GOVERNMENT INTERVENTION IN INDUSTRIAL R&D SOME LESSONS FROM THE INTERNATIONAL EXPERIENCE FOR INDIA

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August 1997

This paper is a part of the project titled, **Models of Organising Industrial R&D** funded by the Japan Foundation-Asia Centre, Tokyo. Thanks are due to Jennifer Sue Bond of the National Science Foundation of USA for making available various data on industrial R&D in Asian countries. Sanjaya Lall provided active encouragement to work out the ideas. I am also grateful to K K Subrahmanian, Rakesh Basant, K P Kannan and participants of a seminar at the Centre for providing critical comments on an earlier draft. The usual disclaimer holds.

ABSTRACT

There is now substantial empirical evidence, based essentially on the experience of developed countries, that there is underinvestment in industrial R&D consequent to the gradual withdrawal of the state. It is generally observed that government can solve this problem of underinvestment in two ways: by increasing the profits of innovators, or by undertaking R&D in areas where the private sector underinvests. An examination of the nature of government intervention in developed countries show that it is increasingly moving towards the latter variety. However, contrary to normal impression, the extent of government intervention in industrial R&D in India is of the former variety. The state has been using tax incentives as the major instrument for stimulating R&D by production enterprises. Direct grants, which has become the dominant instrument of intervention in the west, is considered to be better as it can be targeted towards specific projects. In fact the efficacy of tax incentives to encourage R&D requires further scrutiny. The state in India also have to intervene for making available technically trained manpower to engage in industrial R&D radically redesigning the higher education system, by improving the incentive system for those working in the R&D system etc. The paper thus underscores the fact that there is enough space for the Indian state to increase its interventionist role in industrial research contrary to the arguments for its gradual withdrawal.

JEL Classification: O32, O38

Key Words: appropriability, government intervention, industrial R&D system, technology policy.

Introduction

As part of the general theme of reducing the role of government from various activities, though not stated very explicitly, a view is that government should intervene less in the area of technology generation: the focus of attention should be on in-house R&D centres attached to business enterprises. But it is a rather well established proposition in economic theory, and backed by a number of case studies, that firms are unable to capture the full benefits of their investments in R&D. Two reasons are adduced. First, competitors can learn something from the results and appropriate part of the reward. Second, in highly competitive markets for technology-intensive products, the rewards to innovation are very short-lived since they are rapidly transferred to consumers in the form of reduced prices. In the absence of proper compensating mechanisms industrial firms therefore tend to underinvest in R&D. There is already evidence for it from the OECD countries in the sense that the industrial R&D expenditures has been flagging or showing negative rates of growth[1] . This has once again brought into focus the positive role of government in promoting industrial R&D and innovation.

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1 See Guinet and Kamata (1996), pp. 22-25.

India has been undergoing a phase of economic liberalisation since 1991 the basic rationale of which has been to reduce the role of government from various spheres of economic activity. It is in this context that we see the deregulation of the industrial and the external sectors, privatisation of public sector enterprises etc., Under the prevailing mood of *rolling back the state,* it is felt, though not stated explicitly, that the government should intervene less in the area of technology generation and its subsequent development. This has manifested itself in the form of the country not having an explicit policy statement on technology[2] in keeping with the changes in the external environment. A second manifestation is the policy that increasingly the government research institutes will have to generate a larger proportion of its budget from external sources other than the government.

The basic theme analysed in this paper is to understand the precise role to be played by government in promoting technology generation. The focus is not on government itself conducting the R&D but rather on the specific instruments or modes through which it can provide an enabling environment for the private sector to do research. In keeping with this objective, I first examine the rationale for state intervention in industrial R&D and illustrates this with the current debates on the theme in developed countries as in most developed countries there is now a move towards having a national technology or a public innovation policy. In the light of this examination, the lessons that India can draw from the former experience are mapped out. The paper thus concludes with making some informed comments towards framing a policy for the local development of technology in the Indian industrial establishment.

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2 The last Technology Policy Statement was announced in 1983.

The Rationale for and Approaches to Government Intervention in R&D

An important feature of the innovation systems in the West is the declining rates of growth in Industrial R&D expenditures. See Figure 1. In the US the rate of growth of the industrial R&D expenditures started declining since the mid 1980s while in the case of the EU, the decline set in from about 1987 or so.

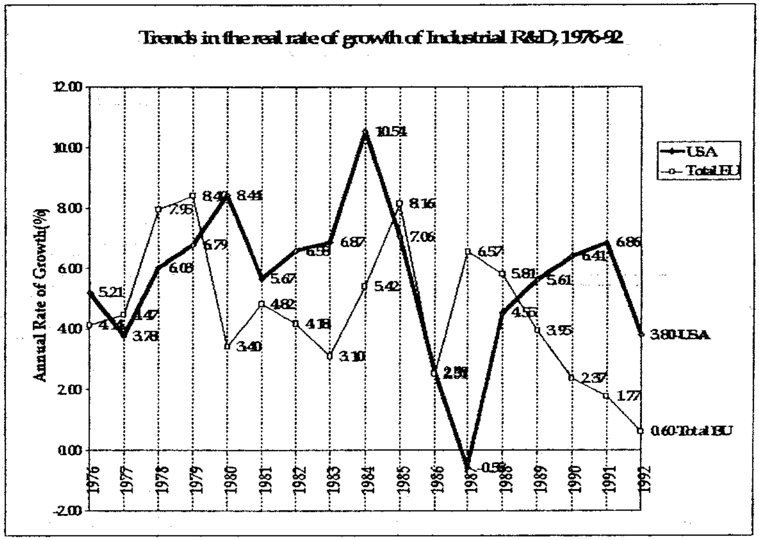

Figure 1

Along with this declining rate of growth , one also observes the gradual withdrawal of the state from financing of industrial R&D. See Table 1.

Table 1: Extent of Government Intervention in the Financing of Industrial R&D in the US, Japan and the UK (per cent)

Year	USA		Japan		UK	
	State	Industry	State	Industry	State	Industry
1970	43	57	1	99	32	63
1980	32	68	2	98	30	61
1988	33	67	2	98	33	67

Source: National Science Foundation (1991), p.23

The US case is particularly interesting[3] . Growth in total US R&D expenditures[4] has been slow since the mid-1980s. From 1980 to 1985, R&D spending increased on average by **6.6 percent** per year in real terms. From 1985 to 1996, by preliminary calculations, it slowed to **1.4 percent**, in comparison to a 2.6 annual real growth in GDP. The NSF(1996a) attributes this slow down to a slackening in both Federal and non-federal support for R&D, as a proportion of GDP, though Federal support has been declining at a faster rate than non-federal support. Consequently, the 4-percent rise in real R&D during 1995 was much more the exception than the rule. From 1985 to 1996, the proportion of GDP spent on R&D has fallen consistently, from 2.8 percent to 2.5 percent (based on current projections). The Japanese case is very interesting. Government in the country has only a limited role in financing industrial R&D (Table 1) almost the entire expenditure is expended by

3 This data contained in this section is based on NSF (1996).

4 In the USA, industrial R&D accounts for over 52 per cent of the overall R&D expenditute. See NSF (1993), p. 107.

the private sector itself[5]. According to the estimates by OECD (1996a) the average annual rate of growth of R&D expenditures in the business enterprise sector declined to 7.4 per cent during the period 1985-1989 from 11.2 percent during 1981-85. Thus it is found that the withdrawal of the state from industrial R&D is accompanied by a progressive decline in its growth rate.

Even in the advanced capitalist economies there is an explicit recognition of the need for government intervention to correct for possible underinvestment by the private sector. The most commonly cited argument favouring government intervention is due to the problem of appropriability. A formal statement of this argument is to be found in Arrow (1962). This problem arises because there are certain kinds of industrial research where the new findings are difficult to be kept as secrets either because know-how leaks easily and patent protection is ineffective[6]. The knowledge that is acquired in the absence of a market transaction is commonly referred to as an R&D spillover. The studies by Reinganum (1981) and Spence (1984) formally showed that, as R&D spillovers in a given industry increase, the incentive to undertake R&D diminishes. The empirical evidence on the R&D spillovers is scant, and

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5 This issue of apparently low government intervention in industrial R&D requires some explanation. Government has ofcourse intervened by placing restrictions on technology imports and by poroviding financial incentives, tax credits, and low-interest loans, to encourage technological accumulastion. See Odagiri and Goto (1996).. Another explanation is interms of the **almighty role** assigned to MITI. See Fransman (1995), pp. 95-119. However as argued below (on pp.8-9), the government in Japan is showing very clear signs of wanting to increase its role in promoting industrial R&D.

6 The rationale for patenting is simple: in effect it grants patent-holders a monopoly and allows them to reap higher profits than they would in a competitive market. The prospect of such monopoly profits is what encourages firms to innovate in the first place. But empirical research into the effectiveness of patents across the US and Western Europe shows that it is the least effective means of appropriability. See Mansfield (1986), and Habib (1994).

only a few studies have estimated their effects with any rigour[7]. The most cited study is by Mansfield and others (1977). They calculated the divergence between social and private returns for seventeen innovations and found that the median social return was twice as large as the private return. Using US data Bernstein and Nadiri (1988) also reached similar conclusions when they found that the excess of social return over private return varied from as low as 9 per cent for machinery to a high of 76 per cent in petroleum product industries. Estimates on returns to R&D for developing countries are practically non-existent. The study by Basant and Fikkert (1993) is an important exception. Their estimates, based a sample of firms in the Indian manufacturing sector, range from 19 to 80 per cent.

The argument for government intervention in civil industrial R&D has manifested itself in the form of what is increasingly termed as ***public innovation policies***. There is now an active debate both in the US and in the UK calling for policies for government intervention in technology generation. In the UK the debate is led by Stoneman (1993) who argues for some of government intervention to stimulate civil industrial R&D.

Though much of the industrial R&D in the west is performed and financed by the private sector, there are various instruments or modes through which governments have intervened to prevent possible underinvestment. I first provide a summary of these various measures and then go on to discuss them in some depth. The purpose of the survey is to draw some lessons, on the basis of this, for an appropriate technology policy for India. See Table 2.

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7 For a brief review of the literature on returns to R&D, see Evenson and Westphal (1994), pp. 55-57.

Table 2: Alternate Policies and Instruments for Government Intervention in Civil Industrial R&D

Types of Measures	Financial Measures	Non-financial Measures
Public provision of goods and services	* Subsidising exchange of R&D personnel between public and	* Bridging institutions for exchaning aand sharing knowledge. * Dffusion Policies * Education and training; * University and government R&D; * Management of the public sector.
Modification of market incentives	* Tax incentives for R&D * Direct funding through grants, soft loans, loan guarantees for R & D projects; * Joint or co-operative R&D projects between government and the private sector.	* Public procurement particularly in defence * The IPR regime * Competition policy for R & D projects; * Foreign trade and investment policy.
Support of the improvement of market mechanism	* Creation or improvement of specialised financial market mechanisms (e.g. venture capital)	* Risk sharing

Source: Stoneman (1993) Guinet and Kamata (1996).

It will now be instructive to find out which of these innovation policy tools are the most common. For discussing this I rely on a survey of innovation policy tools contained in Folster (1988) and reported again Folster (1991). I restrict the presentation of Folster's results, to three developed countries, namely the US, U.K., and Japan. See Table 3.

Table 3: Analysis of Policy Recommendations by Type of Tool, in Per cent of Country Total

Policy Measures	**US**	**U.K.**	**Japan**
1. Subsidies and tax credits to firms	23	25	7
2. Education	15	19	7
3. University and government R&D	18	12	38
4. Management of the public sector	19	31	33
5. Laws and regulations	16	3	4
6. Foreign trade policy	9	10	9

Note: These percentages are arrived at by counting the number of policy recommendations in a number of public innovation policy statements since 1987.

Source: Folster (1991), p. 23.

The comparison shows a clear difference between Japan and the other two countries. Subsidies and tax incentives are an important component of the innovation policy in bo th the US and in the U.K. On the contrary, the extent of government intervention in Japan is the least[8]. In most of the developed world the preoccupation with laws and regulations as innovation policy tools seems to be diminishing in favour of subsidies and trade policy[9]. Following Folster (1991), the subsidy instruments can be divided into two broad categories: general and selective while selective subsidies are further subdivided into self-financing and non self-financing. See Chart 1.

Chart 1.

Subsidy Instrument

General Subsidies

1. Tax deduction for R &D purposes;
2. Tax deduction for a rise in R & D expenses
3. Personnel grant towards costs of R &D personnal

Selective Subsidies

Non Self- fiancing

1. Project grants;
2.Project laons at subsidised interest rates;
3. Conditional loans and loan guarantess

Self-financing Subsidies

1. Fee-based loan guarantees,
2. Royalty grants
3. Stock option gants;
4. Convertible loans;
5. Equity invetments

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8 This scenario, I believe is slowly changing. For instance, in 1992, Japan's basic policy for Science and Technology called for a doubling of the government's R&D budget as soon as possible. If such an expansion in the budget is achieved, annual government R&D investment would be around $ 18 billion in the year 2000, approximately double the 1992 budget in constant yen. See NSF (1997) for more details. Further, the Japanese government has enacted a law called ***Japan's Basic Law for Science and Technology (Law No. 130)*** which came into force on November 15, 1995 to provide more state support to the conduct and organisation of especially industrial R&D. The Article 17 of the Law states that, "in consideration of the importance of the role played by the private sector in S&T activities in Japan, the nation should implement necessary policy measures to promote private sector R&D by encouraging initiatives in the private sector". However whether the necessary policy measures include further financial subsidies needs to be researched into. In compliance with the Law's requirement that the government establish a "Basic Plan for Science and Technology," the Prime Minister tasked the Council for Science and Technology on December 29, 1995 to develop a proposal for a Basic Plan.

9 For an excellent survey of technology policy in developed countries, see Mowery (1994), pp. 7-55.

The chart can be simplified into *three* main categories of support (OECD, 1996):

* **Direct financing measures to support R&D activities of manufacturing enterprises:** This support is given through a variety of investments like direct grants, tax concessions, loans and loan guarantees, equity capital etc.;

* **Civilian and defence-related R&D contracts awarded to manufacturing enterprises:** In most of the countries much of the contracts are defence related. Civilian R&D contracts focus on energy and information technology. The rules governing the appropriation of intellectual property rights that result from such contractual research vary widely. In some countries, these rights are attributed to the public contractor while in others to the contracting firm. Contracting firms may derive a sizeable competitive advantage from the appropriation of intellectual property rights; and

* **Support to intermediary R&D institutions serving the enterprise sector**: The services covered by these institutions cover a broad range of technological fields and include testing, secondment of R&D staff to manufacturing enterprises, training, consulting, and R&D co-operation with firms. Although these institutions are reported to price their services at market rates to cover costs, contributions from government appear to play a regular and important role in balancing their budgets.

A recent survey by the OECD (1996b) has for the first time quantified in an exhaustive manner the entire gamut of public support to manufacturing R&D by the major public players in national R&D systems of the OECD countries. Data are reported according to the above-mentioned three categories. See Figure 2 for the type-wise trends in the public support.

R&D contracts signify the most important component but however it has been nearly stagnating. The direct support to R&D is the next important segment and it has been growing at a rate of nearly 9 per cent per annum: the decline in 1993 is perhaps due to reporting gaps[10]. All

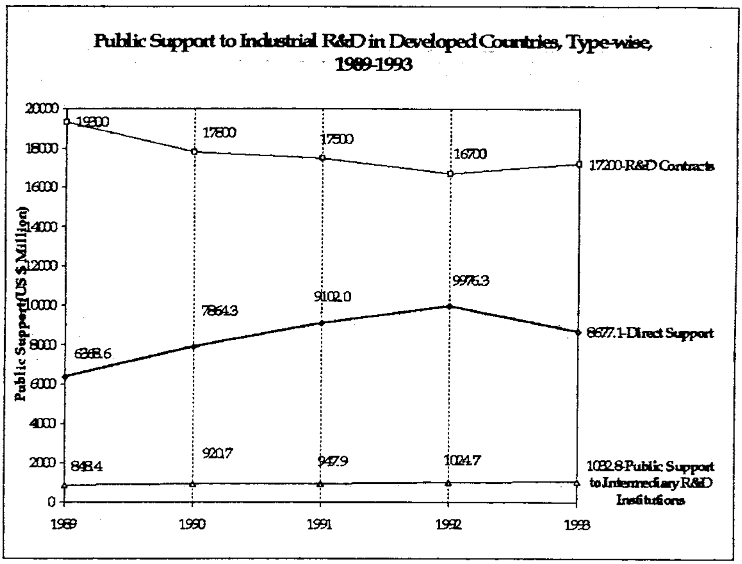

Figure 2

10 See OECD (1996b), p. 27.

the three put together account for as much as 15 per cent (approximately) of the total industrial R&D budget of the region. Since direct support to R&D is the one that is relevant for our discussion I now present the details on it. See Table 4.

Table 4 : Direct Support to R&D and Technological Innovation Programmes in the Developed Countries-Financing Instrument-wise (Current Million $)

Financing Instrument	1989	1990	1991	1992	1993
Grant	2709.2(42.5)	3590.0(45.6)	4144.4(45.5)	5334.5(53.5)	5079.8(58.5)
Tax Concessions	2251.8(35.4)	2468.2(31.4)	2825.4(31.0)	1973.0(19.8)	1716.9(19.8)
Loan	79.4(1.2)	99.5(1.3)	152.5(1.70	454.8(4.6)	80.2(0.9)
Guarantee	Nil	Nil	Nil	Nil	Nil
Equity Capital	Nil	Nil	Nil	Nil	Nil
Mixed	1297.8(20.4)	1655.1(21.0)	1863.4(20.5)	2074.4(20.8)	1655.1(19.1)
Unclassified	30.3(0.5)	51.4(0.7)	116.0(1.3)	139.4(1.4)	144.8(1.7)

Note: Figures in parentheses indicate percentage share of the total

Source: OECD (1996), p. 28

Among the direct support mechanisms, grant appear to be the most dominant form. Moreover it has also increased its share rather significantly. Tax concessions, while the second most important, has eroded its share by nearly one-half. This disenchantment as if it were with tax concessions warrants a closer look. This is because increasingly developing countries such as India are showing signs of replacing direct support to R&D with that of indirect subsidies like tax concessions. I am interested in two dimensions of this subsidy, namely the specific form it has taken in various countries and second examining the empirical evidence on its efficacy as a tool for stimulating investments in R&D by private sector firms.

i. Nature of Tax Incentives

The aim of a tax incentive is essentially to make investment in R&D less costly to the firm and at the same time increase post-tax profitability by offering tax relief on R&D expenditure. The joint effect should be greater investment in R&D (Stoneman, 1993). Many countries have used this instrument. In most countries the R&D tax credit allows a firm to reduce its tax liability by an amount that is proportional to the increase in its R&D expenditures(relative to a base period). Thus R&D tax credit tends to increase the firm's R&D because it reduces the price of R&D[11]. According to Mansfield (1985) besides this benefit, tax credit may also have an effect via the change in cash flow. A recent survey of the tax treatment of R&D expenditure in twenty developed and developing countries[12] (KPMG, 1994) is presented in Table 5.

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11 A formal proof for this is available in Mansfield(1985), pp. 403-7.

12 The twenty countries are Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong, Ireland, Italy, Japan, Korea, Netherlands, Singapore, South Africa, Spain, Switzerland, Taiwan, UK, and US.

Table 5: Percentage Share of the Number of Countries Offering Tax Deductions on R&D Expenditure

Nature of the deduction	Availability of tax deduction for revenue base R & D expenditre	Availability of tax deduction for capital expenditure on fixed assets linked to R & D
* The entirety of the expenditure	85%	90%
* art of the expenditure		
* An amount greater than the expenditure	5%	0%
If deduction is available, is that deduction available	10%	10%
* in the first year	55%	10%
* in the period 1-3 years	0%	30%
* in the period 1-5 years	20%	40%
* in a period greater than five years	0%	20%
* at the taxpayer's discretion	45%	0%

Source: KPMG (1994), pp. 1-2.

The following inferences can be drawn from the study:

1. Majority of the countries covered in the sample allow almost the entire revenue and capital expenditure expended on R&D to be deducted from the taxable income during a year;

2. In fact in some 10 per cent of the number of countries an amount even greater than what is spent is allowed to be deducted[13] ; and

3. Much of the revenue expenditure deductions are admissible in the first year itself while much of the capital expenditure deductions are admissible in the first five years.

An interesting finding of the survey is that it was in only 60 per cent of the countries that the concepts of Research or Development is defined for tax purposes. This means that it is possible for companies in some of the countries[14] in the sample to claim tax concessions for activities which may not necessarily qualify as R&D like for instance quality control and testing, market research etc.,. Finally in a majority of the countries granting capital expenditure deductions, it is possible to capitalise intangible intellectual property rights for the purposes of these deductions.

The tax incentive schemes of the countries vary in its exact nature or characteristics. Australia has got one of the most liberal schemes while at the other extreme is Japan and the US. See Table 6.

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13 The countries are Australia, Singapore and Belgium.

14 The countries are Belgium, China, France, Italy, Netherlands, South Africa, Switzerland and the UK.

Table 6: Characteristics of the Tax Incentive Schemes for R&D Expenditure in Australia, Japan and the US

Characteristics	Australia	Japan	USA
1. Year of Introduction	1985	1967	1981
2. Nature of tax-deduction	The companies which spend A$ 20,000 or more on qualified R & D are allowed to deduct 150% of that amount from their taxable income	The companies rece-ive a tax-credit equal to 20% of the incre-ase in qualified R&D over the highest previous year's R&D expenditre, upto a maximum of 10% of the company's taxabilites.	Until July 1, 1995, companies received a tax-credit equal to 20% of the increase in qualified R&D over a defined base amount (average of the 1984-88 period Thereare provisions for carrying forward credits not used in the current fiscal year
3. Special Features	R&D must involve appreciable novelty or technical risk, results should be exploited in Austra-lia, and there should be high Australian content	There are special incentive for small and medium-sized businesses, for expenditures on special R& D activi-ties and the acquisi-tion of facilities for basic research	Start-up companies that do not yet have tax-liabilities are offered a special tax-credit if they spend tax-credit if they spend more than 3% of their turnover on R&D

Source: Guinet and Kamata (1996), p. 24

ii. Effectiveness of Tax Incentives

The flagging or negative growth of business R&D expenditures in most of the developed countries has once again brought to the fore the efficacy of fiscal measures in general and tax-incentives in particular to promote innovation. As seen earlier the main aim of tax incentives is to prevent private sector enterprises from possible underinvestment in industrial R&D by reducing the cost of doing it. Needless to add the percentage reduction in R&D cost brought by a given nominal rate of tax credit or concession will depend on the rate of corporation tax and usually it will also vary from firm to firm. Guinet and Kamata (1996) adduces several reasons for this. Firstly, many firms may not have sufficient taxable income to offset against the tax-credit. A second source of complication arises with incremental tax-credit mechanisms as the real impact of tax credit on any firm's total R&D costs will depend on how the base for calculating the eligible increase in R&D expenditures is defined and on sector-specific factors influencing the pace of R&D growth. An empirical study[15] of this issue based on the American experience found that on an average the effective rate of tax credit was about five times below its nominal rate of 20%; and the benefits from the incremental tax-credit scheme varied considerably across industries and firms.

From the point of view of policy makers the most important question to be answered is how the firms respond to tax-induced change in R&D cost. There are two methodologies for empirically testing this proposition. The first technique employ the simple survey method of essentially questioning senior R&D managers about their response to changes in the tax incentive system. The second technique employs econometric techniques to estimate *the price elasticity of R&D*- the percentage increase in R&D induced by a percentage fall in its cost.

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15 The details of the study by Hall, B, " R&D tax policy during the 1980s: Success or Failure", **Tax Policy and the Economy,** 1993, pp. 1-35 are quoted in Guinet and Kamata (1996), p. 23.

The most important study employing the first technique is by E. Mansfield (1985). His study was based on a survey of firms in the US, Sweden and Canada. The main conclusion of the study was that "R&D tax credits and allowances appear to have had only a modest effect on R&D expenditures". In each of the countries R&D tax incentives increased R&D expenditures by not more than 1 or 2 percent. Second in all these countries the increased R&D expenditures due to the tax incentives seem to be substantially less than the revenue lost by the government. This is best captured by the ratio of tax-incentive-induced increase in R&D spending to the foregone government revenue and this ratio raged from 0.3 to 0.4 in all the three countries. Mansfield thus concluded that R&D tax incentives *in their present form* are unlikely to have a major impact on the rate of innovation. However Mansfield's study is contested by Branscomb (1985) who argues that the question should only be posed at a specific industry level. For instance he says that R&D expenditures of some industries such as the IT industry increased even during a phase when there were significant reductions in the sales revenue of the industry due to the existence of the facility. He also felt that to dismiss the tax credits as inconsequential on the basis of a study of the data for the first three years of its operation was premature as the firms were just beginning to understand the usefulness of it. Second, the limited impact of the tax credit could also be attributed to the low corporate profits, taxable income and hence the ability to employ it during the period under question. So the survey technique which Mansfield employed is now increasingly discarded.

There are now atleast three studies econometrically estimating the price elasticity of R&D, once again based on the US experience. The first one is by Bernstein and Nadiri (1989) who estimated a relatively low price elasticity of 0.40 implying less than proportionate growth in

R&D expenditure as cost went down. But more recent studies[16] estimated the price elasticity to be around unity implying an almost proportionate increase in R&D in response to a reduction in the cost of doing it.

There are some well known problems of cheating by firms to obtain tax credits. This cheating manifests itself by *relabeling* some routine expenses as R&D expenditure. Mansfield's survey found this on a substantial scale in the case of Canadian firms. On the contrary an official study by the Government Accounting Office of the US found that relabeling though exists is only on a small scale. But this problem is likely to be more acute in developing countries where the propensity to cheat is rather high for understandable reasons.

Thus the evidence on the efficacy of tax-incentives is rather mixed. The main weakness of this form of incentive is that it is very blunt (Stoneman, 1993) as it is very difficult to direct it at specific projects or industries. In fact as the US case has shown that only some firms and industries may actually benefit from it. However it is still preferred to a direct government subsidy especially in a phase of economic liberalisation. This is due to a number of reasons: (1) They involve less interference in the market and thus allow private sector decision-makers to retain autonomy in devising their R&D strategies in response to market signals; and (2) Tax-incentives are easier to administer and are less discretionary compared to direct project subsidies often granted on a case-by-case basis. Project grants are also less predictable as they are subject to yearly budget allocations. (3) Given that there is a link between R&D and productivity and if tax incentives raises R&D spending by firms, it can lead to more efficient use of resources at the firm-level. But nevertheless, as indicated in Table 4, the popularity of tax concessions

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16 See Hines (1993) ; and Baily and Lawrence (1987).

as an instrument of public support to R&D is very much on the wane, especially in developed countries.

The Indian Experience

The purpose of this section is to map out the main features of the industrial R&D system in the country and the lessons that India can draw from the experience of the developed countries interms of promoting industrial research in the country. It is sometimes felt, especially in official circles, that with the so called globalisation of technology and with the country removing restrictions on firms from importing technology from abroad it may not be that essential to strengthen the country's research system[17]. This is an extremely fallacious argument. That there is no empirical evidence for globalisation of technology, implying large scale decentralisation of R&D activities by MNCs to developing countries, has been established by a study by Patel and Pavitt (1995). Second, even if firms want to unpack the technologies which they have imported from abroad and develop local capabilities they ought to be investing in in-house R&D activities.

Industrial R&D system in the country consists of the Government Research Institutes or GRIs (most of whom come under the purview of the Council for Scientific and Industrial Research [CSIR]) and in-house R&D centres in productive enterprises in both the public and private sectors. Some limited amount of research also goes on at the Universities and at the Indian Institutes of Technology. The planned form of industrial development which the country subscribed to almost religiously from the early 1950s up to the early 1990s has growth with technological

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17 The scientists and engineers in the country has been lulled into a feeling of complacency that "we shall not reinvent the wheel". The ambivalent government policies are to be blamed for this state of affairs rather than to the alleged machinations of some external forces such as the MNCs.

self-reliance as one of its main planks. This has undergone some changes with the gradual liberalisation of the industrial sector since 1991. The subscription to the dirigistic ideology meant that the government has intervened in the R&D system rather heavily. This intervention manifests itself in two explicit forms: (1) government itself financing and performing R&D through GRIs; and (2) government encouraging productive enterprise in the productive sector to perform R&D by granting them a host of fiscal concessions. A third but less explicit form of government intervention is in the area of providing the infrastructure for industrial research. A main component of this infrastructure is the provision of trained manpower(of scientists and engineers) from the higher education system which is almost entirely government-owned.

Some Stylised Facts about Industrial R&D in India

First of all India devotes only about 0.8 percent of GDP on overall R&D efforts while Japan spends about 2.9 percent and Korea about 1.9 percent. Secondly industrial research in India accounts for only 4 per cent of what Japan spends and little over a third of what Korea expends. In fact until recently India used to spend even three times the Korean expenditure in the period up to the early 1980s. See Table 7.

Table 7: Industrial Research in India, Korea and Japan, 1975-1990 (R&D expenditure is in constant 1987 PPP$ and growth rates are in percent)

Year	Japan	G Gate	S. Kores	G. Rate	India	G. Gate	Ratio of India to Japan	Ratio of India to Japan
1975	11263		NA	NA	327	NA	0.03	NA
1976	11738	4.22	94	NA	365	11.62	0.03	3.88
1977	12358	5.28	222	136.17	413	13.15	0.03	1.86
1978	12890	4.30	234	5.41	551	33.41	0.04	2.35
1979	14553	12.90	215	-8.12	597	8.35	0.04	2.78
1980	16525	13.55	238	10.70	670	12.23	0.04	2.82
1981	18505	11.98	302	26.89	747	11.49	0.04	2.47
1982	20208	9.20	482	59.60	872	16.73	0.04	1.81
1983	22651	12.09	839	74.07	930	6.65	0.04	1.11
1984	25203	11.27	1156	37.78	947	1.83	0.04	0.82
1985	28708	13.91	1550	34.08	983	3.80	0.03	0.63
1986	29084	1.31	2051	32.32	1079	9.77	0.04	0.53
1987	30984	6.53	2372	15.65	1128	4.54	0.04	0.48
1988	34241	10.51	2988	25.97	1304	15.60	0.04	0.44
1989	38448	12.29	3491	16.83	1444	10.74	0.04	0.41
1990	42213	9.79	3733	6.93	1392	-3.60	0.03	0.37
Average		9.28		33.88		10.42	0.04	1.52

Source: National Science Foundation (1993), pp. 112-113

Thirdly, Industrial R&D accounts for only less than a quarter of the overall national R&D in India while a lion' share of the national R&D in other Asian countries such as Japan and South Korea is devoted to Industrial R&D. In fact Korea is one country which has systematically raised its share of Industrial R&D. See Figure 3. As far as the Indian data are concerned there can be some underestimation as a part of the R&D expenditure incurred by the Departments of Space, Defence Production and Atomic Energy has important civilian spillovers though there aren't any systematic estimation of the extent of such spillovers to the industry. This is thus an area for further research.

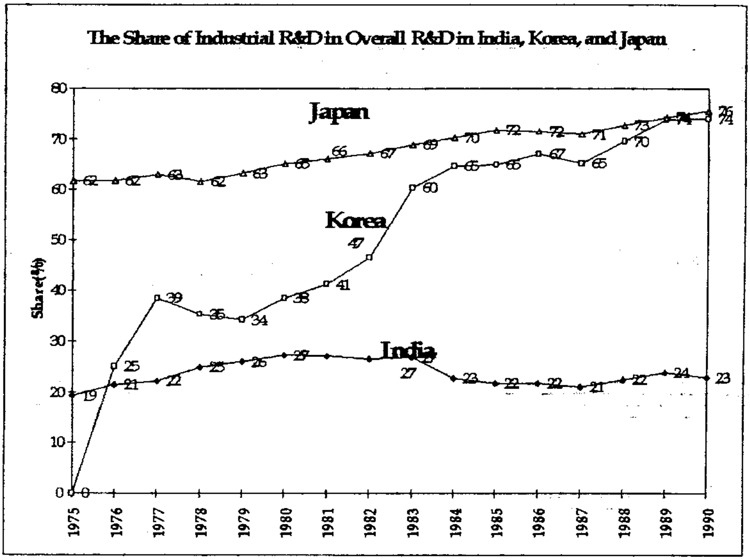

Figure 3

Fourthly, contrary to the normal belief the extent of government intervention[18] in performing R&D in the industrial sector is only about 59 per cent. See Table 8.

18 This is measured as the share of the Government (GRIs + Public Sector Enterprises) R&D spending expressed as a percentage share of overall industrial R&D.

Needless to add my measure of the extent of government intervention captures only the direct intervention by the state . If one adds the indirect intervention measures the actual intervention is likely to be higher. But the main problem is the quantification of these measures.

Fifthly, as a corollary of the above much of the industrial R&D in the country is actually done by in-house R&D centres in both the public and private sector industry. This is best indicated by the ratio of R&D spending by the GRIs to that of the production enterprises. See Figure 4.

Table 8: Extent of Government Intervention in Industrial R&D in India (Rs in Crores at Current Prices)

Year	Production Enterprises		GRI's	Govern-ment	Extent of Government Intervention(%)
	Public	Private			
1978-79	551.90	58.80	440.35	992.25	56.67
1979-80	734.10	921.50	591.90	1326.00	59.00
1980-81	853.65	1206.91	690.0	1543.65	56.12
1981-82	1075.53	1470.00	787.70	1863.23	55.90
1982-83	1224.63	1669.54	1140.84	2365.47	58.62
1983-84	1616.55	1763.24	1241.86	2858.41	61.85
1984-85	2357.55	2010.67	1464.83	3822.38	65.53
1986-87	2357.00	2698.00	1723.35	4080.35	60.20
1987-88	2884.70	2870.40	1851.29	4735.99	62.26
1988-89	3421.20	4068.60	2093.28	5514.48	57.54
1989-90	4129.00	4779.50	2395.21	6524.21	57.72
1990-91	4145.30	4564.80	2491.89	6637.19	59.25
1991-92	4843.90	5248.60	2745.50	7589.40	59.12
1992-93	5867.10	6498.90	2962.90	8830.00	57.60
Average Rate of growth(%)	**20.54**	**17.19**	**16.27**	**18.64**	

Notes: 1. GRIs = Government Research Institutes which are essentially the CSIR Laboratories;
2. State here means GRIs + Public Sector Enterprises;
Source: Government of India (Various Issues).

Sixthly, even in production enterprises investments in R&D accounts for only a small fraction of the investments in new plant and machinery. This shows that Indian firms pay very little attention to the domestic development of disembodied technology. Rather they prefer the easier route of technology imports from abroad. See Figure 5.

Seventhly, the ratio of R&D investments to advertising has significantly come down since the mid 1980s. See Figure 6. This means that firms have tended to give relatively more importance to product differentiation than to making real technological improvements.

Eighthly, very little of the output of the research results of GRIs are actually commercialised in the industry (Mani, 1996). This is indicated by the low earnings ratio of the CSIR labs. The ratio is defined as the share of the income generated by sale of technology to the industry , by way of royalty, sales premia etc., in the total budget of these labs. See Figure 7.

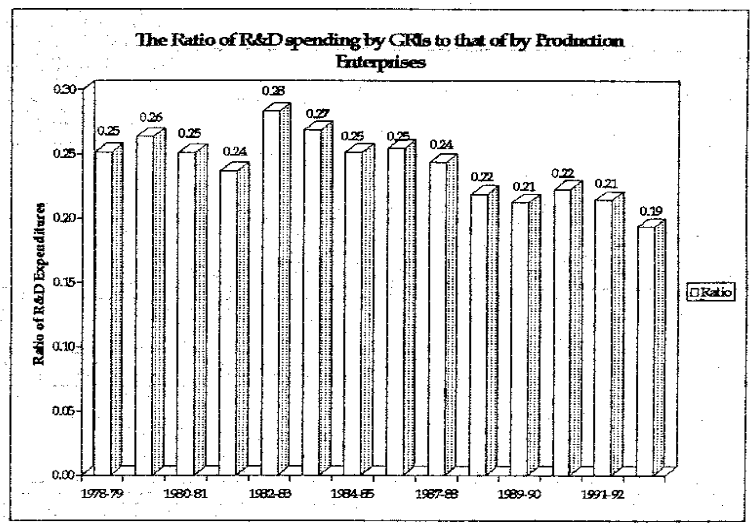

Figure 4

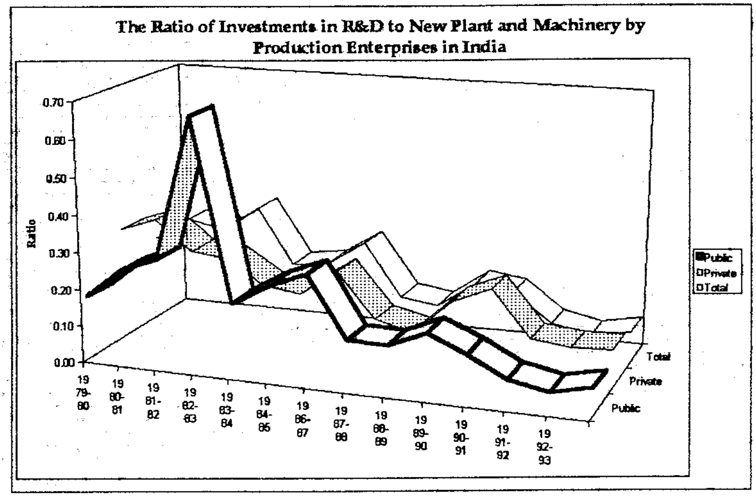

Figure 5

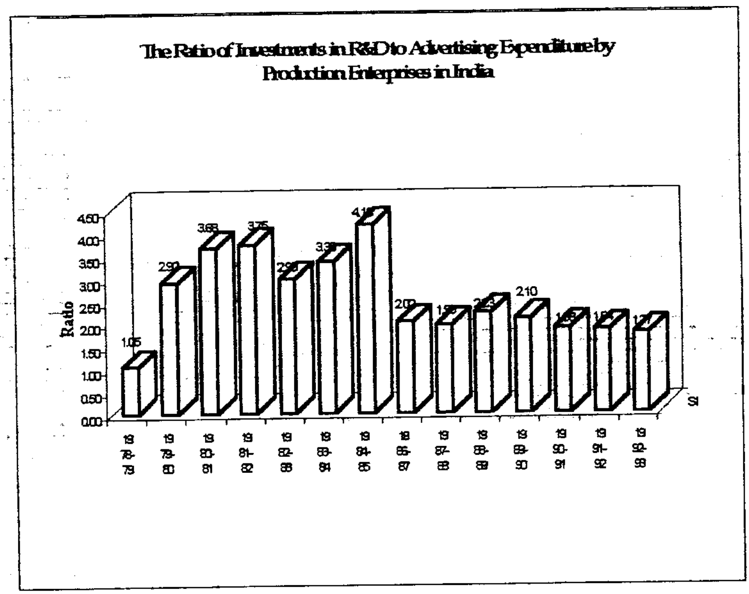

Figure 6

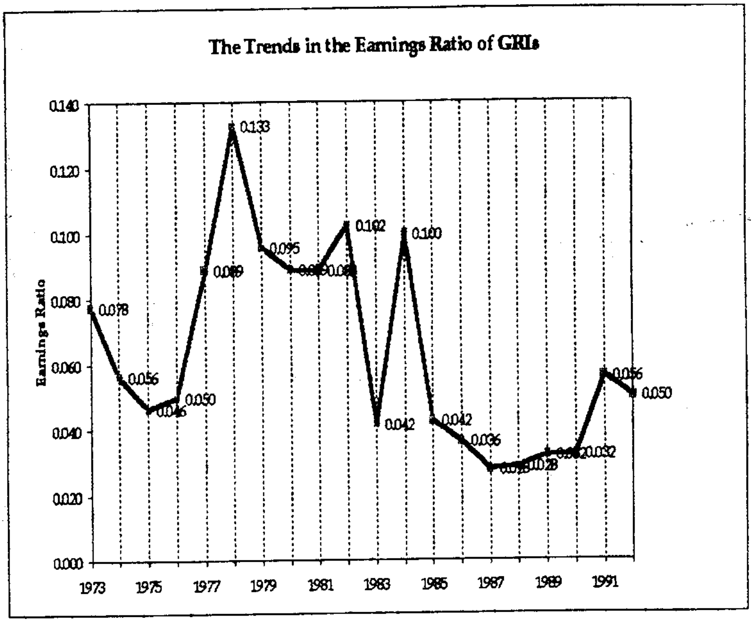

Figure 7

Finally, in terms of the output of R&D, measured by the number of patents published by Indians in India, it is the private sector industry which accounts for a larger share of about 37 percent of all patents published in India. The share of the state sector consisting of the GRIs[19] and public sector enterprises is only about 24 percent and much of it is contributed by the GRIs. This means that industrial research accounted for nearly two thirds of the total number of patents published by Indians in the country. See Table 9.

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19 It should however be added that when the GRIs were established they were not expected to or encouraged to file patents. But this scenario has changed. Infact the strategic plan prepared for the CSIR up to the year 2001 states explicitly, that the system should (a) hold a patent bank of 5000 foreign patents (up from 50). (b) realise 10% pf operational expenditure from intellectual property licensing etc., See CSIR (1996), p. 4.

Table 9: Distribution of Industrial Patents Published in India by the State and Private Sector Industry , 1974-75 through 1991-92 (Number)

Fiscal year End-ing	Industrial patents publi-shed by Govt.	Industrial patents published by private sector	Total Indus-trial patents	All Patents	Share of Govt.(%) in indus-tiral patents	Share of private sector (%) in indus-trial patents
1975	135	139	274	477	49.27	50.73
1976	119	142	261	446	45.59	54.41
1977	110	202	312	705	35.26	64.74
1978	215	200	415	757	51.81	48.19
1979	152	172	324	553	46.91	53.09
1980	71	183	254	477	27.95	72.05
1981	83	115	198	327	41.92	58.08
1982	77	141	218	408	35.32	64.68
1983	110	191	301	452	36.54	63.46
1984	61	136	197	335	30.96	69.04
1985	216	245	461	709	46.85	53.15
1986	63	178	241	445	26.14	73.86
1987	102	203	305	488	33.44	66.56
1988	194	284	478	692	40.59	59.41
1989	103	344	447	543	23.04	76.96
1990	100	93	193	337	51.81	48.19
1991	136	156	292	472	46.58	53.42
1992	921	38	230	365	40.00	60.00

Source: National Science and Technology Management Information System. (1994), p. 42

In sum, industrial research though accounting for only about a quarter of the total national R&D expenditure does account for very nearly two-thirds of the output of R&D in terms of the number of patents published. Within the Indian industrial R&D system, the state sector accounts for nearly 59 percent of the total expenditure but its share in the output of R&D is lower (39 per cent) than that of the private sector industry. It is against this background that I discuss the incentives given for promoting industrial research in India. Analytically speaking one could divide the incentives into two: fiscal and non-fiscal. Fiscal incentives include tax credits, project grants etc., while non-fiscal incentives consists essentially of the supply of human resource for industrial research. I discuss each of them seriatim.

Fiscal Incentives for Industrial Research in India

The history of the fiscal incentives for industrial research in India can be traced to 1973. From that year onwards, the practise of recognising in-house R&D centres(by the Ministry of Science and Technology) was initiated. The recognised R&D centres are entitled to a host of fiscal incentives. This is summarised in Table 10.

Table 10 :A Summary of Fiscal Incentives for Recognised Industrial Research in India

Nature of Fiscal Incentives	Scope
1. Tax incentives-	
* Direct tax exemptions	* Under Sections 35(1 and 2) of the Income Tax Act, both *revenue and capital expenditure* on scientific research incurred by the in-house R&D unit on activities related to the business of the company is allowed to be *fully (100%)* deducted from the

	taxable income for that year. As per the Union Budget for 1997-98, the deduction for *capital expenditure* has been raised to *125%* for a specified set of industries such as *drugs and pharmaceuticals, electronic equipment, telecom equipment* etc.,
* Indirect tax exemptions	* Under Section 80-1A of the Income Tax Act a five year tax holiday has been allowed to companies created exclusively for participation in R&D activities. * All recognised scientific and industrial research organisations are eligible for exemption on customs duty on the import of scientific equipment, instruments, spares, accessories as well as consumables for research and development activities and programmes; * Full exemption from customs duty on plans, designs and drawings; * Goods developed and patented in India and concurrently in specified countries have been exempted from levy of excise duty for a period of *three* years.
2. Weighted tax deduction for sponsored research	* A weighted tax deduction of 125% of the financial contribution made by industry on R&D projects and programmes sponsored by industry in approved national labs, Universities, Indian Institutes of Technologies etc.
3. Investment allowance on plant and machinery set up based on indigenous technology	* This allowance at an enhanced rate is under section 32 A (2B) of the Income Tax Act, 1961. The Secretary, Department of Scientific and industrial Research is the prescribed authority for certifying the investments made on plant and machinery based on technology. This incentive is more to generate commercialisable technologies rather than to do mere R&D which may not result in any saleable technologies.
4. Depreciation allowance on plant and machinery established	* This is a system whereby accelerated depreciation in respect of blocks of assets. The rate structure is

on the basis of indigenous technology.		rationalised by reducing the number of rates as also by providing for depreciation at higher rates.
5. Incentives for GRIs:		
Matching grant for modernisation of GRIs	*	The Union Budget for 1996-97 initiated this scheme and in the budget for 1997-98 this is made permanent.
GRIs are allowed to invest in the equity of private sector enterprises	*	The GRIs are allowed to capitalise their know-how sales to private sector firms thereby getting a better return to their investments.

Source: DSIR (1989), pp. 98-102., DSIR (1995-96), pp. 55-58.
Government of India (1995-96)

Thus direct tax incentives are the most dominant type. But there have been no studies so far on its effectiveness. A simple but unsophisticated way of measuring its effectiveness is to trace the trends in the real rate of growth of in-house R&D expenditures in production enterprises. A major limitation is the non-availability of data during the pre-introduction period(i.e., pre 1973). Data are available only since 1977-78-five years after the introduction of the incentive scheme. A second limitation is the very sharp increase in the rate of growth in 1980-81. In order to overcome its effects I have plotted the real rate of growth including that year(GR-1) and excluding the year (GR-2). See Figure 7. If one goes by GR-2, it is seen that the real R&D expenditure has only shown rather violent fluctuations[20] implying thereby that the incentives have not been successful in continually raising the real rate of growth (though, as indicated in Table 8, in nominal terms the expenditure has shown continuous increases). See Figure 8.

20 The violent fluctuations in R&D expenditure may also be caused by problems in reporting. In order to take care of this problem I have plotted the rate of growth of average R&D expenditure per production enterprise. This series also showed violent fluctuations.

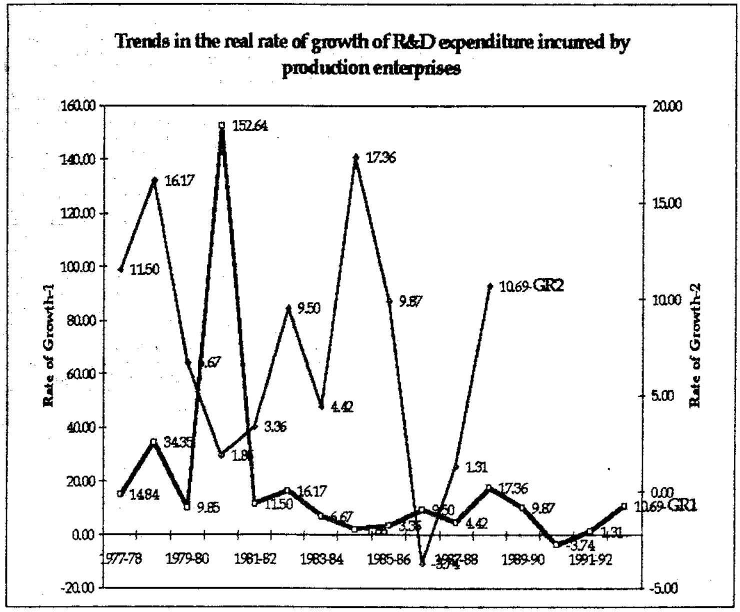

Figure 8

Finally as indicated above, in order to reap the incentives the production enterprises, in both the public and private sectors, have resorted to *relabeling.* This is because there are no mechanisms or arrangements either within the Department of Scientific and Industrial Research (DSIR) or within the Central Board of Direct Taxes (CBDT) to audit the R&D expenditures[21] purported to have been incurred by an enterprise during a year. This increases the propensity to relabel[22]. In

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21 A recent amendment to the Companies Act requires firms with recognised in-house R&D Centres to disclose not only the expenditure on R&D but also the output interms of new products and processes developed in the firm's annual report for the year. To mention this in the report, the items will have to be audited by the duly appointed charted accountants.

22 In fact the tax incentives to in-house R&D centres were as high as 133.33 per cent during the 1980s. It is the realisation of this growing tendency to relabeling that has reduced it to a 100 percent setoff.

the light of these comments a comprehensive study on the efficacy of direct tax incentives to stimulate in-house R&D by the production enterprises is warranted.

The Table (table 10) does not discuss any direct grant given for conducting industrial R&D. In the early 1980s the central government promoted mission oriented R&D approach in two high technology areas, namely in telecom and in advanced computing. This was institutionalised by establishing two research organisations, the Centre for Development of Telematics (C-Dot) focusing on the former area and the Centre for Development of Advanced Computing (C-Dac) in the latter area. Both of them had innovative organisational structures liberal funding and had to develop and commercialise certain well defined key technologies within a definite time frame . The C-Dot which was charged with the responsibility of developing a family of digital electronic switching systems was initially very successful. But extreme political interference in its functioning has virtually sounded its death knell[23] . The C-Dac has been equally successful in developing parallel processing technology in advanced computing. But todate there have been no independent evaluation of its functioning. A common element in both the organisations is that though they are exclusive R&D organisations set up outside the production system, the mission oriented approach ensured that they have a high degree of interaction with the production enterprises. Despite the availability of sufficient evidence on the utility of these types of R&D organisations, the government has not extended this to other areas of high technology.

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23 A detailed evaluation of the C-Dot experiment is available in Mani (1992), pp. 107-113.

Finally it was as late as in 1996-97[24] that the government introduced a scheme by which direct grant was made available to production enterprises to carry out research leading to commercialisation. Firms could get funding for specified projects after a competitive process. Known as the *Technology Development and Application Fund*, it is administered by the Technology Development Board functioning within the Department of Science and Technology. The origin of this fund could be traced to the R&D Cess Act of 1986 prescribing a levy of 5 per cent tax on all payments for import of disembodied technologies by production enterprises. The fund thus accumulated is to be used for establishing a venture capital scheme with one of the leading state-owned development banks in the country with the ultimate aim of providing risk capital to commercialise domestically developed technologies. It is seen (Mani, 1996) that the shame had not been successful in fulfilling these objectives and the growing realisation of this has led to its recasting.

In its first year of operation the fund was allotted Rs 300 million and it has granted assistance to 16 projects in health, chemicals and pharmaceutical industries. In the second year (i.e., 1997-98) a sum of Rs 700 million is allocated. The main weakness of the fund is in the nature of its funding: it depends crucially on two sources, namely the proceeds from the R&D Cess and budgetary allocations. With increased liberalisation of technology imports through the automatic route there may also not be reliable estimates of the R&D Cess. So it remains to be seen whether the government will have even accurate data on the quantum of R&D Cess to be collected in a year.

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24 The Technology Information, Forecasting and Assessment Council (TIFAC) has been for some time providing direct assistance to production enterprises for upscaling and commercialisation of indigenous technologies under its Home Grown Technology(HGT) programme. From current press reports not more than five projects have been supported under the programme. However from initial reports the programme is considered to be a success.

Thus as against the developed country pattern the role of direct grants for industrial research is only secondary.

Human Resource for Industrial Research

The country has an extensive university system which has increased in enrolments by a factor of 20 since 1947. Almost all the universities are owned and governed by the state. Traditionally speaking science and engineering has been given much importance essentially supported by massive governmental subsidies. This has ensured a steady supply of scientists and engineers. Despite this, the density of scientists and engineers engaged in R&D is one of the lowest compared even to other Asian countries. See Table 11.

Table 11: Density of Scientists and Engineers in R&D in India, South Korea, Japan, the US and the UK

(Scientists and engineers in Research and Development per 10, 000 of the labour force)

Year	India	S.Korea	Japan	USA	UK
1975	NA	7. 89	45.55	55.30	30.6
1980	2.45	12.49	53.10	60.00	35.8
1985	2.78	24.66	63.74	71.83	45.0
1990	3.34	37.22	74.21	74.50	45.6

Source: National Science Foundation (1993), p. 123

This shows that there is considerable scope for increasing the employment, given the vast reservoir of technically trained personnel available in the country.

A second point is about the oft repeated complaint of the industry of serious mismatches between the type of human resource available and the type of human resource required for carrying out especially applied research in frontier areas[25] . This is because the Indian higher education system has traditionally emphasised degrees in natural sciences to engineering. See Table 12. This emphasis on fields of natural science has resulted in the country's scientific strengths in high energy physics, plant biochemistry, solid state and inorganic chemistry, microelectronic materials, polymers and ceramics (NSF, 1987). In engineering there is significant variation in the quality of students. Those passing out from the Indian Institutes of Technology(IITs) are considered to be world class. But a large number of them go abroad immediately[26] . In fact according to a study by the National Science Board[27] about 76 per cent of the Indian doctoral recipients (in science and engineering streams) from US universities have plans to stay back in the US while about 58 percent of them have firm plans to remain in that country. This indicates the extent of brain drain from India and the process can seriously hamper supply of the right kind of personnel for industrial research. But no efforts have been made by the state to reverse this trend as the both the state and the domestic industry is very often unable to provide the right kind of environment for these highly discerning graduates.

25 The governments of both Taiwan and South Korea have expanded their investments in R&D to support research and training of scientists and engineers for their high technology industries like electronics.

26 According to one estimate (Maddox, 1984) the proportion of IIT graduates going abroad is as high as 80 per cent among computer science graduates.

27 The data refers to 1991. The corresponding figure for S Koreans are 37 and 23 percent. See National Science Board (1993), pp. 288-291.

Table 12: Ratio of Advanced Degree (Master's and Doctoral) Holders in Natural Science to those in Engineering in India, Japan, and S Korea

Year	India	Japan	S Korea
1975	13.80	0.24	NA
1976	12.18	0.27	0.69
1977	10.75	0.25	0.69
1978	9.48	0.22	0.61
1979	9.44	0.23	0.55
1980	9.74	0.25	0.49
1981	10.05	0.26	0.43
1982	10.37	0.25	0.39
1983	10.70	0.25	0.55
1984	11.04	0.23	0.54
1985	11.33	0.24	0.73
1986	8.55	0.22	0.58
1987	8.35	0.22	0.61
1988	8.86	0.22	0.33
1989	8.56	0.22	0.31
1990	8.69	0.22	0.34

Source: National Science Foundation (1993), pp. 84-85.

Summing up

In this paper I have mapped out the extent of government intervention and the nature of incentives given to civilian industrial R&D in a host of developed countries and in India. It is seen that, contrary to normal impression, the extent of government intervention in industrial R&D in India is not very high. The state has been using tax incentives as the major instrument for stimulating R&D by production enterprises. But in the developed countries direct grants are becoming the dominant instrument as it can be targeted towards specific projects. There are essentially two lessons which India can learn from the experiences of developed countries. Firstly, the interventions by the state in the technology market has to be very selective essentially to foster and develop technologies which are very strategic in nature. Secondly, their experience also supports the belief that national technology policy designed to give domestic firms a competitive edge has not become obsolete in a so called globalised world. On the contrary, economic policy debates in the west have devoted increasing attention to the design and implementation of policies to aid the growth of high-technology industries.

In fact the efficacy of tax incentives to encourage R&D requires further scrutiny. The state in India also have to intervene for making available technically trained manpower to engage in industrial R&D radically redesigning the higher education system, by improving the incentive system for those working in the R&D system etc. Thus there is enough space for the Indian state to increase its interventionist role in industrial research contrary to the arguments for its gradual withdrawal.

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