PUBLIC POLICY AND EXPENDITURE ON R&D IN INDUSTRY

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Public sector R and D in India has recorded a negative growth since 1991. Although there has been an increase in private sector investment in R and D, this cannot completely arrest the impact of the withdrawal of public investment and will result in a weakening of India's competitive strength in a rapidly globalising market.

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Knowledge and information technology have virtually reduced the world to a global village. Innovative investment is the key dynamic force behind this change in the global economy. However, a large proportion of investment in innovations has been concentrated in western countries, mainly by multinational firms. The survival strategy of multinational firms solely depends upon the exploitation of innovations and securing a competitive advantage in international markets. It is widely recognised that innovations originate in western countries but have been adopted in less developed countries to enhance efficiency levels in several leading sectors. However, adaptations and transfer of technology is not without cost. The governments and private firms of less developed countries have been allocating scarce resources to update technologies not only to provide quality products to consumers but also to build competitive advantage for the future. The R and D expenditure incurred even to adapt or master existing technologies has been recognised as a first step towards innovation. The recent success in reverse engineering in strategic technologies in the newly industrialising countries is ample proof. Multinational firms, whose innovative investment is largely commercially-oriented, have taken it as a threat to their monopoly power to innovate and exploit in the international markets, and have framed intellectual property laws. Multinational firms' operations in international markets and the establishment of subsidiaries in several less developed countries without the help of local firms. has permitted them to exploit the innovations on a much larger scale than before.

This development, which also has secured monopoly rights from WTO, can have far-reaching effects on innovative investment in less developed countries. This paper attempts to examine the impact of global changes on the rate, structure and spread of industrial R and D expenditure in India. The paper covers the period 1976 to 1997 and is divided into four sections. The extent of internationalisation of technology is examined in Section I. Section II examines the growth and structure of R and D expenditure in the industrial sector. Interstate disparities in R and D expenditure are analysed in Section III. Conclusions and policy implications have been presented in the final section.

I

The recent explosion of information technology has vastly reduced the cost, time and space in communication among the economic agents of production. This revolution of communication technology has generated new waves of dynamism. Information technology created opportunities for the expansion of economic activities beyond the boundaries of national economies. This process of increasing economic integration and growing interdependence among nations is widely known as globalisation. The term techno-globalism has been used to describe the process of generation, transmission and diffusion of technologies, a process now increasingly international in scope. The term originated with the media but the academic world adopted it quickly and started exploring it in the early 1990s [OECD 1992; Freeman and Hagedoorn 1992]. Historically, national economies have been associated with the international economy in numerous ways. The most prominent among these are technology, trade and investment. Thus, techno-globalism is one part of the ongoing process of globalisation process.

Globalisation has been seen as panacea for all the ills of the developed economies in general and national innovations in particular. The growing body of economic literature suggests that technological activities are becoming international in scope. Archibugi and Michie (1997) have successfully drawn an analytical distinction between three different processes – global exploitation of technology, global technological collaboration and global generation of technology – which were subsumed in literature under the term techno-globalism. Traditionally, firms have been exploiting technology to expand their business in the international market; recently, however, the pace has increased manifold. The empirical evidence presented by the authors on the increase in hi-tech exports and patents secured by firms in foreign markets clearly shows the international exploitation of innovations. However, there are wide variations across countries. For instance, Japan has been expanding its business at the highest rate among the G-7 countries, and the countries at the periphery of technological competition are being courted in a big way. The phenomenon of global technological collaboration has been noticed very recently and data collected in the 1980s reported 4,629 technology cooperation agreements among advanced countries. Disaggregation analysis reveals that European firms are cooperating more with US-based firms because of the larger technological capabilities offered by the latter. Multinational firms are the key players in technology generation, accounting for 75 per cent of all industrial R and D in the OECD countries. Therefore, the extent of decentralisation of R and D and other inventive activities of MNCs can reveal the location of global generation of technology. In this context, the most handy indicator is the patent controlled by foreign firms. The evidence cited by the authors on foreign-controlled patenting is very low for major OECD countries such as the US and Japan. This indicates that global generation of innovation is far from satisfactory. Innovation activities of MNCs are largely confined to their home countries. Collaborations take place only in

those countries where they can learn and enhance their capabilities if the host country is weak. Archibugi and Michie have stressed that innovation capabilities are nation-specific and increasingly diversified, and that international operations of large firms are exploiting and perpetuating this diversity. To create empirical evidence and determine the location of innovations, Patel (1997) has examined the patented innovations of 59 of the world's largest enterprises. According to this study, MNCs tended to be loyal to their home-base country when they have to locate a strategic asset such as technology. However, Cantwell (1997) does not agree with Patel's findings and is of the opinion that the share of innovations generated by firms in host countries has increased considerably. Empirical literature on global generation of technology for OECD countries is not conclusive. However, the global exploitation of technology by increasing the size of the market and acquiring economies of scale is without dispute.

To reap the benefits of techno-globalisation, the Indian government dismantled external and internal controls beginning July 1991. Consequently, the flow of MNC investment has increased and has also undergone a dramatic change. In the pre-reform period, MNCs collaborated with domestic industry to advance into the wider market. However, the emphasis has shifted in the post-reform period from technical collaboration to foreign direct investment. The number of average annual foreign technical collaboration agreements increased from 661 in 1991 to 982 in 1995 and declined to 595 in 1998, but foreign direct investment approvals have increased from 289 in 1991 to 1,191 in 1998. During this eight-year period trends have reversed because the equity-participation policy has attracted foreign direct investment from MNCs rather than collaborations [*Economic Survey 2000*; Kumar 1998]. Foreign technology flows have increased remarkably as is indicated from the increase in the intensity of foreign patents (Table 1). Foreign patent intensity (that is, the ratio of foreign patents to domestic patents) has increased from 1.65 in 1975-76 to 3.25 in 1995-96. All this leads us to conclude that foreign flows of technology have substantially increased. Yet, due to lack of availability of information, it is difficult to ascertain whether the MNCs are also locating their innovation bases in the country. However, the present phase of globalisation is liberally allowing foreign technology to exploit the vast and pent-up demand of the Indian middle class.

II

India's economic reforms are now a decade old, and their impact is now visible in various sectors of the economy. Dismantling of domestic control on industry and integrating it with the outside world throws up both opportunities and challenges. However, industrial growth has shown signs of instability. Economic reforms, initiated in 1991, were based on the presumption that domestic liberalisation and internationalisation of industry would enable it to perform better through allocating resources more efficiently as well as increase its competitiveness in the international market. It needs to be noted here that when Indian industry was exposed to international competition, technological revolution in generic technology was the mainstay of competitiveness. However, high productivity and hi-tech based industrialisation in developed

Table 4: Changes in Industrial R and D Intensity

Year	R and D-Sales Turnover Ratio		
	Total Industrial Sector	Public Sector	Private Sector
1976-77	0.67	0.64	0.71
1980-81	0.77	0.72	0.83
1985-86	0.63	0.56	0.70
1990-91	0.52	0.45	0.61
1997-98	0.49	0.30	0.64

Source: Estimated from the data collected from DST, *Research and Development in Indian Industry* (various issues), New Delhi.

Table 1: Trends in Domestic and Foreign Patents

Year	Patent Application Field		Foreign/Domestic Patent Ratio	Number of Patents Scaled		Foreign Domestic Patent Ratio
	Domestic	Foreign		Domestic	Foreign	
1975-76	1129	1867	1.65	426	1894	4.45
1980-81	1159	1795	1.55	349	670	1.92
1985-86	999	2506	2.51	451	1500	3.33
1990-91	1180	2584	2.19	379	1112	2.93
1993-94	1266	2603	2.06	442	1304	2.95
1995-96	1545	15021	3.25	-	-	-
	1.75	8.04	4.60			

Source: Government of India, DST, *Research and Development Statistics* (various issues).

Table 2: Trend of Growth Rates of Industrial R and D Expenditure
(at 1981-82 prices)

Year Sector	Total Industrial R and D Expenditure	Public Sector Industrial R and D Expenditure	Private Sector Industrial R and D Expenditure
1976-77 to 1997-98	8.61	5.93	9.93
1976-77 to 1990-91	10.29	11.06	9.70
1991-92 to 1997-98	6.68	-7.08	13.25

Source: Estimated from the data collected from DST, *Research and Development in Indian Industry* (various issues), New Delhi.

Table 3: Changes in the Pattern of Industrial R and D Expenditure
(at 1981-82 prices, Rs crore)

Year	Total Industrial R and D Expenditure	Public Sector Industrial R and D Expenditure	Private Sector Industrial R and D Expenditure
1976-77	122.55	48.54	74.01
	(100)	(39.61)	(60.39)
1980-81	212.12	96.16	115.96
	(100)	(45.33)	(54.67)
1985-86	324.49	143.17	181.32
	(100)	(44.12)	(55.88)
1990-91	510.12	219.24	290.88
	(100)	(42.98)	(57.02)
1997-98	785.37	156.57	628.80
	(100)	(19.94)	(80.06)

Source: Estimated from the data collected from DST, *Research and Development in Indian Industry* (various issues), New Delhi.

countries and more so by multinational enterprises, is the fundamental source of comparative advantage in international markets. This secured comparative advantage is based on massive innovative investment, which not only continuously expanded frontiers of knowledge and technology but also reduced the comparative advantage less developed countries had in terms of a low wage rate. Thus, competing in international markets and securing a comparative competitive advantage requires developing technological capabilities both in terms of increasing innovative investment and human resource development through imparting new skills and upgrading existing ones. Indeed, it was expected that after initiating economic reforms there would be a huge effort both by the government and private agents of production to increase the quantum of innovative efforts and push industry towards frontier technologies to secure a competitive advantage in new areas of production. It is important to note here that the theoretical and empirical literature on technological progress clearly shows that even in the process of globalisation, technology development and capabilities essentially reside within the national boundaries. Therefore, it is expected that there will be a marked increase in indigenous R and D efforts crucial for the successful implementation of economic reforms. In this section an attempt has been made to examine the extent of indigenous industrial R and D investment during 1976-97. Also, comparative analysis of pre- and post-reform R and D expenditure is made.

India has a low R and D spending. In 1996-97, R and D expenditure was Rs 8,340.17 crore, or 0.66 per cent of the gross national product. Of this, industrial sector R and D expenditure was Rs 2,333.01 crore, or 28 per cent of the total. Interestingly, the industrial sector contributes 25 per cent of the gross national product but accounts for 28 per cent of the total R and D expenditure, implying a disproportionate emphasis on this sector. However, it is important to analyse the impact of the changes in economic policy on the extent and composition of industrial R and D expenditure.

In contrast to the public sector, industrial R and D expenditure in the private sector has grown at a faster rate and is higher compared with the overall industrial R and D expenditure at 9.93 per cent per annum during the period under study. Sub-period rates of industrial R and D expenditure growth have a reflection on the post-reform trends. Therefore, we have estimated sub-period growth rates of R and D expenditure, and that too at a sectoral level. The overall industrial R and D expenditure grew by 10.29 per cent per annum from 1976-77 to 1990-91, which is the pre-reform period. However, real industrial R and D expenditure in the post-reform period has grown by 6.68 per cent from 1991-92 to 1997-98. This clearly shows that deceleration in industrial R and D expenditure has occurred in the post-reform period. A comparison of the sub-period growth rate in private and public sector industrial R and D expenditure shows that the latter grew at a higher rate (11.06 per cent per annum) compared with the former (9.70 per cent per annum) during 1976-77 to 1990-91. However, not only have trends been reversed in the post-reform period but private sector industrial R and D expenditure has since grown at 13.25 per cent, which is higher than that in the pre-reform period. It is significant to note here that in the post-reform period, public sector industrial R and D expenditure recorded a negative growth rate of 7.08 per cent per annum. This clearly reflects the impact of macroeconomic policies of reduction in fiscal deficit, public investment and decay of public institutions for want of funds. Deceleration of industrial R and D expenditure growth, despite its increase in the private sector exposes the weaknesses of private sector industrial R and D investment, which do not even neutralise the reduction of R and D investment by the government. Thus the private sector alone will not be able to face the onslaught of global competition pressure and will certainly weaken domestic productive agents.

A breakdown of industrial R and D expenditure from 1976-77 to 1997-98, through which the changing pattern of industrial R and D expenditure can be examined, is presented in Table 3. It shows that industrial R and D expenditure has posted a steady increase from Rs 122.55 crore in 1976-77 to Rs 785.37 crore in 1997-98. Public sector share rose from Rs 48.54 crore in 1976-77 to Rs 219.24 crore in 1990-91, and decreased substantially to Rs 156.57 crore in 1997-98. The relative share of public sector industrial R and D expenditure, which was 39.61 per cent in 1976-77 increased to 45.33 per cent in 1980-81. It fell slightly but remained high, that is, at 44.12 per cent in 1985-86 and 42.98 per cent in 1990-91. It is important to note here that in the post-reform period the public sector's share dwindled to 19.94 per cent. In contrast, private sector industrial R and D expenditure in the post-reform period has improved substantially.

The absolute rise in industrial R and D expenditure is not sufficient to draw a conclusion about the trend and direction of innovative efforts. Therefore in Table 4 we have estimated the R and D expenditure-sales turnover ratio, which is a rough indicator of R and D intensity. The R and D intensity of the overall industrial sector in 1976-77 was 0.67, which increased to 0.77 in 1980-81. Thereafter, it started declining. The R and D intensity fell from 0.52

in 1990-91 – the pre-reform period – to 0.49 in 1996-97. However, public sector R and D intensity declined substantially during this period to a low of 0.30. Private sector industrial R and D intensity increased from 0.71 to 0.83 during 1976-77 to 1980-81. It declined thereafter from 0.70 in 1985-86 to 0.61 in 1990-91. A comparison of private sector industrial R and D intensity within the pre- and post-reform period shows that it has remained almost constant. Although private sector industrial R and D has gone up both in absolute terms and in its growth rate compared from that in the pre-reform period, the R and D intensity has not shown a significant improvement. This remarkable finding of the study with respect to private sector R and D intensity is close to earlier studies on R and D intensity [Goldar and Ranganathan 1998-99].

To examine the structure and direction of R and D expenditure in the industrial sector, we have estimated its relative share and industrywise growth rates in Table 5. This includes the growth rates, both for the overall period and sub-periods, for the 18 industries that spent 1 per cent or more of the total industrial R and D expenditure in 1976. Seven industries (fuels, commercial office and household equipment, rubber goods, machine tools, metallurgical industries, drugs and pharmaceuticals, and defence industries) recorded growth rates of 10-14 per cent per annum during 1976-1994 and together account for 28.75 per cent of the total industrial R and D expenditure in 1976. Five industries (electrical and electronics, textiles, chemicals, telecommunications and fertilisers) recorded growth rates of 5-10 per cent per annum and accounted for 33.42 per cent of total industrial R and D in 1976. Soaps, cosmetics and toiletries, agricultural machinery, dyestuffs, industrial machinery, and cement and gypsum recorded growth rates of 2-5 per cent. The paper and pulp industry recorded a negative growth rate of 2.25 per cent per annum during 1976-1994. The low share and slow rate of growth of R and D clearly shows rising disparities in acquiring innovative or adaptation capabilities in technologies. However, four industries had a meagre share of R and D expenditure in 1976 but recorded higher rates of growth afterwards. A comparison of pre- and post-reform R and D growth rates shows that a larger number of industries suffered a deceleration in the rate of growth. Only four industries, namely, dyestuffs, soaps, cosmetics and toiletries, textiles and fuels achieved a marked increase in growth in the post-reform period. Two industries, agricultural machinery and paper and pulp, recorded negative rates of growth both in the pre- and post-reform period, but the declining trend has slowed in the post-reform period. A perusal of the table and analysis clearly indicates that innovative investment in the industrial sector after the reforms has been pushed to the background. Furthermore, the R and D intensity has gone down during the post-reform period. This indicates that innovative investment efforts have suffered and must consequently have reduced the competitive capabilities of industries in a fiercely competitive world.

Table 5: Industrywise Growth Rate in Industrial R and D Expenditure
(at 1981-82 prices)

Name of Industry	Relative Share in 1976 (Per Cent)	Growth Rate Per Annum			
		1976-77 to 1994-95	1976-77 to 1982-83	1983-84 to 1990-91	1991-92 to 1994-95
Electrical and electronics	16.26	9.22	19.22	4.07	-4.06
Chemicals	14.70	6.75	5.93	7.60	6.55
Defence industries	12.18	10.14	9.59	13.99	8.18
Drugs and pharmaceuticals	9.64	10.18	9.28	10.36	9.66
Telecommunications	7.18	5.87	7.82	4.88	4.73
Metallurgical industries	4.51	10.66	23.0	6.22	2.43
Fertilisers	3.43	5.11	4.37	9.01	3.82
Dyestuffs	2.64	2.93	-6.82	1.49	5.85
Cement and gypsum	2.62	2.06	-2.42	3.22	2.93
Soaps, cosmetics and toiletries	2.27	4.98	10.67	1.36	3.91
Industrial machinery	2.26	2.09	22.31	6.87	5.74
Rubber goods	1.87	11.87	10.48	12.89	10.87
Textiles	1.85	7.66	26.06	0.88	2.70
Fuels	1.35	13.94	23.10	5.95	7.79
Agricultural machinery	1.31	3.31	13.26	-3.22	-2.03
Machine tools	1.20	11.18	12.37	13.16	8.75
Commercial office and household equipment	1.16	13.70	-1.01	14.70	14.04
Paper and pulp	1.11	-2.28	9.63	-9.12	-4.41

Source: Batalvi, P (2000).

Table 6: Growth Rate of Industrial R and D Expenditure across States
(at 1981-82 prices)

State	1976-96	1981-90	1991-96	Relative Share	
				1996	1976
Andhra Pradesh	10.11	2.87	1.10	7.72	7.96
Bihar	7.04	2.28	-16.94	1.64	5.61
Gujarat	8.44	5.35	14.66	7.51	8.03
Haryana	10.91	10.15	3.51	4.63	4.04
Kerala	7.96	8.65	6.86	3.48	1.30
Karnataka	9.71	11.39	-9.26	10.26	23.24
Madhya Pradesh	9.58	3.80	13.26	0.71	2.71
Maharashtra	14.65	9.23	11.55	35.63	32.03
Orissa	7.42	0.87	-20.76	0.20	0.85
Punjab	10.31	17.92	26.86	4.22	0.18
Rajasthan	16.33	7.11	7.11	1.05	0.02
Tamil Nadu	9.36	9.03	8.53	8.56	5.08
Uttar Pradesh	11.64	5.39	-0.90	4.08	2.18
West Bengal	5.82	7.56	-4.16	2.22	5.91

Source: Government of India, DST, *Research and Development in Industry* (various issues).

III

India's economic growth in the post-reform period shows dynamism in some states and retardation in others. Modern economic growth is technology-driven. Thus, it would be expected that research and development efforts must have been stepped up in the regions/states that have shown economic dynamism. The relative shares of R and D expenditure and growth trends across states and over time are given in Table 6. The analysis is confined to 14 major states that incurred 99 per cent of the total industrial R and D expenditure in 1976. However, there is a reduction in the concentration of R and D expenditure, thereafter, across states. In 1996, 14 states accounted for 92 per cent of the total Indian industrial R and D expenditure. In

1976, Maharashtra accounted for 32.03 per cent of the total industrial R and D expenditure; this share rose to 36 per cent in 1996. Not only is Maharashtra's share of industrial R and D expenditure higher, it has also recorded a substantially higher growth of 14.65 per cent per annum during 1976-77 to 1996-97. Karnataka's share has gone down from 23.24 per cent in 1976 to 10.26 per cent in 1996. These two states together accounted for more than 55 per cent of the total industrial R and D expenditure in 1976. However, this concentration came down to 45 per cent in 1996. Maharashtra's R and D growth is higher in the post-reform period, which is contrary to Karnataka's experience. The relative share of R and D expenditure has risen in Tamil Nadu, Uttar Pradesh, Kerala, Haryana and Rajasthan. However, Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh, Orissa and West Bengal have shown a relative decline between 1976 and 1996. The relative position of Punjab has improved from 0.18 per cent in 1976 to 4.22 per cent in 1996. However, its relative share has remained quite low throughout and was as low as 0.83 per cent in 1995. It is difficult to ascertain why Punjab's share jumped suddenly, and that too in the public sector. A comparison of growth rates during 1981-90 and 1991-96 (pre- and post-reform periods) shows that Bihar, Karnataka, Orissa, West Bengal and Uttar Pradesh witnessed negative trends in the post-reform period. Growth has also decelerated in four other states, namely, Andhra Pradesh, Haryana, Kerala and Tamil Nadu. Industrial R and D expenditure growth accelerated significantly in Gujarat and Madhya Pradesh. However, Rajasthan's figures show a constant trend. Deceleration has thus occurred in all but three of the important states.

IV

India's four decades of development experience in general and technological development in particular were essentially planned for self-reliance. Sustained efforts were made to establish institutions for technology capability development. This attempt was essentially led by government initiatives. However, the private sector was also encouraged to participate. The role of science and its applications for substitution during scarcity of natural resources and enhancement of new opportunities has been recognised in technology policy resolutions. Availability of foreign technological assistance has also been supplemented to enhance domestic technology capabilities. Despite the import substitution strategy that remained in operation till July 1991, the gap of technology and productivity widened compared with that in industrial countries. Since technology was regarded as public good, larger efforts to develop technologies essentially remained public. Towards the last quarter of the 20th century two significant developments took place. One, there has been a shift in technology development efforts. Nearly 75 per cent of the commercially-oriented innovative expenditure was incurred by MNCs, propelling international institutional arrangements to protect technologies developed through private efforts. Second, adaptations of technologies by newly industrialising countries such as South Korea and successful reverse engineering by them has been taken by the MNCs as a threat to their monopoly position in technology. This has led the WTO to declare intellectual property rights and not only allowed the exploitation of technology on a global scale but has also imposed restrictions on public funding of research and development [Mani 1991].

India adopted a liberalised industrial and technology policy in July 1991 backed by the structural adjustment programme of the World Bank and International Monetary Fund. Policy controls have been dismantled and tariff walls have been scaled down. The government has been essentially engaged in fiscal-deficit control. This has led to the reduction in government R and D expenditure and institutions engaged in technology capability development are decaying for want of funds. The impact of changes in industrial and technology policy on industrial R and D expenditure is visibly negative and deceleration in industrial R and D investment has occurred across the board. Private industrial R and D expenditure has accelerated investment efforts, yet it has remained incapable of arresting the deceleration caused by the public sector decline in R and D. The reversal of deceleration requires massive efforts and a proactive role by the government which is difficult as well as costly, yet involves substantial future welfare gains. EPW

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