry	NIC 1998	Domestic Capital Goods (In Rs. Crore)			As a per cent of Total			As a per cent of Gross Fixed Asset		
		1991-95	1996-01	1991-01	1991-95	1996-01	1991-01	1991-95	1996-01	1991-01
Production, processing and preservation of meat, fish, fruit, vegetables, oils and	151	852	940	1791	0.66	0.47	0.54	18.20	5.69	8.45
Manufacture of dairy products	152	551	586	1137	0.43	0.29	0.34	13.89	4.91	7.15
Manufacture of grain mill products, starches and starch products, and prepared an	153	158	719	878	0.12	0.36	0.27	9.93	12.77	12.14
Manufacture of other food products	154	1730	3214	4944	1.34	1.60	1.50	8.97	5.91	6.71
Manufacture of beverages	155	682	619	1301	0.53	0.31	0.39	12.85	3.97	6.22
Manufacture of tobacco products	160	361	738	1099	0.28	0.37	0.33	8.94	5.74	6.51
Spinning, weaving and finishing of textiles	171	7396	8546	15942	5.71	4.26	4.83	12.26	4.54	6.42
Manufacture of other textiles	172	150	176	326	0.12	0.09	0.10	16.99	4.34	6.60
Manufacture of knitted and crocheted fabrics and articles	173	442	724	1166	0.34	0.36	0.35	15.42	6.12	7.94
Manufacture of wearing apparel, except fur apparel	181	1556	2327	3883	1.20	1.16	1.18	11.26	4.62	6.05
Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	191	58	55	113	0.04	0.03	0.03	23.84	9.53	13.76
Manufacture of footwear	192	34	139	172	0.03	0.07	0.05	3.09	3.00	3.02
Saw milling and planning of wood	201	1	1	1	0.00	0.00	0.00	3.30	2.36	2.72

Table 5 (contd.)

Manufacture of products of food, cork, straw and plaiting materials	202	213	274	487	0.16	0.14	0.15	15.06	6.06	8.21
Manufacture of paper and paper product	210	1894	5260	7154	1.46	2.62	2.17	8.62	8.63	8.63
Publishing	221	148	463	612	0.11	0.23	0.19	10.03	5.55	6.23
Printing and service activities related to printing	222	2	13	15	0.00	0.01	0.00	2.77	7.92	6.48
Reproduction of recorded media	223	19	26	45	0.01	0.01	0.01	33.66	2.04	3.36
Manufacture of coke oven products	231	128	456	584	0.10	0.23	0.18	14.53	9.21	10.01
Manufacture of refined petroleum products	232	39312	50235	89547	30.35	25.06	27.14	19.50	7.68	10.46
Manufacture of basic chemicals	241	13388	20720	34108	10.34	10.34	10.34	9.82	6.10	7.16
Manufacture of other chemical products	242	3316	7610	10927	2.56	3.80	3.31	11.39	6.99	7.92
Manufacture of rubber products	251	1214	2320	3534	0.94	1.16	1.07	7.76	6.88	7.16
Manufacture of plastic products	252	2091	3229	5319	1.61	1.61	1.61	19.00	6.62	8.90
Manufacture of glass and glass products	261	665	1021	1686	0.51	0.51	0.51	17.38	7.18	9.35
Manufacture of non metallic mineral products n.e.c.	269	3671	8472	12143	2.83	4.23	3.68	7.94	6.96	7.23
Manufacture of Basic Iron and steel	271	21709	22804	44514	16.76	11.38	13.49	11.11	4.89	6.73
Manufacture of basic precious and non ferrous metals	272	4680	5522	10202	3.61	2.75	3.09	8.89	4.61	5.91
Casting of metals	273	349	646	995	0.27	0.32	0.30	17.99	9.02	10.93

Table 5 (*contd.*)

Manufacture of structural metal products, tanks, reservoirs and steam generators	281	1654	2557	4211	1.28	1.28	1.28	17.07	8.11	10.22
Manufacture of other fabricated metal products; metal working service activities	289	514	1026	1540	0.40	0.51	0.47	14.25	6.71	8.14
Manufacture of general purpose machinery	291	1314	1657	2971	1.01	0.83	0.90	6.66	3.71	4.61
Manufacture of special purpose machinery	292	1157	1525	2682	0.89	0.76	0.81	6.95	4.09	4.97
Manufacture of domestic appliances n.e.c	293	431	972	1404	0.33	0.49	0.43	14.08	8.24	9.45
Manufacture of office, accounting and computing machinery	300	150	274	424	0.12	0.14	0.13	14.11	6.92	8.45
Manufacture of electric motors, generators and transformers	311	299	404	702	0.23	0.20	0.21	7.32	3.66	4.65
Manufacture of electricity distribution and control apparatus	312	6	4	10	0.00	0.00	0.00	3.75	1.47	2.26
Manufacture of insulated wire and cable	313	553	1604	2157	0.43	0.80	0.65	9.01	9.32	9.24
Manufacture of accumulators, primary cells and primary batteries	314	264	561	825	0.20	0.28	0.25	12.71	5.18	6.39
Manufacture of electric lamps and lighting equipment	315	42	15	57	0.03	0.01	0.02	16.34	3.47	8.28
Manufacture of other electrical equipment n.e.c.	319	473	689	1161	0.37	0.34	0.35	10.40	4.79	6.14
Manufacture of electronic valves and tubes and other electronic components	321	1018	287	1306	0.79	0.14	0.40	11.09	1.45	4.49

Table 5 (*contd.*)

Manufacture of television and radio transmitters and apparatus for line telephone	322	165	511	676	0.13	0.25	0.20	8.38	9.09	8.91
Manufacture of television and radio receivers, sound or video recording or reprod	323	806	2139	2945	0.62	1.07	0.89	12.48	7.97	8.85
Manufacture of medical appliances and instruments and appliances for measuring	331	58	83	140	0.04	0.04	0.04	11.76	6.06	7.57
Manufacture of optical instruments and photographic equipment	332	34	11	45	0.03	0.01	0.01	15.38	2.30	6.34
Manufacture of watches and clocks	333	181	89	270	0.14	0.04	0.08	15.55	2.89	6.35
Motor vehicles	341	1568	7538	9106	1.21	3.76	2.76	7.17	7.91	7.78
Manufacture of parts & accessories for motor vehicles and their engines	343	1379	3213	4593	1.07	1.60	1.39	9.71	6.78	7.45
Building and repair of ships and boats	351	180	618	798	0.14	0.31	0.24	5.19	14.27	10.23
Manufacture of railway and tramway locomotives and rolling stock	352	54	43	97	0.04	0.02	0.03	7.64	4.46	5.80
Manufacture of aircraft and spacecraft	353	44	925	969	0.03	0.46	0.29	0.92	15.17	8.94
Manufacture of transport equipment n.e.c.	359	572	2036	2607	0.44	1.02	0.79	7.38	8.48	8.22
Manufacture of furniture	361	2	10	12	0.00	0.00	0.00	26.27	13.55	14.77
Manufacturing n.e.c	369	9800	23828	33628	7.57	11.89	10.19	10.88	7.85	8.55

Source: Authors' estimation based on Prowess Database, CMIE (2002).

However, by collapsing these four OECD technological classifications we have categorised Indian industries into two groups, i.e., high-technology and low-technology industries. The high-technology group includes OECD high-technology and medium-high-technology industries whereas the low-technology group covers OECD medium-low-technology and low-technology industries[10]. Out of the total 56 industries 24 are classified as high technology-intensive industries and the rest 32 as low technology-intensive industries.

5.1 The PCA Approach to Composite Technology Index : Construction of an overall technology acquisition index for Indian manufacturing involves two types of issues : first, freeing different technology indicators from scale of measurement and second, aggregating the scale-freed indicators by assigning appropriate weights to arrive at a composite index.

This study has used principal component analysis (PCA) method to construct the composite technology index. The PCA removes the problem of measurements by standardizing individual indicators and then objectively provides weights to standardized variables in aggregating them into the composite index[11]. The weights assigned are known as 'factor loadings' and are in fact correlation coefficients of the variables with the constructed principal component.

However, there is a difficulty in employing the PCA for the purpose of composite index making. This is concerned with the way PCA method is structured. One can have as many principal components as the number of indicators. The first principal component explains the maximum variance in the set of standardized indicators while the second component explicates the maximum in the residual variance (i.e., variance not explained by the first component) and so on. In many instances the first principal component which is normally used as the composite index may explain only about a moderate percentage of total variance in the indicator matrix.

For example, in the present study the first principal explained only about one-thirds of the total variance. Since much of the variance is left unexplained, using first principal component as composite index is not reasonable. In order to overcome this difficulty and account for 100 per cent of the total variance in the composite index, we have extracted all principal components. Then these principal components were aggregated by using eigen values as weights to obtain the composite index. The composite index, thus, devoted is as follows :

$$\text{Composite Technology Acquisition Index} = \frac{\sum_1^n l_i P_i}{\sum_1^n l_i} \qquad (1)$$

where P_i and l_i respectively denote the i^{th} principal component and its eigen value. Using eigen values as weights in aggregation is jsutifiable as they provide lower weight to successive factors extracted in accordance with their variance explaining power.

The composite technology acquisition index (CTAI) has been constructed using four technology measures such as R&D intensity, foreign disembodied technology intensity, foreign capital goods intensity and domestic capital goods intensity. All these indicators are averages over the period 1991-2001. For example, R&D intensity is the cumulative R&D investment over 1991-2001 as a per cent of cumulative gross value added over the same period. As most of the developing countries, including India, are increasingly considering foreign direct investment as a means of new technology acquisition the study has broaden the concept of technology acquisition to include FDI as another indicator. The study has constructed CTAI in two variants, one excluding FDI and another including FDI.

The industry wise average foreign ownership participation during 1991-2001 has been employed to capture the effort of an Indian industry in acquiring technology through FDI route[12]. It should be noted that the share of foreign controlled firms in industry sales or output has been used as the measure of FDI role in Indian manufacturing by several studies (Chandra, 1977; Kumar, 1994; Arthreye, and Kapur, 1999).

However, these studies in identifying foreign firms usually employed some arbitrary cut-off of ownership share like least 25 per cent or 10 per cent of the ownership resting with foreign entity. But the present study has used actual average foreign ownership share, which has the advantage of removing these arbitrary elements as well as indicating exact level of foreign ownership in a particular industry.

A notable feature of the average foreign ownership participation in Indian manufacturing during 1991-2001 can be mentioned here[13]. The highest incidence of foreign ownership in Indian manufacturing during 1990s is observed in manmade fibers where foreign promoters, on an average, contributed about 38 per cent of total industry ownership. Motor vehicle emerged as the second most FDI participated industry with 18 per cent ownership share. The foreign ownership share in other industries ranged from 0 to 15 per cent. Out of the total 56 industries, while 15 industries had foreign ownership share of at least 10 per cent, 13 reported between 5 and 9 per cent, 23 industries had less than 5 per cent and 5 industries reportedly had no foreign ownership share.

Therefore, this suggests that irrespective of liberalisation measures undertaken during 1990s, incidence of FDI in Indian manufacturing is not so dominant and except manmade fibers, foreign ownership share in Indian manufacturing varies moderately among individual industries.

5.2 PCA Results and Discussion : The eigen values, factor loading and constructed Composite Technology Acquisition Indices (CTAIs) are provided in the Table 6, 7 and 8[14]. With or without inclusion of FDI, the first and second principal components explain only about 34 and 27 per cent of total variance respectively (Table 6).

Table 6

Principal Components and Total Variance Explained 1991-2001

Principal Componenet	Without Foreign Direct Investment			With Foreign Direct Investment		
	Eigen Values	Per cent of Variance	Cumulative Variance	Eigen Values	Per cent of Variance	Cumulative Variance
1	1.359	33.98	33.98	1.682	33.65	33.65
2	1.065	26.62	60.59	1.353	27.05	60.70
3	1.000	25.00	85.59	1.064	21.29	81.99
4	0.576	14.41	100	0.577	11.53	93.52
5				0.324	6.48	100

These two components together cover around 60 per cent of the total variance, which suggests that the first component alone or even taking the second component into consideration also does not lead to a composite index wholly representative of the individual technology indicators. Hence, it is appropriate to construct a composite index as shown in equation 1, which takes into account the influence of all principal components.

Table 7 shows that weights attached to individual variables across different principal components vary as they assume sometimes positive or negative signs. It should be noted that weight or factor loading of R&D intensity is crucially dependent upon inclusion of FDI in the indicator matrix. The weights of R&D intensity in the first and second components, which are most dominant explanators by construction, turn out to be negative excluding FDI but when FDI is included R&D came out with positive weights. This could be due to the fact that the in-house R&D of Indian enterprises tends to benefit from knowledge-spillovers generated by the intangible assets brought in by foreign firms and/or their R&D activity. Including or excluding FDI, the weight of disembodied foreign technology has been observed to be positively contributing to the two most dominant components, first and second principal components.

The constructed Coposite Technology Acquisition Indices (CTAIs) along with their rankings have been furnished in Table 8. To know whether the inclusion of FDI significantly changes the ranking of Indian industries in the overall technology acquisition index the non-parametric Spearman rank correlation test was conducted. The Spearman's rho which equals-0.016 was found to be statistically not different from zero[15].

This indicates that the industrial ranking of CTAI including FDI has little resemblance with that of CTAI excluding FDI. The inter-industry scores of overall technology acquisition index excluding FDI varies between a minimum of – 0.92 and a maximum of 2.2 as can be seen from the Table 6. Of the total 56 industries, the index score is equally divided between two opposite numerical signs e.g. positive for 28 industries and negative for another 28 industries. Among the top 15 technology acquirers in Indian manufacturing only four high-technology industries such as manmade fibers, electric lamps and lighting equipment, office, accounting and computing machinery, domestic appliances (n.e.c.) featured in the list, while the rest 11 are low-technology industries.

Among the bottom 15 industries in terms of scoring magnitude more number of high-technology industries are seen. Nine high-technology industries such as 'electronic valves and tubes and other electronic components', 'electric motors, generators and transformers', special purpose machinery, general purpose machinery, electricity distribution and control apparatus, 'railway and tramway locomotives and rolling stock', 'other electrical equipment n.e.c.', other chemical products, and 'accumulators, primary cells and primary batteries' can be figured out in the bottom list.

Table 7

Principal Components and Factor Loadings, 1991-2001

Variables	Principal Components								
	Without Foreign Direct Investment				With Foreign Direct Investment				
	1	2	3	4	1	2	3	4	5
R & D Intensity (per cent)	– 0.500	– 0.659	0.435	0.335	0.910	0.094	0.005	– 0.015	– 0.403
Disembodied Foreign Technology Intensity (per cent)	0.326	0.229	0.894	– 0.206	0.325	0.576	– 0.635	0.365	0.164
Embodied Foreign Technology Intensity (per cent)	– 0.517	0.760	0.108	0.379	0.853	– 0.162	0.276	– 0.185	0.367
Embodied Domestic Technology Intensity (per cent)	0.857	– 0.014	– 0.021	0.514	– 0.042	0.518	0.765	0.380	3.E-03
FDI participation (per cent)					0.133	– 0.847	– 0.016	0.514	3.E-05

Table 8

Composite Technology Acquisition Index for Indian Manufacturing, 1991-2001

Technology Category	NIC1998	Industry	Without Foreign Direct Investment		With Foreign Direct Investment	
			Composite Index	Rank	Composite Index	Rank
Low Tech	223	Reproduction of recorded media	0.699	6	2.085	1
High Tech	243	Manufacture of manmade fibers	2.199	1	1.808	2
High Tech	341	motor vehicles	0.089	21	0.971	3
High Tech	315	Manufacture of electric lamps and lighting equipment	0.979	3	0.664	4
High Tech	321	Manufacture of electronic valves and tubes and other electronic components	-0.704	55	0.536	5
High Tech	242	Manufacture of other chemical products	-0.389	46	0.383	6
High Tech	291	Manufacture of general purpose machinery	-0.592	51	0.367	7
High Tech	359	Manufacture of transport equipment n.e.c.	0.059	23	0.293	8
High Tech	343	Manufacture of parts & accessories for motor vehicles and their engines	-0.093	29	0.291	9
High Tech	312	Manufacture of electricity distribution and control apparatus	-0.538	50	0.274	10
High Tech	314	Manufacture of accumulators, primary cells and primary batteries	-0.351	43	0.27	11
High Tech	319	Manufacture of other electrical equipment n.e.c.	-0.467	48	0.198	12
Low Tech	231	Manufacture of coke oven products	0.715	5	0.185	13
High Tech	292	Manufacture of special purpose machinery	-0.617	52	0.182	14
High Tech	300	Manufacture of office, accounting and computing machinery	0.261	12	0.166	15
High Tech	323	Manufacture of television and radio receivers, sound or video recording or reprod	0.198	16	0.165	16

Table 8 (*contd.*)

High Tech	332	Manufacture of optical instruments and photographic equipment	0.053	25	0.159	17
Low Tech	172	Manufacture of other textiles	-0.313	42	0.143	18
High Tech	311	Manufacture of electric motors, generators and transformers	-0.625	53	0.135	19
Low Tech	192	Manufacture of footwear	-0.627	54	0.115	20
High Tech	322	Manufacture of television and radio transmitters and apparatus for line telephone	0.027	27	0.073	21
Low Tech	160	Manufacture of tobacco products	-0.27	38	-0.015	22
Low Tech	261	Manufacture of glass and glass products	0.395	9	-0.02	23
Low Tech	251	Manufacture of rubber products	-0.25	35	-0.028	24
High Tech	293	Manufacture of domestic appliances n.e.c	0.252	14	-0.036	25
High Tech	333	Manufacture of watches and clocks	-0.288	39	-0.046	26
Low Tech	369	Manufacturing n.e.c	0.258	13	-0.049	27
Low Tech	152	Manufacture of dairy products	0.163	17	-0.08	28
Low Tech	232	Manufacture of refined petroleum products	0.626	7	-0.087	29
High Tech	241	Manufacture of basic chemicals	0.006	28	-0.089	30
Low Tech	289	Manufacture of other fabricated metal products; metal working service activities	0.039	26	-0.118	31
Low Tech	252	Manufacture of plastic products	0.113	18	-0.139	32
Low Tech	171	Spinning, weaving and finishing of textiles	-0.266	36	-0.149	33
Low Tech	173	Manufacture of knitted and crocheted fabrics and articles	0.056	24	-0.164	34
High Tech	331	Manufacture of medical appliances and instruments and appliances for measuring	-0.204	33	-0.175	35
Low Tech	271	Manufacture of Basic Iron and steel	-0.119	32	-0.198	36
Low Tech	272	Manufacture of basic precious and non ferrous metals	-0.305	41	-0.277	37

Table 8 (*contd.*)

Low Tech	181	Manufacture of wearing apparel, except fur apparel	-0.29	40	-0.277	38
Low Tech	269	Manufacture of non metallic mineral products n.e.c.	-0.268	37	-0.307	39
Low Tech	210	Manufacture of paper and paper product	0.092	20	-0.314	40
Low Tech	361	Manufacture of furniture	0.988	2	-0.329	41
Low Tech	222	Printing and service activities related to printing	-0.247	34	-0.337	42
High Tech	313	Manufacture of insulated wire and cable	0.098	19	-0.34	43
Low Tech	221	Publishing	-0.353	44	-0.37	44
Low Tech	151	Production, processing and preservation of meat, fish, fruit, vegetables, oils and	-0.108	30	-0.376	45
Low Tech	281	Manufacture of structural metal products, tanks, reservoirs and steam generators	0.198	15	-0.408	46
Low Tech	154	Manufacture of other food products	-0.368	45	-0.41	47
Low Tech	273	Casting of metals	0.296	11	-0.419	48
Low Tech	153	Manufacture of grain mill products, starches and starch products, and prepared an	0.482	8	-0.43	49
Low Tech	202	Manufacture of products of food, cork, straw and plaiting materials	-0.118	31	-0.434	50
Low Tech	351	Building and repair of ships and boats	0.391	10	-0.458	51
Low Tech	191	Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	0.772	4	-0.485	52
High Tech	352	Manufacture of railway and tramway locomotives and rolling stock	-0.469	49	-0.509	53
High Tech	353	Manufacture of aircraft and spacecraft	0.078	22	-0.52	54
Low Tech	155	Manufacture of beverages	-0.426	47	-0.52	55
Low Tech	201	Saw milling and planning of wood	-0.915	56	-0.548	56

Note: Technological classification of industries is based on OECD Science, Technology and Industry Scoreboard 2003, Annex 1.2. Classification of manufacturing industries based on technology.

Overall this result suggests that the high-technology industries in Indian manufacturing have not done well in accumulating new technology during 1990s. Low-technology industries such as furniture, 'tanning and dressing of leather, manufacture of luggage, handbags and saddlery', coke oven products, reproduction of recorded media, refined petroleum products, 'grain mill products, starches and starch products', glass and glass products, building and repair of ships and boats, casting of metals, manufacturing n.e.c., and 'structural metal products, tanks, reservoirs and steam generators', seem to have been the leading industries in the overall technology acquisition by Indian manufacturing. This is a matter of concern because Indian high-technology industries who supposed to lead India's global competitiveness are lagging behind their low-technology counterparts in terms of overall technology acquisition.

The industrial ranking of CTAI including FDI, however, indicates that the above concerns may not be so high once FDI as another indicator of technology acquisition is taken into consideration. The inter-industry scores of overall technology acquisition index with FDI suggests that among the top 15 technology acquirers in Indian manufacturing only two low-technology industries such as reproduction of recorded media and coke oven products featured in the list (Table 8). The rest top 13 industries are high-technology industries, which, in the order of index scoring are manmade fibers, motor vehicles, electric lamps and lighting equipment, electronic valves and tubes and other electronic components, other chemical products, general purpose machinery, transport equipment n.e.c., parts and accessories for motor vehicles and their engines, electricity distribution and control apparatus, "accumulators, primary cells and primary batteries", other electrical equipment n.e.c., special purpose machinery, and "office, accounting and computing machinery". Among the bottom 15 industries in terms of scoring only three high-technology industries such as aircraft and spacecraft, railway and tramway locomotives and rolling stock, and insulated wire and cable appeared.

This divergent pictures depicted by CTAI excluding FDI and CTAI including FDI may not be surprising as the Spearman's rank correlation test indicated that the ranking of both these indices differ significantly from each other. Taking all the five modes of technology acquisition namely R&D, disembodied technology import, capital goods import, investment in domestic capital goods and FDI, the Indian high-technology industries appears to have done well relative to low-technology industries. Therefore, the study brings out the fact that in the construction of any composite technology index inclusion of all the relevant technology indicators is very crucial for inter-industry comparisons.

To see how have technology-intensive Indian industries performed in the late 1990s as compared to early 1990s, the CTAI including FDI has been computed for both the periods.

Table 9 in the text summarizes the constructed index scores for these two periods of time. It can be seen that inter-industry ranking had changed significantly between these periods.

Table 9
Period-wise Composite Technology Acquisition Index for Indian Manufacturing: 1991-1995 & 1996-2001

Technology Category	NIC 1998	Industry	1991-1995		1996-2001	
			Composite Index	Rank	Composite Index	Rank
Low Tech	223	Reproduction of recorded media	0.092	18	-0.454	50
High Tech	243	Manufacture of manmade fibers	-0.042	29	0.161	19
High Tech	341	motor vehicles	-0.289	42	-0.303	40
High Tech	315	Manufacture of electric lamps and lighting equipment	-0.513	51	-0.439	48
High Tech	321	Manufacture of electronic valves and tubes and other electronic components	-0.356	47	-0.611	53
High Tech	242	Manufacture of other chemical products	-0.161	33	-0.019	27
High Tech	291	Manufacture of general purpose machinery	0.016	22	-0.308	41
High Tech	359	Manufacture of transport equipment n.e.c.	0.653	6	-0.124	31
High Tech	343	Manufacture of parts & accessories for motor vehicles and their engines	0.736	5	-0.337	43
High Tech	312	Manufacture of electricity distribution and control apparatus	-0.007	24	-0.437	47
High Tech	314	Manufacture of accumulators, primary cells and primary batteries	0.336	12	-0.172	33
High Tech	319	Manufacture of other electrical equipment n.e.c.	0.825	3	-0.287	39
Low Tech	231	Manufacture of coke oven products	-0.887	55	-0.789	56
High Tech	292	Manufacture of special purpose machinery	-0.062	30	-0.532	52
High Tech	300	Manufacture of office, accounting and computing machinery	-0.381	49	-0.125	32
High Tech	323	Manufacture of television and radio receivers, sound or video recording or reprod	-0.182	35	-0.426	46
High Tech	332	Manufacture of optical instruments and photographic equipment	0.186	15	-0.629	54
Low Tech	172	Manufacture of other textiles	1.627	1	1.112	3

Table 9 (*contd.*)

High Tech	311	Manufacture of electric motors, generators and transformers	-0.151	32	0.946	4
Low Tech	192	Manufacture of footwear	0.196	14	0.436	5
High Tech	322	Manufacture of television and radio transmitters and apparatus for line telephone	-0.269	40	0.05	24
Low Tech	160	Manufacture of tobacco products	-0.035	27	0.224	16
Low Tech	261	Manufacture of glass and glass products	1.277	2	1.484	1
Low Tech	251	Manufacture of rubber products	-0.267	39	-0.094	30
High Tech	293	Manufacture of domestic appliances n.e.c	0.479	9	-0.196	34
High Tech	333	Manufacture of watches and clocks	0.518	8	0.097	21
Low Tech	369	Manufacturing n.e.c	-0.54	52	-0.314	42
Low Tech	152	Manufacture of dairy products	-0.233	38	-0.224	36
Low Tech	232	Manufacture of refined petroleum products	-0.475	50	-0.284	38
High Tech	241	Manufacture of basic chemicals	0.121	17	-0.406	45
Low Tech	289	Manufacture of other fabricated metal products; metal working service activities	0.083	19	-0.446	49
Low Tech	252	Manufacture of plastic products	0.153	16	-0.002	26
Low Tech	171	Spinning, weaving and finishing of textiles	-0.18	34	0.398	8
Low Tech	173	Manufacture of knitted and crocheted fabrics and articles	-0.334	44	0.068	23
High Tech	331	Manufacture of medical appliances and instruments and appliances for measuring	-0.031	25	0.305	14
Low Tech	271	Manufacture of Basic Iron and steel	0.243	13	0.379	9
Low Tech	272	Manufacture of basic precious and non ferrous metals	-0.332	43	0.019	25
Low Tech	181	Manufacture of wearing apparel, except fur apparel	-0.36	48	-0.456	51
Low Tech	269	Manufacture of non metallic mineral products n.e.c.	-0.211	37	-0.384	44

Table 9 (*contd.*)

Low Tech	210	Manufacture of paper and paper product	0.015	23	0.351	12
Low Tech	361	Manufacture of furniture	0.62	7	0.258	15
Low Tech	222	Printing and service activities related to printing	-0.033	26	0.087	22
High Tech	313	Manufacture of insulated wire and cable	-0.04	28	0.376	10
Low Tech	221	Publishing	-0.273	41	0.136	20
Low Tech	151	Production, processing and preservation of meat, fish, fruit, vegetables, oils and	0.037	21	0.431	6
Low Tech	281	Manufacture of structural metal products, tanks, reservoirs and steam generators	-0.352	46	-0.211	35
Low Tech	154	Manufacture of other food products	0.775	4	0.358	11
Low Tech	273	Casting of metals	0.365	11	-0.058	29
Low Tech	153	Manufacture of grain mill products, starches and starch products, and prepared an	0.068	20	1.282	2
Low Tech	202	Manufacture of products of food, cork, straw and plaiting materials	-0.069	31	0.399	7
Low Tech	351	Building and repair of ships and boats	-0.751	54	-0.052	28
Low Tech	191	Tanning and dressing of leather; manufacture of luggage, Handbags saddlery & harn	-0.594	53	-0.663	55
High Tech	352	Manufacture of railway and tramway locomotives and rolling stock	-0.934	56	-0.267	37
High Tech	353	Manufacture of aircraft and spacecraft	-0.344	45	0.319	13
Low Tech	155	Manufacture of beverages	0.453	10	0.206	17
Low Tech	201	Saw milling and planning of wood	-0.185	36	0.171	18

Note: Technological classification of industries is based on OECD Science, Technology and Industry Scoreboard 2003, Annex 1.2. Classification of manufacturing industries based on technology.

Of the total 24 high technology industries, exactly half have moved downward in industry rankings because of their low level of investment in technology acquisition during 1996-2001. Significant downward movements include other electrical equipment n.e.c. (from rank 3rd in 1991-95 to 39th rank in 1996-2000), parts and accessories for motor vehicles and their engines (from 5th to 43rd rank), transport equipment n.e.c. (from 6th to 31st rank), watches and clocks (from 8th to 21st rank), domestic appliances n.e.c. (from 9th to 34th rank), accumulators, primary cells and primary batteries (from 12th to 33rd rank), optical instruments and photographic equipment (from 15th to 54th rank), basic chemicals (from 17th to 45th rank), general purpose machinery (from 22nd to 41st rank), electricity distribution and control apparatus (from 24th to 47th rank), special purpose machinery (from 30th to 52nd rank), and television and radio receivers, sound or video recording (from 35th to 46th rank). Of the 32 low technology industries only 12 industries have witnessed a downward movements in their rankings. This suggests that only 38 per cent of low technology industries have seen downward movements in their rankings whereas 50 per cent of India's knowledge-based industries seen adverse rankings in the late 1990s. The fact that relatively more number of high technology industries have done poorly in acquiring new technology than low technology industries raises a serious concern on the technological activity in Indian industries. The policy makers should put more focus on these high-technology industries that have slided back in the 1990s.

6. Conclusion and Implications

This study examined the trends and patterns of technology acquisition in Indian manufacturing during the period 1991-2001. As compared to the previous period, the 1990s has seen dramatic liberalisation in Indian technology policy with a view to withstand global competitiveness. Liberalisation measures, among many others, include free imports of capital goods, lifting of foreign ownership restriction in majority of the industries and putting in place automatic approval procedures for FDI, and liberal policy regime for foreign technology collaborations. The present scenario of increased reforms towards integrating India with the global economy necessitates a clear analysis of the technological activities of Indian industries as technology forms the basis for global competition.

The study, to begin with, distinguished four modes of technology acquisition for Indian manufacturing such as in-house R&D, import of disembodied technology, foreign capital goods' import and investment in domestic capital goods. Later on, FDI has been added as another mode of technology acquisition. As far as Indian manufacturing is concerned information on all the technology indicators are not available at standard industrial classification, hence, this study constructed a new technology indicator database for Indian manufacturing. First, a concordance was developed between Prowess database of CMIE and SIC Revision 1998. Second, using the concordance technological measures were derived from the Prowess database for 56 Indian industries at three digit level. Then the analysis was conducted by examining inter-industry distribution of absolute level of individual

technology measures, their intensities and then by constructing a composite technology acquisition index.

A few pertinent conclusion from the research can be summarized here.

First, the R&D intensity and dis-embodied technology intensity of Indian manufacturing have been rising during the period 1991-2001 contrary to the national level trend of declining R&D intensity. This increasing trend of manufacturing R&D intensity is observed to be broad-based among Indian industries between the periods 1991-95 and 1996-2001 whereas increase in dis-embodied technology intensity is limited to a small number of industries. The results indicate that liberalisation of technology import policy does not have any adverse impact on in-house R&D activity in Indian manufacturing vis-à-vis foreign disembodied technology import.

Second, the technological activities in Indian manufacturing is highly concentrated in character. The analysis revealed that large chunk of technological activity is confined to a small set of industries either in terms of R&D, import of disembodied technology or investment in foreign and domestic capital goods.

Third, the investment of Indian manufacturing in accumulating capital goods, foreign as well as domestic, has seen dramatic decline in the 1990s.

Fourth, the FDI participation in Indian manufacturing is quite moderate (less than 18 per cent) over 1991-2001 except the manmade fibers where 38 per cent of industrial ownership rest with foreign promoter.

Fifth, the overall technology acquisition index over 1991-2001 which includes FDI suggests that high-technology industries in Indian manufacturing are doing well in technology accumulation.

However, policy makers should not be complacent on the fact high-technology industries have done better in the overall technology acquisition index including FDI than low-technology industries. The higher technology acquisition levels of high-technology vis-à-vis low-technology industries may be merely reflective of their sectoral differences. Given the definition of high technology industries as those that intensively produced and used technology, it may not be surprising that they are also more technology acquires in Indian manufacturing than low-technology industries. A composition of detailed industry- level technology acquisition in Indian industries with global peers may throw more insights on how many Indian industries are performing better in the international context. The analysis by bifurcating the sample period into 1991-95 and 1996-2001 suggests that half of the Indian high-technology industries have slided downward in inter-industry rankings in the late 1990s. This is enough to suggest that technology acquisition efforts of these high technology industries have suffered setbacks in

relative term. Targeting these low performing industries with appropriate policies are hence called for.

The fact that technology activities are concentrated in a small number of industries in Indian manufacturing, possess another concern for policy makers. The sectors which are not doing well in total manufacturing technological activities should be given more special focus and incentives for innovation. The rising technology intensities are surely encouraging trends but are not enough for serving India's long term strategic advantages in the global market. The technology intensity of Indian knowledge-based industries must be pushed forward to the levels of global competitors. The declining intensity of capital goods employment, foreign and domestic, is another area which need to looked into. Slower rate of employing new vintages of capital goods can put Indian industries at a disadvantageous position vis-à-vis their competitors.

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