

# **Globalization of In-house R&D in India**



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# Globalization of In-house R&D in India:

## Executive Summary

*The competition for emerging markets and technology leadership is not new, but the intensity and globalization of that competition are. The pace of technology is accelerating, specialization and systems requirements are increasing, and newer technologies are rapidly becoming important, redefining competitive value-add across a broad range of traditional markets and facilitating major emerging growth markets. Globalization of economy and influx of multinationals in the developing countries, the extent to which R&D directly influences business results has steadily increased. Taking India as a case where the industrial performance is undergoing a tremendous change in the era of liberalization and globalization, present paper tries to trace the changes in the R&D management practices. The paper is based on data obtained from five Indian in-house R&D units in manufacturing sector.*

## **1. Introduction**

The role of knowledge and organizational capabilities instead of capital and manpower is increasingly becoming decisive to create wealth in the globalization era. However, the most important competitive weapon may prove to be the skilful management and deployment of technology resources rather than the resources themselves. This is why the management of technology on a global scale has become an issue of such tremendous importance to leading technology firms.

A highly uncertain business environment has been caused recently by intense international technological competitiveness; the downturn in profits due to the maturation of technology; the diversification of market needs; the expansion of operational range through business diversification and growing diversity of new technology seeds and basic technologies. This complexity of today's competitive business environments has made R&D as one of the most important sources for the organization to gain advantage in the market. There is a sharp rise in

the amount of R&D investment and the increasing time required to obtain results from R&D. This scenario is equally true for both developed as well as developing countries. Like any other economy, as an important segment of the Indian economy, industrial R&D plays the dominant role in the national effort to be competitive in the global market. It plays a key role in the national effort to find new ways to be innovative and to establish its hold in the global market.

## **2. Indian R&D in Post-Liberalization**

The Indian industries are passing through a very dynamic business environment due to the pro liberalization policies of the Government. The science and technology policy of 2003 spells out the growing emphasis and commitment on R&D by the government. It seeks to achieve synergy between industry and scientific research and envisages creation of "Technology Transfer Organizations" as associate organizations of universities and national laboratories to facilitate transfer of know-how generated. It further seeks to encourage the transfer, to industry, of know-how generated by scientists and technologists, through flexible mechanisms for financial returns. The Policy further seeks to encourage, through innovative mechanisms, investments by industry in education/research and R&D, either in-house or through outsourcing. The policy encourages research and innovation in areas of relevance for the economy and society, particularly by promoting close and productive interaction between private and public institutions in science and technology. A new section on Intellectual Property Rights (IPR) has been added to protect the rights of the inventors. The Science Technology Policy, 2003 is further widening the scope of R&D by adding the IPR and international cooperation issues. It states "To promote international science and technology cooperation towards achieving the goals of national development and security, and make it a key element of our international relations and to establish an IPR regime which maximizes the incentives for the generation and protection of intellectual property by all types of inventors.

The regime would also provide a strong, supportive and comprehensive policy environment for speedy and effective domestic commercialization of such inventions so as to be maximal in the public interest". This Policy, reiterates India's commitment to participate as an equal and vigorous global player in generating and harnessing advances in science and technology for the benefit of all humankind. Hence it is apparent that export orientation, the intellectual property regime, TRIP, TRIM and the World Trade Organization (WTO) has directly or indirectly injected a market-oriented goal direction in industrial research.

Due to changes in industrial policy and the economic scenario in the country, organizations are facing an open economy, competition from multi-national companies, free pricing systems and public participation in equity (Pande 1999). Organizations in India have responded to market reforms, liberalization and globalization by improving efficiency, importing technology and by increasing in-house R&D (Bowonder & Richardson 2000). The number of in-house R&D units recognized by Department of Scientific and Industrial Research has increased steadily from about 100 in 1973 to about 1222 in 1998 and 1195 in 2004. Consequent to increase in number of in-house industrial R&D units, the investment in R&D has also been steadily increasing as may be seen from the Table 1.2<sup>1</sup>. The total investment on R&D by industrial sector has increased from Rs. 207.06 crores<sup>2</sup> in 1980-81 to Rs. 903.49 crores in 1989-90 to Rs. 2000 crores in 2000-2001 to 2300 (2003).

Though the R&D expenditure in India is 0.8% of GNP (2003), in terms of actual amount, it is very much less compared to the actual amount spent by many developing countries. In contrast to the developed countries where almost 80% on the total R&D is incurred by the industry, in India, the share of expenditure by industry and the Government is around 28% and 72%

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<sup>1</sup> No authentic information was available regarding the investment on R&D by industrial sector right upto 1957-58 and also no separate information was available for public sector industries till 1971-72.

<sup>2</sup> 1 crore = 10 million

respectively. While in developing countries the percentage share of R&D expenditure incurred by Industry in the range of 5-25%, in developed countries bulk of the national R&D expenditure (up to 80%) is incurred by the industry.

In addition to efficiency, quality, and the flexibility, companies need to simultaneously cut costs, increase quality levels, shorten development time and introduce innovative products that customer's value (Kumpe & Bolwijn 1994). The 'new' environment for product development can be characterized by the following factors (Boer 1991; Gupta & Wilemon 1990; Nevens, Summe & Utal 1990):

- Increased domestic and global competitions
- Continuous development of new technologies that makes existing products obsolete
- Higher product development costs
- Increased pressure on R&D to be accountable to business needs
- Increased sensitivity to social and environmental concerns
- Increased need for involvement of external organizations in new product development process.

Change in the economic environment also induced firms to update their technologies. As a result, technology imports increased significantly in the globalized period (Agarwal 2000). However, it appears that the increase in technology imports were substantially higher in industries which had developed technological capabilities (Niosi 1999). Thus the role of technology imports changed from filling gaps in the availability of technology to upgrading the existing technologies to international standards (Basant 1997; Agarwal 2000). Product

differentiation, demand conditions and technology related factors dominated the determination of technology imports instead of government policy forces (Subrahmanian 1991).

The traditional perception of R&D is that of an activity whose main objective is the creation of new product and processes. A more modern version of this conventional view is that R&D enhances productivity (Onyeiwu 1996). This view of R&D has also resulted in R&D units pursuing only commercially viable R&D endeavors. Though the R&D units came up as a consequence of troubleshooting and technical services, the shift in focus towards the 'innovative' has occurred in past few years. The company has started viewing R&D as a business endeavor.

Such changing business environment coupled with new criteria for marketplace success is forcing companies around the globe to rethink the way industrial R&D is managed. The absence of literature on the R&D management in India puts forward the ground for the study of changes in the Indian R&D management over the years. India being the industrializing country, this study holds more relevance in understanding the trends of the R&D management over the years and what it would be in coming decade.

Against such backdrop, the present paper discusses the changes in In-house R&D management practices in the India industries taking metallurgical sector as a case study. The paper presents the overview of the project management life cycle process, with a detailed discussion about project selection, planning and the quality management procedure. Certain pitfalls of the project management process have also been pointed out. Recommendations are made to improve the R&D project management practices in manufacturing industry in particular and the process industry in general.

### **3. The Field Research**

The empirical study involved a multiple case study of five in-house R&D units of manufacturing industry in India. Among these five, two falls under the public limited company under the government of India and three are private limited companies. These companies are Indian industrial giants in the metal industry. The research tools were a semi-structured interview schedule; focus group discussion and the questionnaire survey, which was used to collect data from senior managers. The interview schedule allowed the researcher to ask standardized questions to the interviewee, and "steer" the interview process. All interviews were tape recorded and later transcribed. The questionnaire was analyzed for the descriptive statistics. This helped in getting additional data on the subject. The subject size for the study was 47 for the interview and 75 for the survey. Purposive sampling chose the respondents and only top four managerial level of the company participated in it as the objective was to gain insight about the overall process and not the individual experiences.

### **4. Major Changes in the In-house R&D Management in India**

An overwhelming majority of the respondents (84%) agreed that the management of R&D in their organizations has changed "considerably" or to a "great extent" in the last 8-10 years. Only 2% indicated "no change" at all, and 9% noticed "no appreciable change". On the question of how has R&D management changed in the last 8-10 years, its causes, and changes that are anticipated for the future, the following factors were identified.

#### ***Increased Focus on Achieving Business Results***

It was found that increasingly, R&D is held accountable for directly contributing to business results in the short term. 88% respondents made this observation. To successfully contribute to achieving successful business results, technology and business strategies need to be closely integrated. There is a growing realization that the technology clearly shapes the business strategy and business objectives in turn influence the technology strategies. In the words of General Manager (GM) of SAIL, *“As firms tighten their ties to the customer, research must be aligned in the same fashion.”* A *Business Week* (1995, 23) article focusing on R&D management changes indicated that “the theme at every company is to tie R&D more to business needs.” Such efforts reduce wasteful iterations in setting product requirements and conducting research that has impact on corporate performance. Deputy General Manager (DGM), INDAL R&D notes that *“We may not get patents or Noble Prize for this, but our management is happy as it makes sizable impact on the business.”* There is stress on reduction of manufacturing cost.

In this study, 78% of the respondents perceived that the influence of business-strategy in shaping R&D activities has increased in last 8-10 years. This may explain the ongoing shift from the more basic, long-term research to increased applied, short-term research. The shift in R&D management practices is from product refinement to product development based on customer needs and future growth areas. The encouragement is for R&D activities, which can give quick results. Hence it is seen that ‘economic consideration’ rather than ‘high technology orientation’ more and more drives R&D activities. The companies are focusing on short-term solutions, concentrating on core businesses and growth through incremental innovations. Companies are linking funds to support R&D activities with the business needs of their operating units.

The study found that business strategy is shaping technology strategy to a much greater extent than the other way around. The companies realize that to integrate the two strategies, more efforts are to be made in successfully accomplishing this integration process. Increasingly, R&D focus has shifted from 'R' to 'D', from 'basic' to 'applied' to 'product' development. The success depends on speed of commercialization and rapid, effective learning to introduce the next product generation. Whether a focus on shorter-term results will have a negative effect on long-term investment in R&D and business competitiveness remains to be seen. Due to the shorter-term focus, the difficulty in measuring R&D performance has diminished somewhat.

### ***Restructuring of R&D Organization***

There has been a shift in the organizational structure of R&D in the last 8-10 years, as reported by 78% of the respondents. This is directly linked to the earlier issue of linking R&D to the business. Due to the restructuring there is less emphasis on fundamental and long-term research, and more emphasis on solving specific problems of business divisions.

There is a shift in the funding scheme to the R&D units. The funds are directly under the control of the management and are given to the R&D on need-risk basis in the annual budget. Rarely R&D people have access to the funds on which they can work according to their own wish. The scientists need to be really flexible in nature and work on the projects in company's and business general interest. Managers are cutting down on risky endeavor and directing research to solve specific problems. Both scientists and managers reported that their company did not have plans for what their products would be in 4-5 years or what business they would be in another 5-10 years later.

Another feature of restructuring is the de-layering of the organizational structure. The companies were trying to organize the R&D unit in a fairly flat structure, mainly to improve the communication pattern and to reduce the overheads. There still exists a hierarchy of managers but they are fewer in numbers. There is direct connection between the R&D people and the managers. In fact due to 'dual ladder' career path, everybody, scientists and managers are clear about all the happenings of the company including technology and hence the communication between the people has been increased. The structure of the organization has become more flexible in nature and the emphasis is laid on the newer practices of management. Due to restructuring the scientists and the managers have become more aware of the business needs, and the business division people have become familiar with the scientific expertise available to them.

### ***Nature of R&D Productivity***

According to 87% of the respondents, the nature of R&D productivity has undergone a sea of change in last few years. Indian industries have started focusing also on new product and processes, filing and sealing patents along with the adaptive work that they undertake for the technology transferred from abroad.

As a part of adaptive work the enterprises first acquire foreign technologies and then undertake R&D to adapt those technologies to the local environments. It is seen that the technology that Indian R&D buys are generations old and hence with the kind of adaptation they need to compete with the global player of the same technology is commendable. Technology is mainly imported from foreign collaborators, and indigenous technology takes a back seat. The main reason given for this by the GM, TISCO was that *"In India no guarantee is given for the technology, whereas foreign companies give guarantee in the form of money back for failure"*.

Another reason, as indicated by a senior manager, is that “*India not doing basic research.*” Hence the company relies on more proven foreign technology. The tacit dimension and dynamic nature of technology requires considerable innovation on the part of the receiver to keep up with the technology frontiers. In addition to adaptation work that the In-house R&D units undertake, the R&D units in metal industry also undertake the ‘innovative’ R&D. Since the presence of MNCs are very limited in this sector (DST 2000: 14), the Indian companies are trying to compete with each other and also in the global market especially in post liberalized era, with introduction of new products and also new processes at cut down on cost and maintenance of quality. It was commendable to note that the Indian metal prices were at par and even lower in the global market (DST 2002:48). Selection of technology depends on quality of raw material. Raw material for metal industry differs in different places, so for a particular technology to work, the local adaptation to the available raw material gets most important. In the words of a scientist, RDCIS: “*Metal industries are peculiar, the foreign technology that we import hardly work on our local raw materials. Hence adaptation to the raw material is the most important work that R&D does*”. The adaptation is also done in the machinery and spare parts. GM INDAL opined “*what we get from abroad is always one generation older equipment. So we have to make that technology work with our capability and with same technology compete in the global market.*”

### ***Implementation of Quality Systems***

One of the major changes reported by 83% of the respondent, for the last 8-10 years was emphasis on quality systems. Quality in R&D work has become increasingly important as companies commit themselves to quality improvement programs in all areas of their activity. Quality improvement forms an important part of their competitive strategy.

The units are having policies for the environment and the safety. All five R&D units had a certification of ISO9001 and above. The rationale behind the proposed revision to the ISO 9000 standard (ISO 9000-1:2000) provides an "ideal" opportunity for the R&D managers to achieve the benefits of total quality management (TQM) and thus improvement in various key performance dimensions. It continually focuses on increasing the effectiveness and efficiency of the organization processes, listening and responding to the growing needs and expectations of its customers, increased attention to communication and work environments, and greater orientation towards measured success of systems, processes and products. They strive to maintain the quality of product and processes. It is concluded earlier that the units mostly work for the existing business including trouble-shooting; the quality management plays an important role in the task accomplishment.

All the companies are ISO 14001 certified. This is another change, which is being noted. This is the new international voluntary standard for environmental management systems (EMS). This is made a mandatory part of the R&D unit, and in all the units, there is a special section devoted to it. This certification keeps the quality maintenance in the matter of environmental management. The respondents had opposing views whether this certification is actually necessary. One group favored it by saying that *“After we started following this, we actually reduced on waste, safety has increased, environment and the plant looks clean. We are able to reduce waste emission and hence this has overall increased the productivity of the plant”*. While the other group sees it as the *‘ploy of the western countries’*. According to them *“Since they have moved ahead in the R&D and technology, and they don’t have to bother about these kinds of things, they have come up with this certification. We should first bother about improving our technology and then about nature and green revolution.”* But in spite of this debate, all the companies are maintaining ISO 9001 and ISO 14001 for the process and

environment. This is done actually *“To compete in global market. If we don’t have these certification, our products will be considered inferior when compared to global benchmarks”* according to the GM SAIL.

### ***Increase in formal R&D Management Practices***

The new strategies and practices to manage R&D effectively have been implemented from time to time. The increase in formal R&D management practices over the years has been reported by 79% of the respondents. There has been a formulation of project selection, execution and implementation procedures. Procedures of obtaining customer satisfaction index and financial impact with certification benefits of the projects have also been implemented. Technology dissemination center (TDC) had been established to improve interactions between R&D and shop floor personnel in many sample units. A new category of EID (equipment & instrument development) projects is introduced over the years in TISCO. Measurement of research output in terms of certified annual benefits and customer satisfaction index has been established. Regular monitoring of projects through ‘quarterly review performance’ has been introduced.

The Total Quality Management procedure, which makes it mandatory to document everything have been made an essential feature of the R&D units. In fact, at HINDALCO, the quality documentation department has been called a part and parcel of the R&D center. In addition to this, the project management practices have been formalized and systematized in the sample units. R&D is no longer left ‘to its own’. They are made accountable with the introduction of formal management practices.

### ***Managing Technical Personnel***

Greater attention is also being devoted to how R&D organizations recruit, train, evaluate reward, and manage the career of technical personnel according to 65% of the respondents. Increasingly R&D managers recruiting people who could do both—possess good technical skills and are effective team players. The scientists who are having good business management skills and have sound knowledge of market savvy are preferred now. Also, more training time is allotted to developing interpersonal and communication skills and managing group dynamics. The researchers are given an opportunity to learn various business functions through job rotations, dual career path, and making contributions to various organizational objectives.

The human resource management in R&D units has become an important issues and the company is addressing the issue more effectively in recent years. The HRM is conceptualized along four dimensions: Human resource planning; Performance appraisal; Reward systems and Career management. The company is trying to find an adequate match between an employee's long-term career objectives and the company's future goals.

### ***Increased Emphasis on Cross Functional Teamwork***

Increased emphasis on cross-functionality as opposed to being 'technology driven' or 'production driven' was one of the most significant changes in R&D management practice according to 95% of the respondents. The respondents indicated that this trend would continue in the future. R&D also is increasingly involving non-R&D groups in the projects, in determining R&D's priorities, as well as in helping plan the organization's technology strategies. As a consequence, R&D needs to forge significant, long term relationships and establish productive linkages with non R&D groups both within and external to their organization.

Even though the emphasis on cross-functional integration is increasing, it was found that a significantly large number of respondents were concerned about their limited involvement with some key groups and interfaces. Many of the respondents (82%) noted that they needed to make greater efforts to bridge this ‘involvement gap’ to create further synergy between their R&D group and other business functions in and external to their organizations. They agreed that “*open, frequent and early communication between R&D, marketing, manufacturing, customers...is important,*” there are many areas that need strong bridge building efforts. Less than half the respondents placed greater importance on developing linkages with other organizations and only 12% indicated that the use of outside contract research firms are increasing.

## **5. Factors Contributing Changes in R&D Management**

To address factors that are driving such changes in R&D management, a content analysis of the responses was performed. It identified the following important factors promoting changes in R&D management:

### ***Changes in the Government Policy***

About 94% of the responded indicated that the biggest issue that impacted R&D management practices has been the changes in the government policy in early 90s. Due to liberalization and globalization policy which opened the Indian economy to the global world, the role of R&D has changed considerably. The company needs to directly compete with the global giant and hence the importance of technology has been heavily emphasized in the companies. Due to this change, the R&D management has become more challenging for most of the companies.

### ***Changes in Business Environment***

This factor is significantly related to the earlier factor of government policy. The new business environment is characterized by domestic and global competition; increased governmental deregulation; pressure regarding environmental, safety, and health issues; rapid advances in technology; growing market fragmentation; and more sophisticated, demanding customers. These changes in the business environment have forced the companies to have a new look at R&D management practices according to 76% of the respondents.

### ***Growing Importance of R&D Business Strategy Linkages***

R&D's realization is that its future depends on corporate profitability and a willingness to respond quickly to meet business and customer needs. 79% of respondents noted that the changes they've made in their R&D management practices were due to the pressures to become more market driven and profit oriented. They need to improve the profitability of the company through innovations and commercialization. Their accountability has increased for the product and process development and hence they need to manage their R&D in certain ways. The emphasis has shifted from long-term basic and fundamental research to short term profit making projects.

### ***Resource Constraints***

75% of the respondents mentioned that there is a growing pressure to accomplish more with less resources and funds, has caused significant changes in their R&D practices. The fact that most R&D groups are doing more with fewer resources has prompted some to seek partners and alliances. In other cases, R&D managers are searching for more efficient ways to conduct their R&D activities.

### ***Changes in Management Attitudes***

38% of the respondents indicated that they have been influenced to a great extent by the new attitudes and approaches taken by their management. The change in management attitude and policy for the whole company brings about a considerable change in R&D practices. The management realizes that they need to work together in designing technology and business strategies that have synergistic impact. They are playing an important role in contributing to the development of business strategies, and are becoming more articulate about business needs. The management has become more aware of leading R&D efforts that will support the business strategy, but in turn this has resulted in major changes in the R&D management practices over the years.

## **6. Anticipated Changes for Future**

Questions were asked about the anticipated changes over the next 10 years. The responses were again content analyzed. The response pattern was almost same as the changes that have come about over the years. Most of the respondents felt that the same changes would continue to occur over the years due to market fluctuation and demands. The government policies are going to remain more or less the same; hence the R&D management practices are also going to remain same. But few responses indicate that R&D management would change towards a certain direction.

### ***Generating more Resources***

Resource crunch is a major problem faced by the R&D department. The money comes from the annual budget, which is considered to be 'not sufficient'. The 56% of the respondents feel that in near future, R&D would generate more internal resources for themselves through alliance

and external consultancies. They will become more self-sufficient in terms of finance. More focus will be on external earning with reorganization of expertise.

### ***Production based Research***

There would be more focus on large impact projects with external benchmark, which requires more and more interdisciplinary projects according to 47% of respondents. Due to this there will be emergence of multi-disciplinary R&D teams, in contrast to specialists in various technological disciplines. 38% of the respondents say that there will be more focus on future support to the organization. This implies that there will be some new areas of expertise and more contribution to business results in long-term basis. Innovation and basic research with long-term emphasis would gain importance in near future to stay competitive in the world. There will be development of new value added products to replace the intangible materials like plastics, wood and other hard and precious metals. The supply of products will go beyond customer expectation and delight, and hence for that educating customer for use of the product in better ways in the need of the hour. Hence it is implied that the projects will be driven more by market/ customer demands for new products rather to solve the operational problems of production shop.

The R&D unit would become a research organization not just remain as problem solving department. The focus would grow in the areas of modeling and simulation to reduce time and cost of experimentation and acquire expertise for prediction on cost and quality of products. There is anticipation for an appreciable improvement in analytical skills to get the quick solution of chronic problems. There will be more usage of information technology (IT) to improve the process control. IT was seen as a major change, which would come about in the R&D over the years, as it is a quick way to improve the products and processes.

### ***Managing Technical People***

Changes are anticipated in the management of technical personnel and the HRM (human resources management) issues for the professionals of R&D according to 55% of respondents. There will be expertise development of personnel in specific areas. There will be a flexible working hour and no restriction on time rather emphasis will be on work results. The rewards and pay package will become directly proportional to the output of the professionals, because research work is directly linked to the business profits. The number of professionals for R&D would increase over the years, and there will be recruitment of more PhDs, as the focus would be a shift towards long-term basic research

### **7. R&D's Emerging Scope**

Based on the responses about the changes that have come over the past 8-10 years and the anticipated changes felt, it was analyzed that R&D is changing towards a certain direction. The scope of R&D has changed and has emerged differently. The Table 2 shows the R&D's emerging scope.

Table 2: R&D's Emerging Scope

	<b><i>Changes in R&amp;D management practices</i></b>
Emphasis	On applied and developmental work
Evaluation	Against the contribution to profits of the company
Driver	Market/ customer
Priority	Improving business performance
Strategies	Vague, not clearly defined as it overlaps with the business strategy
Working style	Cross-functional teamwork
Time horizon	Short term results are expected
Locus of innovation	Collaborative Approach

Resources	Scarce resources
Structure	More towards flatter informal side
Setting of standard	Against quality systems and benchmarks
Practices	Increase in formal R&D management practices

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## 8. Summary and Implication

It is noted that R&D management practices have changed significantly over the last 8-10 years in India. R&D is being asked to focus its efforts on few high-impacts; customer focused projects rather than becoming involved in unconnected “blue-sky” projects. This has also been pointed in the literature (Barpal 1990; Business Week 1995). The traditional in-house R&D model followed by most companies is fast changing. Rather, the collaborative approach is a whole new way of managing distributed innovation. Sawhney (2002) has also concluded in the same direction .To successfully contribute to achieving successful business results, technology and business strategies need to be closely integrated (Ganguly 1999; Rousseal 1998). There is a growing realization that the technology clearly shapes the business strategy and business objectives in turn influence the technology strategies (Wolff 1989; Atlee 1992). The need to create synergy between technology and business strategies also has implications for Chief Technology Officer (CTO). As Chatterji (1993, 45) asserts, *“The CTO can no longer just translate the business strategies for his R&D organizations but must participate fully in the development of the strategies...R&D organizations must create a new mind-set that places corporate vision, objectives and values over the loyalty to science and engineering...the CTO will be expected to play the dual role of a business-person first, technologist second.”*

The results from this study indicate that there has been a significant increase in the emphasis on cross-functional teamwork and focusing R&D on achieving business results. The images of isolated R&D groups engaged in research that may or may not have ‘value

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addition' for the organization are largely gone. Organizations also are making their R&D efforts more and more accountable for improving business performance, and there is greater synergy between the business and technology strategies. Takahashi (1997: 32) also addresses the need for strategic analysis by suggesting that managers must ensure that R&D projects match the corporate strategy and that *"the most critical role for an R&D manager is to keep the R&D projects abreast of the corporate strategy at all times"*.

In conclusion it can be said that R&D management is undergoing important and significant changes in the wake of liberalization. The findings reported in this paper also have implications for understanding the changing needs and the future changes in R&D management. To remain competitive in global market Indian R&D managers have to understand the changing market scenario. It has become mandatory for the R&D managers to understand the source and context of these changes as well as their consequences.

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## **10. Appendix**

The sample of the study includes five in-house R&D units in Indian Manufacturing sector. The units are SAIL (Steel Authority of India Limited); NALCO (National Aluminium Company ); HCL (Hindustan copper Limited); TISCO (Tata Iron and steel company); HINDALCO (Hindustan Aluminium limited); and INDAL (Indian Aluminium Company). Among these SAIL and NALCO are public limited company under Government of India and TISCO; HINDALCO and INDAL are private limited with private ownership. All these companies are big players and industrial giants in India having R&D base for at least 20 years.