CHAPTER I

INTRODUCTION
Preamble

According to Peter Drucker, the world-renowned management guru [1], ‘the essence of any business enterprise, the vital principle that determines its nature, is economic performance’ and ‘management can only justify its existence and its authority by the economic results it produces’. In this management is unique and, ‘the first definition of management is therefore that it is an economic organ, indeed the specifically economic organ of an industrial society’ and ‘...every act, every decision, every deliberation of management has as its first dimension an economic dimension.’. Thus the, ‘management’ s first job is managing a business’ and it also means, ‘...in the first place that the skills, the competence, the experience of management cannot, as such, be transferred and applied to the organization and running of other institutions.’

This preamble is very apt here as the management in Research and Development (R&D) context is fundamentally different from management of other domains.

Everybody would agree that the Indigenous Research and Development (R&D) is very essential for the economic development of the country. However, it appears that, despite its crucial importance, its high visibility and its spectacular rise in the recent years, the R&D and more specifically R&D management is the less known and not so well understood. Very few people with in an R&D know what their management does and what it is supposed to be doing, how it acts and why, whether it does a good job or not.

It also appears, that the attention R&D is getting is less than adequate. Further, it also seems that, where there is substantial R&D taking place, its management is not as much scientific or effective as it could be expected from the R&D community, and its leaders. This phenomenon is, at times, attributed to the cultural factors. The current situation of global setting, where competition is the word and time to market, application oriented research, taking the fruits of research to the public, doing fundamental research at the frontiers, dumping by the rich and advanced countries, economic liberalization etc., are posing greater threat to the Indigenous R&D, and it appears that in the ultimate reality the Indian R&D is desperately striving to cope up. [2]

The present work, therefore, attempts to understand and analyse this much-needed R&D Management and tries to propose viable guidelines for achieving effectiveness.
INTRODUCTION

Introduction to R&D and R&D Management

Research is concerned with the search for new knowledge, with ideas and with intention. Research is associated with Development, which is more relevant for industries, which rely heavily on technological innovation for survival; and this is especially true for high technology change areas.

Then, there is a distinction between invention and innovation: An invention is an idea or drawing or model for a new or improved device, product, process or system. In the economic sense, an innovation is only accomplished with the first commercial transaction. Thus, not only invention, but also an innovation is required to generate profits. A similar though not entirely analogous distinction may be drawn between Research and Development. Research is that part of the process dealing with invention, while Development is concerned with taking that idea and turning it into a commercial product.

At this point, it is interesting to note that the Research and Development did not always exist in the structured and highly organized form found today in the modern organizations. Individuals, often working alone, made the early discoveries at the time of the Industrial Revolution. In the later half of the eighteenth century coteries and clubs were developed which served to aid communication between individual workers. The diffusion of knowledge became more formalized with the appearance of technical journals. In 1800s to 1900s the number of scientific and technical journals have increased from a few to few hundreds. Science and technology evolved into a domain of groups of specialists working from Universities and other organizations: And science got organized into various specialties and scientists became salaried professionals. Down the line, changes also occurred in the Industry. Development by improvement and application became too difficult for workers trained only in traditional methods and through technical trainings done separately for the purpose, which in reality proved to be disadvantageous to both academia and industry. Despite many innovations, formalized R&D is of recent origin. In general the growth of certain industries was stimulated by technological innovations that facilitated the growth of professional in-
house industrial R&D, this was ably supported by the close relationship between industry and universities. The role of R&D in the growth of Electronics Industry amongst other things has been demonstrated well. [5]. With the advent of faster rates of technological change, it has become more important than ever for an organization to carry out R&D so that a continual improvement in products can occur. As has been mentioned earlier, not only must R&D be carried out as a separate critical function with in an industry, but adequate integration in-house, and also between the industry and educational institutions must occur. Although not exclusively confined to industry, R&D may be viewed as the main method by which an organization* promotes growth through technological innovation, from within. [3]

It is the various aspects of the industrial R&D and means for improving the effectiveness of this function that are discussed here in this work.

Further, the R&D could be classified in to three categories of R&D: viz., basic research, applied research and experimental development. This is based on classification recommended by the Organization for Economic Cooperation and Development (OECD) report on “The Measurement of Scientific and Technical Activities”.

i. Basic research is original investigation undertaken in order to gain new scientific knowledge and understanding. It is not primarily directed towards any specific practical aim or application. In pure basic research, it is generally the scientific interest of the investigator, which determines the subject studied. In oriented basic research the investigator is directed towards a specific field by the employing organization.

ii. Applied research is original investigation undertaken in order to gain new scientific or technical knowledge. It is directed primarily towards a specific practical aim or objective.

iii. Experimental (or commercial) development is the use of scientific knowledge in order to produce new or substantially improved materials, devices, products, processes, systems or services.

* The words Organization(s), Institution(s), Firm(s), and Company(ies) have been used interchangeably throughout this report to represent the equivalent meaning.
From the above classification, it would appear that in industry most activities fall under applied research or experimental development. Here again, there are many activities related to R & D but which nevertheless are not R & D activities. The inclusion or exclusion of an activity must be based on the presence or absence of an appreciable element of novelty. Activities to be excluded from R & D are scientific education, the activities of scientific and technical information personnel, general purpose data collection, testing and standardization, feasibility studies for engineering projects and patent and license work.

The Research & Development being a vital activity has to be undertaken from the initial stage itself, in any organisation, and by according it a special status and also appropriately integrating it in to the overall organisation. [4]

Typically, the R&D and its Management calls for:

- A strong determination/commitment,
- Authority to impose self constraints,
- Ability to make decisions,
- Understanding a situation in its entirety,
- A broader perspective and long term vision, and above all,
- A wider technical / scientific proficiency.

Then only, R&D could be expected to deliver, high quality and high reliability professional products and technologies that are upgraded from time to time as the situation changed/improved and this would result in commendable commercial results.

Typically the ways in which research output may be evaluated are the three key factors, [3] as follows:

i. The economic value of the technology produced as opposed to the cost of the research that produced it.

ii. The amount of technological output per unit of scientific effort expended (productivity).

iii. The degree to which the program’s technology supports company goals.
The first two factors strictly refer to output-input relationships but do depend on the measurement of the amount and economic value of R & D outputs. The third factor refers to the effectiveness of the program. The measurement of the economic value depends on the valuation of the technology.

Further, the R&D Productivity parameters in case of R&D Institutions could be in terms of increased market presence and increased market share, in general, and Technology Development, in particular. But, at the organizational level, it is expected to be the Innovation (products, services, processes), Patent productivity, quality orientation (Salable Quality Products in time!), reduced Product Development Cycle Time, Business orientation from design stage itself (i.e. Business generated by that particular product vis-à-vis the time, money and effort put in), etc. It is possible to include as many parameters as feasible (say reduced R&D costs, increased profits, reduced R&D uncertainty etc.), and it is essential that specific standards are set in each case either from literature, from case studies of other organizations in similar area, or from experience, or even a wishful target to be fulfilled.

Besides, the R & D output as technology assets create a barrier to the entry of other firms into the organization's business. In addition to patent protection, other forms in intellectual property such as copyrights, particularly of computer software, also are quite essential — hence usable as a measure. There may be great non-economic results such as the happiness of the members of the enterprise, the contribution to the welfare or culture of the community, etc [1], yet if it does not improve or at least maintain the wealth-producing capacity of the economic resources entrusted to it, the R&D Management could be considered to be not really successful.

**R&D in India and Effect of Economic Liberalization**

In the independent India, the Government of India (GoI) put a lot of thrust to promote R&D in the country. R&D was happening at the educational institutions and by the interested individuals. The political leadership at the helm supported research strongly and took a series of initiatives for strengthening the same, mostly in the public sector. In view of the non-existence of corporate R&D at that time, way back in the fifties and sixties the GoI founded a series of scientific and industrial research laboratories, with an
express intent of fostering R&D by creating the supporting infrastructure in the public sector for research [6]. Initially the focus was on industry, agriculture and health. Most of the capital equipment was imported. Innovations did not thrive as there was no incentive for innovation and it appears that the country has neglected the Innovation, the key driver of competitiveness. The interventions were basically targeted towards enhancement of R&D supply, but the demand for R&D was poor. Licensing restrictions on expansion of industrial capacity and high levels of tariffs on exports acted as a major disincentive for innovation. There was no competition as the Indian industries were over protected. [2] $

Innovation was not a priority earlier as the economic policy was inward looking. The policy overemphasized self-reliance prior to the liberalization of the economy. Government of India had started about 42 national laboratories to support industrial and scientific research with the idea of creating a supply of research services. Yet it was only in the 1990’s that they focused on commercialization of research. The system that started in the fifties was revamped in 1988 to enhance partnering with industry. The Council of Scientific and Industrial Research (CSIR) prepared a new institutional vision in 1995 [7]. In spite of all these, the research expenditure as a percentage of GNP continued to be low. The design and development of new products have remained an area of weakness, because of the high levels of protection provided to indigenous industries. Over emphasis on self-reliance and the neglect of R&D investments by the industry along with the policy of protecting local technical effort have resulted in poor competitiveness in global trade. India’s share in world trade is 0.7 percent compared to that of China, which is 4.0 percent. Though economic liberalization started in the early 1980s the basic control mechanisms did not change till 1991 when the country adopted a series of new measures to liberalize and open the economy to external competition. This included a set of economic policies aimed at eliminating industrial licensing, reducing protection for internal products, allowing foreign direct investment and minimizing government controls. [2] $

The emergence of intense competition meant that firms have to derive competitiveness through innovation and ability to adopt to changing market conditions and anticipate future technologies and economic trends as well as on short term marketing tactics and long term production strategies. The overriding importance of innovation as the determinant of economic growth was finally noticed. The proportion of high technology based products in global trade has been increasing and technology based products and services have become the drivers of trade. This has been mainly due to low levels of resource allocation for industrial R&D by the government and the focus on the supply side of innovation along with the poor industrial R&D efforts by the private firms. High levels of protection the country accorded to goods produced internally have led to weak product development capability, as there are no incentives to innovate. Technology and research have been known for its low appropriability. Large firms did not spend on R&D and innovative small firms did not come up. Small innovators had low access to capital markets and entrepreneurship was on a low key. On the whole, innovation was accorded a low priority in India. Though the supply side of innovation was strong, the demand for innovation continued to be weak. The result was that the share of high technology based exports in India’s exports remained below 10 percent of the manufactured exports. Mission oriented and institutional R&D in space and atomic energy continued to deliver results though the industrial R&D was weak. This indicates that the low levels of industrial R&D was not due to lack of skills, but due to the absence of competition. Industrial R&D in whatever nominal way it manifested prior to liberalization was mostly in large public sector firms. Protected market had two negative aspects: firms did not participate in the global trade and consequently did not innovate. Thus, it was observed that, in the past, the Government policies being highly regulatory and protective, in a way failed to motivate R&D, and did not stimulate any major improvement in quality or productivity. This was the scenario prior to 1991.

Liberalization of the Indian Economy

The Indian economy went through a crisis in the end of eighties and the crisis reached its peak in the summer of 1991 when foreign exchange reserves had plummeted to a lowest ever level. The overall economic growth had declined to 1.1 percent. It was at this stage that the newly elected Government decided to remove all the major controls...
and liberalize the economy through a series of reforms aimed at opening the economy to market forces. [9] The main reforms carried out between 1991 and 2002 are:

- De-licensing of many industrial sectors reserved for public sector.
- Reduction of duties on imported machines.
- Lowering of interest rates, and
- Removal of control on capital markets.

These measures exposed Indian industry to competition and it started looking outward. These changes have increased the demand side of research. The foreign direct investment showed a substantial rise and the foreign currency reserves have also increased. In retrospect, Indian economy benefited considerably, by integrating with the global economy. Though the gap between developed and a developing country is still large, the operation of the market forces is inducing growth of forces supporting innovation. Technological capability is a purposive activity that does not result automatically from a passive learning process and requires enterprises to invest in specific areas like training, information collection, engineering, design and experimentation.

A brief overview of the growth of Science and Technology (S&T) in India is presented here for a better understanding and completeness. Development of Science and Technology in India could be seen in three distinct phases, namely:

- 1947's to 1960's: The infrastructure buildup phase
- 1970's to 1980's: The re-orientation phase and
- 1990's onwards: The market orientation phase

After the independence the country laid an emphasis on rapid industrialization, increasing agricultural productivity and the establishment of a strong base for scientific and technological infrastructure. As the industry was not in a position to invest in R&D, the government took direct responsibility for this task. During the 1970's the science policy and plans came in for re-examination and re-orientation, as the foreign
technologies introduced till then had contributed very little to the enhancement of technological capability. The research institutions had mostly confined to the invention end of the innovation chain and the interaction between industry and research institutions had been poor. Consequently the import of technology came under modified regulations. This enabled the research institutions to direct their efforts in areas where foreign technology was not permitted. Indian Patent Act allowed only processes to be patented. Tax incentives were introduced to promote in-house R&D in the industry. In the market orientation phase, accountability and questions relating to returns on investments in S&T have become important. The industrial policy statement adopted in 1991 gave a major shift in favour of a business approach to Indian R&D in the wake of adoption of liberalization and globalization phase. At present, scientific and technological activities in India are carried out under a wide set up consisting of Central and State governments, higher education sector, public and private sector industry and non-profit institutions and associations. The linkages among them, however, continue to be weak.

The Science and Technology
The three major S&T policy statements have been adopted in the post independence period, namely Science Policy Resolution of 1958, Technology Policy Statement of 1983, and Science and Technology Policy of 2003. The recently adopted policy statement recognizes the inevitability of the processes of globalization and liberalization of the Indian economy. Among other things, it articulates the need for reconstruction of academic scientific system, technology development through appropriate reward mechanisms, measures to increase active involvement of industry in both basic and applied research, generation and management of intellectual property. [From official web site Department of Science and Technology, Government of India]

The national system of innovation [Schumpeter as quoted in [2]] essentially depicts the role the set of institutional actors together play in influencing innovative performance at a macro level and can explain the reasons for the presence or absence of innovations, as well as its successful commercialization. The system of innovation will be effective if there is a demand for innovation. The policy framework of a country should enable the
market for innovations to evolve. Scholars have shown that the rate and character of technological advancement is influenced by the institutional structures supporting it and that institutions also strongly condition whether and how effectively new technology was accepted and absorbed into the economic system.

The main reason for the absence of demand for innovation has been the prevalence of low levels of competition. The emergence of WTO norms has changed this completely. If indigenous firms have to survive in a competitive context, they have to innovate. Also, globalization of markets has made it necessary for the firms to create intellectual property that could help them to recover the investments they are making. Innovation has become the essence of competitiveness in both product markets as well as in services. The changes in the innovation system have to be seen in this context.

The Overall R&D Expenditure
India continues to spend less for R&D in comparison with that of the other developing countries such as, Korea, China and Brazil. There has been an increase in the total R&D outlay in current prices in the past three decades. It has grown four fold since 1990-91 as shown in Table 1.1, but the expenditure on R&D as a percentage of GNP has just held on at the same level. Since India has a population more than 1000 million, the R&D spending per capita has been very low. A recent study by Rand has shown that R&D expenditures by most of the developing countries have been substantially lower than that of developed countries. Overall R&D intensity of India is also lower than that of Brazil, Hungary, Ireland, China, Singapore and South Korea, which invest more than one percent of their national product. In developed countries like Japan the allocation for R&D is about three percent of the national product. This also explains partly why the share of exports of India in the world trade did not experience any major change for a long period of time.

Industrial R&D
The private sector industries did not invest much in R&D prior to the economic liberalization. The major R&D provider was the government and government firms. Some of the large public sector corporations were the major spenders in the earlier years. The post liberalization years have brought in a perceptible difference. The need
for creating intellectual property and exploiting it across many markets has become the focus of industrial R&D, especially by the large high technology firms (only those in the Electronics, IT and Telecom areas are indicated) as shown in Table 1.2, ranked in terms of R&D expenditure for the year 2001-02.

Table 1.1 depicts the National Expenditure on R & D 1980-81, 1990-91 and 2000-01 to give a comparison as to the actual figures as well as, as a percentage of R&D spend. This figure, viz., 0.86% appears to quite insubstantial, both in numbers and its effectiveness.

### Table 1.1 National Expenditure on R & D

<table>
<thead>
<tr>
<th>Particulars</th>
<th>1980-81</th>
<th>1990-91</th>
<th>2000-01*</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNP of current prices (Million Rupees)</td>
<td>1305230.0</td>
<td>5034090.0</td>
<td>20606000</td>
</tr>
<tr>
<td>Expenditure on R&amp;D at current prices (Million Rupees)</td>
<td>7605.2</td>
<td>39740.0</td>
<td>176602</td>
</tr>
<tr>
<td>Expenditure on R&amp;D as percent of GNP</td>
<td>0.58</td>
<td>0.85</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Source: Research and Development Statistics: 2000-01
Department of Science and Technology, Ministry of Science and Technology, 2002
Budget of India documents – 2002-03*

The Table 1.2 depicts the R&D expenditure of a few firms that are working in the high technology areas in the Electronics, IT and Telecom areas. This information is a part extract of the table of R&D expenditure: Top 20 firms operating in India

### Table 1.2 R&D expenditure of Top 20 firms operating in India (part)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bharat Heavy Electricals Ltd. (3)</td>
<td>796</td>
<td>75</td>
<td>76511</td>
</tr>
<tr>
<td>Bharat Electronics Ltd. (4)</td>
<td>783</td>
<td>112</td>
<td>19473</td>
</tr>
<tr>
<td>Reliance Industries (5)</td>
<td>749</td>
<td>152</td>
<td>57120</td>
</tr>
<tr>
<td>ITI Ltd. (9)</td>
<td>497</td>
<td>83</td>
<td>24322</td>
</tr>
<tr>
<td>Hughes Software Systems Ltd. (15)</td>
<td>334</td>
<td>0</td>
<td>23488</td>
</tr>
<tr>
<td>Ramco Systems(16)</td>
<td>268</td>
<td>31</td>
<td>9384</td>
</tr>
<tr>
<td>BPL Ltd (17)</td>
<td>264</td>
<td>0</td>
<td>12979</td>
</tr>
</tbody>
</table>

Source: [extract form Bowonder B et al ]
In addition to BHEL and BEL, other firms such as Tata Engineering, Dr.Reddy's Lab, Ranbaxy, Wockhardt, and IOC are focusing on commercializing innovations. Yet India has to go a long way in industrial R&D. The number of firms undertaking research has not been substantial. About 86 percent of Indian joint stock companies (total number of firms is 8334) have reported no spending on R&D, in the annual reports for the year 2001-02. At the same time the firms that have the strategic intent of staying competitive are increasing their R&D spending. A closer look at the private companies in the automobile, pharmaceuticals and software, the three sectors where the country seem to have fared better – the R&D intensity is the highest in pharmaceuticals and the lowest in the automobile segment. Table 1.3 indicates the R&D expenditure in Software industry. The percentages are low when one compares these with the efforts by the global firms.[10] The R&D investments of global firms and their R&D spending are substantially higher amounts for R&D when compared to the corresponding Indian firms.

Table 1.3 indicates the R & D Expenditure by Software Firms for years 1992 –2002 in the Country, and it could be seen that these figures show an increasing trend.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales Million Rs</th>
<th>R&amp;D Expenditure Million Rs.</th>
<th>R&amp;D Intensity: R&amp; D as percentage of sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>25164</td>
<td>72</td>
<td>0.29</td>
</tr>
<tr>
<td>1998</td>
<td>31431</td>
<td>90</td>
<td>0.29</td>
</tr>
<tr>
<td>1999</td>
<td>44806</td>
<td>382</td>
<td>0.85</td>
</tr>
<tr>
<td>2000</td>
<td>55023</td>
<td>414</td>
<td>0.75</td>
</tr>
<tr>
<td>2001</td>
<td>84453</td>
<td>649</td>
<td>0.76</td>
</tr>
<tr>
<td>2002</td>
<td>92353</td>
<td>1045</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Source: [Bowonder B et al ]

Increase in R&D thrust along with accelerated new product development has been one of the strategies used by the high tech firms for enhancing the competitiveness. Both the pharmaceutical firms – Dr. Reddy Laboratories and Ranbaxy – appearing high on the R&D spenders list have licensed molecules to global pharmaceutical firms for clinical trials. This is the first time Indian companies have licensed new molecular entities to global firms for commercialization. The Table 1.2 also indicates that the
private sector firms have started hiking the R&D spending. Prior to the liberalization of the economy most of the firms in this category came from the public sector indicating a shift in the strategic intent among the private sector firms. Tata Engineering has designed and developed a car that has been able to capture a reasonable share of the market in the small car segment.

Nonetheless, in the international context, R&D spending by Indian firms is lower both in magnitude and as a percentage of sales turnovers. The conclusion that can be made at this juncture is that competition has increased new product activities by firms that have a strong intention of remaining competitive have shown an increase. The R&D investment have been focused mainly in automobiles, pharmaceuticals, and software. In other sectors this continues to be low. If Indian industry has to become competitive it has to raise the R&D expenditure and focus on new product creation. An analysis of distribution of R&D investment by Indian firms show that only 7 firms spend more than Rs.500 million per year for R&D 463 firms spend less than Rs.10 million according to the annual reports. Of 8334 firms only 644 firms have shown that they are actively involved in R&D, as shown in Table 1.4. These 644 firms include 57 Electronics firms, and 42 firms in Electrical machinery line. The rest of firms that account for 7690, have not reported that they are carrying out any major R&D activity. These firms will not be able to face global competition without any product development capability.

Another interesting statistic from the Indian scenario is presented in the following Table 1.4, that shows the dismal state of R&D Investments (year 2002) in the country despite the economic liberalization and need for R&D Investment.

<table>
<thead>
<tr>
<th>R &amp; D Investments (Rs. Million)</th>
<th>Number of Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 and above</td>
<td>7</td>
</tr>
<tr>
<td>100 to 499</td>
<td>28</td>
</tr>
<tr>
<td>50 to 99</td>
<td>32</td>
</tr>
<tr>
<td>10 to 49</td>
<td>114</td>
</tr>
<tr>
<td>Less than 10</td>
<td>463</td>
</tr>
</tbody>
</table>

Source: [Bowonder B et al ] TOTAL 644
Government R&D

The government funded R&D has also undergone some changes. The broad pattern shows that a major chunk goes into mission mode R&D in areas such as space, ocean development, atomic energy and defense. Defense R&D continues to be the major activity with more than 60 percent of the total R&D allocation as shown in Table 9. The increase in defense R&D has been due to the initiation of multi-agency projects such as Integrated Guided Missile Development Programme (IGMDP), Light Combat Aircraft, Main Battle Tank etc. IGMDP saw for the first time the induction of a missile developed in the country through indigenous R&D. Similarly, the Light Combat Aircraft has been flown successfully in 2001 and is likely to be inducted into the Indian Air force. This is the world’s smallest supersonic fighter aircraft and it is made using predominantly fiber-reinforced composites. The expenditure on defense R&D has increased substantially. This has been done for increasing the production of defense equipment that currently account for substantial foreign exchange outflow. Similarly, the R&D efforts from the Centre for Development of Telematics (CDOT) under Ministry of Communication and IT, GoI, have resulted in low cost country specific Telecom Switching Equipment, which helped in revolutionizing the telecom scenario in the country by mass deployment (more than 2.5 Crore telephone lines) and a huge ancillary development. [from website of CDOT] Relatively significant expenditure on industrial R&D emanates from the belief that industrial R&D has to be performed by the corporate sector. The low levels of R&D will certainly affect industrial competitiveness of India vis-à-vis countries such as Taiwan, Singapore, Israel and Korea.[10,12] The major perceptible change in government R&D is that the mission-oriented projects are replacing open-ended research programmes. This will induce demand-pull innovations.

According to NR Narayana Murthy, CMD and Mentor of Infosys the inexpensive and rugged telecom switches developed by CDOT (guided by Sam Pitroda) is one of the two extremely important technological innovations that have transformed the lives of Indians like never before (the other one being the Satellite Instructional Television Experiment SITE led by Prof. Yash Pal); and transformed the Communication in the country and brought the entire nation together. (Source: 30th Anniversary Issue of India Today, July 3 2006)
There have been many changes in the area of industrial research as well. Government of India has increased its allocation to various scientific agencies in the last decade as indicated in Table 1.5. CSIR also started a new initiative on emerging technologies through targeted consortia research. In each project a number of labs are involved as well as selected experts. Government R&D is becoming more result oriented and mission based. This is likely to enhance effectiveness of government oriented R&D. The linkages are evolving as consortia research is increasing and this will induce national system of innovation to be a networked one.

Table 1.5 depicts the R&D expenditure by major scientific agencies, all from Government; note that there has been substantial rise (~300%) in the spending.

<table>
<thead>
<tr>
<th>Agency/year</th>
<th>1990-91</th>
<th>1998-99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Council of Scientific &amp; Industrial Research</td>
<td>2491.88</td>
<td>7133.20</td>
</tr>
<tr>
<td>Defence Research &amp; Development Organization</td>
<td>6810.00</td>
<td>23002.00</td>
</tr>
<tr>
<td>Department of Atomic Energy</td>
<td>2755.40</td>
<td>8367.00</td>
</tr>
<tr>
<td>Department of Biotechnology</td>
<td>413.67</td>
<td>944.69</td>
</tr>
<tr>
<td>Ministry of IT</td>
<td>330.30</td>
<td>620.97</td>
</tr>
<tr>
<td>Ministry of Non-Conventional Energy Sources</td>
<td>160.20</td>
<td>89.50</td>
</tr>
<tr>
<td>Department of Ocean Development</td>
<td>278.05</td>
<td>848.16</td>
</tr>
<tr>
<td>Department of Science &amp; Technology</td>
<td>1198.26</td>
<td>2989.95</td>
</tr>
<tr>
<td>Department of Space</td>
<td>3862.22</td>
<td>15155.60</td>
</tr>
<tr>
<td>Indian Council of Agricultural Research</td>
<td>2762.51</td>
<td>8440.41</td>
</tr>
<tr>
<td>Indian Council of Medical Research</td>
<td>445.41</td>
<td>862.57</td>
</tr>
<tr>
<td>Ministry of Environment &amp; Forests</td>
<td>1620.93</td>
<td>3779.50</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>23128.82</strong></td>
<td><strong>72233.55</strong></td>
</tr>
</tbody>
</table>


There has been a discernible result in patentable innovations after economic liberalization. New patent registrations, patents filed by the International R&D companies operating in the country and number of Indian patentees, are some of indicators that showed a growth. There has been a ten-fold increase in the patents filed in the US Patents and Trademarks Organization (USPTO) by Indian firms during 1996-2002 over the previous slab of 1991-95 as shown in Table 1.6. The Patents taken by
non-Indian R&D labs also show a remarkable increase. This clearly shows that the focus has shifted to patentable innovations indicating better conceptualization of research centers, especially the new ones.

Table 1.6 presents number of Patents granted by the USPTO to organizations operating in India, 1991-95 and 1996-2002, that shows a phenomenal increase, thanks to the new regime. But it could also be seen that the MNCs operating from India have justified their presence.

<table>
<thead>
<tr>
<th>Agency</th>
<th>No. of patents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1991-95</td>
</tr>
<tr>
<td>Total Indian assignees</td>
<td>54</td>
</tr>
<tr>
<td>Council of Scientific and Industrial Research</td>
<td>25</td>
</tr>
<tr>
<td>National Research Development Corporation</td>
<td>-</td>
</tr>
<tr>
<td>Individual patentees</td>
<td>29</td>
</tr>
</tbody>
</table>

**Patents taken by Non-Indian R&D labs operating in India with Indian Inventors**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Instruments Inc.</td>
<td>11</td>
<td>63</td>
</tr>
<tr>
<td>General Electric Co.</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>IBM Corp.</td>
<td>-</td>
<td>31</td>
</tr>
<tr>
<td>Lucent Technologies Inc.</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>Intel Corp.</td>
<td>-</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: [Bowonder B et al ]

An increasing trend [IPO website] is also clearly seen in the number of patents granted by Indian Patent Office IPO, as shown in Table 1.7. The recent amendments to the Indian Patent Act adopted in a move towards adhering to the intellectual property norms under TRIPS has boosted the patenting in India by many MNCs. More than 77 global firms have set up R&D centers in India as direct subsidiaries [2, 11, 12] this resulting in a better utilization of Indian R&D Capabilities and thereby improved R&D outputs from the country. Thus globalization has proved to be a powerful driving force and motivator for the country’s development in a way [13], and it is expected by the Industry Leaders that in the coming years, there would be a healthy competition between Indian R&D establishments and Global Companies operating in India. Only by focusing on innovation India can become a high technology player in the global context, otherwise India will find it quite difficult to balance the trade.
Table 1.7 depicts the distribution of patents filed in the Indian Patent Offices (IPO) during 1995-2001, in different categories, that show an increase in trend.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>1692</td>
<td>1994</td>
<td>3182</td>
<td>3087</td>
<td>3729</td>
<td>1895</td>
<td>2680</td>
</tr>
<tr>
<td>Electrical</td>
<td>276</td>
<td>470</td>
<td>718</td>
<td>441</td>
<td>585</td>
<td>312</td>
<td>402</td>
</tr>
<tr>
<td>Electronics</td>
<td>611</td>
<td>853</td>
<td>1636</td>
<td>1252</td>
<td>1674</td>
<td>836</td>
<td>1347</td>
</tr>
</tbody>
</table>

Source: [Bowonder B et al ]

To put it in a nutshell, the R&D scenario in the country has changed totally, with the recent developments, and broadly speaking, with the reforms and measures carried out from 1991 have exposed the Indian Industry to competition and it started looking outward. These changes have increased the demand side of research. In retrospect, Indian economy benefited considerably, by integrating with the global economy; and the globalization has changed the ways in which companies can create value through greater heterogeneity and greater complexity.

A brief word about the Sample Domain

The Indian Telecom R&D traditionally was a part of the single mammoth service provider with in the Government, the role and contribution were not adequate enough and hence massive imports were taking place. There was an R&D set up available in the country with another giant manufacturing set up also under the same Government ministry. This lead to a kind of monopoly situation and the costs of telecom equipment and service were prohibitively expensive. This also in a way prompted more imports as the domestic demand increased. At this juncture a new out fit was created – though within the Government frame work itself, but with a clearer mandate and good amount of autonomy. This new R&D set up revolutionized the way R&D is done and focused on mass deployment of Telecom products all over the country – which were very cost effective and also reliable. The socio economic changes and impact brought in by this set up were a phenomenon. However, with the sweeping changes that have come in the Telecom sector both technologically as well as politically as policy changes, this set up is facing challenges: putting it differently, the trends of Mobile and WiLL phone
presence vis-à-vis land line (where the organization's core competences are) and the approaches with in the Organization to cope with the current situation are the challenges faced. This was further complicated as new MNC players started entering the fray with deep packets and tried to exploit the economically available R&D expertise in the country coupled with their muscle power. This forms the basis of the problem of this study, as to how to cope up to face the challenge and to be effective – for survival and to be competitive. Table 1.8 presents indicative statistical data of IT&Telecom in India.

Table 1.8 presents the Statistical update of IT & Telecom Scenario in India as on 31-5-2006 (Indicative Data) that clearly shows the spread and magnitude of IT/Telecom in the country. More details provided in the Chapter II.

<p>| TABLE 1.8 | Statistical update of IT &amp; Telecom Scenario in India |</p>
<table>
<thead>
<tr>
<th>As on 31-5-2006 (Indicative Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian population</td>
</tr>
<tr>
<td>Fixed Phone subscribers</td>
</tr>
<tr>
<td>Mobile Phone subscribers</td>
</tr>
<tr>
<td>Fibre Route laid down in India</td>
</tr>
<tr>
<td>Internet subscribers</td>
</tr>
<tr>
<td>Internet users (@5 users/connection)</td>
</tr>
<tr>
<td>Broadband subscribers</td>
</tr>
<tr>
<td>No. of ISPs in India</td>
</tr>
<tr>
<td>PC owners</td>
</tr>
<tr>
<td>TV homes</td>
</tr>
<tr>
<td>Cable TV homes</td>
</tr>
<tr>
<td>Cable TV operators</td>
</tr>
<tr>
<td>TV coverage by Area (with DTH)</td>
</tr>
<tr>
<td>No. of call centers/BPOs/ITES</td>
</tr>
<tr>
<td>IT Manpower available in India</td>
</tr>
<tr>
<td>ITES &amp; S/W Export achieved (2005-06)</td>
</tr>
</tbody>
</table>

Source: Compilation by S.K. Aggarwal, DIT, New Delhi

www.skagarwal.in
REVIEW OF LITERATURE

Many scholarly books and learned papers have been written and hence available on the subject of management but not as many concerning the Management of Research and Development. Writings in the Management area typically have been by the individuals with a background in specific management disciplines such as general management, marketing, finance or human resources, but not as many in the area of R&D Management. In those writings, the R&D Management topics have been covered from a very limited narrow point of view so to say. There have been some good writings in the areas concerning R&D management such as performance evaluation and so on, but these were with the influence of their domain specificity of the authors, from where they have grown. When written by R&D Managers who have grown to the level from being scientists or engineers, concerned treatment has always tended to be from a middle level management and more likely with a scientific/technical orientation given: that is, more about R&D and not so much about the R&D Management per se. Even otherwise, one consequence of this was that the treatment has been based on local and not global in its approach. A further drawback that could be seen was that there was lack of treatment in the interpersonal considerations and finally there was no integrated approach to the R&D management, in particular. Thus the role of R&D and R&D Management have not got the requisite appreciation they deserved and corresponding overall projections were only very limited and few.

One exceptional yet highly excellent landmark publication reviewed, was by John H Dumbleton [3], who incidentally has attempted to remedy the above limitations by giving the complete picture and requisite overall treatment. Dumbleton discusses the high technology R&D in terms of its position in the strategy-structure relationship of the firm has been presented – intended to benefit the R&D Managers (and R&D Staff) and the Top management of the firm. The five major areas covered in great detail viz., the nature of R&D, the strategy and structure relationships, the creativity, the R&D process and the R&D interface – are all having a direct bearing on the effectiveness of the industrial R&D. Dumbleton also discusses ways of evaluating the performance of R&D – a topic that normally frustrates top management in its efforts to quantify the returns on investments in R&D. Dumbleton also discusses at length, the positioning of
R&D in the firm and suggests that it shall be placed in an appropriate level in the organizational hierarchy and direct top management patronage for it to be effective. The subject of creativity – in relation to intelligence, personality and ability – are also elaborated. Project selection, evaluation of alternatives, project planning and control are also discussed in detail. Dumbleton also discusses the relevant soft factors and dispels the prevalent myths in the management literature about the assumed ideal conditions and rationality in the organizations. In many a way, Dumbleton presents a complete picture and stimulates insights in the R&D management area.

Review of some studies in Global context

In today’s competitive environment, the Productivity of Research and Development becomes crucial for the success of any organization. The improvement in R&D productivity directly depends on the R&D performance in an organization and therefore measurement of the R&D performance assumes the critical importance, hence this area was taken up first, to review in the literature.

In the literature Research and Development performance measurement, is quite well documented. Dumbleton [3] while describing the management of high technology R&D elaborates on both the Effectiveness of R&D (i.e. optimum achievement from the R&D) and the Efficiency of R&D (i.e. optimum resource usage). Further, Dumbleton suggests that depending on the industrial sector, a 70/30 ratio is the right balance with 70 percent of the projects of the demand-pull type an 30 percent of the supply-push type. This in a way indicates where the high technology R&D has to look for and which way the valuable resources have to be distributed in an R&D Organization.

Audrey Verhaeghe and Rivka Kfir [14] studied a knowledge intensive technology organization (KITO) (an IT/Telecom high technology R&D), with a specific reference to managing innovation as a performance measure. Grover [15] dealt with maximizing patent productivity as a critical performance indicator, rightly so in the fast changing technology areas, where only the innovation is the insurance against obsolescence and defense in today’s competition. Bill Nixon [16] describes a case study for research and development performance measurement. Inge C Kerssens-van Drongelen and Andrew
Cook [17] describe a set of design principles for the development of measurement systems for research and development processes. Here as could be seen the stress is on the R&D process itself. Roger Whitley et al [18] describe a method of evaluating R&D performance by using the new sales ratio, as a parameter towards the worthiness of various R&D efforts. Literature also covers aspects of evaluation of R&D processes and effectiveness through measurements by Ellys Lynn [19].

Here it had been seen that the various techniques become very much particular industry oriented and/or generalized from one industry to all. It was also noted that there exists total disparity in viewpoints, when same R&D Productivity or Performance measurement was studied by the R&D People themselves or by the Finance.

As such and especially from finance perspective the Performance measurement remains a vexing problem for business firms and more so for R&D organizations. The performance one wishes to measure (long-term cash flows, long-term viability) and the performance one can measure (current cash flows, customer satisfaction etc.,) are not the same.

The balanced scorecard propagated by Robert S Kaplan and David Norton [20, 22,23,24], which has been widely adopted by the US firms does solve these underlying problems of performance measurement to some extent, but may exacerbate them because it provides no real guidance on how to combine dissimilar measures into an overall appraisal of performance. Beginning in 1992, Robert Kaplan and David Norton transformed the persistent observation that measures were generally uncorrelated into a prescription for business practice: managers should track multiple measures to gauge the performance of their firms. The balanced scorecard was intended to make sense of the myriad of financial and non-financial performance measures that emerged by organizing them into four broad categories: the four domains of performance being -- financial, customer, internal business and learning & innovation. Kaplan and Norton recommend that measurements to take place in the four domains of performance: financial, customer, internal business and learning & innovation. The notion of balanced scorecard was viewed at as a tool for communicating strategy / framework for action. But the scorecard has floundered as a device for measuring and rewarding.
performance. Nevertheless, the scorecard has remained immensely popular as a tool for tracking progress toward strategic objectives, an aspiration far more modest than measuring and rewarding the performance of the firm and its people \[20,22,23,24\] and therefore Robert Kaplan \[25\], strongly proposes that the balanced score board become the CEO's management system as a preferential methodology to steer the organizations effectiveness. Thus the near successful approach of Balanced Business Score Card \[20\] developed by Robert S Kaplan and David Norton proved to be of extreme utility in assessing R&D Productivity.

However, Marshal W Meyer's \[21\] "Rethinking Performance Measurement: Beyond Balanced Score Card", studies the limitations and pit falls of Balanced Score Card and proposes a partial solution thru a measurement technique called activity-based profitability analysis (ABPA), especially to take care of the problem of combining dissimilar measures. ABPA estimates the revenue consequences of each activity performed for the customer, allowing firms to compare revenues with costs for these activities and hence to discriminate between activities that are ultimately profitable and those that are not. The ABPA, unlike the scorecard, has the virtue of focusing attention on the basics: what are we doing, what does it cost, and what will the customer pay for it: the firms that persistently ask these questions will do better than firms that don't. ABPA is simply a structure for asking these questions in a disciplined way. Ideally, the performance measures of choice would meet the following requirements: \[21\] Parsimony (three financial and three non-financial measures), Predictive ability, Pervasiveness, Stability, and Applicability to compensation. These requirements of ideal performance measurement are very stringent, far more stringent than the requirements of the balanced scorecard. The balanced scorecard imposes only the two requirements on measures, parsimony and predictive ability in principle, scorecard measures are more parsimonious than the potpourri of measures tracked by most large firms, and non-financial scorecard measures predict financial results. The scorecard does not address pervasiveness other than acknowledging that scorecards and scorecard measures are likely to vary across different parts of the organization. Nor does the scorecard address the stability of measures. Moreover, as noted, Kaplan and Norton are cautious about using scorecard measures to compensate people. \[21,22,23,24\]
Joseph A Ness and Thomas G Cucuzza, [26], describe the Activity Based Costing (ABC) and how this tool is used for one time profitability studies; but elaborate on tapping the full potential of this ABC as a critical management system and use it as a powerful tool for continuously thinking and improving, by demonstrating two successful case studies: Chrysler Corp and Safety-Kleen Corp.

According to Robert G Eccles [27], the organizations business performance cannot be found in financial data and the measurement manifesto shall include the metrics like quality, customer satisfaction, innovation, market share, which then would reflect the performance and economic condition as well as the growth prospectus more realistically. Robert G Eccles suggests that five activities are essential for this purpose, but he strongly advocates the perseverance and conviction of the CEO, in this endeavor.

In a totally different perspective, Robert Simons and Davila Antonio, [28] propose a business ratio ROM – return on management, a rough estimate that gauges the pay back from the company's scarcest resource – the management, managers time and attention.

Departing slightly away, Christopher Meyer [29], describes how the right measures help teams excel, especially in the present day's faster and flatter multifunctional teams that constitute the organizations. Christopher Meyer argues that traditional performance measurements that primarily focus on results only do not support such new structures and do not help in indicating what must be done to improve the performance. The new focus is teams, not just managers. The shift suggested is from command-and-control to empowered teams – which evolve their own measures based on the strategic goals.

Finally, the management guru, Peter F Drucker [30], elaborates on how companies have profited by shifting from traditional cost based accounting to the activity based costing that integrates the value analysis, process analysis, quality management and the costing as a single analysis -- and by using it, Drucker affirms that the knowledge-based organizations get cost information and yield control. Thus the information executives truly need would incorporate four kinds of diagnostic information, viz., foundation, productivity, competence and resource allocation. It is truly an integrated approach for knowledge-based organizations.
However the above literature review poses a doubt as to whether, the several purposes of performance measures are being met or not, which often becomes debatable; but for that matter, it is equally doubtful if any measures meet all of the requirements? Possibly one can think of the following four types of measures [21]: the valuation of the firm in capital markets (total shareholder returns, market value added), financial measures (accounting measures like profit margins, ROA, ROI, ROS, and cash flows), non-financial measures (for example, innovation, operating efficiency, conformance quality, customer satisfaction, customer loyalty), and cost measures. It is apparent that the problem of separating cost drivers from revenue drivers is fundamental to performance measurement. Removing costs and cost divers without knowledge of their consequences for revenue can lead to untoward results. Adding a revenue component to activity-based costing that can help separate cost drivers from revenue drivers analytically by revealing the revenue consequences of activities. Finally, in a multi-Product/Project Scenario, the Investment analysis reflects on the value of a portfolio as opposed to a single investment. [21] Optimization of the portfolio requires balancing forecast returns with forecast risks. From the literature very little indications are available on how to integrate risks with R & D management as it has so far with investment management.

Sreenath Settur et al have studied the performance measurement as a means for improving organizational effectiveness of R&D Institutions. One other key approach is from the R&D Process Perspective, besides the finance point of view.

The message from the preceding discussion is two fold: First, Financial frameworks are not adequate enough to satisfy innovation managers, nor the more judicious financial analysts and Second, a broader selection of non-financial measurements are required to judge R & D effectiveness adequately, wherein Customer satisfaction and New products and services as a percent of sales are most important; and a selection of internal process metrics are also needed to support the financial frameworks is also desirable.
Effectiveness of R&D Processes by Evaluation through Measurements was studied by Ellys Lynn [19] who emphasizes a quantitative approach to evaluation based on the philosophy that, “what gets measured, gets done; so be sure you measure what you want!” As seen already, in recent years, the metrics chosen by Organizations have branched out from being purely economic, financial and accounting also to include non-financial metrics such as measures of customer satisfaction, timeliness, and quality to name a few. The distinguishing thrust is in trying to develop plausible cause-and-effect relationships between inputs and R&D processes and outcomes of interest to general management – there by the contribution of many R & D management actions to the success of the firm.

Including R & D in a balanced scorecard for management had its focus on the additional non-financial perspective of the customer, internal business, and innovation and learning based on a survey of measurement practices. [25] New products as a percentage of sales prove as an effective means of focusing new product selection for profitability and growth [18]. Cost managers, on the other hand, favor quality, time, and cost as outcome or-impact-focused non-financial metrics.

The key task for R & D managers is to manage the R&D process [19]. To accomplish this, additional evaluation metrics have been identified for the transitions stages from idea to concept and down through the chain to delivery to the customer. The following overall metrics could be used: More R & D staff per supervisor, Length of cycle times, Percent of projects using concurrent engineering, Subjective evaluation of rewards, Percent passing stage gates, Subjective evaluation of technical accomplishments and Percent of submitted project proposals accepted and so on.

Other approach could be looking form Innovation point of view: Patents and copyrights per million dollars of sales, Sales protected by intellectual property rights, Percent of started ideas passing each subsequent stage and becoming commercialized products or services, R & D department effectiveness index, Quality Target etc..
An additional metric could be incremental profit minus incremental costs. Accelerating the innovation process requires first improving upstream process towards the customer (R & D marketing interface and the flow of information), next improving downstream toward operations (designing for quality, reducing the prototype to manufacturability time) and finally managing internally to the innovation organization itself (focusing your R & D patent policy on quality rather than quantity). Technology assets thus generated from the Innovation create a barrier to the entry of other firms into the company's business. Much of the research to date has been done on patent protection.

Thus the Research and Development performance measurement could also take other approach that is Patent Productivity as demonstrated by Robert Grover [15] and also OD for enhanced R&D Patent Productivity as proposed by Mary Mathew.

There is an entirely different perspective by Clayton M Christensen, [31,32,33,34] in terms of disruptive technologies that have caused serious tremours in the high technology growth areas. Clayton M Christensen describes how large companies could not capitalize on the opportunities brought about by major disruptive changes in their own markets and technology domains. Clayton M Christensen and Michael Overdorf [32] who have analyzed these patterns have created a framework for the benefit of R&D managers to assess the abilities and disabilities of their own organizations as a whole. Clayton M Christensen demonstrates that when the organization is young its resources define its success, where as when it is more mature, its processes define their abilities. They argue, in large well-established companies, the values and value system they carry would determine what they can or cannot do. Because the resources are more adaptable to change than the processes and values, smaller companies tend to respond effectively to any major market shifts, much better than the larger ones. However, Clayton M Christensen suggests how larger companies also can capitalize on opportunities. Christensen explains why good management can lead to failure: Well-managed companies are excellent at developing the sustaining technologies that improve the performance of their products in the ways that matter to their customers. But they at times fail in differentiating Sustaining versus Disruptive Technologies and in Disruptive Technologies versus Rational Investments; and tend to focus on Trajectories of Market Need versus Technology Improvement [31]. This happens because, their management
practices are biased towards, the traditionally correct approaches viz., listening to customers, investing aggressively in technologies that give those customers what they say they want, seeking higher margins, targeting larger markets rather than smaller ones: these stem from their being big and some thing that is correspondingly big only would attract their interest and attention. In contrast, the disruptive technologies, however, are distinctly different from sustaining technologies, and the big companies typically depend on customers and investors for resources, small markets don't solve the growth needs of large companies, new markets that don't exist can't be analyzed, the new Technology supply may not equal market demand and finally an organization's capabilities define its disabilities. Then Christensen [31,32] suggest specifically, managers faced with disruptive technologies are advised to do the following:

1. Give responsibility for disruptive technologies to organizations whose customers need them so that resources will flow to them
2. Set up a separate organization small enough to get excited by small gains
3. Plan for failure. Don't bet all your resources on being right the first time. Think of your initial efforts at commercializing a disruptive technology as learning opportunities. Make revisions as you gather data.
4. Don't count on breakthroughs. Move ahead early and find the market for the current attributes of the technology. It is found outside the current mainstream market. Find that the attributes that make disruptive technologies unattractive to mainstream markets are the attributes on which the new markets will be built.

Clayton M. Christensen, Musso C.S., and Anthony S.D [35] observed that the companies need to match their research activities to the industry situation, and that they can only successfully commercialize a new technology if they control all of the activities with which that technology interacts - attempting to do otherwise is likely to end in frustration. After a technology is "good enough" for the marketplace, the necessary locus of integration shifts backwards. In these circumstances, they advise that companies ought to focus their research activities on individual pieces that add value. Those companies that continue to integrate their research activities across the entire
value chain face the possibility of research "leaking" to specialist companies. In short, companies should not employ a one-size-fits-all-forever strategy for capturing value across the life cycles of their technologies. Rather, the right strategy will depend on finding the decoupling point, for each technology, at each point in time. [35] Jay Paap and Ralph Katz [36] also studied the effect of disruptive innovations and address the issue of how to anticipate and cope with the eventualities. According to them, organizations in today's hypercompetitive world face the paradoxical challenges of "dualism," that is, functioning efficiently today while innovating effectively for tomorrow. Corporations, no matter how they are structured, must manage both sets of concerns simultaneously. To do this, organizations have to understand and learn to manage the dynamics of innovation that underlie both disruptive and sustaining innovations. Most analyses have been flawed by giving too little weight to the interactions between needs and technologies. Based on a dynamic model of these interactions, Jay Paap and Ralph Katz[36] propose three distinct patterns of substitution are identified that illustrate how these two forces intersect. Clayton M Christensen et al [33, 34] also present solutions to this apparently paradoxical situation.

It is interesting to note a few disruptive in the area of interest as below:

<table>
<thead>
<tr>
<th>Established Technology</th>
<th>Disruptive Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire-line telephone</td>
<td>Mobile telephony</td>
</tr>
<tr>
<td>Circuit-switched telecommunications networks</td>
<td>Packet switched communications networks</td>
</tr>
<tr>
<td>Notebook computers</td>
<td>Hand-held digital appliances</td>
</tr>
<tr>
<td>Desktop personal computers</td>
<td>Sony play station II, Internet appliances</td>
</tr>
<tr>
<td>Standard textbooks</td>
<td>Custom assembled, modular digital textbooks</td>
</tr>
<tr>
<td>Manned fighter and bomber aircraft</td>
<td>Unmanned machine controlled aircraft</td>
</tr>
<tr>
<td>Microsoft windows operating systems and applications software written in C ++</td>
<td>Internet protocols (IP) and Java software protocols</td>
</tr>
</tbody>
</table>

It has also been seen on how many successful companies in the past could not survive in the changed scenario. There are good examples near home, in India also.
One additional aspect for review that came about was the Leader factor: and undoubtedly the leader makes a lot of difference. It was been seen that many organizations have thrived because of their strong leadership. Leadership is quite different from mere supervision and management – which could be learned through suitable means. At the same time there seems to be no definitive solution to leadership problem, and it has been observed that a good leader in one situation is perhaps an indifferent leader in another situation. According to Handy (Handy CB, Understanding Organizations, Penguin, UK,1976, as quoted by John H Dumbleton [3]), approaches to the definition of what makes a good leader fall in to three categories viz., Trait Theories, Style Theories, and Contingency Theories. Dumbleton [3] asserts that there is evidence that supportive styles of leadership give higher employee satisfaction and this style should work bettering an unstructured environment such as Research and Development and as a sustainable mode of working with the highly qualified and highly self motivated people in R&D who are willing to take responsibility in their work. Dumbleton [3] concludes that leaders are to some extent born and not made, but it is always possible to learn the art of leadership. At the very least, a manger should analyze the four sets of influencing factors viz., his own habitual style, the group, the task and the environment and make an informed choice as to the preferred style of leadership.

On the other hand, Melvin Sorcher and James Brant [37] question whether one is picking the right Leaders, in an organizational set up, and argues that some attributes that seem like good apparent indicators (like being a team player, operational proficiency, dynamic public speaking, ambition etc.,) of potential leadership are paradoxically, just the reverse. They suggest an evaluation process that will help avoid the trap and become immune to the vulnerability (through similarity and familiarity) of misidentifying the leadership talent. They suggest that using a carefully crafted series of probing questions on the leadership criteria and on soft attribute criteria such as personal integrity, that are intrinsically difficult to asses otherwise. Psychologists James Waldroop and Timothy Butler [38] examine the root causes of drawbacks and flaws in the otherwise competent individuals and suggest concrete tactics that help people recognize and correct the behaviour patterns and managing away the bad habits and grow to be effective leaders. The bad habits patterns covered are: the hero, the
meritocrat, the bulldozer, the pessimist, the rebel and the home run hitter; and remedial steps are proposed for the flawed performers to overcome and be successful leaders. James Waldroop and Timothy Butler strongly advise that in economies driven by knowledge in people's heads, as is the case in R&D organizations, all good managers have to think like psychologists in order to maximize the potential of their people, and help turn the brilliantly flawed performers into spectacular achievers.

Natalie Shope Griffin [39] recommends personalized management and leadership development for the individuals. Natalie Shope Griffin classifies the potential leaders into four kinds of managers-in-training viz., reluctant leaders, arrogant leaders, unknown leaders, and workaholics; and suggests that these managers do not lack skills but there is no single kind of leader-in-training. Natalie Shope Griffin outlines specific training programs for each type of prospective leader, and which turn them successful leaders. John Hamm [40] discusses why entrepreneurs don't scale i.e. many of those executives who excel at starting a new business or projects fail as their ventures grow or as the projects progress. John Hamm states that barring the rare exceptions like Bill Gates, Steve Jobs, or Michael Dell, most entrepreneurs fail to switch from the original traits of loyalty to one's comrades, task orientation, single-mindedness and working in isolation to the challenge of scaling. Only if they grow as leaders they can achieve this, as they are open to learning and change. This happens to leaders who scale regardless of their background, skill or talent.

Jim Loehr and Tony Schwartz [41] define an integrated theory of performance management that addresses the body, emotions, the mind and spirit through a model called the performance pyramid. Jim Loehr and Tony Schwartz demonstrate through case studies as to how executives have used this model to increase their professional performance and quality of their lives. They suggest this for all corporate environments that are changing at warp speed, performing consistently at high levels is more necessary than ever. The high technology R&D is a good case here. Warren Bennis G and Robert J Thomas [42] look at the aspect of what makes a great leader, and their research suggests that one of the most reliable indicators and predictors of true leadership is the ability to learn, from even the most negative experience. They
conclude that an extraordinary leader is a kind of phoenix rising from ashes of adversity (shaping crucibles) - stronger and more committed than ever: the most critical factor being the adaptive capacity for making the great leader. Andrew Leigh and Michael Maynard [43] attempt to define the Perfect Leader and his characteristic features. Donald N Sull [44, 45] explains why some good companies go bad and elaborates on how great managers remake them, stressing the ability and competence of the leader at the helm of affairs. Another factor that clearly emerges is the culture in the organization is one of the key factors influencing the resurrection in such companies. Robert Kegan and Lisa Laskow Lahey [45] argue that there are many underlying fears and complexes in the individuals that form the real reasons why People won't change. In fact, they say that always the people would project what is the acceptable behaviours and/or responses and not the true ones, for fear of rejection, or even possible punishment, hence not so willing to any change. The authors also suggest how to circumvent such a situation, and squarely zero on to the cultural factors being the real influencers.

The reason for the review of literature regarding the Leaders and Leadership is the basic fact that they are the ones who could effect an R&D environment, motivate the research staff and foster R&D despite multitude of negative influences or hurdles. Their role is unparalleled. The culture and willingness to change are equally influenced by the leadership factor. There are many living examples in Indian context as well.

Having reviewed the leader/leadership aspect, it is essential to turn the attention towards the staff or people whom these leaders lead or in other words the people who are willing followers of their leaders (if not with blind faith) and deliver what has been envisioned. The People factor is the most critical one in management, and more so in a knowledge worker scenario as is the case in R&D. According to The Economist, less than 10% of today's jobs in USA are in manufacturing and less than 15% in Britain: put in other words, workers of Western world are employed largely in service industry, where they are paid for their brain than their brawn. Many of them can be called “knowledge workers” (a word coined by the management guru, Peter Drucker more than 35 years ago,) and nearly 40% in number, according to Thomas Davenport. According to Davenport, “knowledge workers” are those whose “… primary tasks involve the
manipulation of knowledge and information” and are instrumental creators of wealth in the western economies. According to Davenport (as quoted in The Economist) measuring the performance of these knowledge workers “…is most essential and one of the most important economic issues of our time.” Being the creative part of the organization, these “knowledge workers” viz., the R&D Scientists and Engineers do not lend themselves so easily to be measured or managed!

Gretchen B Jordan [47] in a most interesting fashion deals with what matters to R&D workers. According to Jordan little empirical information is available to help laboratory managers attract and retain productive R&D workers. Most employee attitude surveys do not focus on the specific attributes that scientists and engineers consider to be particularly important for research organizations. To address this deficiency, the U.S. Department of Energy, in the most comprehensive study on the subject to date, surveyed 2,200 R&D workers in 40 organizations within three major laboratories to determine what constitutes a good research environment and what improvements might be needed to best serve the needs of R&D workers. Thirty-six factors were found to be most important to R&D workers. These findings can help managers to plan their next employee attitude survey and to take actions that improve attraction and retention of R&D workers and R&D performance.[47]

Donald Reinertsen and Leland Shaeffer [48] deal with whether to have lean R&D in similar line as lean manufacturing. They observe that R&D executives are just beginning to consider implementing the principles of lean manufacturing. Because R&D has different economics and different value creation mechanisms than manufacturing, lean R&D must differ substantially from lean manufacturing. Many familiar lean concepts such as controlling queues, reducing batch size, and reducing waste can easily be transported into R&D organizations. Others, like variability reduction, must be approached very differently, because eliminating all variability in R&D also eliminates all value-additions. Lean principles, used skillfully, offer the potential to simultaneously improve the cost, quality and speed of the R&D process. This approach could help effectiveness and efficiency in R&D an set up.
Aiman-Smith Lyndaet et al [49] suggest that organizations must be innovative all across the value chain, not just in R&D, in order to succeed in today's rapidly changing economic environment. As a part of the Industrial Research Institute subcommittee a reliable survey tool, using good psychometric (measurement theory) practices has been developed and can be used to assess the level of an organization's Value Innovation potential, the Value IQ. They propose that using this assessment tool can produce useful information for managers who want to strengthen innovation in their organizations.[49]

Moitra and Krishnamoorthy[50] elaborate on innovation from the R&D staff. They argue that as technology-based competition becomes central to the business landscape, R&D will be a major determinant of enterprise competitiveness. To stay ahead, leaders have adopted several approaches to R&D and innovation generation, including in-house R&D, R&D outsourcing, R&D partnerships and alliances, and technology-based acquisition. According to them, a new approach, "Global Innovation Exchange," is emerging on the scene, that leverages the World Wide Web to draw upon the expertise of the global R&D community to solve specific technical and business problems. It holds significant promise and has far-reaching implications for innovation-centric businesses.

Edelheit [51] stresses the critical role played by individual innovators in an organization. According to him, needs of Business and economic realities have driven R&D for years (at GE). Its funding model has been an important driver of these realities, most recently with research focused on helping businesses to win market share with next-generation products. At the heart of this focus is the idea that every individual must be vital and share the same values as the rest of the company. At the same time, corporate research teams with GE's businesses on multiple-generation product development, in services as well as products. Game-changing technology is a primary goal, as is the striving for the proper balance for corporate R&D between being an insider and an outsider in all technologies. And driving all of this are the passions of the lab's leaders.
Lyne [52] also stresses the critical need that every technology-based company shall keep R&D focus in alignment with corporate business strategy. Ensuring that the unique perspective of the R&D organization is included in the corporate strategic planning process is often a greater challenge, but one that is crucial for a company confronting new and emerging technologies with the potential to significantly change the competitive landscape. International Paper has found a "Voice of Technology" protocol and an Innovation Council to be effective in creating such alignment and fostering R&D input into the strategic planning of the business. This again is a pointer to the role of innovators i.e. the people.

Germeraad [53] while stressing the financial metrics’ need in an R&D to optimize R&D's productivity and justify returns on continued funding, argue that there are actually rich sources of appropriate R&D metrics such as managing any form of intellectual capital utilizing common measurement elements.

Bowonder et al [10] also credit innovation. R&D spending, R&D intensity as tools have indicated improvement in area like network communications. Interestingly, at the same time, more firms are seeking to acquire intellectual assets from external sources. Managing intellectual assets will require competence to integrate external and internal knowledge assets so that innovation efficiency can go up while idea-to-market time goes down and product pipelines get richer. This affirms the need of innovation and creativity that drives the organization and the people are the real drivers in this.

David Dubois [54] discusses the role of Innovation in Economics and Scott Allen [55] deals with what to do when Great Idea becomes mainstream: that is economic perspective of the innovation and the advantages one wishes to gain from such and suggest defensive mechanisms for that. Kylie Sayer [56] debates about the empowerment of people in a specific case study in BPR, where as Peggy Holman and Tom Devane [57] describe group methods in dealing with change involving the people. Daniels Aubrey [58] describes in an elaborate fashion as to how to bring out the best in people. These basically target the people factors in the organization.
Hamel Gary [59] in his paper titled “Waking up IBM”, in HBR, describes as to how IBM turned around and became a e-business giant: this change being effected not from imposing from top, rather, from its staff. IBM allowed the ideas, initiatives and enthusiasm to bubble up from below: an exemplary turnaround and success for its people and its technology savvy and innovative culture, and participative management. Another success story from IBM [60] as to how it stayed ahead in today’s rapidly changing and highly competitive business environment – where one has to keep up to the demands from the customer at an economical scale. The contextual collaborations could be defined as organizing, navigating, and sharing the information through messaging solutions and helps in manage all the related information required in a project or organization.

Deviating a little, Goldratt Eliyahu M and Cox Jeff [61] describe the theory of constraints in a manufacturing set up and help how to over come the constraints and to continuously improve. Vicky Wright and Liz Brading [62] describe a balanced performance, wherein they propose that a well-balanced performance management be evolved, that would help bringing the two non-compatible issues viz., Quality and Performance (thereby pay) at least to be complimentary to each other. Daniel Babcock and Lucy Morse [63], in their comprehensive publication, Managing Engineering and Technology, describe all relevant aspects of Technology development – starting from innovation through maturity.

Jean-Francois Manzoni and Jean-Louis Barsoux [64] discuss in detail why some employees perform poorly - when probed the concerned managers would contend that the poor performance is the employees’ fault. The authors affirm that it is not always true and suggest that it is the bosses themselves – albeit accidentally and with best intentions – who are often responsible for an employee’s sub-par achievement and poor performance. They call this dynamic “the Set-up-to-Fail Syndrome”, and discuss the dysfunctional work relationships and also suggest means to breakout of the negative spiral, so as to regain the valuable productive energy.
Based on more than two decades of breakthrough research, Teresa M Amabile [65] provides insightful guidelines on how to nurture and stimulate creativity: in today’s knowledge economy creativity is more important than ever. Teresa Amabile argues, that many companies unwittingly and not on purpose, employ managerial practices that kill Creativity. In pursuit of the worthy business imperatives like productivity, control and efficiency, they undermine creativity and kill it. Teresa Amabile argues asserts that creativity and business imperatives can co-exist, for this the managers have to change their thinking first. Teresa Amabile says that the three factors in creativity viz., expertise, ability to think flexibly and imaginatively, and motivation, could be enhanced, but it is much more effective and simpler to influence the last factor viz., intrinsic motivation: for example intrinsic motivation is high when employees feel challenged but not over whelmed by their work – the task of managers therefore is matching people to right assignments. In innovative companies creativity would thrive.

Daniel Goleman [66] declares that a Leaders singular job is to get Results. Even with all leadership training and expert advise, effective leadership still eludes many people and organizations. Based on quantitative data Goleman outlines six distinct leadership styles each one springing from different components of emotional intelligence – each having its own impact on company performance. Goleman elaborates the Coercive, authoritative, affiliative, democratic, pacesetting and coaching leadership styles and maintains that with practice managers can switch among the six leadership styles to produce powerful results, thus turning the art of leadership into a science.

Michael Goold and Andrew Campbell [67] lament that Organizational Structures evolve in fits and starts and shaped more by politics than policies. When the executives face this, many cannot take any meaningful action as they lack a meaningful framework to guide them. The authors suggest such a framework through defining four ‘fit’ tests and five ‘good design’ tests for evaluating well-design of Organization and upon redesign the tests could be repeated to verify their appropriateness. They also assert that organizational decisions are inevitably complex and advise caution.
Felix Barber and Rainer Strack [68] assert that when the people are the most important assets, a few of the standard performance measures and management practices become misleading and irrelevant. This danger is more prevalent in what the authors call 'People Businesses', wherein operations with high employee costs, lower capital investments, and limited spending on activities that are aimed at generating future revenues – a realistic description of R&D! The authors argue that RoA, RoE etc will not help much and would tend to mask weak performance or indicate volatility where it doesn’t exist. The authors advise replacing them with financially rigorous people oriented metrics for example reformulation of a conventional calculation of economic profit such as EVA so that people productivity could be gauged, rather than the capital productivity; and subsequent to this one could enhance it operationally, reward the people appropriately and price advantageously. This approach is well suited for R&D.

Gary L Neilson, Bruce A Pasternack, and Karen E Van Nuys [69] describe the Passive - Aggressive Organizations that are friendly places to work, people are congenial, conflicts are rare and consensus is easy to reach: yet even the best proposals fail to get traction and a company can go nowhere so imperturbably that it is easy to pretend everything is fine! Interestingly such companies are not saddled with passive aggressive employees but with well-intentioned ones only – who are victims of flawed processes or policies. Typically this situation arises in a growing organization where in the poorly thought-out attempts to decentralize would give rise to multiple layers of managers – whose authority to make decisions become unclear. As a result many managers hang back and information does not circulate freely, this in turn leads to lack of clarity in assessing performance of employees and organization. Initiatives would be minimal and people just do to get by and become cynical. Breaking from such a pattern is very hard – in such cases bringing in an outsider would be a better solution: who would have to address all obstacles in one go, clarify decisions, see that decisions stick, reward people for adding value and sharing information, and not for negotiating the corporate politics. This, according to the authors, is the only way to protect the healthy ones from elements of the passive-aggressive organization and to avoid an eventual financial distress.
Another interesting paper reviewed is from Richard Florida and Jim Goodnight [70], who deal with Managing for Creativity. They assert that the creative capital in the organization that is the creative thinkers whose ideas are turned in to valuable products and services: they pioneer new technologies, birth new industries and power economic growth. Authors address the issue of how well to accommodate the complex and chaotic nature of the creative process while increasing efficiency, improving quality and raising productivity. When done the company would enjoy low employee turnover, high customer satisfaction, continued revenue growth and success. The authors suggest a framework for managing creativity with three guiding principles: help employees do their best without distractions, make managers responsible for sparking creativity and engaging customers as creative partners so as to deliver superior products; and with an underlying mandate to foster interaction and nurturing relationships. This is the way to invest in a company’s future creative capital.

Lewis Gray [71] deals with Biological Limits on Professional Performance and defines Hypoxia (lack of oxygen to brain as one goes up into the atmosphere or high mountains) in an organizational set up. The performance concerns as one goes too up in the organizational hierarchy are enumerated by Gray, they are incapacity (one breaks), unawareness (or denial and one thinks that one is OK), and wrong timing (one breaks just when one can least afford to). He advises that to counter the performance problems (caused by Hypoxia) one could do good planning (checklists, routines, milestones) and practice (routines, milestones); but cautions that these don’t prevent hypoxia but they only compensate for it.

The CNN has compiled the top 25 innovations list during 1980 to 2005, and tries to single out, "25 non-medically related technological innovations that have become widely used since 1980, are readily recognizable by most, have had a direct and perceptible impact on our everyday lives, and/or could dramatically affect our lives in the future." Table 1.9 depicts these top 25 innovations list.
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<td>Modern Hearing Aids</td>
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<td>Short Range, High Frequency Radio</td>
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(Source: CNN.com, January 18, 2005)
San Murugesan and Bhuvan Unhelkar[72] while discussing a roadmap for successful ICT Innovation: and turning great ideas into successful implementations, suggest that innovation is a necessity and not an option. According to them it is essential to recognize the three major kinds of innovation: incremental, transitional, and transnational. And then discuss ICT (information and communication technologies) being the basis for innovation. They also discuss the roadmap for ICT innovations and suggest that even if an innovation is revolutionary if there is no process available to take it to market, such innovation won’t create or sustain anything. Lee Devin and Rob Austin [73] deal with Planning to get lucky that is making Creativity and Innovation on Schedule. Alan Chachich [74] discusses how to manage the risks of Product Innovation.

Continuing with innovation, nearer home, Choung Jae-Yong [75] explains the Patterns of Innovation in Korea and Taiwan; and Oingrui Xu, Jin Chen and Bin Guo [76] present the Perspective of Technological Innovation and Technology Management in China. Kyung Ho Chung, Jungwan Hong, Seungwoo Seo, and Kyeongtaek Kim [77] elaborate on the Recommendations from the Commercialization of Government-Sponsored Telecommunications R&D with Multiple Development Cycles in Korea. A contrary perspective about how Venture Capital thwarts Innovation has been explained by Bart Stuck and Michael Weingarten [78] – who argue that the technology bubble during the IT boom saw an explosion of venture capital funded startups, but a dearth of innovative original ideas or focusing on totally new technology and taking them to commercialization; but having out and out commercial approach is an inappropriate approach and VCs appear to encourage more of business types and many a VCs sell of well before a real technical take of, Innovation thus becomes a casualty. Innovation needs patient investing rather than boom-bust mentality as in VCs. Cathy A Rusinko [79] describes the importance of R&D and Manufacturing interfacing and need for a good integration as a facilitating factor in the Product Development starting from innovation. Eric H Kessler and Paul E Bierly III [80] study the relation between innovation speed and effectiveness of the innovation, and suggest that faster may not essentially be better. Michael Bommer and David S Jalajas [81] look at innovation from a different angle, that is, the size of the Technology based firms (Large or Small) and their sources for Innovation sources. David J Skyrme[82]; auHildreth and Chris Kimble
deal with yet another important factor viz., Knowledge Networks and Networking: As Innovation has become more and more difficult at an individual level due to the increased complexity and prohibitively high cost even at an organizational level, the Knowledge Networking is the only solution – either in creating an collaborative enterprise or as communities. This is catching up in the industry as a viable alternate approach for improved innovation.

Authors Thomas A Kappel and Albert H Rubenstein [84] elaborate on the Information Technology and its omnipresent contribution in the innovation and Creativity, which are essential for Design. The authors consider the modern technologies of design and their impact on creativity and also analyze such design issues as problem structure, engineering knowledge, expert systems, ideation, and the social context of technologies that affect their adoption and use. There exists a general bias toward the goals of effective coordination over enhanced creativity in the systems supporting design. To put the other way round, the information from the fruits of IT gets converted as Knowledge. Then, the Knowledge Utilization Process has been studied by Matti Verkasalo and Pentti Lappalainen [85] and they propose a method of measuring the Efficiency of such utilization process. It is imperative that such transformation is a key parameter in making the R&D effective. The role of the knowledge workers and their performance are the next natural step and this is presented by Joseph C Paradi, Sandra (Rehm) Smith and Claire Schaaffnit-Chatterjee [86], with a specific reference to teams involved in R&D at one of the premier Telecom R&D center.

Moving on to another dimension: Projects and Project selection – authors Anne DePlante Henriksen and Ann Jensen Traynor discuss as to how to select an R&D project and propose a practical R&D project-selection scoring tool and suggest that it would be quite useful. In an interesting paper, Eugene B Lieb [88] suggests that as the eventual success of any early research project is uncertain and need to arrive at an optimal number of R&D projects to develop. Lieb presents a model to determine an average optimal number of research projects to be developed. And conclude that an optimum fraction of projects that should be developed usually exists and that optimum fraction is critically dependent on the relative average research project cost and
effectiveness compared to development. Robert F Bordley [89] states that much of the technical literature emphasizes R&D project selection in the author’s experience with R&D project selection and suggests that the emphasis should be on the generation of high-quality R&D projects through effective communication of corporate priorities, implementation issues, and related technical efforts. The R&D Project Selection is definitely an important part of the solution to effective R&D management and the main benefits of the project-selection system are not just in discovering the best projects to fund but in stimulating researchers to develop better projects in line with the firm’s strategic intent, i.e., its overall long term direction viz., profitable project generation. Ronald N Kostoff, and Robert R Schaller [90] describe the role and benefits played by the well defined Science and Technology Roadmaps and Thomas Åstebro [91] describes a few key success factors for Technological Entrepreneurs’ R&D Projects. Aaron J Shenhar [92] states that research literature on the management of projects has been quite slow in its conceptual development and still suffers from a scanty theoretical basis. One of the main impediments in the study of projects has been the absence of constructs and the little distinction that has been made between the project type and its managerial and organizational style. Shenar proposes a two-dimensional theoretical model for the classification of technical projects: Projects are classified according to four levels of technological uncertainty at the time of project initiation and three levels of system scope, which is their location on a hierarchical ladder of systems and subsystems and accordingly considerable differences are found in management style, project organization, and operational practice when moving along each of the model’s two axes and author suggests that a carefully selected management style may lead to better implementation and to an increased chance of project success. Linda Sattler and Vinay Sohoni [93] study in a Semiconductor Fabrication/Manufacturing Industry (Fabs) where in order to stay competitive, Fabs must increase throughput and lower the costs and at the same time processes are becoming more complex with shorter life cycles. In this environment, some Fabs are turning to their workforce for the added capacity, flexibility, and speed. The authors examine the effect of participative management techniques on manufacturing performance. Analyzing an international samples show that participative management has a statistically significant and positive correlation with manufacturing quality and a positive, but not statistically significant, correlation
with quantity; but the individual components of participative management - power, information, rewards, and knowledge - to the lowest level of the organization in a congruent fashion and this suggests that those Fabs that utilize participative techniques do so efficiently. Paté-Cornell M. Elisabeth and Robin L Dillon [94] present the various lessons learnt at the famous NASA and detail the management of faster-better-cheaper projects and discuss the success factors and indicate future challenges there of. Suleiman K. Kassicieh et al [95] deal with the aspect about commercialization of projects and distinguish them with respect to Disruptive and Sustaining Technologies and enumerate the various factors that differentiate them.

Tom De Marco [96] succinctly describes the steps of a high tech IT project management scenario; and Tom De Marco and Timothy Lister [97] deal with the highly productive projects and teams. The orientation in the latter one being more about the people who are the key input in knowledge environment; and they coin a new phrase Peopleware (like Hardware and Software as used in IT industry) and stress its criticality & vitality. Researchers Holger Ernst, Christopher Leptien, and Jan Vitt [98] deduce that the distribution of scientific (and technical) performance indicates that there are great variations in the output of industrial research and development personnel and by analyzing the patenting output from research and development personnel, one is able to measure their technological performance. The inventor portfolio provides a method to measure and identify key inventors who are characterized by a large number of patent applications, which are of high quality. The findings of their study suggest that the technological performance of inventors defined by the number and quality of filed patents is highly concentrated; and interestingly a very small group of key inventors is responsible for the major part of the company's technological performance, and thus for the company's competitiveness. These findings, in turn, have major practical implications for human resource management in industrial R&D departments. Susanne G Scott and Reginald A Bruce [99] state that there have been relatively few theoretically based empirical studies of leadership in research and development (R&D) settings despite theoretical indications of its importance and that some recent studies have found support for a relationship between transformational leadership and R&D project success. The authors study the transactional and transformational nature of
leader-member-exchange (LMX) theory and analyze and then conclude that the problem-solving style and individual innovative behavior has a positive relationship. Duksup Shim and Mushin Lee [100] detail the different styles of R&D Project Leaders, more specifically about their upward influence styles and their effectiveness. At a slightly lower levels in the organization, viz., at the level of Supervisors in R&D Laboratories, a detailed study has been done as to their using their Technical, People, and Administrative skills effectively has been discussed elaborately by Rene Cordero, George F Farris, and Nancy Di Tomaso [101]. Edward F McDonough III, Kenneth B Kahn, and Abbie Griffin [102] deal with the prevailing scenario of multi-location R&D and product development: and discuss the way the R&D teams situated in globally disbursed locations yet expected to perform efficiently and effectively. The critical role played by the Communication and managing the communication in such a scenario is well established by the authors. Manuel E Sosa et al [103] similarly deal with the communication needs (more specially the technical communication) in a distributed product development scenario (that too in a Telecommunication Company) and describe the various factors that influence technical communication, for effectiveness. Alexandra von Meier [104] looks at the occupational cultures in an organization as to how they affect and become challenge to the technological innovation. Similarly, Lee Soo-Hoon, Wong Poh-Kam, and Chong Chee-Leong [105], attempt to explain the R&D outcomes from the perspectives of human and social capital. Bernard et al [106] deal with software projects particularly and argue that the organizational culture as well as the communication has a direct impact on software projects. The individualistic (western) culture and collective (eastern) culture have different impacts even within a single organization. Prasad Lakshmanan and Albert H Rubenstein [107] study various factors influencing R&D project success, with more stress of success at the interface point of R&D and Production, essentially highlighting the importance of communication and environment in an organization. Grant Michelson and Suchitra Mouly V [108] deal with a special case of communication that is not given much attention in general (because it is taken for granted!): rumour and gossip, and its (predominantly negative influence) in an organization. Chao C Chen, Cameron M Ford and George F Farris [119] discuss another less studied aspect especially in R&D: motivation. The authors state that earlier researches on compensation have focused
primarily on individual benefits derived from monetary rewards and tacitly assumed
that diverse organization members hold similar beliefs regarding the efficacy of specific
rewards and claim that this present work [109] compares the beliefs held by members of
diverse demographic groups in R&D organizations regarding the extent to which
different types of rewards produce organizational benefits. The effects of Reward types
and the perceptions of Diverse R&D Professionals from different ethnic groups and
genders are studied by them and found to be distinctly different and conclude that
understanding these differences in beliefs across a diverse group of employees could
affect the management of rewards in R&D settings.

Moving on to a different dimension that affects most: Quality. The general treatment of
Quality is not covered intentionally herein, such as the writings of Quality Gurus like
Juran, Crosby, Deming, Taguchi etc.. It is paramount that quality innovation be done in
an organization and quality products/software/services are critical for economic success
of any organization. Here what is reviewed is a few of such of the works which from
the R&D Management point of view have some bearing from quality perspective.

Bonnie Holzer [110] deals with the aspect of Quality auditing in a public sector service
(non-manufacturing) environment and Williard I Zangwill [111] covers the top
management involvement about quality and elaborates on the likely mistakes CEOs
make about Quality. Zangwill brings about the insights from top-quality firms and
reveals ten mistakes CEOs make that may prevent them from developing and delivering
excellent quality outputs. These include: failing to lead, planning (only) for financial
goals, believing that customer satisfaction is sufficient, believing that quality means
inspection, quality is expensive, managing by intuition not fact, usage of misguided
incentives/developing a distorted culture, changing targets frequently, failing to follow
best practices etc... It is an integrated effort that brings about quality and the
management system and the processes followed. Just a mere PR type of lip service
about customer satisfaction and quality will not be useful A good leadership is a must.
Eitan Naveh and Alfred A Marcus [112] discuss about one of the quality systems that is
mostly dominating the industry today, the ISO 9000, and affirms about the
preconditions for the ISO 9000 Quality Assurance Standard would lead to performance
improvement in an organization: though it is intrinsically expected always! Many Electronics, IT and Telecom companies have adopted and accredited with ISO 9000 certification. (For R&D it is known as ISO 9001 – 2000). However for exclusive use of software industry CMM has been brought out by Software Engineering Institute, Carnegie Mellon University, USA at the behest of Dept of Defense of USA; which later has been upgraded to additionally include System Engineering and Product Development, [113, 114] this new scheme CMMI has become quite popular and many organizations are adopting it. This in reality brings in the Processes and Management together and helps in continuous improvement and in commercial gains as well. Robert T Futrel, Donald F Shafer and Linda I Shafer [115] however, explicitly deal with Quality Software Project Management. A guide to the Project Management Body of Knowledge (PMBoK Guide) [116], has been in vogue from the Project Management Institute (PMI), USA.

The review would be incomplete without touching upon the total Organizational perspective, one that holds the knowledge workers and facilitates R&D. There are many that cover this aspect, a few are indicated here: Richard Cross [117] discusses the Organizational Change in a special situation, viz., when all work is Knowledge Work. The classic Management Control Systems by Robert N Anthony and Vijay Govindarajan [118] covers the most relevant Management aspects. Gareth R Jones [119] and Osborn RN et al [120] present excellent coverage of Organizational Theory, both text and cases. Zohar Laslo and Albert I Goldberg [121] present a form of the organization structure viz., Matrix Structure, that is most prevalent in high technology organizations and highly successful approach. The authors describe the Matrix Structure Performance and affirm about need for Optimal Adjustment to Organizational Objectives: this is the crux of the problem.

Joel Spolsky [122] describes a simple model for effective software firms:

Best Working Conditions → Best Programmers → Best Software → Profit.
Spolsky suggests that a software company where 'we would want to work', such a company would attract 'best programmers' that would lead to profits. Spolsky argues that the thinking that we need only 'low cost' programmers and a 'King David' type
leader who would all these to perform, dose not hold good. Software companies need not only best managers/leaders but also best programmers (reducing cost does not help always and not this way) and Spolsky affirms that the software design adds value faster than it adds cost. The need for best programmers arises from the fact that the spread and variations (standard deviation) are higher; but Spolsky asserts that there is no correlation between the quality of work and the amount of time spent. He further concludes that there is an optimal team size and that adding manpower to a late software project makes it later (Brook’s Law). The author demonstrates that by using more mediocre programmers instead of a couple of good ones—no matter how long they do work—can not produce what good programmers could: Really talented software developers are the only hope for remarkableness. (Hitting the High Notes!)

David A Wheeler enumerates The Most Important Software Innovations till date in informative paper—which dispels many a myth and shows the path forward.

It is essential at this juncture to add a word of explanation as to why such an elaborate literature survey as above has been made and presented: The R&D, R&D management are the topics which in fact have been covered relatively less widely, and the treatment has been in very narrow packets; that too about the high technology R&D (say Electronics/IT/Telecom) is relatively miniscule. Further, the gamut of topics that are essential in the present study also demand such a wide and in depth search of what has been done in the area. Thence the various aspects like R&D, R&D Management, Productivity, Performance, Performance Measurement, Disruptive Technologies, factors affecting Organizational Effectiveness, Creativity, Innovation, Speed and Quality of Innovation/R&D, R&D interface to other functions, Knowledge Management and Knowledge Networks, People Factors, Leadership, Organizational Behavior, Change Management, Design of Organizations, Innovation and R&D Patterns in Technology (IT/Telecom), VC, HR, Influence of IT/ICT in R&D, Knowledge Worker and Performance, Motivation and Rewarding, R&D Project selection and Road Map, Project Management, Commercialization aspects, Human Factors in R&D, Relation between R&D staff and others, Organizational Environment,
Communication, Culture, R&D Outcome, Top Management's key role, Quality, Quality Systems, Organizational Structures and effect on R&D and so on with specific reference to high technology R&D organizations has been reviewed from the available literature: with a special focus on the domain of interest. Hence publications from Harvard Business School (HBR), Institute of Electrical and Electronics Engineers (IEEE) USA, Institute of Electrical Engineers (IEE) UK, Research & Technology Management/Industrial Research Institute, R&D Management, Project Management Institute (PMI), Quality Progress, TQM, Software Engineering Institute (SEI) and some good inputs from the Internet World Wide Web have been considered. The above listing is primarily from abroad. Some of these would be revisited again.

In the following section, the Review of some Studies in Indian Context are presented so as to give a completeness of the picture and to bring out what exactly has been done so far; as a firm foundation and to substantiate the novelty and originality of the present research work and to demonstrate its usefulness.

Review of Some Studies in Indian Context

There have been some studies done in Indian context and therefore scholarly publications are available in the area of present interest and some of those are reviewed here in. First and foremost publication valuable in the present study is by Bowonder B, Kelkar V and Satish K.G that is an Issue Paper from Administrative Staff College of India ASCI, Hyderabad which takes a macroscopic view of the R&D in India and at the same time provides insights in to the micro level aspects as well. It has to be acknowledged that this publication has given great boost to the researcher both in terms of valuable information and morale. Nagpaul P S, Pruthi S, Jain A and Wahid A[124] in their well researched paper “Image of Indian Science – an Inside View” which was based on an elaborate survey of nearly 500 scientists of the ISCA (Indian Science Congress Association) have described the factors that influence/stimulate Science and Technology, objectives, and improvement in performance and management. Ashok Jain and Gupta VK[125] have studied Management of R&D in India, and assert that R&D by itself does not ensure economic performance and state that, “Management of R&D is concerned with creation of an infrastructure for carrying out research,
mobilization of men, material and money and provide an environment conducive to creativity and integration of research with the requirements of Industry and Society”. The authors proceed to show that India’s expenditure on R&D as a percentage of GNP, number of scientists/engineers per 1000 population, and those in R&D, and conclude that India is far behind compared to not only developed nations, but also to some developing countries as well. These same conclusions were drawn by Bowonder et al. The authors further argue that Research is individual oriented and R&D Management needs to reorient and focus on improving work culture, reward system, personnel policies and delegation of responsibility. If adequate return were not coming, industrial research would not attract investment. They stress that there is urgent need to bring about requisite changes in R&D Management systems and cultures. [125]. Bikash Bhadury [126] discusses on what ails Indian Management. Bhadury stresses that Managers are needed, and not administrators. Bhadury advises strongly for Planning for future, commitment and vision, improving technical competence and professionalism, avoiding sycophancy and develop leadership and this is quite essential for management.

M A Qureshi [127] discusses aspects of commercialization of indigenous technology and the critical role played by the financial institutions. Qureshi argues that there is no rigorous methodology for selection of right technological research programs, and more importantly the resource allocation is made without taking in to account the whole chain of activities leading to the commercialization of results of research. He argues that the firms also are more interested in existing markets than developing new markets for new products; and he also argues about the need for simplification of lending procedures. HS Rao [128] discusses the importance of management of technology transfer from laboratory to Industry and stresses the importance of innovation chain, and defines the process of technology transfer and the components thereof. Accordingly management of technology transfer is a complicated operation, but primary factor here in is the status of technology – the out come from R&D. The Telecom R&D Institution studied has an excellent track record in this area and proud of its strength that is visibly seen. P S Nagpaul [129] discusses the important issue of Productivity of Scientific Teamwork and Management and Policy Issues. Nagpaul describes the criteria of Research Performance both in quantitative and qualitative measures and goes on to stress the factors of group
structure, Human resources, control, leadership and its effect on the performance of research group, and research effectiveness: this focuses on the critical role played by individuals in R&D. Dick Sharad [130] declares that the Project Management shall be a way of Life and analyzes awareness of Project Management in India and concludes that it is gaining much attention in the industry. KS Krishnan [131], in a contrasting pattern describes Empowerment In Project Management and states that Project management in today's world is filled with challenges at multiple levels. There are many dimensions to this art of management. An important aspect lies in unleashing the power of teams. According to Krishnan, the concept of empowerment can be a catalyst in making teams more effective and explores how truly empowered teams work and the role of project managers in creating such teams. Collective ownership, self-organizing teams, non-hierarchical structures, intrinsic quality and role of leadership make it possible. The project manager provides the motivation needed for the team and that will ensure growth and satisfaction for each and every member, which will transform into success of the entire project! This is more relevant in an R&D environment. Subroto Bagchi [132] enumerates the lessons in entrepreneurship from the Indian IT industry, and shows the way to success. According to Bagchi, the first lesson from the IT industry is about its adherence to Quality and great organizations are built by people with an "abundance" mindset and Leaders exemplify personal integrity which others follow and to be world-class, you have to be hierarchy-free and he asserts that it is all about ordinary people delivering extraordinary results: defining the people power!

Parag Diwan's "Productivity & Technology Management" [133]; AS Rao's "Management of Technology Change" [134], and Anil Rawat and AS Rao's "Management of Corporate R&D and Innovation [135] are some useful reference books of Indian origin that cover the topics of interest and give explanations of relevance, in general.

NCAER Report [136] on Socio-Economic Impact of Rural Telecom Services brings out the deep and long lasting impact affected by the Telecom R&D Institution, implying the socio-economic relevance and delivery from any R&D and agrees Nagpaul et al [124] and Bowonder et al. Biswatosh Saha [137] discusses the importance of State Support
for Industrial R and D in Developing Economies: Telecom Equipment Industry in India and China, and quotes the case of the Telecom R&D Institution that is studied as primary sample and it is quite interesting to note the similarities and parallels drawn by Saha. Saha stresses the importance of state support for R&D, more specifically in the context of late industrializing economies such as India and discusses the problem of inadequate investment in technology by domestic firms – primarily engaged in “technology catch up” and states that it is rooted in their dependence on technologically advanced foreign firms and their inability breakdown the non-technological barriers to entry in to product market. Saha also explains the need to be sensitive to the stage of technological development and the nature of the industry in designing the policies for state support for industrial R&D for effective innovation. Saha affirms that in India (and in China) state support has immensely helped development of telecom technology capability and through access to a protected domestic market or by creating an assured demand, preferential purchase policies etc facilitated the entry as well as the technology learning in domestic firms. The commercialization and mass production approach of the Telecom Institution in question has also helped development of huge set of ancillary industry, unlike most other Government sponsored research institutions. Saha proposes that with a well-rounded industrial policy intervention only such initiatives would succeed in long run.

Now a look at the R&D, in MNCs - both Foreign and Indian. G.Wille and BK Chandrasekhar [138] explain the R&D experiences in India of General Electric, a high end well acknowledged innovation based company. The out line the R&D processes followed that aid better research out puts and at the same time indicate that concentrating on core competencies of the company is essential, and at the same time not spending energies on trivial and non-critical activities helps improving efficiencies. This phenomenon interestingly has been practiced in the Telecom Institution in question for more than two decades quite successfully. Nithyanandan Radhakrishnan [139] discusses on building successful software companies in developing countries, quoting the case of India and Infosys. Nithyanandan describes the scale and status of IT industry vis-à-vis that of Global scenario, and according to him Indian influence is only about 4% - includes IT Industry and IT Services. IT industry’s key success has emanated
from the fact that Indian IT companies are preferred by 70% of US companies and constitute anywhere 30-60% savings to those companies in terms of cost savings. [Source: Statistics quoted from Strategic Review 2004, The IT Industry in India, NASSCOM New Delhi, 2004]. Nithyanandan explains the reasons for India's success: widely publicized success stories of home grown IT companies (Infosys, Wipro, TCS etc), high quality delivery, conducive policies of Government, abundant pool of technical graduates and successful expatriate population. At Infosys, the additional factors like Innovative Leadership and pioneering practices, Global Deliver Model (viz., produce where it is cost effective and sell where it is most profitable), comprehensive and sophisticated end-to-end solutions, commitment to superior quality and process execution, longstanding direct customer relationship, and Leadership and Learning. Technology Management and Harnessing Intellectual Property is another key dimension. This paper clearly defines what could be achieved and how – a guide from Infosys, who in a relatively short span rose to great heights in IT map of the world.


Sunil K Dhavan, Santanu Roy, and Suresh Kumar [142] who have studied a number of Indian R&D Laboratories come with a the definition of Organizational Energy that is present in an R&D Laboratory and analyze how that helps in R&D performance. PS Nagpaul and Santanu Roy [143] have studied similar set of laboratories (basically the CSIR laboratories – the largest congregation of Government sponsored Labs - are covered in these studies) and they propose a multi-objective measure of research performance for measurement and improvement tool.). Santanu Roy (and his co-authors) [142,143] having thus studied a huge network of Indian R&D Laboratories provides essential insights and present indicators and measures and establishes a good quantitative base line for Organizational Effectiveness. These are to be viewed in conjunction with the over view and guiding force of Mashelkar [7]
L Prasad[144] explores the work they do in R&D and studies the implications for the management of knowledge workers: this research being a part of a larger study on understanding the aspirations of engineers in R&D, basically in a PSU. Prasad studies how the work one does in R&D influences an individual's perception of the work environment and attitudes & behavior and job satisfaction. He further compares the virtuous circle of professional order vs vicious circle of political entourage. He comes up the set of managerial implications to tap the “psychological contract” of R&D scientists and engineers, and advises to minimize mundane work/tasks, and where this is not possible to do job rotation to prevent boredom; allow them to stay with a project from start to finish; allow free time (15-20%) to work on ideas of their own choosing; and finally encourage “intra-preneurship” One of the nice works in India.

An entirely new perspective has been elaborated by Suchitra Mouly, [145, 146] viz., the Ethnographic Approach. By definition, the Ethnography is the systematic, organized and detailed description of a particular culture and includes the procedures through which such information is collected. In other words, the term ethnography refers to both the research procedures and the descriptive results and thus encompasses both the means and the ends. Scope of Ethnographic Research could be subdivided as Macro-ethnography and Micro-ethnography depending on the Social Units studied; the micro-ethnography covering a single social situation like R&D teams in an organization.

Thus the Organizational ethnography is an application of ethnography in a limited sense to organizations, as unit of setting. Suchitra Mouly [147] provides a critical Literature Review of Organizational Ethnography: Researchers Lambright and Teich originally did applying it to R&D setting [148]. There are very few investigations of organizations in the Indian context that have adopted a distinctly ethnographic paradigm. In fact the only one path breaking pioneer work was that of V Suchitra Mouly [145,146], which was followed up with a book (with Jayaram K Sankaran)[148] that introduced organizational ethnography to Indian researchers as a viable mode of inquiry into organizations. Recognizing that survey has been a dominant method in the study of organizations in the Indian context, they also make a critical appraisal of the
two research methods, survey and ethnographic, besides making a normative argument for ethnographic research, and how they applied it successfully in the study of a public-sector R&D team. [145, 148] The central thesis of Suchitra’s ethnography was very specific. From a general point of view, these findings may not sound startling or novel, but it is important to note that they are empirically well-grounded in the investigation of the public-sector R&D team and helps to understand the nature of and reasons for the relative failure or in the least, the ineffectiveness of public-sector R&D in India. Suchitra Mouly and Jayaram K. Sankaran [150] continue application of Ethnography approach while they present the aspect of barriers to the cohesiveness and effectiveness of Indian R&D project groups as insights from four publicly funded R&D organizations.

Subroto Bagchi [151] presents a different future in IT Industry, which could be coped with only building Employee Commitment. According to Bagchi, in near future employees will not need organizations as much as organizations will need them and People will not be configured around businesses, as much as businesses will be configured around people. Authority is dead or dying and it is being replaced by influence; Leadership will be the most important requirement for yielding influence. Commitment is the aligned response of people to issues, events, goals, a code of conduct, and a value system. Bagchi asserts that you do not build commitment: it is not about the result, it is about the process; and goes on to enumerate twenty things about building commitment – all about People factors.

Quite interestingly, there have been some Doctoral Theses in this line: Subrata Pandey [152] who has studied the organizational and individual characteristics in R&D organizations; Sandhya Iya [153] who has worked on conceptualization and measurement of the uncertainty experienced by R & D personnel in relation to job involvement, work involvement, and work motivation; Pulak Kumar Das [154] who has studied the Pay, Promotion and Pay Satisfaction of R & D Personnel in Some Indian Manufacturing Organizations; Prabha Nair [155] who has worked on Organizational Factors Influencing Success or Failure of Creative Performance of R & D Scientists: A Comparative Methodology for Identification; Ravichandran [156] who has done a Study...
of Organizational Innovativeness: Analysis of Some Correlates and Causal Factors; Jothilakshmi [157] who has done a Study of Leadership and Influence Patterns in Defense R & D Organizations: A Qualitative Approach; and Chandra Mohan [158] has done a study on the Leadership Styles of Indian Managers – A case Study of Visakha Patnam Port Trust: followed up in a book form Chandra Mohan and Krishna Niak [159] are good examples (not limited to, but includes) of the growing interest the academic institutions towards R&D and its various aspects of relevance.

Continuing about the studies on effectiveness of R&D organizations, more specifically Government sponsored research laboratories: Santanu Roy, PS Nagpaul, and Pratap KJ Mohapatra [160], Santanu Roy and Sunil K Dhawan [161] and Dhawan Sunil K and Santanu Roy [162] are credit worthy. Santanu Roy (and his various co-authors) [160,161,162] having thus studied a huge network of Indian R&D Laboratories provide essential insights and present indicators and measures and establish a good quantitative base line for Organizational Effectiveness. Santanu Roy and his co-authors have identified four broad concepts (Latent variables) viz., R&D Effectiveness (its manifest indicators being meeting the Organizations R&D objectives, meeting quality requirements, Innovativeness, Productiveness, Contributing to Science and Technology), Recognition (its manifest indicators being National and International reputation of the Organization's work, Citations/demand for publications), User Orientated Effectiveness (Social Value of Out Put, Usefulness in solving Societal problems, use of R&D results) and Administrative Effectiveness (Success in meeting time Schedules and being with in the Budget). A model also was developed and with elaborate data collection and mathematical treatment have validated its reliability. Work Environment, Organizational Energy and Energy Generating / Energy Draining Activities, Satisfaction and dissatisfaction with work environment and group process in R&D Organizations have also been studied and acknowledged to have significant impact on effectiveness of R&D organizations.

Sony [163] discusses an altogether different aspect, but with much relevance, that is the mediocrity in the organizations and as to how it manifests and erodes the successful organizations also. This portrait, unlike John H Dumbleton [3] and Tom De Marco and
Timothy Lister [97] who were more indicative, cursory and polite, tends to be very pointed and aggressive. Sony is very critical of Political activities in an organization, and decries the mediocrity for the failure of many a good organizations.

There are many writings on Quality in the Indian context, however only a few are reviewed here which throw some light on organizational wide implications from Management perspective in IT domain. Govardhan [164] deals with Strategic Quality Targeting in Transient Economies; Jagdish and Promod Verma [165] describe Wipro’s Quality Journey; and Vishu Hegde [166] deals with Intrinsic Quality - Quality in Knowledge Era are reviewed here. Govardhan [164] argues that it may not be really essential to develop/launch fully loaded products i.e. products full functionality called for in a product taking the global scenario, in view of the Quality Elasticity. Unlike the Price Elasticity in Economics which is a linear falling relationship between price and demand; the quality-demand relation in transient economies like those in India, is non-linear, in fact it is like a bell curve – a high end quality beyond a point would trigger lowering of demand because of purchasing power; the quality expectation in customers has to be triggered in steps to sustain business volumes. Govardhan suggests that a Progressive Desire Syndrome that is time based needs to be created progressively wherein the consumers’ intrinsic willingness to pay more for better quality. The author suggests that QFD (Quality function deployment) is a good tool for this. Jagdish and Verma [165] describe quite elaborately the initiatives taken at Wipro in their exceptional quality journey in the recent past. Anirban Basu also explains the concepts of ISO9000, CMMI, 6 Sigma in the specific context of Software Quality. Vishu Hegde [166] starts with describing evolution of civilization as Agriculture era (Labour intensive, Local with Mass production & distribution challenges); Industrial era (Mechanization, Mass production, Globalisation, and Manufacturing driven economy, Product Design and innovation challenges); and Knowledge era (Extreme Globalisation, Anytime-Anywhere like. Internet, Knowledge driven Industries & Economies, Thinking & Collective-wisdom challenges and Challenge in knowledge era is accuracy & speed of thinking): that is the knowledge era is primarily characterized by its design/creation intensive nature and hence the Quality Management is more Human centric & Knowledge centric and the Collective wisdom is the key. Hence the Intrinsic
Quality and Quality has to be built-in (in-grained) where the action happens that is at the line function itself. Since Quality is Value as Perceived by Customer, the Intrinsic Quality thread flows right from the Customer side. In a high quality organization is ingrained in day-to-day working and thinking at all levels within the organization and quality is seen in the context of customer value and business value, according to Hegde.

Finally about the Intellectual Property and Intellectual Property Rights (IPR): Prabudha Ganguli [167 & 168] is one of the best known IPR activist and proponent in the country who in a way is spearheading the IPR movement in India. Government of India has formulated Indian Patent Act & Patent Rules in 1970 and amended in 2003 [169] which as a act was passed in 2005. This final version incorporates the new modifications necessitated by the WTO. Maity [170] presents an over view of the of the Controller-General Of Patents, Designs & Trade Marks as applicable in India. Venkataraman [171] describes the salient features of the amendment. Lakshmi [172] describes the New Initiatives for Effective Exploitation of Intellectual Property at an IT/Telecom organization and suggests that aggressive patenting, avoiding reverse engineering, entering in to useful collaborations, working in the frontiers of technology as the tools with which an organization can cope with the onslaught of new patent regime and the powerful MNCs. Lakshmi also suggests that having a good IP/Patent portfolio would benefit an organization in improving its reputation, in attracting collaborations, barring competitors from entering in its business line, and also avoiding infringement. Mary Mathew [173] deals with entrepreneurial R&D and suggests an Organization Design for enhanced patent productivity - since the IP value added would be of high economic potential. Urmi Chattopadhyay [174] explains understanding organization designs for Patent Productivity in ICT sector (the IT and Telecom together – Information and communication technologies the new acronym encompassing the convergence phenomena) and studies the organizational designs through disparity of ICT professionals with varying patent experience: as could be seen various organizations have different notions about IPR and their stress on that also is varying. Yet the need of the hour is to take all necessary steps to protect intellectual capital, as per Lakshmi[172]
A word of explanation: Such an elaborate literature survey and review as above has been undertaken and presented considering both foreign and Indian contexts; in view of the fact that R&D, R&D management being the topics covered relatively less widely, and the treatment being in narrow packets especially for R&D in Electronics/IT/Telecom. Further, the gamut of topics that are essential in the present study also demanded such a wide and in depth search of what has been done in the area. Thus the wide and in-depth literature survey is intended to give a comprehensive picture and to bring out what exactly has been done so far; as a firm foundation and to substantiate the novelty and originality of the present research work, in addition to demonstrating its usefulness. Quite a few of the above publications mentioned above will be appropriately revisited in this report.

Need for the Study

From the above discussion, it appears that no real synergistic approach is in place. Further, it also seems that, the R&D Management has not been studied from the R&D perspective per se and as a means in improving the organizational effectiveness of Research & Development Institutions. Hence it was felt necessary to have an overall approach to study a given situation in totality. Hence this.

Objectives of the Study
The objectives of the present study were:

- to profile the domain of IT/Telecom and R&D therein
- to understand the organization(s) and management thereof
- to analyze the various factors that influence effectiveness
- to identify the parameters which as end results would reveal improvement in the organizations' effectiveness
- to suggest a possible Model(s) and study their effect
- to try implementing the suggestions and see the actual effectiveness
- to examine a few other organizations to see if these findings are portable
- to evolve a set of possible suggestions that help in improving organizational effectiveness of the R&D Institutions – through an integrated approach.
Research Problem

In today’s competitive environment, the R&D Productivity is very crucial for the success of the organization. Thus, the improvement in R&D Productivity and its Effectiveness constitute the expected outcome of this study. This implied that it was imperative to understand what constitutes the R&D Productivity; how to measure the R&D Productivity; what are the various parameters that affect the performance of R&D organization(s), then arrive at a set of practical means for improvement and to analyze the applicability, acceptability and validity of the same. The present study addresses these issues, and aims at evolving an integrated model, that would help meeting the challenges of liberalization.

Hypothesis

With this background, the present study was undertaken, in which an attempt was made to examine the R&D and R&D Management from the general standpoint. The various factors that affect management of R&D were studied and suitable remedial steps were identified as follows:

1. Monolith Characteristic of the Management
2. Road Map Definition
3. Pruning of Projects
4. Appropriate Review Mechanism
5. Conducive Environment for R&D
6. Integration (or de-compartmentalization)
7. Career Growth in Salary/Scales
8. Career Growth in Positions
9. Creation of Parallel (off-line) Structure
10. Sense of Identification & Pride in the Organization

A simple Model depicted as the “Pyramid of Success”, [© Sreenath Settur], containing the above ten elements, prioritized, and sub-categorized as Generic (#1, 5, 6 &10), Career (#7, 8 & 9) Project (#2 & 3), and Review (#4) requirements, was suggested for efficient and effective management.
In addition, the factual effect of organization structure on the effectiveness was also expected to be understood. The important role played by the appropriate review mechanism and that of the critical role of performance measurement as a means for organizational effectiveness as an Integrated Approach, which forms a part of the overall Review, was also expected to be established. The Integrated Approach that applies "the integrated model for improved organizational effectiveness employing knowledge networks" [© Sreenath Settur], including the Business Orientation, Quality, Innovation/IPR (Intellectual Property Rights) and Service attitudes, was also suggested to aid in improving the overall Organizational Effectiveness.

Thus the Hypotheses for the present study were:

i. the Ten elements as above have influence and effect the performance of the organization in the stated order of priority

ii. the bottom two (Generic & Career) layers form necessary conditions, and the top two (Project & Review) layers form both necessary and sufficient conditions

iii. the top two (Project & Review) layers correlate positively, and the bottom two (Generic & Career) layers correlate negatively

iv. the Pyramid of Success Model as proposed is valid and aids in improving effectiveness of the organization

v. the Integrated Approach as proposed aids in improving the overall Organizational Effectiveness

Scope of the Study

To begin with, the unit of study chosen in this case was various R&D groups in one single organization as was described previously. This approach was taken as no immediate parallels could be drawn in Indian context, and it was felt that the unit under consideration was a true representative of the R&D in the country, that too in a high end technology area, which was vastly filled with big Indian and MNC players as well. However, as the study progressed the scope was extended to some more groups and to a few other organizations in the IT/Telecom domain. This was done with the intention of studying them separately as well as, as a comparative study.
Sources of Data
This study was based on primary and secondary sources of data. The main source of primary data was from the Managers and Engineers/Scientists and Staff interviewed/interacted from various R&D Groups and Organizations. This primary data collected consisted of information from the interviews, discussions, and observations/interactions – both individually and in teams/groups, and occasionally done multiple times, and also through questionnaires (hard copy/e-mail) used. A brief note on considerations for interview and questionnaire is appended at the end of this Chapter.

On the other hand, the secondary data was through information obtained through the senior managers (of their experiences, approaches, opinions, and opinions they had obtained from other experts etc.) and from various international/national journals, magazines, issue papers, in-house news letters, websites, internal reports/documents, presentations, Conference proceedings, News Papers, publications, reference books etc.

Methodology
The study being both exploratory as well as comparative in nature, poses a peculiar situation. Thus, the Methodology of research was initiated through suitably framed questionnaires and carefully designed interviews across various cross-section of the organization with significant sample size (across all departments/cadres). This gave insights in to what was the current status and possibilities for where to reach. Here the quantitative techniques were employed suitably.

However, as the study progressed, it was strongly felt necessary to study the current prevailing situation of the organization(s) and to understand it fully so as to capitalize with in this challenging zone. An attempt was made to further the study in a fashion that is radically away from traditional means. This was, primarily in view of the certain inadequacies experienced in applying such techniques. Hence the Ethnographic approach. (The other limitations of the present study are indicated in Chapter V)
The understanding of the organizations, has further prompted the need for an integrated approach that would cover all the relevant areas concerning the R&D (viz., nature of R&D, strategy and structure relationships, creativity, the R&D process and the R&D Interface) vis-a-vis the performance and productivity of the organization; and have a direct bearing on the effectiveness of industrial R&D. The creativity process in R&D that primarily depends on the intellect, personality and general ability of individuals does not lend itself easily to scrutiny by quantitative means. Similarly, the areas of motivation, leadership, group dynamics, and interface and relationships with external environments present a domain that does not get captured realistically. At the same time the fundamental assumption of rationality in the organizations appears to be only a myth and an Ideal situation; instead the private agendas of individuals seem to be omnipresent. These could be looked at as political activities in side an organization that have an unexplained, yet very serious influence. These considerations and issues further justify application of the Ethnographic approach, in the study of an R&D Organization.

Thus both qualitative and quantitative methods were applied in a complementary manner, so as to derive maximum benefit from the study.

Organizational Ethnography Approach

The Organizational Ethnography is an application of ethnography in a limited sense to organizations, as a unit of setting. By definition Ethnography is the systematic, organized and detailed description of a particular culture and includes the procedures through which such information is collected: meaning that the term ethnography refers to both the research procedures and the descriptive results and thus encompasses both the means and the ends. The Organizational Ethnographic is that subdivision of ethnographic that covers a single social situation in an organization, like R&D teams.

At this juncture, it is necessary to put forward some observations made as a part the present study. It appears that typically, in an organization the middle management, rather than the real top, manages the real R&D. And typically, the attention to interpersonal considerations (such as individuals, teams/groups, both intra and inter) and the totality/global considerations rather than the local considerations, poses a serious concern. [3,4] In general, the individuals engaged in R&D are not strong in the
area of human relationships, and would have learned management considerations on job only. Hence the role of R&D does not generally get appreciated to the degree it deserves. It seems that this tendency could lead to the resource wastage and/or threaten the very existence of the organization, on the other extreme. This understanding has further prompted the Researcher [175] of the dire need for an integrated approach that covers all the relevant areas concerning the R&D (viz., Nature of R&D, Strategy and Structure relationships, Creativity, the R&D Process and the R&D Interface) vis-à-vis the Performance and Productivity of the Organization; and have a direct bearing on the effectiveness of industrial R&D. It was also observed that the Creativity Process in R&D that primarily depends on the Intellect, Personality and General Ability of Individuals does not lend itself easily to scrutiny by quantitative means. Similarly, the areas like Motivation, Leadership, Group Dynamics, and Interface and relationships with External Environments are also a domain that does not get captured realistically. At the same time the fundamental assumption of Rationality in the Organizations appears to be only a myth and an Ideal situation; instead the private agendas of individuals seems to be omnipresent. These could be looked at as Political activities in side an organization that have an unexplained, yet very serious influence. [175] These considerations and issues further prompt the inadequacy of quantitative methods in the study of an R&D Organization. This is the reason why an entirely new perspective that was elaborated and applied by Suchitra Mouly [145, 146,147], viz., the Ethnographic Approach has been found to be quite appropriate.

The Ethnographic approach:
The Ethnographic Approach is a relatively new qualitative paradigm of inquiry into organizations, referred to as organizational ethnography. Ethnography is the process of describing a culture from the members' point of view. In other words, the goal of ethnography is to “grasp the native's point of view, his relation to life, to realize his vision of his world”. The term ethnography also refers to a cultural description, i.e., a written text that discusses a social group or a knowledge system and purports to bear a close resemblance to life in the group or to knowledge in the social system. One can trace the development in ethnography from the studies of primitive tribes to modern settings.
Definition of Ethnography: Ethnography is the systematic, organized and detailed description of a particular culture and includes the procedures through which such information is collected. In other words, the term ethnography refers to both the research procedures and the descriptive results and thus encompasses both the means and the ends.

With its focus on understanding the culture underlying any given community, ethnography emphasizes viewing the culture from its members’ points of view. An ethnographic description must 'represent its host culture with fidelity' and 'closely assemble the original cultural reality' (Werner and Schoepfle, 1987a, p.24, as referred by Suchitra [148]). Ethnography thus aims at providing an 'insider's picture' of the community under study.

Then, Organizational ethnography refers to doing ethnography in an organizational setting. As a paradigm it has emerged in the wake of a recent resurgence of qualitative methodology in organizational studies. It is observed that the fruits of quantitative, survey-based research – which has so far held a monopolistic stronghold on organizational studies - have not been commensurate with the research efforts. For various reasons, such as enumerated earlier, researchers of organizations are increasingly adopting qualitative modes of inquiry, including organizational ethnography.

In his introduction to the special issue in 1979 of the Administrative Science Quarterly on qualitative methodology, John Van Maanen cited several reasons for this phenomenon. The epistemological stance of quantitative research has been positivistic. Individuals, groups and organizations have implicitly been assumed to behave regularly according to general principles just as objects in the physical world conform to natural laws. This stand has been the rationale behind the survey design of per formulating hypotheses and then testing them across settings to statistically validate them. Nomothetic postulates, derived from the hypothetic deductive paradigm, offer explanations for the behavior of individuals groups and organizations. However, these are consistently at variance with the always-contextual understanding given by the
concerned social actions. Increasingly it is being recognized that data, which may not be quantifiable or scalable, may nevertheless be useful in understanding a given social situation or in testing a given theoretical framework. [148] Observers of organizations are increasingly sceptical about the ability of conventional techniques of data collection to yield data that adequately portray the social phenomena under study. These techniques also include the questionnaire and the formal interview.

While conducting the ethnography's in organization, to appreciate and describe the culture of an organizational setting, a researcher typically spends an extended period of time in the setting doing ‘field work’, which comprises participant observation, informal interviews and document analysis, among others. The objective of the researcher is to see the view from-the-inside of the setting. Although there are different ethnographic paradigms for the analysis and interpretation of ethnographic data, they all emphasize the need for prolonged fieldwork and empathy with the insider members of the setting.

Scope of Ethnographic Research could be subdivided as Macro-ethnography and Micro-ethnography depending on the Social Units studied; the Micro covering a single social situation, like R&D teams in an Organization. Some details are given below:

**Ethnographic Research Procedures:**
Doing ethnography involves first and foremost fieldwork, including observing, asking questions, participating in group activities and testing the validity of one’s perceptions against the intuitions of natives. Since there is no best method for capturing the fullest details of a given culture or community, ethnographers have to evolve a new a set of appropriate procedures for each new situation. These appropriate procedures depend, on the relationship of the ethno-grapher and the community under study, the type of data being collected, and the particular situation in which fieldwork is being conducted.

**Data collection:**
Fieldwork, which is the equivalent of data collection in quantitative research, mainly makes use of two tools. The first is participant observation. Here, as the term implies,
the ethno-grapher not only observes the events in the community but also participates in them by becoming an accepted member (at least partially) of the community. The other important tool is the open-ended ethnographic interview, which is flexible in nature.

**Participant observation:**
The most common method for collecting ethnographic data in any domain of culture is participant observation. Participant observation refers to research characterized by “a period of intense social interaction between the researcher and the subjects, in the milieu of the latter”. During this period data is unobtrusively and systematically collected. A participant observer experiences being both an insider and an outsider simultaneously; and moderating and maintaining a balance between being an insider and an outsider, between participation and observation.

**Ethnographic interviews:**
Interviewing may be used to get a wide range of cultural information on important community events and “descriptions of encounters among members of the community in different contexts”. Interviews are often formal and contrived, but they are an efficient and necessary supplement to observation and participation. This also enables the researcher to capture the discrepancies between the ‘ideal’ and ‘real’ values, beliefs, and perceptions that a community holds.

**Data analysis:**
Here Analysis is a search for patterns and ethnographic analysis as a search for cultural patterns. Domain analysis, which is the starting step in ethnographic analysis, involves searching for domains i.e. the cultural categories under which smaller categories that give meaning to members’ perceptions are included. These give an idea of the prevalent, shared or diverse opinions that the members hold about that aspect.

Upon further observation and probing the domain analysis helps us to:

i. Summarize the pattern of perceptions on a given topic;

ii. Open up further inquiry into these aspects; and

iii. Get a more complete picture of diversity or convergence
Thus, the Organizational ethnography is an application of ethnography in a limited sense to organizations, as unit of setting. Researchers Lambright and Teich who described the characteristics of scientists as organizational members did applying it to R&D setting. [As quoted by Suchitra, 147] They then reviewed how various organizations could accommodate or exacerbate the tensions that arise from research. They considered both those organizations, which sponsor research and those organizations or subunits that perform research. The authors looked at the operating norms of each and how they interact. They deal with the consequences of research for the environments of organizations. They then discuss how organizations attempt to use research to alter their environments. Finally, they suggest ways in which organizational designs might contribute better to both the performance and the utilization of research.

There are very few investigations of organizations in the Indian context that have adopted a distinctly ethnographic paradigm. In fact the only one path breaking pioneer work was that of V Suchitra Mouly that introduced organizational ethnography to Indian researchers as a viable mode of inquiry into organizations. Recognizing that survey has been a dominant method in the study of organizations in the Indian context, they also make a critical appraisal of the two research methods, survey and ethnographic, besides making a normative argument for ethnographic research, and how they applied it successfully in the study of a public-sector R&D team. [148]

The central point is that ethnography becomes very specific and from a general point of view, the findings may not sound startling or novel, but it is important to note that they are empirically well grounded in the understanding of the R&D teams and organizations. Further, an ethnography study could at least be regarded as a preliminary (albeit important) step in a long-term research agenda that seeks to understand the nature of and reasons for the relative success or failure, the effectiveness or ineffectiveness of R&D organizations. It is observed that the ethnography is not merely an idiographic statement of the effectiveness or ineffectiveness of an Organization, since it has ability to fully capture the factors leading to its performance, and at the same time it provides a scope for improvement path. At this juncture, it is worth noting that from a qualitative methodology perspective, it may be neither possible nor
desirable to statistically validate the approach across various R&D settings, in view of their specificity and presence of their own peculiarities.

This rich background has prompted the Researcher, to embrace a study, Suchitra's work serving as a conceptual framework to initially guide in-depth investigations of other public-sector R&D teams, in this case, to the R&D Organization(s) in question. Thus an attempt has been made by the Researcher, to demonstrate the evidence of the potential of the Organizational Ethnographic approach by its application in the present study of R&D settings of the Organization(s) in question, and it is expected that through this study substantial qualitative insights be gained about the reasons for the success as well as failures of the R&D setup.

It must be hastened to add that, after understanding the strengths of both quantitative and qualitative research (e.g. survey and ethnography etc.), it was strongly felt that, both qualitative and quantitative methods are necessary in the present study and hence applied in a complementary manner, so as to derive maximum benefit from the study.

Techniques of Data Collection

The primary data was from the Managers, Engineers/Scientists and Staff interviewed / interacted from various R&D groups and organizations. This primary data collected consisted of information, from the well structured but personalized probing interviews, discussions, and observations/interactions – both individually and in teams/groups, and occasionally done multiple times, and also through questionnaires (hard copy/e-mail) used. The total Sample Size was 319 (319 members responded out of 409) covering all strata of the primary sample organization was considered. However, for the later part of the study, as it was noted that taking the full gamut of subjects as employed earlier would not be of much use, hence only the Managerial staff from different locations of the organization, covering various domains of R&D and support functions were considered. Thus the Sample Size here was 108.

The variables selected in the Study were the ten factors enumerated earlier (depicted as Pyramid of Success) at the organizational (internal) level and the factors like Business Orientation, Quality, Innovation/IPR (Intellectual Property Rights), and Service aspects
besides Knowledge Networks. The factors relating to technology, people and processes; and the other relevant factors/areas of general concern like organization structure, performance measurement and conducive environment were also considered.

**Both qualitative and quantitative methods were applied in a complementary manner, so as to derive maximum benefit from the study.**

**Data Analysis**

A few simple statistical tools, like percentage, central tendency and dispersion, and correlation / regression co-efficient etc., were appropriately used to analyze the data collected through the quantitative means. Where as the data compiled via the non-quantitative means was analyzed separately and verified for validity appropriately. The statistical technique most crucial for the present study was the Correlation Analysis; an explanation is in order:

Correlation Analysis is a methodology to identify the relationship between two variables. Generally correlation analysis is carried out to explore the relationship between a process output variable and an in process or input variable. The output variable is denoted by y and is also called dependent variable. The in process or input variable is denoted by x and is also called independent variable. Using correlation, it is possible to identify the type as well as the degree of relationship between two variables. There are two types of correlation, positive correlation and negative correlation. If the variable y increases as x increases and vice versa, then x and y are positively correlated. If variable y decreases as x increases and vice versa, then x and y are negatively correlated. If there is no increasing or decreasing trend (and the points are scattered in the x vs y scatter plot), then there is no relation. The scatter plot may not clearly bring out the correlation many a time, and hence statisticians have evolved other measures for correlation and thus correlation co-efficient r is developed. The coefficient of correlation r can take any value from -1 to +1. A negative r is an indication that the variables (x and y) are negatively correlated, while a positive value of r indicates that the variables are positively correlated; and whenever r is close to zero then there exists no correlation between the variables.
The computation of coefficient of correlation is presented here in a simplified form:

From the table representing pairs of values of x and corresponding values y, the mean values for both variable x and y are computed (Mean is equal to total of all values divided by the number of values). Now the difference between the variable (x or y) and their respective means are computed and tabulated. The corresponding (x-mean x) and (y-mean y) are multiplied and their cumulative sum is computed (S xy). The sum (S xy) thus obtained will be a positive figure in case of positive correlation and negative in case of negative correlation. This is the basic logic of correlation coefficient. But S xy cannot be considered as a measure of correlation because of scaling problem, i.e. if the scale of both x and y values are changed (say multiplying or dividing by 20, 100 etc) the S xy will show a different value. To avoid scaling problem, the coefficient of correlation is calculated by dividing S xy by square root of (Sxx x Syy).

Thus the Coefficient of Correlation \( r = \frac{S_{xy}}{\sqrt{S_{xx} \times S_{yy}}} \)

Where \( S_{xy} = \text{Sum of } [(x-\text{mean } x) \times (y-\text{mean } y)] \)
\( S_{xx} = \text{Sum of } [(x-\text{mean } x) \times (x-\text{mean } x)] = \text{Sum of } [\text{Square of } (x-\text{mean } x)] \)
\( S_{yy} = \text{Sum of } [(y-\text{mean } y) \times (y-\text{mean } y)] = \text{Sum of } [\text{Square of } (y-\text{mean } y)] \)

This Coefficient of Correlation \( r \) can vary from -1 to +1 only. If \( r \) is negative then the variables are negatively correlated and if \( r \) is positive then the variables are positively correlated; and when \( r \) is close to zero, there is no correlation.

(Source: NIQR News Letter, No.4, October-December 2005)

A further detailed discussion on the Correlation is appended at the end of this Chapter. A detailed discussion on the concept of Necessary and Sufficient Conditions the other technique crucial for the present study - is also appended at the end of this Chapter.
Confidentiality Requirements

The confidentiality demands in these Organizations have prohibited from giving out names of the Organizations and details about the groups and Managers, Engineers/Scientists and Staff interviewed/interacted. Further, in most of the cases there were Non-Disclosure Agreements in vogue and Intellectual Property Rights Protection was critical. These in addition to business reasons have put a lot of constraints during the study and also on publishing some aspects. It is requested that this factor be borne in mind.

Upon entering the employment at any given company ever employee is required to sign an Employee Non-Disclosure Agreement, that he/she thereby agrees to abide by all the norms, rules & regulations stipulated by the company (Company Bye-laws and in case of Publicly funded companies the norms of the Govt. of India as applicable) and he/she also undertakes not to disclose any information in any form/manner, that is detrimental to the interests of Company and in such an event becomes solely liable to compensate company all the remedies deemed fit.

This has become crucial in today’s fast pace of technology change and the criticality of IPR and hence the companies expect that the employee recognizes that the Employee is being hired in a position of trust and confidence and that the company needs to protect confidential information relating it’s Business and expects the Employee agrees and understands that a change of Employee’s duties or job assignments shall not result in, or be deemed to be, a modification of this Agreement. Thus the Employee irrevocably agrees on the treatment of confidential information and he/she shall never directly or indirectly disclose, transfer or use any confidential information without prior written consent of the company. The employee also undertakes to abide by a Non-competition clause under this NDA, to safe guard the company’s IPR as well as business interests. In general the company always has an upper hand.

In view of NDA/IPR demands as above, typical disclaimers are always accompanied and they always assert that any inputs/messages which may contain confidential, proprietary or legally privileged information and that in case one is not the original intended recipient of the information, one is advised not to use, directly or indirectly,
disclose, distribute, print, or copy any part of such inputs and requested to immediately remove/delete it and inform the sender. And they also assert that if at all any views expressed in such inputs/message those of the individuals unless otherwise stated and that nothing contained in them shall be construed as an offer or acceptance of any offer by the company in question, unless sent with that express intent and with due authority of the company. This was a serious constraint in certain respects. This NDA/IPR related factors are to be constantly borne in mind.

CHAPTERISATION

Chapter I Introduction

In this chapter the back ground introductory information relating to the concepts of R&D, R&D Management, R&D in India, Economic Liberalization, its effects and aftermath, Review of Literature, Objectives and Need for the Study, Methodology etc., will be discussed. The Ethnography approach and the Confidentiality Requirements will also be discussed.

Chapter II An Over view of the Domain

In this Chapter the IT/Telecom domains will be discussed and analyzed in detail. The Sample Organization(s) will also be discussed. The Profiles of the subjects will also be presented in detail.

Chapter III Pyramid of Success

In this Chapter the details of the study undertaken, with an attempt to examine the R&D and R&D Management from the general standpoint and the various factors identified therein that affect management of R&D and the suitable remedial steps that were arrived at will be presented. Further, the suggested simple model, depicted as the "Pyramid of Success", for efficient and effective management of R&D at the
Organizational level, will also be discussed. Some aspects such as Conducive Environment for the R&D will also be highlighted.

Chapter IV An Integrated Approach

In this Chapter the Integrated Approach for improving the effectiveness of the R&D Institutions will be presented and the influencing factors like: Business Orientation, Quality, Innovation/IPR, and Service aspects besides Knowledge Networks, that need to be in-built in to the work culture and the factors relating to Technology, People and Processes will also be elaborated. The aspects about the various organization structures, performance measurement and the critical role played by the appropriate review mechanism and other relevant areas of general concern will also be presented. A brief comparison with other organizations examined will also be presented.

Chapter V Conclusions

In this final Chapter, Summary and the results of the study will be outlined based on the critical analysis of the primary and secondary data. Conclusions drawn from the present research work will also be presented which are expected to serve as the suggested practical guidelines for R&D Management in improving the Organizational Effectiveness of Research & Development Institutions, as an integrated approach, which is expected to be portable across any domain.
APPENDICES
TO CHAPTER I
A brief note on considerations for Interview and Questionnaire

In the present study Personal Interviews were preferred as the Researcher could ask the questions face-to-face with the Interviewee. It had advantages: the ability to find the target population directly, the flexibility to let the Interviewee to clarify in real time and more importantly longer and probing interviews are tolerated once arranged in advance.

The first thing decided was the kind of people to interview - the target population, in the present case was quite obvious - determining the target population was critical as interviewing the right kinds of people, will permit successfully meeting the expected goals. The next thing decided was how many people need to be interviewed. Statisticians know that a small, representative sample will reflect the group from which it is drawn - the larger the sample, the more precisely it reflects the target group. (However, the rate of improvement in the precision decreases as sample size increases.)

A final decision was made about sample size based on factors such as: time available, coverage and necessary degree of precision. Care was taken to avoid any biased sample, as a biased sample will produce biased results – though totally excluding all bias is almost impossible; however, recognizing that bias exists one can intuitively discount some of the answers.

During the Questionnaire Design, it was attempted to keep the questionnaire short and simple: when presented with a long tedious questionnaire most potential respondents will give up in horror before even starting. The temptation to add a few more questions just to make a very comprehensive questionnaire was avoided and as necessary placed questions into different groups for various levels of staff covered. Rating Scales (Excellent - Good - Fair – Poor OR on a Scale of 10 to 1) and Agreement Scales (Strongly Agree, Agree, Disagree, Strongly Disagree) etc., are two common types of questions that have been used as both multiple-choice questions and as numeric open end questions. These were later complemented with detailed discussions, as necessary.

Thus, the reference questionnaire that was prepared was used more as a guideline/reference and not to miss out on any important aspect that would matter. However, as most of the questions are leading types and would not have one right
answer, but multiple possibilities, it was felt that it would be more appropriate not to send them by mailers and await responses, but to meet personally. Even though it was not the intention of the Researcher to reach a hundred percent consensus, the idea of knowing 'why', not just 'what' was predominant. This was pursued as a better means to understand the actual situation, in totality.

The awareness of cultural factors was crucial as many respondents have a strong tendency to exaggerate answers. (Researchers may be perceived as being management's agents, with the power to punish or reward according to the answer given.) Accordingly they often give "correct" answers rather than what they really believe. Even when the questions are not overtly pro-management and deal purely with factual information and/or opinions, the desire not to disappoint important visitor (the researcher) with answers that may be considered negative may lead to exaggerated scores. There is a typical desire to please the researcher that translates into a tendency to pick agreeing answers on agreement scales: while logically in the real world, this is unlikely to be true. And, People sometimes give answers they feel will reflect well on them. More people say they are team players than actually are. At times, it was noted, what people say about themselves could be confusing, because for the simple reason that most of us are not very objective about ourselves – contrary to what we tend to believe we are. Hence the questionnaire and interview are carefully designed to elicit telling responses – and care also was taken not to get distracted by the kind of misleading, confusing, irrelevant information that comes from a face to face encounter (the Researcher is viewed as a bound patient listener!)

This is a constant problem in social/management research surveys. This problem is most significant when respondents are talking directly to a person. Hence it was noted that there is a need to always discount "favorable" answers by a significant factor. The desire to please is not limited to the common public; it extends to the R&D community as well. Unfortunately, there is no hard and fast rule on how much to do this. It depends on the situation.
It was also attempted to build good rapport with the respondents/interviewees that promoted eliciting honest responses to such probing questions mostly by good question design, and occasionally by personality, empathy and confidence building.

**Pretest:** As a last step the questionnaire was tested with a small number of interviews before conducting main interviews: it was done on the same kinds of people included in the main study. This test run revealed a few unanticipated problems with question wording, instructions, etc. and helped see if the interviewees understand questions and giving useful answers. Care also was taken, not to combine the results from the pre-test with the results of post-test interviews.

Utmost care was also exercised in not just invariably obtaining mathematically/statistically correct answers to questions, but in choosing sensible questions and appropriately administering surveys with sensitivity and common sense to improve the quality of results dramatically and also to capture the true picture.
Correlation is a statistical technique that can show whether and how strongly pairs of variables are related. For example, height and weight are related - taller people tend to be heavier than shorter people. The relationship isn't perfect. People of the same height vary in weight, and one can easily think of two people known where the shorter one is heavier than the taller one. Nonetheless, the average weight of people 5'5" is less than the average weight of people 5'6", and their average weight is less than that of people 5'7", etc. Correlation can tell just how much of the variation in peoples' weights is related to their heights. Although correlation in this example is fairly obvious the field data collected may contain unsuspected correlations. One may also suspect there are correlations, but don't know which are the strongest. An intelligent correlation analysis can lead to a greater understanding of such field data.

There are several different correlation techniques. The most common type is called the Pearson or product-moment correlation. This brief note also includes a variation on this type called partial correlation. The latter is useful when one wants to look at the relationship between two variables while removing the effect of one or two other variables.

Like all statistical techniques, correlation is only appropriate for certain kinds of data. Correlation works for data in which numbers are meaningful, usually quantities of some sort. It cannot be used for purely categorical data, such as gender, brands purchased or favorite color. Rating scales are a controversial middle case. The numbers in rating scales have meaning, but that meaning isn't very precise. They are not like quantities. With a quantity (such as Rupees), the difference between 1 and 2 is exactly the same as between 2 and 3. With a rating scale, that isn't really the case. One can be sure that the respondents think a rating of 2 is between a rating of 1 and a rating of 3, but cannot be sure if they think it is exactly halfway between. This is especially true if one labeled the mid-points of the scale (one cannot assume "good" is exactly half way between "excellent" and "fair").
Many statisticians say one cannot use correlations with rating scales, because the mathematics of the technique assumes the differences between numbers are exactly equal. Nevertheless, many other survey researchers do use correlations with rating scales, because the results usually reflect the real world. Hence the Researcher’s own position is that one could use correlations with rating scales, but should do so with care. When working with quantities, correlations provide precise measurements. When working with rating scales, correlations provide general indications.

The main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related. If r is close to 0, it means there is no relationship between the variables. If r is positive, it means that as one variable gets larger the other gets larger. If r is negative it means that as one gets larger, the other gets smaller (often called an "inverse" correlation). While correlation coefficients are normally reported as r = (a value between -1 and +1), squaring them makes them easier to understand. The square of the coefficient (or r square) is equal to the percent of the variation in one variable that is related to the variation in the other. After squaring r, ignore the decimal point. An r of .5 means 25% of the variation is related (.5 squared = .25). An r value of .7 means 49% of the variance is related (.7 squared = .49).

A correlation report can also show a second result of each test - statistical significance. In this case, the significance level will tell how likely it is that the correlations reported may be due to chance in the form of random sampling error. If one is working with small sample sizes, choosing a report format that includes the significance level is the right way; and such format also shall report the sample size.

A key thing to remember when working with correlations is never to assume a correlation means that a change in one variable causes a change in another. Sales of personal computers and athletic shoes have both risen strongly in the last several years and there is a high correlation between them, but one cannot assume that buying computers causes people to buy athletic shoes (or vice versa). The second caveat is that the Pearson correlation technique works best with linear relationships: as one variable gets larger, the other gets larger (or smaller) in direct proportion. It does not work well
with curvilinear relationships (in which the relationship does not follow a straight line). An example of a curvilinear relationship is age and health care. They are related, but the relationship doesn't follow a straight line. Young children and older people both tend to use much more health care than teenagers or young adults. Multiple Regression (not included in this note) can be used to examine curvilinear relationships, but it is beyond the scope of this note.

"Significance level" is another misleading term that many researchers do not fully understand. This note may help one understand the concept of statistical significance and the meaning of the numbers produced. This note simplifies the concept of statistical significance as much as possible; so that all non-technical readers can understand and use the concept to help make decisions based on the data.

In normal English, "significant" means important, while in Statistics "significant" means probably true (not due to chance). A research finding may be true without being important. When statisticians say a result is "highly significant" they mean it is very probably true. They do not (necessarily) mean it is highly important. Significance levels show how likely a result is due to chance. The most common level, used to mean something is good enough to be believed, is .95. This means that the finding has a 95% chance of being true. However, this value is also used in a misleading way. No statistical package will show you "95%" or ".95" to indicate this level. Instead it will show you ".05," meaning that the finding has a five percent (.05) chance of not being true, which is the converse of a 95% chance of being true. To find the significance level, subtract the number shown from one. For example, a value of ".01" means that there is a 99% (1-.01=.99) chance of it being true.

People sometimes think that the 95% level is sacred when looking at significance levels. If a test shows a .06 probability, it means that it has a 94% chance of being true. One can't be quite as sure about it as if it had a 95% chance of being true, but the odds still are that it is true. The 95% level comes from academic publications, where a theory usually has to have at least a 95% chance of being true to be considered worth telling people about. In the business world if something has a 90% chance of being true (probability =.1), it can't be considered proven, but it is probably better to act as if it were true rather than false.

(Source: The Survey System)
Concepts of Necessary Conditions and Sufficient Conditions

Everyone is familiar with the concept of a necessary condition. For example, we all know that air is necessary for (human) life. Without air, there is no (human) life. Similarly, everyone is familiar with the concept of a sufficient condition. For example, it suffices (i.e. it is sufficient for) an object's having four sides that it is a square.

Definition of "necessary condition": A condition $A$ is said to be necessary for a condition $B$, if (and only if) the falsity (/nonexistence /non-occurrence) [as the case may be] of $A$ guarantees (or brings about) the falsity (/nonexistence /non-occurrence) of $B$.

Definition of "sufficient condition": A condition $A$ is said to be sufficient for a condition $B$, if (and only if) the truth (/existence /occurrence) [as the case may be] of $A$ guarantees (or brings about) the truth (/existence /occurrence) of $B$.

However, in general a necessary condition is not a sufficient condition. All sorts of conditions may be necessary for others, but do not - by themselves - suffice for, or guarantee, those others. For example, while air is a necessary condition for human life, it is by no means a sufficient condition, i.e. it does not, by itself, i.e. alone, suffice for human life. While someone may have air to breathe, that person will still die if he lacks water (for a number of days), has taken poison, is exposed to extremes of cold or heat, etc.

Examples of Necessary and Sufficient Conditions:

1. Paying tuition fee is necessary but not sufficient for graduation.

   Necessary: You can't graduate without paying your tuition bill.
   Not sufficient: Paying your tuition bill is not enough to ensure that you graduate.

2. Being able to run a 4-minute mile is sufficient but not necessary for being physically fit.
Sufficient: Being able to run a 4-min. mile guarantees that you are physically fit.
Not Necessary: Being able to run a 4-minute mile is not required for being physically fit: One can be physically fit without being able to run a 4-min. mile.

3. Satisfying all the academic requirements and paying all your fees is both necessary and sufficient for being eligible to graduate.

Necessary: You can't graduate unless you satisfy all the academic requirements and pay all your bills.
Sufficient: If you do satisfy all the academic requirements and pay all your bills, then you are eligible to graduate.

Frequently the terminology of "individually necessary" and "jointly sufficient" is used. One might say, for example, there are several necessary conditions for something's being a square, and all of these must be satisfied for something's being a square, hence "each of the members of the conditions is individually necessary and, taken all together, they are jointly sufficient for being a square."

Necessary conditions that are not sufficient also do exist in real life and here sometimes it is easier to specify necessary conditions than sufficient ones. Similarly, Sufficient conditions that are not necessary also exist and then it is easier to specify sufficient conditions than necessary ones.

Then there is the concept of **converse relations** Definition: Two (two-place) relations, \( R_1 \) and \( R_2 \), are **converses** of one another, if and only if, (1) \( xR_1y \) (e.g. Chandra is taller than Rajan) guarantees \( yR_2x \) (e.g. Rajan is shorter than Chandra), and (2) \( yR_2x \) guarantees \( xR_1y \).

It is essential to know that "Is a necessary condition for" and "is a sufficient condition for" are converse relations. If \( x \) is a necessary condition for \( y \), then \( y \) is a sufficient condition for \( x \). And, equivalently, If \( y \) is a sufficient condition for \( x \), then \( x \) is a necessary condition for \( y \). For example "Since having air to breathe is necessary for human life, it follows that the existence of human life (demonstrates, assures, guarantees, i.e.) suffices for the existence of air." Similarly, "Being a father is a
sufficient condition for being male, and being male is a necessary condition for being a father." But being a father is not a necessary condition for being a male [e.g. James is not a father, but is male] and being a male is not a sufficient condition for being a father.

When one picks any two conditions whatsoever, the relationship between the two conditions must be exactly one of the following four possibilities:

1. The first is a necessary, but not a sufficient, condition for the second
   (Eg. "Having a ticket in a lottery is a necessary, but not a sufficient condition, for winning that lottery."); OR
2. The first is a sufficient, but not a necessary, condition for the second
   (Eg. "Winning a lottery is a sufficient, but not a necessary condition, for having a ticket."); OR
3. The first is both a necessary and a sufficient condition for the second
   (Eg. "Today's being neither Saturday nor Sunday is both a necessary and a sufficient condition for today's being a weekday."); OR
4. The first is neither a necessary nor a sufficient condition for the second.
   (Eg. "Being the smartest student in a class is neither a necessary nor a sufficient condition for achieving the highest grade in that class."; "Wanting to succeed is neither a necessary nor a sufficient condition for success.").

The Necessary and Sufficient conditions in mathematics: A condition that must be satisfied for a statement to be true, but that does not in and of itself make it true. In logic, the words necessary and sufficient describe relations that hold between propositions or states of affairs, if one is conditional on the other. A necessary and sufficient condition, then, is one, which by itself, must happen, and is all that needs to happen, for something else to be the case.

- A necessary condition is one that must be satisfied, for the result to happen. Drinking is necessary to stay alive, but not sufficient; if you drank but did nothing else you would die. To say that A is necessary for B is to say that B cannot be true unless A is true, or that whenever (wherever, etc.) B is true, so is
A. If A is a necessary condition for B, then the logical relation between them is expressed as "If B then A" or "B only if A" or "B \rightarrow A" (B implies A).

- A **sufficient** condition is one that, if it is satisfied, the result is certain to happen. Jumping is **sufficient** to leave the ground, but not necessary; there are many other ways one can leave the ground instead without doing that. To say that A is **sufficient** for B is to say precisely the converse: that A cannot occur without B, or whenever A occurs, B occurs. Necessary and sufficient conditions are therefore related. A is a necessary condition for B just in case B is a sufficient condition for A. If A is a sufficient condition for B, then the logical relation between them is expressed as "If A then B" or "A only if B" or "A \rightarrow B".

- By contrast, having an ID card is a necessary and sufficient condition for being allowed into some places (you **must** have an ID card, and also you don't need anything more than an ID card; having an ID card is **enough by itself**). To say that A is **necessary and sufficient** for B is to say two things: A is necessary for B AND A is sufficient for B. Since the phrase "necessary and sufficient" can express a relation between sentences or between states of affairs, objects, or events, it should not be too quickly conflated with logical equivalence. Further, "A is necessary and sufficient for B" does express the same thing as "A if and only if B". "Necessary and sufficient" is another way of saying the logical statement "if and only if" (sometimes abbreviated to "iff").

Where as in logic and technical fields that rely on it, such as mathematics and philosophy, "if and only if" is a connective between statements which means that the truth of either one of the statements requires the truth of the other. Thus, either both statements are true, or both are false. In writing, common alternative phrases to "if and only if" include iff, "Q is necessary and sufficient for P", "P is equivalent to Q", "P precisely if Q", and "P precisely when Q". Many authors regard "iff" as unsuitable in formal writing; others use it freely. In logical formulae, logical symbols are used instead of these phrases; the corresponding logical symbols are "\leftrightarrow", "\Leftrightarrow" and "\equiv", and sometimes "iff". These are usually treated as equivalent.
In most logical systems, one proves a statement of the form "P iff Q" by proving "if P, then Q" and "P if Q" (or its contrapositive, "if not P, then not Q"). Proving this pair of statements sometimes leads to a more natural proof, since there are not obvious conditions in which one would infer a biconditional directly. An alternative is to prove the disjunction "(P and Q) or (not-P and not-Q)", which itself can be inferred directly from either of its disjuncts — that is, because "iff" is truth-functional, "P iff Q" follows if P and Q have both been shown true, or both false.

Here are some examples of true statements that use "iff" - true biconditionals (the first is an example of a definition, so it should normally have been written with "if"):

- A person is a bachelor iff that person is an unmarried but marriageable man.
- For any p, q, and r: (p & q) & r iff p & (q & r). (Since this is written using variables and "&", the statement would usually be written using "<=>", or one of the other symbols used to write biconditionals, in place of "iff").

(Source 1: Norman Swartz, 1997, Department of Philosophy, Simon Fraser University)
(Source 2: Wikipedia, the free encyclopedia)
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