

**FINANCING DOMESTIC
TECHNOLOGY DEVELOPMENT
THROUGH THE VENTURE
CAPITAL ROUTE**

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Working Paper No 263

**Centre for Development Studies
Thiruvananthapuram
December 1995**

Financing Domestic Technology Development through the Venture Capital Route¹

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There is hardly any need to emphasize the crucial role played by technology in the economic growth of nations. Economists have identified three principal sources of economic growth namely enhanced capital, labour and technical progress (Boskin and Lau, 1992). Attempts have also been made with varying degrees of sophistication to quantitatively estimate the relative contributions of the three sources and, invariably, most of the attempts² confirm the significant role played by technology in the growth process.

Much of the industrial technology generation happens in the developed world. This fact can be substantiated by examining the absolute levels of R&D expenditures and its distribution across various countries. Just as the performance of R&D activities is heavily localized in the US the worldwide distribution of R&D performance is heavily concentrated in several industrialized nations. Although several developing countries have greatly expanded the level of national resources they devote to civilian research efforts, the overall financial impact of their efforts is small compared with those of the large industrialized countries. For example, estimated 1990 R&D expenditures in Singapore, Taiwan, South Korea, and India combined was about 10 percent of the US R&D total (National Science Board, 1993). Of the approximately \$350 billion in R&D expenditures estimated for OECD countries, 90 percent is expended in just seven.³ The above data thus substantiates the oft held view that technology generation and its subsequent development is mostly encountered in the advanced countries. Very recently it has been pointed out by a number of writers that there has been a tendency for *technology to globalize* (or *globalization of technology* as it is usually referred to) implying large scale decentralization of technology generation, especially by MNCs, in the developing countries (Cantwell 1992, Dunning 1992, Granstrand and Soljander 1992) during the 1980s. Consequent to this process, it is sometimes argued that developing countries need not necessarily invest in R&D activities as greater part of their technology requirements could be obtained from the process of diffusion of technologies generated by the R&D activities of MNCs in their host economies.

¹ This is the first draft of a chapter of Mani, Sunil and Lall, Sanjaya. *The Indian Industrial Technology System*, (forthcoming). Thanks are due to the participants of an internal seminar at CDS and to Professor Manimoy Sengupta for comments. Financial support from the Ford Foundation is gratefully acknowledged.

² These exercises have become known as growth accounting. For a new approach to this procedure see Boskin and Lau (1992), pp. 7-55.

³ Estimates are for 1990 in purchasing power parity exchange rates (PPP). See OECD (1993).



Patel and Pavitt (1995) has disproved this by examining the US patenting activities of 569 of the world's largest firms(based in 13 countries, and covering 17 product groups). Their analysis show that for an overwhelming majority of them technology production remains close to the home base. See Table 1.

Table 1
Geographic Location of Large firm's US Patenting Activities according to
Nationality, 1985-1990
(percentage shares)

Firm's Nationality	Home	Abroad
1. Japan (139)	99.0	1.00
2. USA (243)	92.2	7.80
3. Italy(7)	88.20	11.80
4. France (25)	85.70	14.30
5. Germany (42)	85.10	14.90
6. Finland (7)	82.00	18.00
7. Norway (3)	67.90	32.10
8. Canada (16)	67.00	33.00
9. Sweden (13)	60.80	39.20
10. UK (54)	57.90	42.10
11. Switzerland (8)	53.30	46.70
12. Netherlands (8)	42.20	57.80
13. Belgium (4)	37.20	62.80
All Firms (569)	89.10	10.90

Note: The prentthesis contains the number of firms based in each country.

Source: Patel and Pavitt (1995), p.37

Their analysis thus show that there is very little empirical support to the often held view that along with increases in foreign direct investments there has been an increasing trend towards globalization of technology. As a natural consequence most developing countries will therefore have to continue subscribing to a dependent path to its technological development often enough importing their technology requirements from abroad and adapting it to local conditions. In fact this relationship between the import of technology and indigenous investments in technology development has long been the subject of policy debate and concern in developing countries. It is evident that the two complement each other to a large extent, and also that in certain respects they can substitute for each other (Lall, S 1993). But it is an equally important requirement that for its successful assimilation and management, imported technology will have to be unpacked and its various dimensions carefully understood. For this developing countries should possess and foster institutions and support structures which facilitates this learning process. The experience of

the more dynamic economies of the developing world amply demonstrates this aspect. In the context references are usually made to the experiences of S.Korea and Taiwan who have, for instance, accumulated sufficient knowledge about previously imported technologies by putting in place the necessary institutions and support structures. Consequently these economies which were once characterised by an emphasis on low-cost labour, assembly type operations are now in the midst of a significant transformation and therefore have made substantial progress in increasing their self-reliance in several areas of technology, such as microelectronics.⁴

An important facet of discussions on economic policy directions in the 1990s is the pronounced trend towards reducing the role of government in all spheres of economic activity be it is in the production of goods and services or in technology. Specifically in the case of technology generation activities a reduced role is envisaged for the government is based on two arguments. First it is generally perceived that industrial innovations are driven primarily by *market pull* rather than *technology push*. While government scientists and engineers may be rather good at identifying new technical opportunities, they lack the experience and knowledge to assess market potential and user needs, with result that the typical government driven technological development frequently tends to be a technical success but a commercial failure. The British-French Concorde project is usually cited as the prototypical example of a spectacular technological achievement driven by government initiative which is proved to be a commercial disaster (Nelson, R.R 1984). Secondly there is an increasing impression that the international technology market is characterised by globalisation of the R&D process. Consequently the multinational enterprises which account for bulk of the R&D activities the world over are now in the process of decentralising their R&D activities away from their home countries (OECD 1992). It is therefore possible for at least some of those developing countries (especially those which attract large chunks of FDI) to secure their required technologies. Both these arguments are of course strongly contested on theoretical and empirical grounds as well. It is against this background of the changed role of government in technology generating activities that we attempt at an examination of the institutional support for such an activity in the Indian context. In keeping with these objectives the paper is structured into four sections. In the first section we attempt at defining some of the key concepts used, namely the concepts of domestic technology generation and its development and the role of institutional support in that process. The second section marshals the main arguments that are made out in favour of government support of this activity and also maps out the nature and extent of government intervention in domestic technology generation/development in a variety of countries. The third section analyses the main barriers to domestic technology development. Finally in the fourth and last section we critically review one of the barriers, namely the financial barrier and examine how far

⁴ See for instance Nelson, R.R (1993).

the institution of venture capital funds is an effective solution to this barrier. Needless to add that this section is with specific reference to the Indian context.

I

Definitions

In the larger literature which come under the rubric of economics of technological change the terms invention and innovation are much used. In the context of developed countries the term invention has the meaning of generating a new idea (be it a new product or process) while innovation means the commercial application of that idea. However in a typical developing country context the terms may not have the same connotation for a number of reasons. Most of the technology requirements are not generated from domestic sources, but imported from abroad and subsequently adapted to local conditions. But in the more developed among the developing countries there is some generation of new technologies, by public and private R&D organizations. The R&D organizations have thus a dual role to play (Cohen and Leventhal, 1989): they not only help in generating new technologies but also aid in unpacking imported technologies and adapting them to local conditions.⁵

Many commentators tend to use the concepts of domestic technology generation and development as to mean the same process. However in our frame of reference we mean technology development as a more general concept than technology generation. In fact technology generation is the first and important step in the process of its development. And there are a wide variety of channels or modes through which technology can be generated and if one were to summarise there are at least three main channels or modes as mapped out in Table 2. Of these three modes, the most important one is channel 1 where technology is generated through R&D activities attached to industrial enterprises and specialized research institutions or laboratories under the ownership of government. Once technology is generated this is then in the normal case transferred to the production department in the case where it is generated by in-house R&D and to interested enterprises in case where it is generated by specialised R&D institutions. This process of transference of a generated technology into a commercial proposition is what we mean by domestic technology development. Quite often certain amount of time can elapse between these two activities. But it is nowhere not so lengthy as that between invention and innovation.⁶

⁵ So even if a developing country were to rely entirely on foreign technologies it still requires an elaborate R&D system to absorb imported technologies. This arises from an important characteristic of technology, namely it is extremely location-specific. This dual role of R&D Unit is examined in detail in, Nelson.R.R (1990),pp.73-74.

⁶ See Stoneman, Paul (1977) for the details.

Table 2
Modes of Generation of Domestic Technology

Channel	Activity	Nature of Activities
1.	Make	In-house R&D Activities Innovative Designs R&D activities of specialised research institutions
2	co-operate	<u>Through Joint Development Projects with :</u> -customers -suppliers -complimentary institutions -competitors -research institutions
3.	Gather	<u>Free technological information from:</u> -universities and public labs -technical literature -inside the industrial group

Source: Barabaschi, S. (1992). p.419

In addition to this process of developing a technology through local R&D efforts there is also the fourth mode or channel of purchasing or importing a technology from abroad and then adapting the borrowed technology to local conditions through in-house R&D efforts. As noted above, in-house R&D centers have a dual role to play. It can be both a new technology to the firm (*technology generation*) and it can at the same time act as a mechanism through which a technology bought from abroad (*technology adaptation*) is adapted to local conditions. In other words domestic technology generation and its subsequent development does not preclude import of technology. In fact actual experience suggests that very often a technology is first imported, some incremental developments are made on it and thus adapted to local conditions. This particular aspect renders the concept of domestic technology generation somewhat ambiguous. On the other hand, the commercial exploitation or utilization of a locally generated technology is what we mean by domestic technology development. After having spelt out the connotations of the term *technology development* we now discuss the various determinants of it. Development of technology is the final result of a complex interaction of incentive structures, human resources, technological effort and institutional factors. It is the interplay of all these factors in particular settings that determines domestic technology development (Lall, S. 1993). Very often there is a large role for government intervention to correct for market failures in incentive structures, technological efforts, institutional factors and so on. Even

some neoclassical economists would accept that market for technology development may fail seriously enough to warrant some offsetting government intervention.

While the determinants of allied concepts like domestic technological capability is discussed (Lall, S 1994) the determinants of domestic technology development (meaning the commercial utilization of domestically generated technologies) are not discussed in sufficient detail. A convenient way of identifying the proximate determinants of this process is to find out the reasons as to why domestic technology development in most developing countries is at a low level. A second way of cross checking these details is by examining the factors that have contributed to the success of this process in some rather well known cases like South Korea where there has been a judicious mixture of domestic technology generation and foreign technology imports in the process of domestic technology development.⁷ Based on these two methods, we identify a number of potential failures or impediments which are listed and then discussed seriatim. It must be added that we, at this stage, do not attempt to rank them in any order.

- information about domestically developed technologies and available for purchase by the industry;
- perceptions about risk and uncertainty involved in the use of domestic technology;
- availability of financial schemes or arrangements;
- the relative costs of purchasing the same technology from abroad vis-à-vis from domestic sources; and
- government policies and specifically technology policies.

Information failures

In a typical developing country technology is largely generated by public R&D organisations such as specialised government laboratories, science and technology institutes and universities. In-house R&D centres attached to industrial enterprises in both public and private sectors form only a minor and insignificant share. Of these various categories, technologies generated by last one does not normally become available for sale or transfer as it is more likely to be used up within the firm itself. If there is more and systematic information about these technologies, there is every likelihood that potential technology-buyers would be aware of its availability. Notwithstanding the existence of certain arrangements like technology data banks and so on often enough systematic information about the various aspects of domestically generated technologies are hard to come by. Even if they are available they are usually spread across a number of sources and not in one central place. If information about domestically available technologies are compiled and made available with

⁷ See for instance World Bank (1993) and Linsu, Kim (1993).

sufficient documentation in one central place, that is likely to enhance the utilisation of domestically generated technologies and hence more technology development.

Risk aversion and information gap

There is certain amount of riskiness attached to the use of domestic technology compared to its foreign counterpart. Consequently even if its explicit purchase price is lower, it may not be perceived to be a cost effective one especially in the case of process technologies. Its alleged superior benefits and features are therefore discounted in view of its uncertain nature. Trouble shooting and teething problems are believed to be on a large scale. Some times it is even perceived to be less than complete. Very often a perception about risk is the single most important determinant of technology development.

Absence of risk capital

An important way of minimising or rather sharing the risk of projects based on domestically generated technologies is to have financial arrangements or schemes that can finance, at least in part, the cost of the project. This financing can take the form of either debt or equity or a combination of both. A fairly recent innovation in this arena is the venture capital fund schemes which represent a formalisation and institutionalisation of high risk-taking activity. The venture capitalist takes a position in the equity of the new enterprises which is based on domestically generated and risky technologies. In addition the venture capitalist would also provide expertise in certain management functions. The existence of such new forms of institutional arrangements is thus one of its more important determinants.

Government Policy and especially technology policy

Government policies map out the external environment within which firms R&D organisations have to operate. If the policies are one of promoting domestic technology generation and its subsequent development by providing explicit incentives (usually fiscal), then domestic technology development can progress. On the contrary, if government policies favour technology import whether through licensing agreements or through an open-door policy towards FDI, then increased utilisation of domestically generated technologies will be affected. In short, government policies have the final say in matters relating to domestic technology development. In fact the link between government policies and economic growth is now well known as it is exemplified by the growing literature, for instance, on the *East Asian Miracle*.

To sum up, in this section we were concerned with spelling out the specific connotation of the term domestic technology development. We sought to distinguish it from domestic technology generation which is one of the first

steps in the process. We also see that in a developing country context, these concepts convey a slightly a different meaning from that of allied concepts such as invention and innovation. A discussion of the more proximate determinants of technology development has made as closer to an understanding of the concept of institutional support which in essence means a set of policies, institutions and arrangements that lead to more technology development. In very specific terms this would consist of favourable government policies which encourages the use of locally developed technologies, financial institutions and instruments which could finance the utilization of domestically available technologies and thereby institutionalise the risk involved in its utilisation. It would also have as its third component an arrangement that would enhance the flow of information from the generators of technology to its potential developers. In essence, the term *institutional support* has three components. See Figure 1.

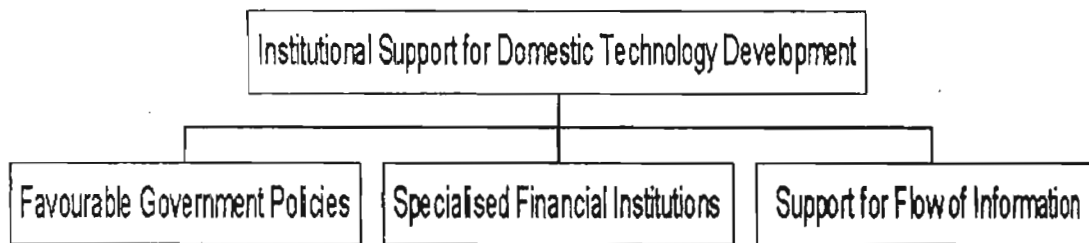


Figure 1

It must, however, be emphasized that the notion of institutional support that we employ here essentially attempts at improving the links between R&D institutions and industrial firms within existing institutional structures. There are other approaches especially the one by Bell (1993) which attempts at improving the links but by changing the structural characteristics: his approach does not take the basic structural characteristics of the system as given. This approach is based on the rationale that if R&D institutions are engaged only in research, and production enterprises only in production, the probability of transfer between them is inherently low, even if some linking institutions like Consulting Engineering and Design Organizations (CEDOs) are created. Bell propose a number of alternative proposals. These range from integrating R&D institutions with in-house R&D centres in production enterprises. Second, instead of attempting to sell technologies to other existing production enterprises, research institutes could create new enterprises or more radically the whole research institute may itself be converted into a production enterprise. While the first proposal has some merit, one is doubtful of the second one as scientists working in a laboratory are not equipped to manage a production enterprise. Even if they are, it can adversely affect future research activities.

We had noted that there is a reduction in the role of government in most spheres of economic activity in the 1990s. However there is a role left for government in a number of those activities which have public good characteristics.⁸ Technology generation and its subsequent development is still one of those areas where even the harshest critic would concede, that there is a roll still left for government to intervene or support. In the next section, we examine the arguments that are normally put forward in support of government intervention in this activity.

II

Government and Technology Development

Almost all the arguments in favour of government intervention in the conventional literature on matters relating to technological activities refers to investments in R&D efforts in a developed country context. However there are several strands of thought in this select literature that is of relevance for our specific purpose. This is because the argument for increased technology development relates back to the more fundamental rationale for government intervention in R&D. If that intervention is seen to support economic growth and to address market failure, then there is need to ensure that the fruits of the research contribute to that objective, and that transfer mechanisms are necessary to overcome any remaining market failures that might inhibit utilisation (Charles and Howells 1992). Market failures frequently occur in R&D activities due to a number of reasons and if one were to examine them there are essentially three reasons as to why it occurs. These are discussed in detail below:

Arguments in favour of government intervention in R&D

The first argument for government support of R&D activities can be traced to the public good characteristics of R&D which itself is based on the *appropriability* framework developed by Kenneth Arrow (1962). The framework rests upon five important propositions (Antonelli, C. 1994).

1. Firms allocate resources to fund activities within the context of profit maximizing decision making ;
2. The critical factors in the allocation of resources is thus the return on this is the return on this investment;
3. Scientific and technological knowledge acquired by R&D activities can be transferred and imitated by third parties at negligible costs;
4. Although returns on R&D investments are consequently very low for the individual firm, they are high from the social point of view ; and

⁸ Science and technology is one of the areas in which the need for government intervention is taken for granted because of their nature as public goods, which makes private benefit to the inventor smaller than overall social benefits. See Odagiri (1992) for an exposition of this argument in detail.

5. The supply of R&D activities is thus expected to be systematically lower than is socially desirable. The result being the conditions of a classic market failure in that markets are not able to allocate the equilibrium quantities in the provision of R&D activities.

Thus Arrow views technological knowledge and the associated information as an output of R&D activities. The public good characteristics of information makes it impossible for its producers to appropriate all the benefits entailing such production, thereby leading to an under investment of resources in R&D activity. This hypothesis has been empirically verified by E. Mansfield and others (1977), for the first time, through comparing the social and private returns from innovative activity. According to this study, while the median social rate of return from the sample of innovations was 56 percent, the equivalent private return was only about 25 percent. The main reason for this large divergence between the two rates of return is that the investor frequently finds it difficult to appropriate the returns from innovation because many of these benefits accrue to imitators who often obtain information quickly concerning the detailed nature and operation of new products and processes.⁹ The consequence is of course considerable underinvestment in R&D by the private industry calling for or necessitating government support.

The second argument is much more specific and it is about the need for and importance of government support for basic research. A good articulation of this argument is to be found in Pavitt (1977). Basic research by definition is characterized by positive externalities and low direct economic values. Though basic research usually accounts for not more than fifteen per cent of the total R&D expenditure of any country it is an important component of total R&D activity in the sense that it provides fundamental discoveries and concepts the application of which leads to new products or processes. The output of basic research, therefore does not have an immediate commercial value. But it can lead to technological improvements in the long term and can also lead to international competitiveness of a country as exemplified by the experience of the US, Japan and Germany all of whom made long-term investments in basic research. A still another reason for underinvestment in basic research by private enterprises is due to its risky nature, high failure rates in its outcomes and the lumpiness of initial investments. Time and cost over-runs, which are not unusual, can be another deterrent. Finally if the industrial market structure obtaining in a country is highly oligopolistic, there is always a tendency for the dominant firms operating under such conditions to concentrate disproportionately high percentage of their innovative efforts on short-term improvement innovations and product differentiation to the neglect of long

⁹ There are many channels through which information on innovation spreads-the movement of personnel from one firm to another, informal communication networks among engineers and scientists working at various firms, and professional meetings at which information is exchanged. See Mansfield, E. et al (1977), pp.221-240.

term radical innovations.¹⁰ The combined effect of all these factors call for government intervention in basic research either through its direct conduct or through provision of subsidies and other forms of incentives to private enterprises conducting it.

The third set of arguments in support of government intervention in research activity rests upon certain specific characteristics of R&D like indivisibilities which can be of two kinds. On the one hand large number of firms may each require small amounts of knowledge in a specific area, which on economic grounds is more optimal to have it conducted or supported by government. On the other hand, the absolute scale of effort required for the development and commercialisation of certain technologies can only be carried out with investments by the state. Examples of this kind would be the high technology areas like space, nuclear energy, computers, aerospace.

These are in essence the three arguments that are normally encountered in the literature advocating a positive role for government to offset for market failures which can lead to underinvestment in R&D activities.

Nature and extent of government intervention

This is accomplished by examining the conceptual issues and second by mapping out the actual extent of government intervention of this activity in select Western countries and in India. The term government intervention has many connotations. It may mean: (i) direct participation by the state in R&D activities; (ii) supporting R&D in private industry through, essentially, a variety of fiscal instruments such as subsidies, tax credits and other deductions or devices which effectively lower the costs of the firm undertaking R&D¹¹; (iii) coordinating and guiding private R&D ; (iv) intervention in technology imports and in FDI; (v) trade policy (infant industries, protection); (vi) domestic competition policy; and (vii) intellectual property laws. In a developing country context government intervention may manifest more in terms of the first two modes of intervention. On the contrary, in a developed country context it may mean only the first mode. Even so, government can be a source of much generic technology as well as fundamental science which then serve as a substrate for technological innovation by the private industrial sector (Brooks, H. 1986). Stoneman (1987) provides a taxonomy of western countries according to how governments actually intervene in the technology development process.

¹⁰ Very often the example of the U.S drug industry is very often cited as a case where long-term innovations were neglected for short-term profits:”

¹¹ The decision to go beyond invention to innovation is made by the firm on the basis of its assessment of the profit to be gained and the cost of carrying the project forward. By lowering the cost of the project to the firm through these various devices, the government can change the balance of the equation and induce firms to undertake projects which they might otherwise forego. For details see Folster, S.(1988), pp.105-112. And for a summary of tax incentives for carrying out in-house R&D expenditure see KPMG (1994) .

According to him countries differ according to their: (a) choice of *approaches* to and (b) the *instruments* adopted for technology development. See Table 3.

Table 3
Taxonomy of Countries according to Approaches and Instruments of Government Intervention

Approaches .	Instruments
State intervention seen as a major part of a process of indicative planning	Fiscal instruments(subsidies,tax credits,concessional loans); and
Providing the correct environment to encourage R&D by private enterprises; and	Legal and regulatory instruments
Diffusion-oriented policies	

Source: Stoneman, Paul (1987), pp.36-37

As far as approaches to government intervention in domestic technology development are concerned, these range from state conducting directly much of the R&D activity to it just providing the *correct* environment to the private enterprises which actually conducts much of the R&D. In terms of instruments, the most popular form of intervention is the state providing various forms of fiscal concessions (subsidies, tax credits etc.) to the private enterprises conducting in-house R&D. In fact, increasingly governments in developed economies are reducing their involvement in *approaches* to government intervention and resorting to the *instruments* as a way of promoting R&D by the private sector, while developing countries use a mix of both. There have been empirical inquiries into the extent and effect of government intervention in R&D activities and especially the policy of stimulating R&D by the private industrial sector enterprises by offering them financial incentives. The oft quoted study of it is by Mansfield (1985) and it refers to advanced economies such as US and Sweden. This study after examining the effect of R&D tax credits on firm's R&D expenditures in about eleven industries during the period, 1981-83 reached the conclusion that the tax credit has had only a modest effect on firm's R&D expenditures of the 110 firms in the sample: without the tax credit, the expenditure would have been about 0.4 percent lower in 1981, about 1 percent lower in 1982, and about 1.2 percent lower in 1983.¹² No attempt is, however, made to generalize from this study that tax incentives do not necessarily lead to increased innovation by firms even in developed countries. The only conclusion that can be made is that the tax credits, *in their present form*

¹² However another study conducted by the same author (Manfield 1984) of 25 major firms in the chemical, oil, electrical equipment and primary metal industries in the U.S regarding energy R&D projects that received support from federal agencies reached the conclusion that without federal support the firms would have financed only a small proportion of the energy R&D.

(emphasis ours), are unlikely to have a major impact on a nation's rate of innovation.

Large scale government investment in industrial activities are usually frowned upon because it may possibly crowd out private investment. The same arguments are made out in the area of R&D activities too. Therefore this proposition has also attracted empirical scrutiny. This results are found in Antonelli (1986) who estimated the elasticity of private R&D spending to government R&D support across 11 industries in 6 countries. The focus variable was positive and less than unity: it was +0.31 including that with every unit of government subsidy, the total R&D budget of recipient firms increase by 1.31 units. Only in about 10 percent of the number of cases was the elasticity co-efficient negative indicating crowding out effects. This finding therefore reinforces our earlier statement that government R&D spending does in fact crowd in private R&D rather than crowding it out as it is sometimes feared. While the positive effects of government subsidy programmes are now more or less accepted, doubts have arisen whether the normal subsidy or support programmes which manifest itself in the form of project grants, subsidised or conditional loans, or in the form of general subsidies or tax credits are indeed the most efficient way of subsidising or supporting private R&D activities. An alternative proposal has been made by Folster (1988) where an incentive subsidy which compensates firms for any private loss and taxes away gain. In addition the firm receives a small fraction of the resulting invention's special value. According to Folster, this mechanism comes close to being perfectly incentive compatible, for using a simulation over a range of hypothetical research projects it is shown that the efficiency of conditional loans and normal grants decline drastically as the government's information about project parameters becomes poorer. More or less based on this concept is the French aid to development programme (Sribu, Jr., 1978). Under this programme, a reimbursement subsidy is paid to industrial firms for the development of specific new products and processes. This has been used variously to induce traditional firms to be more technically venturesome, to average the risk where the project is too large for the firm and to support projects with important external benefits.

We now discuss the actual extent to which governments have intervened in domestic technology generation in the West as well as in India.

Extent of Government Intervention in R&D

A convenient way of measuring the extent of government intervention is to find out how much of the total non-defence (or civil) R&D budget of a country is accounted for by the government. An interesting statistic to start with is presented in Table 4 which lists the top ten R&D funding organisations in the world.

Table 4
The Top Ten R&D Organizations in the World, 1985
(In billions of US \$)

Funding Organization	Amount
1. US Department of Defence	30.33
2. US Department of Energy	5.83
3. US Department of Health and Human Services	4.11
4. UK Ministry of Defence	4.11
5. General Motors	3.63
6. US NASA	3.56
7. IBM	3.46
8. French Ministry of Research and Technology	3.29
9. French Ministry of Defence	2.90
10. German Ministry Of Science and Technology	2.80

Source: Charles and Howells (1992), p.63.

The Table reveals an expected picture, namely that the major R&D funding organisations are all government with the exception of two private enterprises and most of them are defence departments. This shows that much of the involvement of government R&D activity is in the sphere of defence related activities which have spill-over effects for civilian technology.¹³ Another feature of the preponderance of US based organizations and the virtual absence of Japan from the list. This is because in Japan, much of the funding for R&D emanates from the industry itself, (to be elaborated further below).

We now propose to examine the extent of involvement of government in the R&D activity by the industry across a select number of western economies and that of in India. In order to measure the extent of its involvement employ the ratio of industry (business) to government R&D expenditure. An excellent and detailed country by country survey is available in Nelson, R.R (1993). After presenting the general picture we propose to undertake the changing role of government in India, albeit, briefly. But before we present the data, a few caveats may well be in order. These are based on Stoneman (1987).

It would be rather difficult or almost impossible to capture the precise role of government in technology generation/development in terms of just one indicator, namely the data on R&D expenditure alone. This is due to a number of reasons. First of all, some support programmes are in the form of tax offsets,

¹³ This is sometimes questioned. The great success of Japan, with very small military R&D and highly purposeful civilian R&D programmes, has dented faith in military R&D as a vehicle for civilian technological innovation. The realisation that most recent developments of microelectronics owed less to direct military involvement has eroded this faith further.

concessional loans etc. Secondly, the government spending on higher education also should be termed as R&D expenditure as it can go towards creating the skills that are required. Thirdly it is quite common for governments to support technology development projects in enterprises owned by them and most of these may not get termed as R&D expenditure. Finally there are a number of non-quantifiable supports like regulations on foreign technology imports which can provide a fillip to domestic technology generation and its utilisation. However the data on R&D spending by governments is the only reliable data that are available in most countries.

In order to gain a correct picture of the extent of government involvement we attempt to answer the question in terms of who finances industrial R&D. The answer to this is in terms of the percentage share of industrial R&D expenditure financed by the government. See Table 5.

Table 5
Extent of Government Intervention in Industrial Technology Generation
(percentage shares)

Country\Year	1970	1988
USA	43	33
UK	32	20
Germany	18	11
France	32	21
Japan	1	2
Sweden	18	11
India	100	75

Source: 1. National Science Foundation (1991), p.23

2. Government of India (various issues).

The main structural change which occurred in the 1980s both in the financing and in the sectors of R&D performance is a swing from public to private support of R&D in the case of USA, UK, and France. In Japan government funding was/is never an important source contrary to popular impression that it has been. Another important dimension of the Japanese R&D area is that nearly all government funding is for civilian research more or like the German case. According to Uno (1991) in Japan the government can take initiatives in R&D without actually paying for it. Thus government co-ordinates various research efforts in Japan by forming research consortiums which helps in diffusing economic risks involved and thereby preventing or reducing possible under investment in R&D by the private sector.¹⁴ In the UK, it is said that deliberate

¹⁴ Uno goes on to state that the single most effective means of conveying official message to the private sector was through capital rationing. According to him during the period of relative capital scarcity, That is during the period up to 1970, for the sake of international competitiveness, the cost of capital was lowered by keeping the interest rates deliberately at a low level. This situation

government policies have seriously reduced government involvement in R&D funding (Stoneman 1993 and Walker 1993). On the other extreme, in India government funded and performed much of the industrial R&D, the contribution of the private sector industry being small.

In India government intervention in technology generation/development has been an integral part of the planned form of development which it religiously pursued since the 1950s. In this process, growth with technological self-reliance was assigned the pride of place. The central government not only participated, in an intimate and explicit fashion, in the generation of technologies but also placed restrictions on the free import of foreign technologies. As far as industrial technologies are concerned a network of laboratories were established under the umbrella head of the Council of Scientific and Industrial Research (CSIR), each laboratory concentrating on a specific industrial technology. These laboratories being outside the production system had very little interaction with their respective user industries. This is of course fast changing with a number of the labs having excellent track record. More on this point later. In-house R&D centres were not at all common even within public sector enterprises. The next major fillip for industrial R&D during the period since 1973 when government initiated a scheme of granting recognition to in-house R&D centres both in the public and private sector as well. These recognised in-house R&D centres were eligible for fiscal concessions in the form of the entire amount spent on in-house R&D being eligible for deduction from their taxable income during a specific assessment year. This led to a burgeoning of in-house R&D activity in the industrial sector. See Figure 2 (on Page 17) which traces the trends in in-house R&D expenditure in the industrial sector since the mid-1970s.

Industrial R&D is, thus performed by a host of government and private sector outfits. There are also spill overs to the industrial sector from R&D conducted by the Defence Research and Development Organisation (DRDO), the Indian Space Research Organization (ISRO), and the Department of Atomic Energy. Of late, there have been created specific mission oriented R&D centres which are charged with the responsibility of generating and commercialising specific technologies such as the Centre for Development of Telematics (C-DOT) in telecommunications, and the Centre for Advanced Computing Techniques (C-DAC) for the development of advanced computing techniques. So the extent of government involvement in industrial R&D is quite far reaching.

provided a leverage on the government side, which was effectively utilised in favour of the strategic sectors. Thus by not spending any amount on R&D, it was still able to direct or intervene in R&D conducted by private enterprises. See Uno, K (1991), p.5

TRENDS IN IN-HOUSE R&D EXPENDITURE IN THE INDUSTRIAL SECTOR

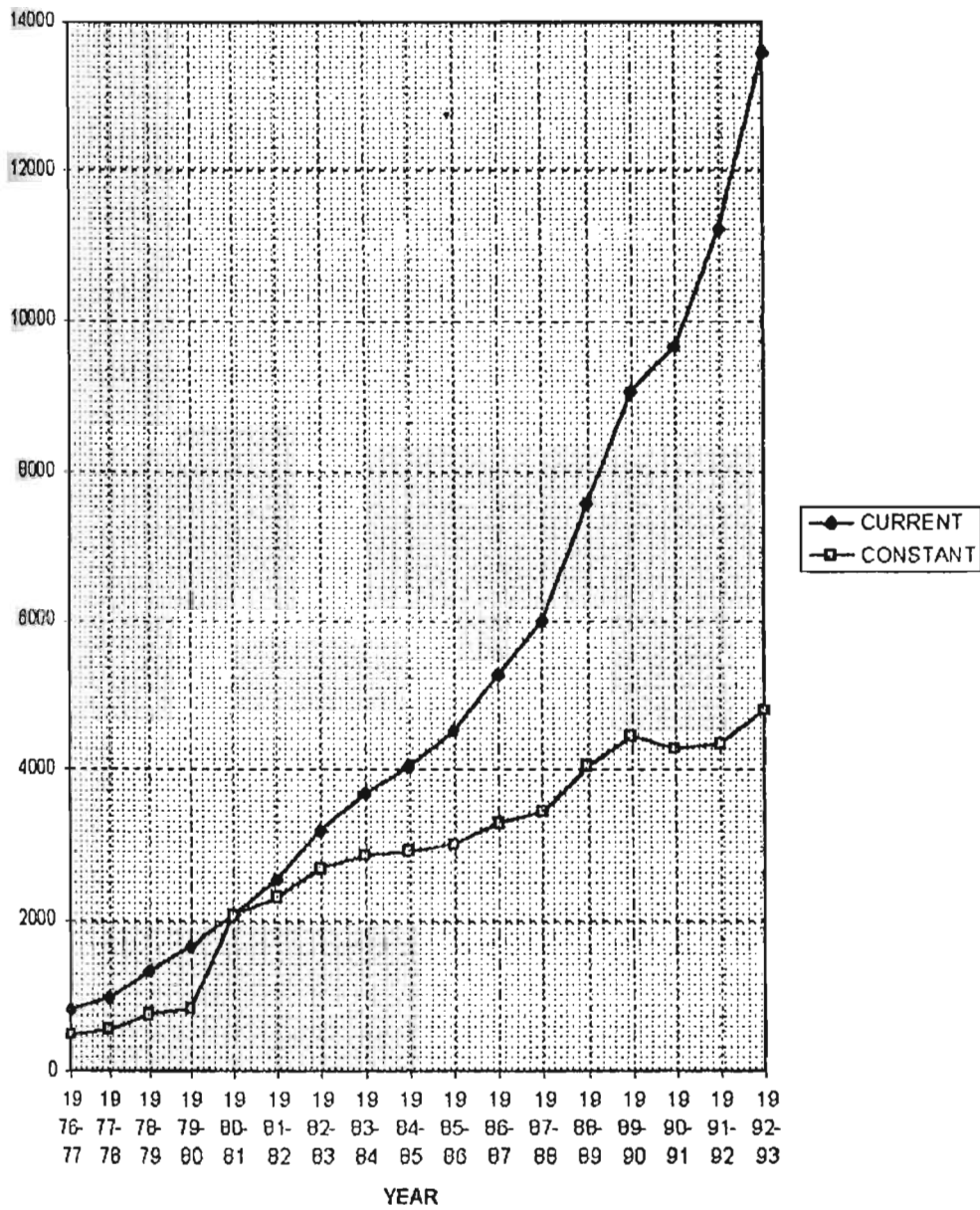


Figure 2

However with the liberalization of the economy since 1991, the nature and extent of government intervention in the generation of technology is very likely to get reduced. The earlier practice of creating industrial capacities in tune with

plan targets (through the licensing system) has been done away with, the import-substitution strategy has been abandoned, and the public sector enterprises are being privatised. As far as domestic technology generation is concerned there are essentially two changes. Firstly, most controls on the import of technology (both embodied and disembodied) have been considerably relaxed.¹⁵ This may lead to increased use of foreign technology as indicated by the very large number of collaboration agreements approved since 1991. Secondly, the central government has drastically reduced its science and technology budget. This has manifested itself in the form of the eighth plan government allocations towards the CSIR budget to be only about 40 percent of its real requirements during the period and further the non-plan expenditure being frozen at the 1990-91 level (CSIR 1993). Effectively this means a decline in the government grants of over 20 percent annually in real terms. The major clientele of CSIR for contract R&D were hitherto the government departments and these facing major budget cuts, their support for R&D programmes in CSIR is already beginning to show a substantial decline. In fact from 1995-96 onwards, the budget allocation for an individual lab in the CSIR network is linked to the type of earning it has been able to secure. For instance, for earnings in the form of royalty, premium, intellectual fee on sponsored project and consultancy research will be given a cent percent matching grant. On the contrary, a matching grant of only ten percent will be given for earnings in the form of job work and testing etc.¹⁶ The earnings ratio of CSIR laboratories defined as the ratio of earnings from industrial research to the total budget of these labs have been on a declining trend especially since the mid 1980s. See Figure 3 (on Page 19).

As a matter of fact the labs have been able to generate only about 4 percent of their total budget from transfer of technology to the industry during the period against an overall average of 7 percent for the entire period under consideration. Thus with increased competition from foreign technology and with a sizable chunk of their budgets to be raised through own efforts, the research institutes will have to re orientate themselves. They will have to pay greater attention to selling the technologies that they generate and also at the same time generate the ones that are required by the industry. In short the interface between the labs and the industry will have to be strengthened considerably. But there are many barriers to this process and in the next section we discuss some of the more important barriers and also examine the institutional solutions to them.

¹⁵ For details of the changes in the policy with respect to technology imports, see Mani, Sunil (1992).

¹⁶ See for instance, Mashelkar, R.A (1995), p.25

TRENDS IN THE EARNINGS RATIO OF CSIR LABORATORIES

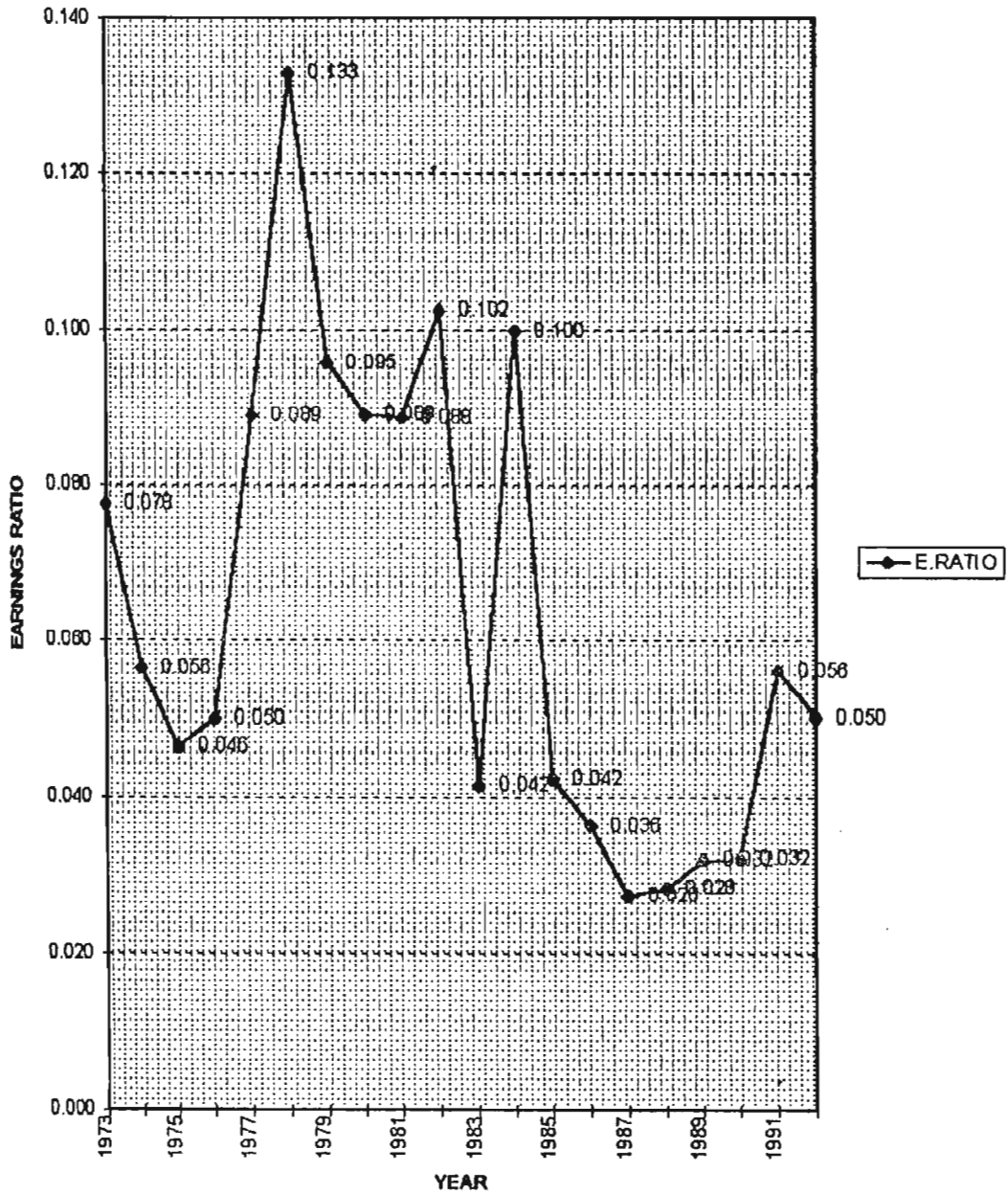


Figure 3

III

Barriers to Domestic Technology Development

In section 1, we argued that there are essentially four market and/or government failures in domestic technology development, namely information, risk and uncertainty, availability of risk capital and above all government's technology policies that may provide the *correct environment* for this process to flourish in a systematic manner. There are however no studies or surveys of this in, especially, the Indian context. Available studies¹⁷, done in the West, have identified the lack of adequate risk finance as one of the most important barriers to this process. This could be explained in the following manner. Under normal conditions if an activity is considered to be risky one could attach probabilities to its potential outcomes. On the contrary, if an activity is considered to be uncertain, one cannot even attach probabilities. The technologies which are developed domestically, usually perceived by their potential users as an uncertain one, fall in the latter category and hence find it difficult to secure funding from the organized but the conventional capital market. This is especially so in the Indian context where typically new industrial projects have a larger debt component than equity and the organized capital market lead by the development banks have a history of discrimination against projects based on indigenous technologies.¹⁸

Analytically speaking the financial requirements of technology generation are of two types (Stoneman 1987) : (1) long-term for R&D, the purchase of technology or the setting up of mass production facilities; and, (2) for working capital which is required to cover the period leading up to the time when the product is commercialised. The traditional banking system has always shied away from extending credits to R&D activities and very often the government had to step in by providing research grants and by awarding contracts. Admittedly with government finances under severe threat, governments have accorded only a low priority to funding of R&D.

In order to better appreciate the financing requirements for innovation , economists have found it useful to identify five different stages in the growth of a new technology-based firm: R&D, start-up, risky growth, regular growth and maturity (Prakke 1993). Table 6 identifies the activities involved in each of the stages and the likely source of such finance.

¹⁷ The most cited study in this area is by Piatier (1984) who surveyed the barriers to innovation in the European Community countries.

¹⁸ It must however be stated that there isn't any systematic documentation of this *commonly accepted statement*. The successful *Swaraj tractor case* where the development bank , IDBI, is supposed to have played crucial positive role is more of an exception than the general case. For a detailed documentation of this case see Bhatt, V.V. (1980)

Table 6
Stages in the Development of a New Technology -Based Firm

Stage of Development	Activity	Type of Financing
1.R&D	Feasibility Studies -technical - commercial Technical Development Market Research	Seed Financing - venture capital funds (rarely) - own funds etc.
2.Start-up	Further development setting up production and sales; reaching break-even	Venture-Capital
3.Risky growth	Further growth; developing a second generation of products	Fledgling finance (joint involvement of several venture capital organizations)
4. Regular growth	Achieving economies of scale in production and sales	Bridging finance (development) investment banks, venture capital, take over by larger firms.
5. Maturity	Broadening technological base and management capabilities	Stock market or other exit route

Source: Prakke.F. (1990), p.80

A major inference that can be drawn from the Table which is largely based on the Western experience is the emergence of venture capital funds as a source of finance in most of the stages. In fact the conventional modes of financing enters the scene only from the fourth stage onwards. But in actuality they are an important source is something that is worth exploring. This aspect is first examined against the experiences of the US and the UK and in the next section we examine the Indian experience with respect to venture capital funds as a solution to the financial barrier to domestic technology development.

A point that is worth clarifying at this stage is that access to a particular source of finance to a firm is also very much a function of its size, i.e. whether it is small, medium or large enterprise. For instance very often small and medium enterprises have less avenues for obtaining their requisite funds for domestic technology development than large companies for whom the conventional banking system or even internal resources can be a source. In fact as we shall

see, venture capital funds are a source of finance mainly for small and medium enterprises.

Venture Capital Funds and Technology Financing

Though informal venture capital financing has deep historical roots, it is only since the 1940s that modern venture capital i.e. venture capital invested by specialist bodies, was invented in the US. Most of the modern venture capital funds are privately owned though some of them receive government support. Typically the venture capital investment is targeted towards new enterprises, often involving new and sometimes high technology. There are three primary characteristics of venture capital funds which make them eminently suitable as a source of risk finance:

(i) It is an equity or quasi-equity investment, which means that the investor is assuming considerable amount of risk since his investments are not secured. Consequently the fund has to take the risk of failure just like other shareholders. This feature makes it different from other forms of finance such as bank loans, leasing and factoring extended by conventional financial institutions where the returns are in the form of interest and capital repayments. In this form of financing in the eventuality of a change in the business prospects of the venture, the lender can bankrupt the borrower by calling of their loans. Thus by participating in the equity capital, venture capital funds institutionalise the process of risk-taking -- a trait that is significant for successful domestic technology development. The major reward to the venture capitalist lies in the growth of the firms in which they invest, ideally resulting in the sale of the firm or its floatation on the stock market.¹⁹ The actual experience shows that this may take five to seven years from making the investment in the first place (British Venture Capital Association [BVCA]1994);

(ii) It is a long term investment .It is not only an investment of money but also of time and money. Investments are not made with a view to short-term profit; and

(iii) Finally it is an active form of investment in which the investor also has a participation in the management of the company. This involvement will vary from firm to firm, but the majority will expect to participate through a seat on the board and thus guiding the firm on strategic and policy matters.

¹⁹ It has been observed from the US venture capital industry that the average holding period for the most successful investments has been 7 to 10 years. The net result of this pattern is that many venture capital funds experience a loss in value during their early years, before starting to experience a steep growth in the rate of return on total portfolio. This *J-curve* phenomenon is common to venture capital funds. For details see Venture Economics (1988), pp.6-8.

In short venture capitalists generally(Coopers and Lybrand 1994):

- Finance new and rapidly growing companies;
- Purchase equity securities;
- Assist in the development of an innovative business idea-often *high technology-based* into product or service;
- Add value to the company by active participation;
- Take higher risks with the expectation of higher rewards; and
- Have a long-term orientation.

Needless to add, these features make it eminently suitable as a source of risk capital for domestically developed technologies. We now examine the world-wide experience of venture capital funds as a source of finance for technology development and specifically in the context of US and the UK (which two countries have the largest number of venture capital funds. See Table 7

Table 7
Profile of Venture Capital Funds world-wide, 1993

Country	First Year	Number of Venture Capital Funds	Invested Capital (US \$ million)
USA	1946	500	3071
UK	1945	119	2247
Japan	1972	80	1000
France	1975	15	770
Korea	1974	4	11
India	1988	10	15

Source: 1.Ibanez, Fernan (1989), p.22.

2.British Venture Capital Association [BVCA] (1994), p.3

3.National Venture Capital Association [NVCA] (1993), p.28

4.UNIDO (1991), p.170

A surprising finding is the fact that despite being a new entrant, size of the Indian venture capital industry is larger than that of S.Korea's.

We now examine the evidence on venture capital funds as a source of finance for technology-oriented ventures. First the evidence from advanced countries such as the US, UK, and western Europe in general is analysed and this provides a background to our subsequent analysis of the Indian case. The best model of financing is a situation where much of the financing is equity -based investments in early stage technology-oriented ventures. The actual situation in a country can be ascertained by analysing the distribution of venture capital investments according to: (a) stage -wise financing; and (b) industry-wise distribution.

The US case

The American venture capital industry is supposed to have played an indispensable role in nurturing the growth of the country's high technology industries. The now famous American computer companies like Digital equipment Corporation, Apple, Compaq, and Sun Microsystems are important examples of *venture capital created companies*. Intel in the late 1960s and Cypress in the early 1980s were venture funded start-ups in the semiconductor industry. Both Microsoft and Lotus are software industry examples. In addition professional venture capital has made it possible to create entirely new industries like biotechnology and the courier /shipping industry. Tables 8 and 9 maps out the stage-wise and industry -wise distribution of VC investments in the country.

Table 8
Venture Capital Investment in the US by Financing Stage
(percentage of investment by value)

Financing Stage	1987	1988	1989	1990	1991	1992	1993	1994
Seed	2	3	4	3	4	3	7	4
Startup	11	9	8	7	6	8	7	15
Other early stage	15	15	16	17	22	13	10	18
Expansion	45	40	47	52	54	55	54	45
LBO/Acquisition	20	29	21	18	3	7	6	6
Other	7	4	4	3	11	14	16	12
Total	100	100	100	100	100	100	100	100

Source: 1. Venture Economics (1993), p.36
2. NVCA (1994), p.29

This shows that on an average the share of early stage financing accounts for over one-third of the investments. Much of the VC investments seems to enter at the stage of expansion of the newly created venture. On the contrary, much of the investments were in technology-based ventures (Table 9). In fact Mowery and Rosenberg (1993) notes that:

the foundation and survival of vigorous new firms also depends on a sophisticated private financial system that can support new firms during their infancy. The US venture capital market played an especially important role in the establishment of many microelectronics firms during the 1950s and 1960s, and has contributed to the growth of the biotechnology and computer industries. Throughout the 1970s, \$100-200 million of funds annually flowed into this industry from the venture capital community, and it is also observed that the flows of venture capital for high-technology firms may have been as much as \$ 2-4 billion annually.

Table 9
Industry-wise Distribution of Venture Capital Investments in the US
(percentage shares)

Industry	1987	1988	1989	1990	1991	1992	1993	1994
Technology related	71	67	64	73	84	71	70	70
Consumer related	16	11	12	10	10	8	10	10
Other products and services	13	22	14	12	6	11	20	20

Sources: 1. Venture Economics (1993), p.28.
 2. NVCA (1994), p.37

The entire investment is equity-based. Thus the current US model is one of equity oriented financing of technology -based ventures at primarily at their expansion stage, though early stage financing is still very important.

The UK Case

The UK position with respect to these two indicators are presented in Tables 10 and 11 respectively.

Table 10
Venture Capital Investments in the UK by Financing Stage
(percentage shares)

Financing Stage	1983	1984	1985	1986	1987	1992	1993	1994
Early Stage	27	22.4	21.9	15.3	7.2	17.9	6	5
Expansion	48.3	40.7	36.1	27.2	22.2	29	32	28
Management buy-out/buy-in	24.2	27.9	38.1	43.8	62.5	65	62	67
Other	7.2	5.2	6.5	6.2	3.1	Nil	Nil	Nil

Source: 1. British Venture Capital Association[BVCA] (1994),p.4
 2. Mani (1994)

Table 11
Industry-wise Distribution of Venture Capital Investments in the UK
(percentage shares)

Industry	1984	1985	1986	1987	1992	1994
Technology related	52.3	50.4	42.6	41.5	32	38
Non-technology related	47.3	47.6	57.4	58.5	68	62

Source: 1. Mani (1994); and 2. BVCA (1994), p. 5.

It is seen from the above tables that in the UK over two-thirds of the investment is going towards management buy-outs and buy-ins in non-technology related ventures. In fact within a matter of two years the investment profile has undergone a radical change as indicated by the fall in the technology related investments. In short in the UK case the venture capital funds are a decreasing source of finance for innovations.

It is against this background that we analyse the role of the emerging venture capital industry as a potential solution to the financial barrier.

IV

The Indian Venture Capital Industry as a Financial Support for Domestic Technology Development

The venture capital funds took its roots in India in the latter half of the 1980s. Within a short span of its birth however, the venture capital industry in India has started moving away from being a source of finance for commercialising technologies. As to be argued below, this state of affairs can be attributed to a great deal to the government guidelines governing its operation. Very recently the government has even repealed the guidelines²⁰ The new regulations are being framed by the Securities and Exchange Board of India (SEBI) and these are expected to distance the industry away from its envisaged role as source of risk capital for *new or relatively untried or very closely held technologies which incorporates some significant improvement over existing ones in the country.* In fact as a necessary consequence of these changes there will be very little differences in their operations compared to the conventional development banks. Towards making these issues clearer we discuss first the origin and structure of the venture capital industry and the analyze the investment behavior of these funds in terms of stage of financing and industry-wise distribution. The source of data for this exercise is largely based on a survey of all venture capital funds in operation in the country as of 1993 and contained in Mani (1994).

²⁰ See Economic Times, Bombay, July 26, 1995.

Genesis of the Indian Venture Capital Industry²¹

As seen earlier economic growth with technological self reliance is one of the stated objectives of India's development planning though in the current context of economic liberalization one might argue that this is more of a rhetorical statement. Most firms in the manufacturing sector have relied on foreign technology imports for their technology requirements and consequently, despite the existence of a number of policies favouring domestic technology generation its actual generation has not been much. There are various ways of measuring the rate of technology generation in manufacturing industries. One way of doing so is to analyse the expenditure on in-house R&D by firms in relation to the amount spent on purchasing technology from abroad. By comparing the two sets of expenditures we define the rate of domestic technology generating effort as follows:

$$\text{Domestic technology effort of the } i\text{th industry} = \frac{\text{R\&D expenditure}}{\text{Direct cost of technology import}} * 100$$

Since consistent time series data on cost of technology imports by public sector enterprises are not available especially for the period after 1984-85²² the rate is computed for the private sector and this is presented in Figure 4.

Though a crude measure, the rate of domestic technology generating efforts in private sector industry started declining since 1982.

²¹ This section draws heavily from Mani (1994).

²² There is however an attempt to develop a consistent time series data set on the direct cost of technology import by the public sector enterprises. See Mani (1992).

**TRENDS IN DOMESTIC TECHNOLOGY GENERATING EFFORTS IN
INDIA'S PRIVATE SECTOR INDUSTRY**

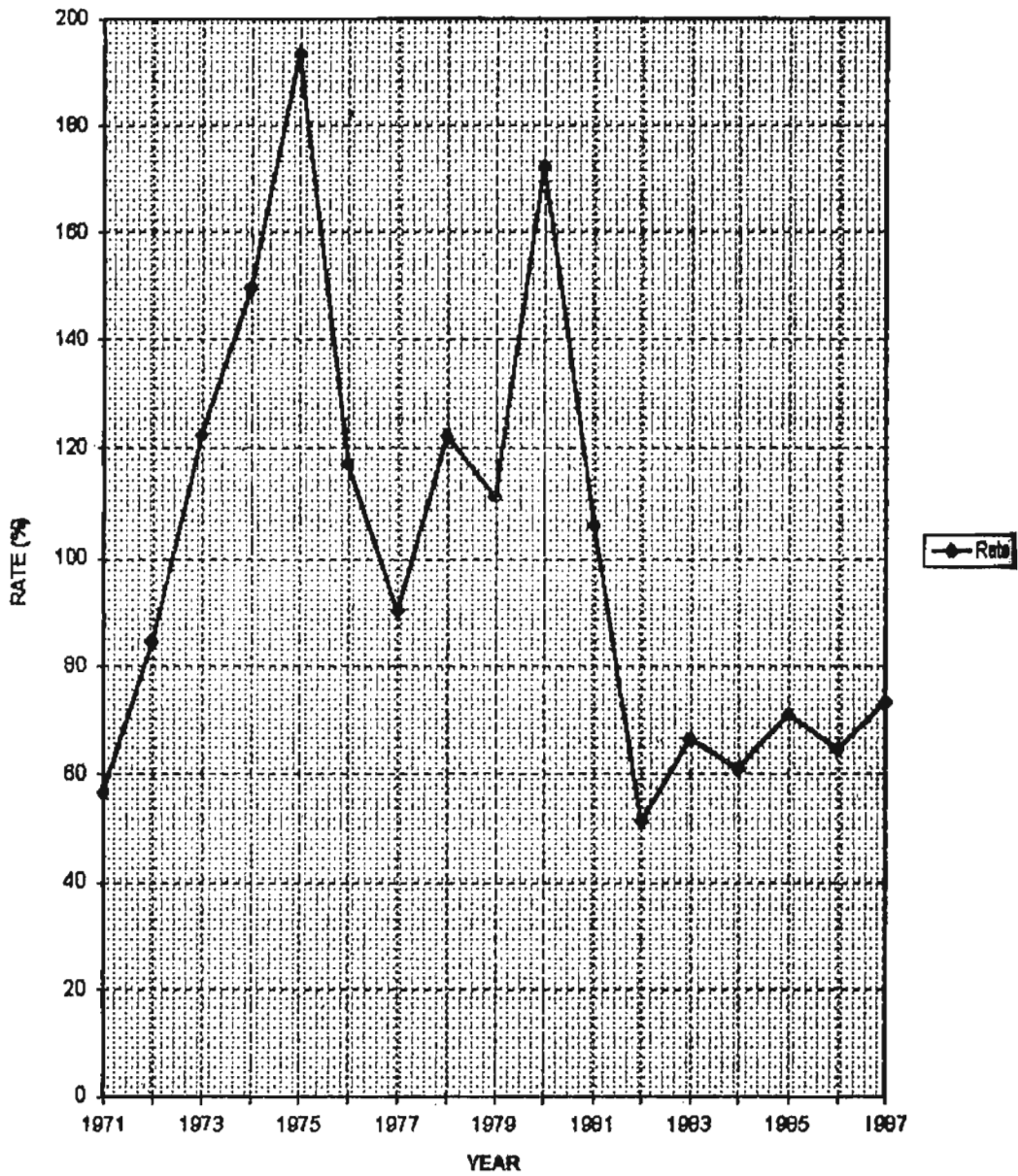


Figure 4

As part of its efforts to reverse this trend, the government enacted the *R&D Cess Act* in 1986 prescribing a levy of 5 percent tax on all payments for import of technology. The fund thus accumulated is to be used for setting up a venture capital fund scheme with one of the leading development banks in the country,

namely the Industrial Development Bank of India (IDBI) with the ultimate object of providing risk capital to units based on domestically developed and unproved technologies. In fact it has been shown that only about 10 percent of what has been collected under this head has actually been transferred to the venture capital fund of IDBI (Table12). Even the estimates of cess collected by two different agencies of the government are at variance with each other.

Table 12
Estimates of R&D Cess Collected and Transferred to the Venture Capital Fund of the IDBI
(Rs in Million)

Year	Estimates Of R&D Cess Collected		Estimates of Foreign Exchange Outgo		Transferred to the VCF of IDBI
	A	B	A	B	
1988-89	163.2	137.8	3264	2746	88.4
1989-90	272.0	223.2	5440	4464	50
1990-91	301.2	300.1	6024	6002	10
1991-92	327.7	220.4	6554	4408	100
1992-93	448.9	369.6	8978	7392	30
1993-94	607.4	490.2	12148	9804	NA
1994-95	636.6	469.2	12732	9284	NA

Notes: 1. Estimate A is by the Controller General of Accounts
 2. Estimate B is by the RBI.

Source: R.Ramachandran (1995)

With the implementation of the new industrial policy (1991) much of the foreign technical collaboration agreements in the industrial sector does not require clearance by the RBI or by the Secretariat of Industrial Approvals (SIA). Consequent to this, there may not even be reliable estimates of the actual foreign exchange outgo on account of technical collaboration agreements. We also adduce evidence to show that the VCF outfit of IDBI does not correspond to the definition of a VCF and so even the limited portion of the R&D cess that is transferred to it does not lead to creation of technology-based ventures.

The actual genesis of the venture capital industry can be traced to a series of efforts by the World Bank in the 1980s (World Bank 1989) as part of its *Industrial Technology Development Project in India*. As part of this project a loan of \$ 45 million was made available to the government to support four venture capital entities for financing technologically innovative and growth oriented small enterprises. The government on the other hand was to relent this amount to four state-owned venture capital funds. All these efforts finally resulted in the notification

of the *Venture Capital Guidelines* of 1988. These *guidelines* govern the details of establishment, management, the nature of assistance, size of investment and the details of exiting from the ventures.²³ All the VCFs in the public sector have been established by either the banks (both development and commercial) or by other financial institutions. This is very likely to seriously hamper their role as financiers of risky projects as experience elsewhere and specifically in the US has shown that credit analysts and lending officers steeped in a conservative financial tradition cannot be expected to become venture capitalists overnight. As mentioned earlier the venture capital association has lobbied with the government and has almost managed (pending announcement of the revised guidelines by the SEBI) to get several of the provisions of the *guidelines of 1988* repealed.

Structure of the Indian Venture Capital Industry

Currently (1995) there are about 10 VCFs in operation. Of them, 7 are in the public sector and 3 in the private sector. One more fund in the public sector is in the offing. Needless to add the industry is still evolving (Table 13).

Table 13
The Structure of the Indian Venture Capital Industry (1993)
(Rs in Million)

Name of Fund	First Year	Size of Fund	No of assisted companies	Total sanctions	Total disbursements	Nature of ownership
1.TDICI	1989	1000	87	414	246	Public Sector
2.IDBI	1987	478	64	43	32	do
3.RCTC	1991	450	10	94	-	do
4.Gujarat	1990	240	8	71	29	do
5.APIDC	1990	135	7	20	5	do
6.Can Fin	1989	100	27	89	50	do
7.SIDBI	1994	100	4	16	NA	do
8.Credit Capital	NA	NA	NA	NA	NA	Private
9.20th Century	NA	NA	NA	NA	NA	do
10.Indus	NA	NA	NA	NA	NA	do

Source: Mani (1994), p.20

²³ For a detailed commentary of the details of the *guidelines* see Main (1994), p.18.

According to certain estimates, the total pool of approximately Rs 2.5 billion is considered to be adequate. These estimates are arrived at on the basis of the number of technologies and licenses transferred and contracted by the various sources of local technology. An aspect brought out by the above Table is that on an average, disbursements have been only 48 percent of sanctions. The precise reasons as to why such a gap exists are not known. As seen earlier, the main return or reward to the venture capitalist is in the form of capital gains at the time of divestment. But in the budget speech for 1995-96, the finance minister had announced an exemption from tax on income by way of dividend and long term capital gains from equity investments made by approved VCFs in unlisted companies in certain sectors. Further an amendment has been made in the SEBI Act providing it with powers to regulate VCFs. These and the other changes contemplated in the revised guidelines is to make VCFs an attractive proposition for investment and this is also expected to increase the number of entrants to the VCF industry and at the same time move it away from the original concept of venture capital funding as an effective solution to the financial barrier to innovations in the Indian context.²⁴

Analysis of VC Investments

The dimensions of investments analysed are: (a) the stage-wise investments; (b) instrument wise investments; and (b) the industry-wise distribution of investment. The *ideal* form of financing is one which involves relatively more equity form of financing in the early stage of firms operating in technology-based industries. However this model is rarely to be found in actuality. The one is more close to this ideal case is the US one. The Indian case we argue below, does show atleast in its initial stages some affinity to emulate the ideal case.

Distribution of Investment by Financing Stage

Table 14
Venture Capital Investment in India by Financing Stage
(percentage shares)

Financing Stage	Average during 1987-93
Start-up	66
Other initial	1
Expansion	33
Others	nil

Source: Mani (1994), p.21

²⁴ This fear is clearly visible from a number of commentaries appearing in the national press finding certain provisions of *Venture Capital Guidelines of 1988* especially the ones dealing with the nature of venture capital assistance (that it should go mainly to enterprises where the risk element is high due to the technology being relatively new, untried or very closely held) extremely restrictive and hence in need of being repealed. For a representative commentary, see Jethanandani, Kishore (1995).

The Table shows that nearly two-thirds of the investment is in start-ups. But it should be mentioned that of late there has been a shift towards financing expansions by existing undertakings- a trend hidden by the above Table as it considers only the average during a period. However not much is known about the beneficiary companies because it is estimated that it will take atleast five years before it begins to show some results.

Distribution of Investments -instrument-wise

Most of the technology -based ventures require equity support for the reasons mentioned earlier ad it is the best way of institutionalising the process of risk associated with new and untried out technologies. The *guidelines* specify that the financial support to the enterprises should be mainly of the equity type though it does not specify the exact amount. The only specification is that the investment in any one firm should not exceed 10 percent of the VCF, and it should be in enterprises where total investment in plant and machinery does not exceed Rs 100 million. The VCFs use a mix of investment instruments: equity and quasi equity instruments such as convertible conditional loans and income notes. But the share of standard loans is expected to be low. It is essential that the share of equity support in their total assistance should be high and if not increasing over time. Based on this idea we construct a simple index to be termed as *financial barrier index*. This is defined as the reciprocal of the ratio of equity to total financing of a project, multiplied by 100. The more close the index is to 100 , the lower the financial barrier and so on. Given the extreme paucity of data we are constrained to have this index only for the largest venture capital company , namely the TDICI (Table 15). This is supplemented with qualitative data from the other firms in the industry.

Table 15
The Financial Barrier Index (FBI)
(based on TDICI'S operations-Rs in million)

Fund	Size of the Fund	Period (years)	Total sanctions	FBI
First VCF-1989	20	10	199	417
Second VCF-1990	1000	12	134	147

Source: Mani (1994), p.23.

There has been a decrease in the FBI over the two funds indicating an increase in equity support. But it must be stated very clearly that the total sanctions in the second fund is only about 13 percent of the total funds available and therefore a full picture is available only after some time. Second, the next major fund, namely the IDBI states very clearly that its assistance:

will be provided mainly in the form of unsecured loan involving minimum formalities before disbursement. The loan would carry a concessional rate of interest of 6 percent per annum during the initial development period which will be enhanced to 15 percent per annum once the process/product is developed and accepted by the market. Besides IDBI will be entitled to charge royalty at a mutually agreed rate on the sale of product arising from venture.

Some grace period is allowed in the repayment of the loan depending on the cash generation of the recipient firm, and it is also stated that some part of the assistance may also be made in the form of equity shares. This depends crucially on the growth potential of the company. Most of the VCFs in our sample also tend to prefer a variety of loan support to equity support. So the evidence on this front presents a rather mixed picture. As noted in section iii, apart from providing the *pure financial support* the factor that makes venture capital venture capital operations rather unique is the managerial support components- the close involvement with the management of the investee firm (Sagari and Guidotti 1992). Through this process of involvement the venture capitalist is supposed to add value to his portfolio, which is accomplished through strategic planning, management recruiting, supplier-customer relations, support in securing additional finance, etc.

Among the VCFs surveyed it is only TDICI which seems to provide such *value-adding* support functions to its assisted companies. This has manifested itself in the form of managerial and technical support. A unique mechanism adopted by the fund is to arrange for an annual gathering of chief executives of the assisted companies to understand their problems and to explore ways to improve mutual interactions. We do not of course have sufficient data from the assisted companies about the real value of these exercises to them. However there is some evidence of general satisfaction with the nature of involvement with its assisted companies (Sesham, Sekhar 1994).

Another very useful support mechanism which the TDICI initiated was *Technology Information Service*. This was essentially to access information from over 800 foreign databases. The company claimed in its second annual report (for 1989-90) that the, 'information services will have an important role to play in improving managerial effectiveness and competitiveness in the years to come'. However in the very next year (i.e. 1990-91) this was dispensed with on grounds of unpopularity and also considered the continuation of the service a *diversion from its main line of activity*. It is a fact that most entrepreneurs and especially those operating in high-tech industries do not have easy access to major developments in their respective areas. This form of embodied technology transfer can very often act as a fillip to domestic initiatives. But with the arrival of many on-line information services like for instance the *Internet* this may be less of a problem.

Industry-wise distribution of venture capital investment

An important characteristic of the industrial economy of most countries is that technology has become an important medium of competition between firms. Technological changes in a number of industries have reduced barriers to entry by lowering the cost of entry and has made a number of industries scale independent, enabling even small scale units to enter areas which have been the exclusive preserve of large scale units. New technologies also imply high-risk and therefore needs a suitable source of finance, which firms with high-risk cannot raise from conventional funding sources. The venture capital investments has therefore emerged as a solution to this problem by specializing in extending primarily equity support to growth-oriented technology-based firms.

The *Guidelines* governing the operations of the venture capital firms is very clear on this respect Second an examination of the primary objective of the various VCFs shows that their investment preference is clearly for technology-based units (Mani 1994). In fact this is brought out by the distribution of their actual investments. See Table 16.

Table 16
Industry-wise distribution of VC Investments
(percentage of investment by value)

Industry	Cumulative Investment, 1988-1992
1.Technology related	78
2.Non-technology related	22
Total	100

Source: Mani(1994),p.27

It is seen that much of the investments are in technology -related ventures, though it is not clear how much of this technology originated from government research institutes. Interviews with the officials of the larger VCFs reveal that increasingly they tend to prefer ventures based on proven technologies which is another way of stating their preference for imported technologies. On the other hand discussions with the government research institutes reveal they are not fully informed about the investment preferences of the funds. There is clearly an information gap between the two. In short most of the Indian venture capital companies being offshoots of existing development banks, despite their autonomous nature, runs the risk of exhibiting similar attitude when it comes to funding risky projects.

In this paper, we were primarily concerned with an examination of the institutional support that is required for an effective development of locally generated technologies irrespective of whether these technologies are developed by the government laboratories or by private firms. We identified three principal support mechanisms, namely a correct external environment, availability of risk capital, and finally an institutional support that can correct for crucial information failures between generators of technology and its developers. The second component can in fact encompass the last one. Therefore, of the three the one which is most tangible and the one which can be operationalised is an institutional arrangement for making available risk capital. There is an explicit recognition of this fact and this manifested itself in the form of the government establishing a venture capital fund industry²⁵.

Much of the support mechanisms that exists in the country are primarily geared towards local generation of technology rather than towards its development. Our analysis of the actual operations of the Indian venture capital industry showed that though they initially started off with precisely the objective of providing an effective financial and information support for domestic technology development, they are increasingly moving away from it.

An important assumption that underlie our analysis is that there are a growing number of technologies that are waiting to be commercialised and which are not in view of the absence of an effective institutional support. This assumption is increasingly proved correct by a number of international collaborations between Indian laboratories and Western technology transfer institutions for joint development and transfer of Indian technologies abroad²⁶.

References

Antonelli, C. (1994). *Technological districts, localized spill overs and productivity: The Italian evidence on technological externalities in the core regions*, **International Review of Applied Economics**, Vol.8, No:1, pp.18-30.

Arrow, K.J. (1962). *Economic welfare and the allocation of resources for innovation*, in Richard R. Nelson (eds.), **The Rate and Direction of Inventive Activity**, Princeton University Press, Princeton, NJ.

²⁵ In addition to the venture capital funds there are a number of financial schemes which are primarily operated by leading development banks in the country. Examples of this would be the TDF, refinance of industrial loans, the bills rediscounting scheme, and the seed capital assistance scheme etc. of the IDBI, the SPREAD scheme of the ICICI and so on. We did not consider any of these schemes as an institutional support as they are all very limited in their scope and activities.

²⁶ In 1989 the largest technology transfer institution in the world, the British Technology Group plc opened its branch in Bombay, among other things to purchase suitable technologies from Indian labs. Very recently an MOU was signed between the CSIR and the American firm Global Exchange of Technology Inc (GET)- an international technology brokerage service. See for details Gurha, Ritu (1995).p.15

Asian Development Bank (1988). **Venture Capital Financing in the Asia-Pacific Region**, Manila.

Barabaschi, S. (1992). *Managing growth of technical information*, in Nathan Rosenberg, Ralph Landau, and David Mowery (eds.) **Technology and the Wealth of Nations**, Stanford University Press, Stanford, pp. 407-434.

Bell, R.M. (1993). **Integrating R&D with Industrial Production and Technical Change: Strengthening Linkages and Changing Structures**, Economic and Social Commission for Western Asia. UN, E/ESCWA/NR/1993/WG.2/16.

Bhatt, V.V. (1980). *Financial institutions and technology policy*, **Economic and Political Weekly**, Review of Management, (May), pp.M-43M-52.

Boskin, Michael, J., and Lau, Lawrence, J., (1992). *Capital, Technology, and Economic Growth*, Nathan Rosenberg, R.Landau, and D. Mowery (eds.) **Technology and the Wealth of Nations**, Stanford University Press, Stanford, pp. 17-55.

British Venture Capital Association, (1994). **Report on Investment Activity**, London.

Brooks, H. (1986). *National Science Policy and Technological Innovation*, in Ralph Landau and Nathan Rosenberg (eds.) **The Positive Sum Strategy, Harnessing Technology for Economic Growth**, National Academy Press, Washington, DC, pp.119-167.

Charles, D. and Howells, J. (1992). **Technology Transfer in Europe, Public and Private Networks**, Bellhaven Press, London, pp.59-82.

Chowdhury, Anis and Islan, Iyanatul. (1993). **The Newly Industrializing Economies of East Asia**, Routledge, London.

Cohen, W.M. and Levinthal, D.A.(1989). *Innovation and Learning: The Two faces of R&D*, **Economic Journal**, Vol.99, pp.569-96.

Cooper, Charles (1994). *Relevance of Innovation Studies to Developing Countries*, in Cooper, Charles (eds.) **Technology and Innovation in the International Economy**, Edward Elgar and United Nations University Press, Aldershot.

Coopers and Lybrand (1994) **Fourth Annual Impact of Venture Capital Study**, National Venture Capital Association, Arlington.

CSIR (1993). Creating an Enabling Environment for Commercialisation of CSIR knowledge base: A New Perspective, A Report submitted to DGCSIR, Pune, (mimeo).

Dunning, J.H. (1992). *Multinational Enterprises and the globalization of inventory Capacity*, in Ove Granstrand and Soren Sjolander (1992). *Technology Management and International Business*, John Wiley and Sons, Chichester.

Folster, S. (1988). *The incentive subsidy for government support for private R&D*, *Research Policy*, Vol.17, pp.105-112.

Florida, Richard L. and Kenney, Martin (1988). *Venture capital-financed innovation and technological change in the USA*, *Research Policy*, Vol.17, pp.119-137.

Government of India (various issues): *R&D Statistics*, Department of Science and Technology, New Delhi.

Government of India (1988). *Venture Capital Guidelines*, Office of the Controller of Capital Issues, Department of Economic Affairs, Ministry of Finance.

Green, Milford (1991). *Venture Capital: International Comparisons*, Routledge, London.

Guha, Ritu (1995). *Selling high-tech nirvana to the world*, *Economic Times*, July 16, p.15

Ibanez, Fernan (1989). *Venture Capital and Entrepreneurial Development*, Policy, Planning and Research Working Papers, WPS 53, The World Bank, Washington.

Jethanandani, Kishore. (1995). *Venture Capital: New Directions*, *The Economic Times* August 4, p.8.

KPMG (1994). *Summary of the Tax Treatment of Research and Development Expenditure in Twenty Countries*, London.

Lall, Sanjaya.(1993a). *Promoting Technology Development: The Role of Technology Transfer and Indigenous Effort*, *Third World Quarterly*, Vol.14, No:1, pp.95-108.

Lall, Sanjaya. (1993b). *Understanding Technology Development, , Development and Change*, Vol.24, pp.719-753.

Lall, Sanjaya and others (1993). **Bank lending for Industrial Technology Development**, Operations Evaluation Department, World Bank, Washington, Report No: 12138, Volumes 1 & 2.

Lall, Sanjaya (1994). *Technological Capabilities*, in Salomon, J.-J., F.R., Sachs-Jeantet, C. (eds.), **The Uncertain Quest**, United Nations University Press, Tokyo, pp.264-301.

Mani, Sunil. (1992) **Foreign Technology in Public Enterprises**, Oxford and IBH, New Delhi.

Mani, Sunil (1994) **Financing Technology-Based Small Firms and Venture Capital Funds: The Indian Experience**, The Centro Studi Luca d'Agliano Queen Elizabeth House (University of Oxford) Development Studies Working Papers, N.78, (October).

Mansfield, E. et al (1977) *Social and Private Rates of Return from Industrial Innovations*, **Quarterly Journal of Economics**, Vol.XCI, pp.221-240.

Mansfield, E. (1985) *Public policy toward Industrial Innovation: An International Study of Direct Tax Incentives for Research and Development*, in Clark, K.B., Hayes, R.H, and C.Lorenz, **The Uneasy Alliance**, Harvard Business School Press, Mass., pp.383-407.

Mashelkar, R.A. (1995) *Matching industry's needs is CSIR'S top priority*, **The Hindu**, August 10, p.25.

Mayer, C (1992). *The Financing of Innovation* in Bowen, Alex and Martin Ricketts (ed). **Stimulating Innovation in Industry**, Kogan Page, London, pp.97-115.

Mowery, David and Nathan Rosenberg (1993). *The US National Innovation System* in Richard Nelson (ed), **National Innovation System**, Oxford University Press, New York, pp. 48-50.

National Science Board (1993). **Science and Engineering Indicators-1993**, U.S. Government Printing Office, Washington, DC., (NSB 93-1).

National Science Foundation (1991). **International Science and Technology Data Update**, Washington, DC., (NSF91-309).

National Venture Capital Association. (1992 and 1994), **Annual Report**, Arlington.

- Nelson, R.R (1984). **Government and Technical Progress**, Pergamon Press, New York.
- Nelson, R.R (1988) *Institutions supporting technical change in the United States*, in Dosi, Giovanni (ed.) **Technical Change and Economic Theory**, Pinter Publishers, London, pp.312-329.
- Nelson, R.R.(1993) **National Innovation Systems**, Oxford University Press, New York.
- Odagiri, H.(1992) **Growth through Competition and Competition through Growth**, Oxford University Press, Oxford.
- OECD (1993) **Basic Science and Technology Statistics**, Paris.
- Patel, Parimal and Pavitt, K. (1995). *Patterns of technological activity: their measurement and interpretation* in Stoneman, Paul (ed), **Handbook of Economics of Innovation and Technological Change**, Blackwell, Oxford, pp. 14-51.
- Pavitt, K (1976) *Government Policies Towards Innovation: A Review of Empirical Findings*, **Omega**, Vol.4, No:5, pp.539-557.
- Piatier, A. (1984). **Barriers to Innovation**, Frances Pinter, London.
- Rosenberg, N et al (eds.) (1992) **Technology and the Wealth of Nations**, Stanford University Press, Stanford.
- Sagari, S. B. and Guidotti, G.(1992). *Venture Capital: The Lessons from the Developed world for the Developing Countries*, **Financial Markets, Institutions and Instruments** , Vol.1, No:2, pp.1-59.
- Sribu, Jr. (1978) *Government aid for the development of innovative technology: lessons from the French*, **Research Policy**, Vol.7 No:4, pp.176-196.
- Stoneman, Paul (1987) **Economic Analysis of Technology Policy**, Clarendon Press, Oxford.
- Stoneman, Paul (1993) **Government Policy and Innovation**, Innovation Seminar Papers, The Economic and Social Research Council, Swindon.
- UNIDO (1991) *Venture apital Financing*, in **Industry and Development**, Vienna.
- Uno, K (1991) **Technology, Investment and Trade**, Elsevier, Amsterdam, pp.91-111.

Venture Economics (1988) **Venture Capital in India, a feasibility study, Canada.**(mimeo)

Venture Economics (1991) **Venture Capital and Technology, New Jersey.**

Venture Economics (1993) **Annual Statistics, Boston.**

Walker, W (1993). *National Innovation Systems: Britain in* Nelson, R. R (1993) *op.cit*, pp.159-191.

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