Globalization, Technological Innovation, and Technology Intensive Exports : Empirical Findings for the Indian Economy

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Abstract

One of the basic constituents of a vibrant technology regime of a country is the extent to which the technological innovation is geared towards its external sector, wherein one of the essential determining factors of innovation of a country is the public expenditure on Research and Development. Globalization has entailed a significant step up in the level of carrying innovation in the countries to cope up with the changing nature and structure of the industries across the globe and to meet the challenges posed by the emerging pattern of competition. The liberalization of the Indian economy in 1991 has widened its scope for going 'global' in terms of technology intensive exports on the one hand, and being innovative on the other. In this paper, an attempt was made to study the impact of the public expenditure on Research and Development on the technology intensive exports of the Indian economy during the pre-and post- liberalization era (1980-81 to 1990-91 and 1991-92 to 2007-2008) on the basis of the log-linear model of regression analysis.

Keywords: **technology regime, technological innovation, research & development, technology intensive export**

JEL Classification: B25, C10, C22, O30

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The transformation of the global economy in the course of globalization called forth structural changes in the manufacturing sector across the globe, coping up with which ensured that there was hardly any alternative available to the firms than to invoke technological capability building, and the technological prowess of the country can be strengthened by investing in in-house Research and Development (R&D). The expenditure on Research and Development (R&D) by an industry or a firm is a convenient measure of technological innovation, and the robustness of the technology regime of a country is reflected by the extent to which the spillover of public R&D sustains technological innovation in the industrial sector.

Nelson and Winter (1982), in this regard, mentioned that :

> The innovative R&D efforts of the firms in the industry take advantage, as it were, of new technological opportunities that have been created elsewhere. Greater R&D expenditure within the industry means that latent productivity is tracked more smoothly, but aside from that, the path of best- practice productivity is unlikely to be much higher than it is when industry R&D expenditures are less. (pp.293-294)

In order to understand the nature, dimension, and trend of expenditure on R&D in India, a closer look at the

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Table 1. National Expenditure on Research and Development (₹ crore)

Year	R&D (Current Prices)	R&D (Constant Prices) (Base:1999-2000)	GDP (Current prices) (₹ crores)	GDP (Constant prices) (₹ crores)	R&D as % GDP (Current Prices)	R&D as % GDP (Constant Prices)
1970-71	168.0	244.1	42981	474131	0.39	0.05
1971-72	214.0	294.5	45731	478918	0.47	0.06
1972-73	234.1	292.7	50304	477392	0.47	0.06
1973-74	253.1	263.2	61649	499120	0.41	0.05
1974-75	324.0	269.2	72566	504914	0.45	0.05
1975-76	398.0	334.3	77071	550379	0.52	0.06
1976-77	391.0	321.7	82845	557258	0.47	0.06
1977-78	450.2	352.1	94552	598885	0.48	0.06
1978-79	558.7	436.9	101619	631839	0.55	0.07
1979-80	674.3	450.3	110887	598974	0.61	0.08
1980-81	760.52	3674.35	132520	641921	0.57	0.57
1981-82	940.73	4103.59	155158	678033	0.61	0.61
1982-83	1206.03	4848.32	173337	697861	0.70	0.69
1983-84	1381.10	5123.85	202750	752669	0.68	0.68
1984-85	1781.55	6117.37	227694	782484	0.78	0.78
1985-86	2068.78	6619.50	254427	815049	0.81	0.81
1986-87	2435.40	7292.59	283681	850217	0.86	0.86
1987-88	2853.07	7799.64	321589	880267	0.89	0.89
1988-89	3347.26	8453.26	383790	969702	0.87	0.87
1989-90	3725.74	8678.20	442134	1029178	0.84	0.84
1990-91	3974.17	8361.19	515032	1083572	0.77	0.77
1991-92	4512.81	8363.31	594168	1099072	0.76	0.76
1992-93	5004.60	8526.18	681517	1158025	0.73	0.74
1993-94	6073.02	9408.79	792150	1223816	0.77	0.77
1994-95	6622.44	9340.94	925239	1302076	0.72	0.72
1995-96	7483.88	9656.11	1083289	1396974	0.69	0.69
1996-97	8913.61	10662.41	1260710	1508378	0.71	0.71
1997-98	10611.34	11921.83	1401934	1573263	0.76	0.76
1998-99	12473.17	12967.51	1616082	1678410	0.77	0.77
1999-2000	14397.60	14397.60	1786526	1786525	0.81	0.81
2000-01	16198.80	15683.37	1925017	1864301	0.84	0.84
2001-02	17038.15	16007.14	2097726	1972606	0.81	0.81
2002-03	18088.16	16353.72	2261415	2048286	0.80	0.80
2003-04	20086.34	17575.41	2538170	2222758	0.79	0.79
2004-05	24117.24	19991.64	2877701	2388768	0.84	0.84
2005-06	28776.65	22963.91	3282385	2616101	0.88	0.88
2006-07	32941.64	24821.63	3779384	2871120	0.87	0.86
2007-08	37777.90	27213.00	4320892	3129717	0.87	0.87

Source: a) Research and Development Statistics: 2007-08- National Science and Technology Management Information System; Department of Science and Technology; Government of India. b) Technological Independence: The Asian experience (United Nations University Press, United Nations, 1994)

Table 2. National Expenditure on Research and Development by Sector (₹ crore):1970-71 to 2007-08

Sector	1970-71	1975-76	1980-81	1985-86	1990-91	1995-96	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Central	112.47	287.63	580.49	1654.06	3058.27	5199.79	11536.33	12251.17	13034.69	15079.95	17851.01	19909.23	22204.77
State	12.58	26.73	59.34	162.78	365.92	657.02	1494.33	1588.15	1689.78	1941.53	2227.42	2461.08	2719.24
Private	14.59	42.35	120.69	251.94	59.98	1627.07	3292.69	3498.30	4471.27	6038.96	7444.21	9128.09	11192.86
Higher Education	-	-	-	-	-	-	714.8	750.54	890.60	1056.80	1254.01	1443.24	1661.03
Total	139.64	356.71	760.52	2068.78	3974.17	7483.88	17038.15	18088.16	20086.34	24117.24	26776.65	32941.64	37777.90

Source: Research and Development Statistics: 2007-08- National Science and Technology Management Information System; Department of Science and Technology; Government of India.

evolution of India's technology policy was necessary. On March, 4, 1958, the Government adopted the Scientific Policy Resolution. One of the aims of scientific policy was "to foster, promote, and sustain, by all appropriate means, the cultivation of science, and scientific research in all its aspects - pure, applied, and educational". The Table 1 shows that during 1970-71 to 1980-81, the expenditure by the government on R&D at current prices (1999-2000 prices) reflected a growth rate of 29.25%. The R&D expenditure as percentage of GDP stood at 0.39% in current prices during the year 1970-71, which stepped up to 0.61% during the year 1981-82.

It was during the Sixth Five Year Plan that the government announced its first comprehensive Technology Policy, 1983. This accorded priority to R&D on the plea that an adequate scale of investment in R&D was necessary for the absorption, adaptation and, wherever possible, improvement on and generation of new technology, making fullest use of overall national capabilities. The growth of national expenditure on R&D, which was 4.32% during the period from 1984-85 to 1994-95 improved to 9.02% during the period from 1995-96 to 2007-08.

The Scientific and Technology Policy 2003 explicitly made it clear that every effort would be made to achieve synergy between industry and scientific research. From the Table 1, it can be inferred that during the period from 2003-2004 to 2007-08, the rate of growth of R&D expenditure was 11.55% ; whereas, during the period from 1983- 84 to 2002-03, the growth rate was 6.30%. It implied that Technology Policy 2003 had been able to provide momentum to the growth of R&D.

The trend of sector wise national expenditure on R&D is revealed through Table 2. The data regarding expenditure on R&D by the Central, State, Private, and Higher Education sectors were provided by Department of Science and Technology (DST), Government of India at intervals.

In the year 1970-71, the share of central to total R&D expenditure was 80.55%, state sector's contribution was 9.01%, and that of the private sector was 10.45%.The corresponding figures for the three sectors in the year 1980-81 were 76.33%, 7.81%, and 15.87%, respectively. This implied that the contribution of the private sector had been on the rise while that of the central and state sectors were declining. During the year 1995-96, the share of the central sector fell down to 69.48%, the state's contribution also decreased to 8.78%, but that of the private sector increased further to 21.75%. In the year 2007-08, the share of the central sector further fell to 58.78%, the state's contribution also fell to 7.20%. On the other hand, the contribution of the private sector further increased to 29.63%.

The Organization for Economic Cooperation and Development (OECD) (2001) classified technology intensive goods. Low technology (LT) category includes a) Food, beverages, & tobacco products, b) Textiles, leather, & footwear, c) Wood, paper, & paper products, and d) Rubber & plastic products; Medium-Low Technology category (MLT) includes a) Other non-metallic mineral products, b) Cement & glass, c) Basic metal & metal products, d) Chemicals excluding pharmaceuticals, and e) Electrical machinery; Medium-High Technology category (MHT) includes a) Non-electrical machinery, and b) Transport equipments; High Technology category (HT) includes a) Pharmaceuticals, and b) Electronics.

The Table 3 shows the percentage of exports of the technology intensive goods in total exports from India

Table 3. India's Exports of Technology Intensive Goods (as % of Total Exports): 1970 -71 to 2007-08

Year / Product	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
LT	50.59	55.05	52.12	50.25	50.58	46.48	49.65	42.31	36.56	40.90
MLT	20.45	14.84	11.46	13.07	16.45	18.30	27.62	17.32	16.77	13.00
MHT	5.43	4.70	4.43	4.69	6.47	6.43	7.49	6.24	6.98	6.99
HT	0.55	0.60	0.52	0.60	0.69	0.55	0.60	0.58	0.99	1.36
Total Exports (₹ crore)	1535.3	1608.2	1971.5	2523.4	3328.8	4036.3	4036.3	5407.9	5726.1	6418.4

Year / Product	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
LT	39.75	37.29	30.44	28.51	29.73	32.16	30.47	46.11	39.04	39.72
MLT	12.54	13.91	11.79	10.53	10.92	11.65	10.53	9.15	10.74	12.77
MHT	7.84	7.92	6.65	5.53	5.65	6.46	6.71	4.90	5.44	5.54
HT	1.00	1.56	1.27	1.59	2.00	1.45	1.30	5.65	6.97	8.62
Total Exports (₹ crore)	6710.7	7805.9	8803.4	9770.7	11743.7	10894.6	12452.0	15673.7	20231.5	27658.4

Year / Product	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
LT	42.42	44.24	43.93	42.72	43.08	44.39	46.31	44.78	44.86
MLT	11.77	11.39	12.10	14.05	13.39	12.98	12.76	12.95	11.66
MHT	6.04	6.03	5.80	5.46	5.69	5.52	6.05	6.07	5.77
HT	8.09	9.33	7.34	7.54	8.26	8.93	9.80	10.23	9.53
Total Exports (₹ crore)	32557.6	44041.8	53688.3	69751.4	82674.1	106353.3	118817.1	130100.6	139753.1

Year / Product	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
LT	41.90	38.73	36.75	34.76	31.84	26.37	25.82	23.79	23.22
MLT	12.47	13.42	13.96	16.12	17.03	21.20	19.00	18.75	17.72
MHT	5.41	5.77	6.29	6.34	7.41	7.84	9.12	9.24	9.92
HT	10.24	10.58	11.11	11.21	11.85	10.74	10.96	10.93	10.61
Total Exports (₹ crore)	159561.4	203571	209018	255137.3	293366.8	375339.5	456417.9	571779.3	655863.5

LT: Low -Technology intensive products; MLT: Medium-Low technology intensive products; MHT: Medium -High Technology intensive products; HT: High -Technology intensive products.

Source: Calculated from the India's imports in Handbook of Statistics of Indian Economy: 2010-11(RBI) and Economic Survey, Government of India:2010-11

Table 4. Growth of Technology Intensive Exports of India: 1970-71 to 2007-08

Growth/Year	1970-71 to1980-81	1981-82 to 1989-90	1990-91 to2000-01	2001-02 to 2007-08
(LT)	13.13%	18.06%	19.03%	12.08%
MLT	10.36%	15.89%	21.71%	25.89%
MHT	20.23%	12.02%	19.56%	30.54%
HT	23.01%	44.99%	23.39%	20.07%

Source: Computed and compiled from Table 3.

during 1970-71 to 2007-08. It was revealed that the proportion of LT intensive goods in total exports gradually decreased over time and that of MLT, MHT, and HT increased gradually.

The exports of HT goods picked up from 1989-90 and reached an all time high of 11.85% in 2003-04, and in the next few years, this exhibited a moderate reduction. It was observed that since the beginning of the episode of

Table 5. Exports of Low, Medium Low, Medium High, and High Technology (LT, MLT, MHT, HT) Products as Percentage of Total Manufacturing Exports of India: 1970- 2007

Year	LT (%)	MLT (%)	MHT (%)	HT (%)	Total Manufacturing Exports (₹crore)
1970	95.66	38.67	10.26	1.05	811.9
1971	102.80	27.72	8.78	1.11	861.2
1972	97.16	21.36	8.26	0.97	1057.5
1973	93.49	24.33	8.72	1.11	1356.2
1974	97.19	31.60	12.44	1.33	1732.5
1975	91.23	35.93	12.63	1.08	2056.2
1976	65.98	36.70	9.95	0.80	3037.5
1977	72.12	29.53	10.63	0.98	3172.3
1978	58.33	26.76	11.13	1.57	3589.3
1979	68.51	21.78	11.71	2.28	3832
1980	67.50	21.29	13.31	1.71	3952.2
1981	63.07	23.52	13.39	2.64	4615.4
1982	58.86	22.80	12.85	2.46	4552.2
1983	56.06	20.70	10.88	3.12	4969.3
1984	56.23	20.65	10.68	3.77	6210.2
1985	54.97	19.92	11.04	2.48	6374.2
1986	48.58	16.79	10.71	2.07	7809
1987	68.02	13.50	7.23	8.34	10625.6
1988	53.95	14.84	7.52	9.63	14641.4
1989	55.12	17.72	7.68	11.96	19931.7
1990	59.22	16.43	8.44	11.29	23319.1
1991	60.11	15.48	8.20	12.67	32413.4
1992	58.00	15.97	7.66	9.69	40659.8
1993	57.03	18.75	7.29	10.07	52244.6
1994	55.59	17.28	7.34	10.66	64067.1
1995	59.43	17.38	7.39	11.96	79433.3
1996	62.97	17.35	8.23	13.33	87377.4
1997	59.05	17.08	8.00	13.49	98659.8
1998	57.77	15.02	7.43	12.28	108506.2
1999	51.93	15.46	6.71	12.68	128760.7
2000	50.26	17.42	7.49	13.73	156858.4
2001	48.27	18.34	8.26	14.59	159146.4
2002	45.54	21.11	8.31	14.69	194764.5
2003	41.91	22.42	9.76	15.60	222828.8
2004	36.27	29.15	10.78	14.77	272872.2
2005	36.68	26.99	12.95	15.57	321260.8
2006	35.39	27.91	13.75	16.27	384261.4
2007	36.74	28.03	15.69	16.79	414457.7

Source: Calculated from the India's exports in Handbook of Statistics of Indian Economy: 2010-11 (RBI) and Economic Survey, Government of India: 2010-11.

liberalization of the economy, the exports of the technology intensive goods have been on a rise.

The growth of the exports of the technology goods is depicted in the Table 4. It is revealed that the growth of the exports of HT goods exceeded that of the others during 1970-71 to 1980-81, 1981-82 to 1989-90, and 1990-91 to 2000-01 ; the growth only fell short of MLT and MHT during 2001-02 to 2007-08 - the period in which exports of MHT goods exceeded all others. The policies of the Government helped in boosting up the acquisition of technology by the Indian firms. A surge of exports of technology intensive goods indicated that the firms had been able to reap the benefits of technological change in the industry facilitated by the acquisition of the same. However, unless this was supplemented by developing capability of adoption of technology, the acquisition would not have been effective.

Since 1950 up to 2007, there was a perceptible rise in the level of world merchandise exports. Globalization opened an opportunity which could be reaped through increasing participation in dynamic and new sectors of world trade (United Nations Conference on Trade and Development [UNCTAD], 2008). Dynamic and new sectors were driven by a sustained rise in demand, shifts in consumer preferences, and technological and skill-related developments. These sectors included beverages, marine products, energy based products (such as bio fuels), minerals and metals in commodities, manufactures such as electronics and electrical products, automotive parts, textiles and clothing items, renewable energy equipment, and services (including IT-enabled services, computer and information services, construction, travel and transport, telecom, audiovisual, financial and professional services, and commercial services). As a group, these dynamic sectors grew on an average of 12% annually over the last decade. Many of them were based on new technologies with high value addition (op cit).

Kumar and Siddharthan (1993) provided a survey of literature on international trade, which puts emphasis on the contribution of technology and skills to the countries' relative competitiveness. Though a major part of the literature was concerned about the role of technology in the foreign trade of the developed countries, very few embraced the perspective of developing countries. Most of these studies indicated that the technology variable characterized by the R&D intensity and technology imports did not appear to be significant in explaining export performance. This was due to the fact that the bulk of the R&D expenditure incurred in the developing countries was of adaptive nature instead of being creative. If an industry has to be technology intensive, its comparative advantage must lie in its competence in undertaking product innovations, which was not the underlying feature of the firms in the developing countries. In addition to this, failure of the firms in the developing countries to gain a competitive edge was accentuated by their inability to compete in terms of shorter product life cycle, firm specific nature of the knowledge, and hence, significant economies of vertical integration and geographical diversification (ibid.).

The extent to which a firm is able to export technology intensive goods is determined by its technological capability. These capabilities are determined by the extent to which in-house R&D is undertaken by an industry, which only reinforces innovation, but also capacitates the industry to assimilate external technological knowledge. Hence, R&D can be regarded as one of the crucial determinants of export performance. As a part of the 'problem-solving' activities when a firm achieves ability and the potential to apply firm-specific technology and speeds up its technical functioning of production processes or its finished products, it is said to have gained the technological capability.

The Table 5 shows the trends of the LT, MLT, MHT, and HT exports as a proportion of total manufacturing exports from India during the period 1970 to 2007. In 1970, the shares of LT, MLT, MHT, and HT exports in total manufacturing exports were 95.66%, 38.67%, 10.26%, and 1.05%, respectively. In the year 1980, the percentages were 67.50%, 21.29%, 13.31%, and 1.71%, respectively. Just before the reforms began, in the year 1990, the figures were 59.22%, 16.43%, 8.44%, and 11.29%. In the year 2007, these were 36.74%, 28.03%, 15.69%, and 16.79%, respectively. Thus, over the years, the shares of LT and MLT exports in total manufacturing exports fell and that of MLT and HT exports registered a significant improvement. What was most striking was the rapid improvement of HT exports since 1980.

During the period from 1970-71 to 1980-81, the rate of growth of the exports of LT intensive products was 13.13% and that of the MLT, MHT, and HT products were 10.36%, 20.23%, and 23.01%, respectively. During the

period from 1981-82 to 1989-90, these figures were 18.06%, 15.89%, 12.02%, and 44.99%, that is, before liberalization took its full form, the growth of the exports of HT products was substantially higher. Even before that, HT exports grew comparatively higher than other technology intensive exports. In between 1990-91 and 2000-01, a comparison of the growth of these exports provided support in favour of the higher growth of HT exports compared to the others. During the period from 2000-01 to 2007-08, the growth of HT exports trailed behind the exports of MLT and MHT since the latter two increased by 25.89% and 30.54%, respectively ; whereas, the growth of exports of HT products was 20.07%. If the rate of growth of national expenditure on R&D at current prices was compared with that, it was observed that over the period from 1970-71 to 1980-81, the figures were 16.30%, 18.77%, 15.09%, and 14.19%, respectively for the periods from 1970-71 to 1980-81,1981-82 to 1989-90, 1990-91 to 2000-01, and 2001-02 to 2007-08 . In what follows, one might be optimistic that the period in which the growth of HT exports was substantial had also been a period of high growth rate of R&D and whenever this growth of R&D fell, it also resulted in lower growth rate of HT exports. This data provided incentive to carry on an analysis of the impact of R&D in India on the country's exports of HT intensive products.

Literature Survey and Identification of Research Gap

There is no specific study unveiling how and to what extent India's R&D has been spilt over to its external sector apart from exploring the changing nature of India's technology-intensive exports.

Agarwal, Gupta, and Gandhi (2004) provided a survey of India's technology intensive exports during 1994-95 to 2002-2003. Kumar and Sidharthan (1993), with the help of a database containing panel data for 640 companies for the period from 1987-88 to 1989-90, applied Tobit model to explain how export behaviour of firms was influenced by various factors. The technology factors represented by in-house R&D appeared to be statistically significant with the positive sign in the cases of four industries, namely, transport equipment, manmade fibres, paper and rubber products and another factor, skill intensity of operations, as a proxy of potential of informal R&D, appeared to have a significant and positive impact in the cases of food processing and transport equipment industries. All these industries were classified as low or medium technology industries. The findings suggested that in developing countries like India, firm's innovative activity contributed to export competitiveness in low and medium technology industries.

Pradhan and Puttaswamaiah (2005) 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 the 3-digit level. It 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 had performed during the period from 1991-2001. The study followed OECD classification of the industries, and the Indian industries were made to collapse into two - high and low technology industries, where the former included OECD high-technology and medium-high-technology industries ; whereas, the low-technology group covered OECD medium-low-technology and low-technology industries.

Technological opportunity is created through the efforts made towards R&D. Pradhan (2003) attempted to empirically verify the impact of economic liberalization on the R&D behaviour of Indian pharmaceutical firms controlling for the effects of several firm specific characteristics, including firm size. The study used the Tobit analysis for a sample of firms over the period from 1989-90 to 2000-01, and the results indicated that competitive pressure generated by liberalization worked effectively in pushing Indian pharmaceutical firms into R&D activity. A host of firm characteristics like firm age, size, profitability, intangible assets, export orientation, and outward foreign direct investment were also found to be important determinants of innovative activity in the industry.

The studies based upon the theme on technology in Indian manufacturing focused on the measurement of productivity in Indian manufacturing, spillover effects of technology ushered through increasing inflow of FDI, technical efficiency of Indian firms, effects of liberalization on Indian manufacturing, and some studies underpinned the factors influencing the technology adoption, acquisition, and innovation separately rather than

concentrating upon the changing character of India's technology regime and its impact on Indian manufacturing. However, the gap in the literature exists in the sense of failing to capture the impact of India's public R&D on technology intensive exports of the country, which is regarded as one of the very characteristics of 'cumulativeness of learning'.

Objective of the Study

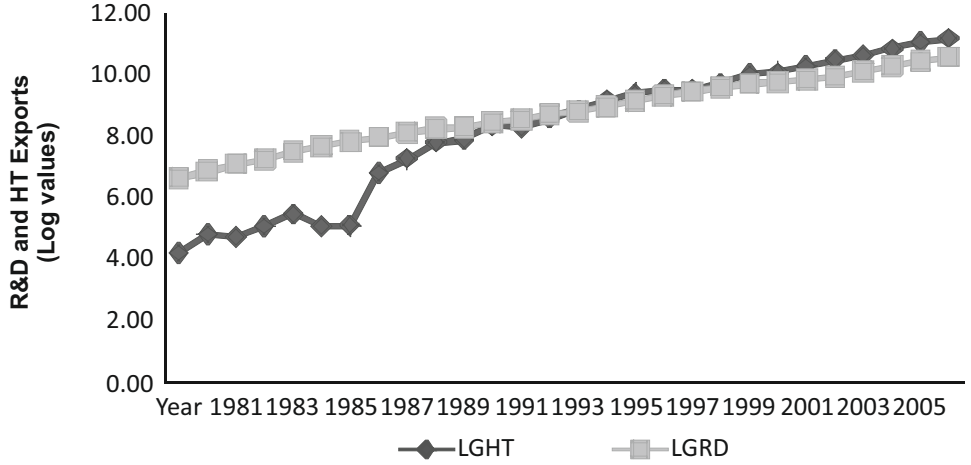
The objective of the study is to explore the impact of India's public R&D on technology intensive exports of the country, whicÜis regarded as one of the very characteristics of 'cumulativeness of learning'.

Data Sources and Research Methodology

The data on national expenditure on R&D in current prices were obtained from the Research and Development Statistics: 2007-08, National Science and Technology Management Information System, Department of Science and Technology, Government of India. Data on the exports of technology intensive exports from India were compiled from the Handbook of Statistics of Indian Economy: 2010-11, Reserve Bank India and Economic Survey, Government of India: 2010-11 based upon OECD classification of industries. The figures are in ₹ crore in current prices and the period considered was from 1980-1981 to 2007-2008.

Before conducting any regression analysis, the time series properties of the variables were examined. While doing so, the variables, that is, high technology (HT) exports and national expenditure on R&D (RD) were transformed into log values since the log values enabled us to find out how and to what extent 1% increase in one variable caused for the change in the other. The trend of the log values of HT exports by India and its R&D are shown in the Figure 1. The outcome derived from the Augmented Dickey-Fuller (ADF) unit root test of the log of HT (LGHT) series revealed that ADF test statistic is 3.374522 which, in absolute value, is larger than the critical value at the 10% level. So, the LHGT series is stationary. The results obtained from a similar unit root test confirmed that log of R&D expenditure at current prices (LGRD) is stationary since the ADF test statistic is -4.363597. Hence, there was no problem of running regression between the variables. Pooling all the observations

Figure 1. Trend of Log Values of R&D and High Technology Exports: 1980-81 to 2007-08



Source:
a) Handbook of Statistics of Indian Economy: 2010-2011.Reserve Bank of India
b) Research and Development Statistics: 2007-08- National Science and Technology Management Information System, Department of Science and Technology , Government of India.

Table 6. Impact of R&D on High Technology Exports by India During 1980-81 to 2007-08

Dependent variable LGHT

Variables	Coefficients
Constant	-10.211
	(-6.157)*
	(1.658)**
Intercept dummy	1.540
	(3.173)*
	(2.171)**
Slope dummy	-1.577
	(-2.807)*
	(0.264)**
LGRD	1.076
	(9.694)*
	(0.218)**
R^2	0.973
F statistic	284.553
S.E	0.39021

for the pre- and post-reform periods, and introducing intercept and slope dummies, the following regression equation model was used:

$$LGHT = \alpha_1 + \alpha_2 LGRD + \alpha_3 D_1 + \alpha_4 (D_1 LGRD) + u_i$$

where, log value of HT exports *(LGHT)* is the dependent and log value of R&D *(LGRD)* is taken as the explanatory variables, D_1 and $D_1(LGRD)$ are the differential intercept and slope dummies, α_3 and α_4 are differential intercept and slope coefficient , respectively and $i = 1,2,3,\ldots,28$ and

$D_1 = 0$ for the period from 1980-1990
$= 1$ for the period from 1991-2007

Empirical Findings

The regression equation which was fitted is as follows :

$$LGHT = -10.211 + 1.076\, LGRD + 1.540\, D_1 - 1.577\, (D_1 LGRD) + u_i \quad \text{(i)}$$
$$\qquad\qquad (-6.157) \qquad (9.694) \qquad (3.173) \qquad (-2.807)$$

't' values are shown in parentheses.

The estimated values are shown in the Table 6. The computed value of R^2 is 0.973, which implies that the explanatory variables explain 97.3% of the variation of the dependent variable. The viability of the model is justified by the *'F'* value, which is quite significant. The estimated coefficients of *LGRD* and the slope and intercept dummies are significant as revealed by the *t*- values within parentheses. There has been a perceptible change in the structure of the equations for the pre- and post-reform periods.

For the pre-reform period, the relation (i) is :

$LGHT = -10.211 + 1.076\ LGRD,$ which implies that the impact of R&D on high technology exports is positive.

For the post-reform period, the relation becomes :

$LGHT = -10.211 + 1.076\ LGRD + 1.540 - 1.577\ (LGRD)$

$= -8.671 - 0.501\ LGRD$

This indicates that in the post-reform period, the R&D did not have any positive impact on HT exports ; rather, it acted as the disincentive for HT exports.

Discussion and Conclusion

The regression results depict that national expenditure on R&D was not geared towards the external sector of the economy during the post-reform period, though it played an important role in the pre-reform era. One probable explanation might be that 'cumulativeness of learning,' one principal component of the technology regime had not been so vibrant in the sense that the outcome of R&D could not spillover to the external sector of the economy. Another reason might be that the high technology exports were mainly performed by firms which either had not benefited by the R&D undertaken by the public sector, or it was influenced by the in-house R&D carried out by the industries which were not reflected in the DST statistics. DST only took into account the statistics of those firms which were recognized by the Department of Scientific and Industrial Research (DSIR). Many firms doing R&D were not recognized as R&D units.

Kumar and Siddharthan (1993) observed, while analyzing the inter firm variation in export behaviour of Indian enterprises with data for a three-year panel (1988- 1990), that technological activities would be important for explaining the export behaviour of enterprises only in low and medium technology industries. This ran counter to our observations since in the pre-reform period, R&D contributed significantly to the exports of HT products. One plausible reason for this dismal performance of R&D in respect of HT exports was that in the post-reform period, a high degree of affiliation with the multi national enterprises helped Indian enterprises achieve higher automation and modernization to break into the international market without taking recourse to innovation. Had this been so, the flourishing of a technology regime that could move the economy towards technological self-reliance would have been a rare possibility.

For the Indian economy, if the composition of the HT exports, consisting of mainly pharmaceuticals and electronics were analyzed, then it was discernible that up to 1986-87, the country's electronics exports did not take place, and for that period, HT exports comprised of mainly pharmaceuticals. Since 1987-88, though the exports of electronics started breaking through, these always trailed after the exports of pharmaceuticals. The Indian pharmaceutical sector has a long history of the participation of MNCs in both manufacturing and R&D (Feinberg & Majumdar, 2001). It has been verified that there was technology spillover from FDI in the Indian pharmaceutical sector, but MNCs gained from each other's R&D spillover, while the domestic firms gained nothing (ibid).

Pradhan (2003) pointed out that by the 1980s, the pharmaceutical industry had achieved technological capability to produce bulk drugs from as basic stage as possible and achieved a high degree of self-sufficiency concerning its requirements of basic raw materials and intermediates. This rising domestic technological capability in the industry was also reflected in the favorable trade balance that the country has been enjoying in pharmaceutical products since the late 1980s as compared to huge deficits of 1960s and 1970s (ibid). The statistical analysis using Tobit's model in Pradhan's study revealed that the export intensity variable was one of the determining factors of R&D intensity which appeared to be significant, leading Pradhan to observe that in a knowledge based industry like pharmaceuticals, the global competitiveness of a firm is driven by high technology, high skill, quality, and reliability. Therefore, entry into the global market requires a strong

technological backup on the part of an entrant, and intense competitive pressure based on technological dynamism ensures that the firm is continuously innovative to be able to stay in the market.

Partly, the failure of the industry to achieve a 'strong technological back up' via continuous innovation might be attributed to the weaker role of R&D in fostering exports. In this respect, a mention must be made of the report prepared by Deloitte, ISB, NSF, NYU Stern, and Krannert School of Management (2007). The report confirmed that to continue moving up the value chain, the Indian pharmaceutical industry needs to start thinking like a knowledge base provider rather than just a material base provider. It must invest in people, and buy and build technologies. It also needs to work with the government to push for changes that benefit the industry. The industry should support intellectual property initiatives, push innovation, and leverage information technology in pharmaceuticals. It needs to work with academia to align curricula with changing industry needs, and be open to global talent and practices.

The electronics industry has mostly been import-dependent. It was observed that most of the companies attracted to this industry in recent years were not interested in setting up manufacturing facilities; on the contrary, they were engaged grossly to assemble the imported kits (Alam, 1990).

In 1970-71, the industries' share of R&D was 10.45%, in 1995-96, it increased to 21.74%, but came down to 19.81% in 2004-05 (Mani, 2008). The study by Bhattacharya and Lal (2008) revealed that the number of firms involved in R&D activity increased 20 times in 1995 from the level in 1990 (i.e. from 44 firms to 853 firms). In the later periods, there was not a major change in the number of firms involved in R&D activity. There was almost a 770% increase in R&D investment from that in 1995. Thus, firms involved in R&D had significantly increased their R&D investment. R&D intensity increased from 0.05 in 1990 to 0.47 in 2007. This increasing contribution by the industry could have been attributable to the rising HT exports, which were not reflected in the data on national expenditure on R&D provided by DST.

The argument that high technology exports got an incentive from the import of technology was not so much tenable. During the period from 1970-71 to 1980-1981, the growth rate of import of technology was 16.72% ; during the period from 1981- 1982 to 1989-1990, the growth rate was 19.87% ; during the period from 1990-1991 to 2000-2001, it grew at the rate of 14.75% ; and during the period from 2001-2002 to 2007-2008, the growth rate was 34.51%. It was discernible that only the period from 2001-2002 to 2007-2008 had been one during which the exports of HT products fell as compared to what it was in other periods, but that was also the period in which import of technology grew substantially.

Import of technology, if supported by the efforts of creating suitable environment for adaptation, may help developing technological capability, and this, in turn, could act as a prime mover of technology intensive exports. However, the weaker role of R&D, in this respect, suggests that India's post-reform agenda, though it took cognizance of the role of technology in the economy's upliftment, lacked sincere efforts in proliferating the knowledge created in the academia or research laboratories to the productive sectors of the economy. The private firms, in the event of growing competitive threat from the MNCs after the liberalization of the economy, had been concentrating their attention and resources to build up their technological competence, but the true features of a thriving technology regime were yet to become decisive in the Indian context.

It is worth remembering what Dutz and Dahlman (2007) observed - that since the 1991 liberalization, the private sector invested the most in R&D in the sectors most open to competition. Enterprise R&D spending as a share of sales increased more than sevenfold between 1991 and 2004. However, domestic innovation efforts, R&D spending, and diffusion and absorption efforts remain low largely because competition pressures - although strengthening - are not sufficiently widespread throughout the economy.

A distinctive aspect of industrial activity, in the context of increasing global competition, is R&D. The prime inputs to this are the financial and human resources and these serve as the best indicators of the commitment of the industry to innovation. In industries, R&D is essential for rendering know-how necessary for production of quality products, ensuring efficiency, exports, and technological self-reliance needed in the country. This is also essential for absorption, adaptation, and upgradation of imported know-how, which helps in solving the day-to-day production problems and for exploring the potential for future industrial expansion.

Implications, Limitations of the Study, and Directions for Further Research

After liberalization of the Indian economy, the scope for exports increased and widened, and at the same time, import of technology and knowledge has become easier for the manufacturing firms to pursue. This has serious implications for the technology regime of the economy, since it weighs much as how and to what extent the technological innovation is geared towards its external sector. The technology-intensive exports of the economy are very much influenced by R&D undertaken by the public sector.

Due to dearth of time-series data for the spending on R&D by the private sector of the economy during the pre- and post- liberalization periods of the economy, the present study was confined to the spending on R&D by the public sector and its impact on technology intensive exports of the economy in a macroeconomic perspective of the Indian economy.

Future research needs to be engineered by incorporating the impact of spending on R&D by the Indian manufacturing firms on their exports of technology intensive goods in the pre- and post-liberalization periods. This would provide a reorientation of how and to what extent liberalization of the economy had ushered in invoking the changes, if at all, in the technology regime of the country.

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