R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

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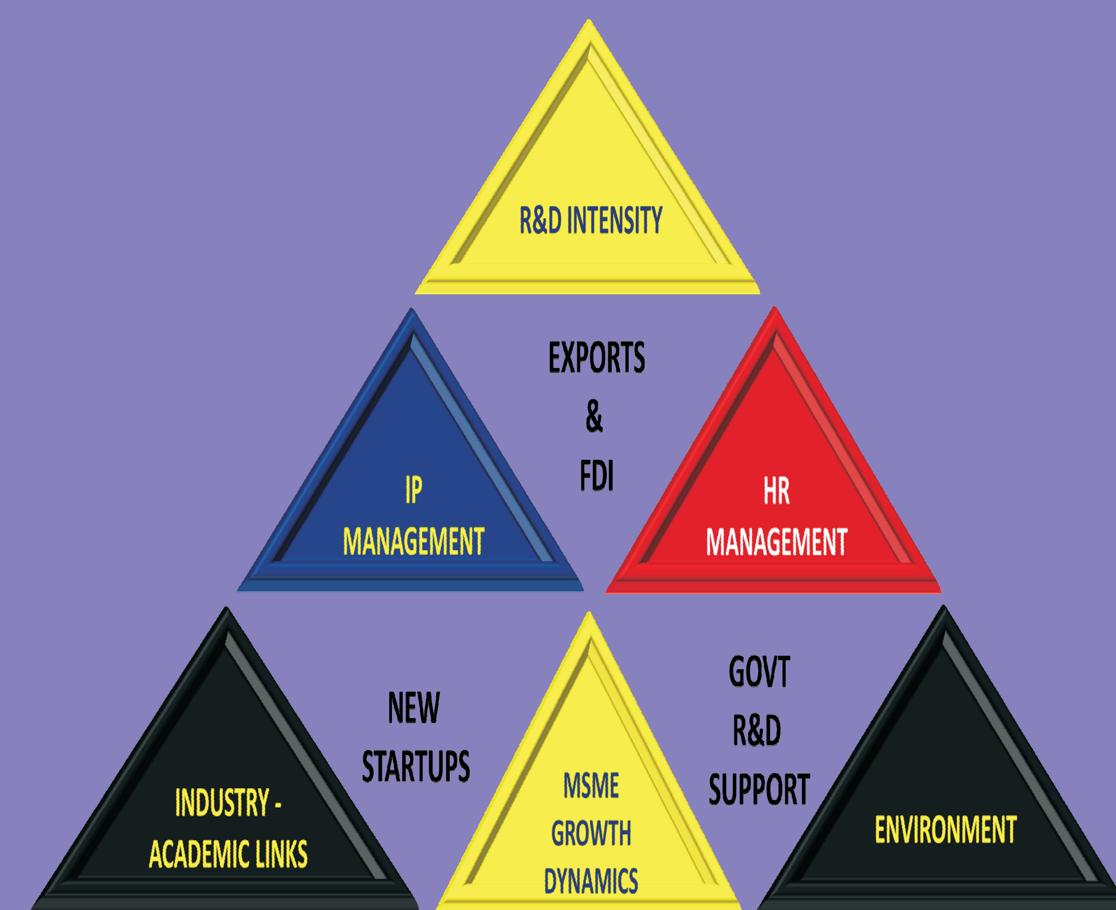

Prepared by
Indian National Academy of Engineering, (INAE)
New Delhi

MAY 2011

Submitted to
Principal Scientific Advisor (PSA)
Government of India
New Delhi

Indian National Academy of Engineering

A Comprehensive Report on

R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

Edited by

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PSI, INAE Project

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Foreword

I am very happy that the Indian National Academy of Engineering has taken this initiative to study the impact of R&D on the Indian chemical sector, one of the most knowledge – intensive industrial sectors of our country.

A study of the chemical sector is always complex in view of its highly heterogeneous structure, the uneven R&D performance and varying technological adaptability among its various segments. The INAE study team led by Dr. K. V. Raghavan, INAE Distinguished Professor and Principal Scientific Investigator of this INAE project, ably supported by Sri D.P. Mishra, Director, TCE Consulting Engineers, Dr. M.O. Garg, Director, IIP, Dehradun and Prof A.N. Maitra, retired Professor of Delhi University, has successfully executed the task.

The report covers very important issues which have direct or indirect relevance to R&D performance of the Indian Chemical Sector. They include R&D intensity, globalization effects on intellectual property generation and protection, growth dynamics of the MSME sector, industry-academic linkages and medium and long-term environmental implications. The recommendations emanating from the INAE study will be of great value while evolving new policy guidelines by the government of India for the sustainable growth of Indian Chemical Sector in the coming years.

I hope that this, the first assignment of its kind to be executed by the INAE with sponsorship from my Office, will be a trend setter for future similar endeavours. I wish all success to the follow-up steps of this project.

R. Chidambaram

(R. Chidambaram)
13th April, 2011

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FOREWORD

Indian National Academy of Engineering has strongly supported the study related to R&D Impact on Indian Chemical sector since it is the backbone for sustenance of a wide spectrum of downstream industries and economic prosperity of the country. The variations and convergence in the approaches brought out by the study is quite striking considering the structural complexities of Indian chemical sector and the magnitude of its downstream applications. The INAE study has provided, for the first time quantified parameters and new findings in less understood areas. In particular, observation that large industry does not necessarily mean more spending on relevant R&D is uncommon and a useful finding. Another remarkable feature of the study is a large number of interactions organized by the INAE team with experts and stakeholders. Equally important is the contributions and willingness of small, medium and large industries to share their experiences and future perspectives with the team. I greatly appreciate the efforts made by the INAE team to draw upon the large national and international data for useful deductions and directions.

It is quite clear that the next phase of growth and innovations in chemical industry would be guided by enhanced research in industry, industry - research / academia synergy, increased funding by the government for innovations, environmentally favourable policies and most importantly attracting the nurturing the young minds for contributing to this important sector of Indian economy.

The Academy is grateful to the dedicated efforts of INAE team lead by Dr.K.V. Raghvan, Principal Scientific Investigator, Shri D.P. Misra, Dr.M.O. Garg and Prof. A.N. Maitra as project consultants. The combined wisdom and experience of the team coupled with the remarkable contributions made by a large number of experts and young researchers has enhanced the quality and usefulness of the study. I am confident that this novel venture shall trigger more advanced studies in specific domains related to chemical research and its industrial applications. I foresee that this report will attract wide readership from educationists, researchers, industrialists and policy makers. It is very appropriate that it is being released during the International Year of Chemistry.

I express my gratitude to Dr.R. Chidambaram, Principal Scientific Advisor who has wholeheartedly supported this study and Dr.P.S. Goel, my predecessor for encouraging the INAE team to embark upon this interesting study which is first of its kind to be undertaken by the Academy.

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Foreword

In our pursuit to do more for engineering in India, a call from office of PSA to the INAE office in April 2009, whether INAE would take up a study on impact of R&D on industry, was a welcome development. We decided to accept it with Dr. K V Raghavan, INAE Distinguished Professor in mind, not only because chemical industry is a very important element of our economy but also because, Dr. Raghavan would set up a standard for such studies to follow on other topics. The past two years have been a rewarding experience with numerous reviews on Indian Chemical Industry at INAE and PSA's office. I am privileged to state that the findings of this report will go a long way in setting up larger goals for the chemical industry in the coming years.

Dr. Raghavan with his team of dedicated consultants and young scientists has undertaken a rigorous exercise to reach the various segments of Indian chemical industry and collecting data that has never been done on such a scale in this country. They have divided the industry into three segments, namely basic chemical sector which has wide production base and endowed with large investments but least influenced by the R&D. The speciality chemical sector with its multifaceted applications as diverse as plastics and leather has been moderately benefited by the R&D but lot more needs to be done. The knowledge intensive sector covering pharmaceuticals and biotechnology has done best in utilizing state of the art R&D inputs, though its scale is such that its impact on national economy is not felt in all segments equally.

The INAE study establishes the linkage between R&D and industrial growth very systematically. It has resulted in a number of actionable recommendations and I am sure with active follow up of INAE and PSA with the stake holders including the Government of India, their implementation will make the desired difference which the engineering fellowship is longing to see for quite some time. I hope, other INAE studies will result in similar outcomes.

I am very grateful to Dr R Chidambaram, PSA to Govt. of India for encouraging INAE to take up these challenging assignments.

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Preface

The Indian chemical industry has the potential to place India on the world map of knowledge intensive products/ processes. Enhancement of its global brand image and R&D intensity are vital for its future growth. Dr P S Goel, the then President of INAE received invitation in April 2009 from the office of the Principal Scientific Advisor to Government of India to undertake a special study on R&D Impact on Indian Chemical Industry. The project activities commenced on 27 May 2009 with the undersigned as the Principal Scientific Investigator and Sri DP Misra, Dr MO Garg and Prof AN Maitra, the Fellows of the Academy as Project Consultants.

The subject coverage of the project has been quite extensive with the core issues like R&D intensity, intellectual property management, growth dynamics of SME sector, industry-academic linkage, government support to R&D commercialization, human resource management and new start-ups adequately addressed. The INAE study team has noted several positive developments in Indian chemical industry in terms of its turnover crossing USD 60 billion landmark, achieving positive international trade balance, marked presence (>5%) of Indian pharma industry in developed nations, significant drop in non R&D performing chemical units, attractive market capitalization of foreign equity and impressive IP record. Some areas of concern include suboptimal R&D inputs in several chemical subsectors, flat decadic R&DI profile of speciality chemical sector despite tremendous opportunities, inadequate R&D access to MSMEs, none too happy IP protection scenario, lack of long term vision in potential subsectors and weaker environmental public image.

Ten major recommendations which can make significant difference to the R&D growth in the Indian chemical sector have been made in Chapter 10. They include creation of a unique revolving technology fund for R&D commercialization to be operated without interdepartmental barriers, enlarging the scope of chemical MSME cluster concept to provide direct R&D access to their constituent units, turnover as the basis for extending technology / product development support, measures to enhance the Indian inventorship of patents and creating an institutional framework for vision and foresight development of potential chemical industry growth sectors.

The core issues pertaining to each subject, as highlighted above are analysed in a three layered matrix covering global and national platforms, all S&T and chemical disciplines and basic, speciality and knowledge intensive chemical domains. This approach has been followed specifically to bring out the dynamics of its R&D performance under domain imposed constraints to suggest appropriate remedial actions. Logically, this report can lead to several subject specific monographs on Indian chemical industry.

This assignment being first of its kind to be executed by the INAE for the Government of India, it has received very enthusiastic support from the academy fellowship and equally strong support from the professional bodies of Indian chemical industry in general and Indian Chemical Council (ICC), Mumbai in particular. The INAE team got the unique privilege of receiving advice and guidance from the Scientific Advisory Committee to the Cabinet (SAC-C), the Conclave of Chief Executives of Indian Chemical sector and the General Body of INAE Fellowship on several vital issues.

The INAE team expresses its immense gratitude to Dr R Chidambaram, PSA to Govt. of India and the senior members of his secretariat for their invaluable advice and guidance during the project review meetings. The team thanks the chairman and members of PRMC for their useful suggestions on project activities.

I express my sincere thanks to the outstanding contributions made by the Project Consultants, the team of subject experts and supporting staff to the project studies and preparation of this report. I finally express my thanks to Dr J S Yadav, Director of IICT for providing the logistic support, personnel and wide range of facilities to the project.

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❖ ***Valuable Inputs***

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EXECUTIVE SUMMARY

The basic objective of the INAE project is to study the impact made by the R&D on Indian Chemical Industry as a whole and on all its important subsectors in terms of R&D intensity, intellectual property management, industry – university (I-U) linkages, fostering new enterprises, government funded R&D utilization and human resource management. The project team collected enormous data from the open literature as well as through opinion surveys and direct interaction with subject experts to develop the current profile of the Indian chemical industry. **This exercise has shown that the turnover of Indian Chemical Industry has crossed USD 60 billion, achieved an export / import ratio of greater than unity and the pharma, biotech and petrochemical sectors have attracted significant FDI inflows as compared to other subsectors.**

The overall R&D intensity (R&DI) of Indian chemical industry is estimated to be 0.9% with knowledge intensive chemical sector registering 4.5%, specialty chemical sector recording a moderate growth at 1% level and the basic chemical sector touching 0.5% in 2007-08. **A sample analysis conducted on 250 leading companies in various subsectors have brought out the mismatch between their turnover growth and R&D expenditure**. While the sectors like pharma and organics have shown the sensitivity of R&D Intensity to the firm size, this behavior is somewhat muted in all other sectors,. **Interestingly, the subsectors of Indian chemical industry have exhibited different threshold limits for incurring R&D expenditure with the drugs / pharma and fertilizer sectors on the higher and lower ends of the scale respectively**.

During 1992-09, the chemical export growth remained steady at a CAGR of 17% and its FDI growth recorded a CAGR of 13.9% with somewhat unstable growth profile. The forward and backward FDI-economy linkages in Indian chemical sector are quite strong. During 1998-03, 24 chemical oriented R&D centres were established by MNCs in India with a planned investment of USD 1.7 billion.

The intellectual property generation and protection profiles of Indian Chemical sector during the transition and post WTO periods, **provide strong evidence of internationalization of research in terms of constantly dropping Indian inventor contribution to the patents filed at IPO, upward trend in overseas collaborations in Indian research publications and Indian inventors filing significant number of patents in overseas patent offices**. The PCT route has emerged as the most favorite pathway for the overseas inventors at IPO. **While research papers in chemical and allied sciences are being published by more than 250 Indian institutions, the top performers with a consistent record are limited in number in most S&T sectors. A silver lining is the significant increase in the quality of research papers published during 1995-09 by the top 10 performing Indian institutes.** While public funded research institutions have done relatively well in publishing research papers, the contribution from universities and industry is somewhat disappointing. An area of concern has been the suboptimal performance of Indian universities in intellectual property protection possibly due to their weak industry linkage and lack of incentives for faculty to pursue industrial research. **The studies have also shown the initial successes achieved in product patenting in India after 2005 with overseas pharmaceutical companies filing the maximum product patents**.

As far as industry – university (I-U) linkages in chemical sector are concerned, the suboptimal performance of Indian universities, with few exceptions, in generating industrially relevant knowledge is evident. Eventhough 2500^{+} projects have been funded by the government in Indian academic institutions with more than Rs. 100 corers funding during 2000-10, they have very little industrial revelance except in the case of IIT's in which certain degree of success has been achieved in making some of their projects industry driven.

The INAE team studied the R&D scenario of micro, small and medium scale enterprises (MSME's) in Indian chemical sector. Their number in organized sector is more than 40,000 with nearly 20% of them exist in 80 chemical clusters spread over 20 Indian states. **Inspite of the central and state government facilitation to Chemical MSMEs, their R&DI is extremely low on account of insufficient R&D inputs**. **This is a matter of great concern considering their overall importance to the growth of Indian chemical sector. Bold initiatives are needed in this area**.

The INAE team noted the strength of the knowledge intensive segment of Indian chemical industry in promoting new technology ventures during the post economic liberalization period. It has, however, shown the need to establish more such ventures in specialty and basic chemical sectors propelled by a strong I-U linkage.

The INAE studies have clearly established that R&D impact on Indian chemical industry is nonuniform across its subsectors on account of system heterogenicities, varied scales of operation, uneven responses to globalization challenges and wide variation in human skills and innovative capabilities. In order to enhance R&D impact on the Indian chemical industry, following recommendations have been made in this report:

- Enhancing the reach and effectiveness of government funded R&D programmes in seamless manner
- Integrated approach for R&D capacity building in chemical MSME clusters
- Enhancing R&D intensity and investment in 3 prioritized turnover zones
- A Technology mission to formulate and pilot test novel I-U linkage models
- Establishing technology innovation centres through PPP in frontier S&T areas
- A two pronged approach to enhance Indian inventorship of patents filed in India
- Improving Environmental Brand Image to sustain future growth
- Technology vision and foresight development for critical chemical subsectors
- New growth oriented HR management policies for chemical subsectors
- Innovative policies to make transnational R&D and FDI as vehicles for Indian innovation.

Apart from the above recommendations, several implementable actions and special studies have been suggested under each chapter of this report.

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Chapter – 1

Objectives, Scope, Information Sources and Major Events of INAE Study

This chapter highlights the objectives and scope of the INAE project on "R&D Impact on Indian Chemical Industry". The study examines 6 major issues viz., R&D intensity, IP generation and protection, industry – academic linkages, utilization of government supported R&D commercialization initiatives, R&D growth in SME sector and human capital. All of them have relevance to R&D growth of Indian chemical sector.

The INAE study has made extensive analysis of the reported information for assessing the impact of R&D on the Indian chemical sector. This chapter discusses the major information sources and their adequacy or otherwise for making an objective analysis of R&D impact. It also establishes the need for undertaking vision studies, to launch surveys and special studies in information deficient areas.

The last part of this chapter focuses its attention on the various events organised / participated by the INAE study team during the implementation of the project. This has enabled the INAE team to consult experts and eminent scientists for their independent opinion on vital issues.

An analysis of recent chemical industry memoranda to Government of India has been made to understand its priorities and concerns on fiscal and non-fiscal issues. The annexures relevant to INAE project activities covering record notes of important meetings, interaction sessions with experts and study visits undertaken by the INAE team during project execution are appended to this chapter.

1. OBJECTIVES, SCOPE AND INFORMATION SOURCES OF INAE STUDY

1.0 Preamble

There has been growing recognition at global level on enhancing the relevance of basic and applied research to promote and strengthen industrial growth, innovation and competitive performance. The Indian chemical industry is envisaged to grow to USD 100 billion by 2015 and position itself on the world map as a supplier of speciality and knowledge chemicals as well as one of the future destinations of global R&D and industrial investment. To meet this challenge, extensive R&D inputs are needed by the Indian chemical sector.

The performance of the Indian chemical industry can significantly influence the economic and societal activities and is of relevance to most of the manufacturing industries in the country across the board. It has to be an irreplaceable provider of innovations to its own basic, speciality and knowledge chemical sectors by becoming a key component of its value chain that end with a variety of consumer products. India has to ensure that a highly competitive R&D and manufacturing base is established in the chemical sector not only because of its industrial importance but also because of the need to continually generate innovations critical to meet the future challenges of Indian society. Innovation through R&D has to become an indispensable and integral activity of Indian chemical sector to avail the benefits of future global opportunities as well as the challenges.

In recent years, efforts have been made in India to study the chemical industry from its growth and global competitiveness perspectives. The CHEMTECH Foundation instituted a study through M/s. KPMG India in 2002-03 to study the Indian chemical industry in depth to formulate a vision for its growth upto 2010 and an action plan that could be implemented to achieve the same. FICCI also carried out a survey of Indian chemical sector in 2010. The Ministry of Environment and Forests with assistance from UNITAR, Geneva under the auspices of Canada-India Environmental Institutional Strengthening Project prepared a special report on the National Chemical Management profile for India around 2002. It covered production, import, export and use of chemicals in India, legal instruments and regulatory mechanisms, government agencies associated with chemical sector management, relevant R&D activities, technical training and education, chemical safety and emergency preparedness. The Research and Information System (RIS) for the non-aligned and other developing countries in 2004 prepared a document on the strategic approach to strengthening the international competitiveness of Indian chemical industry. These studies have underlined the importance being globally competitive for the future growth of Indian chemical industry and the need to recharge its innovation system and R&D intensity from now onwards.

1.1 Objectives of the INAE Study

The INAE study is designed to assess the R&D impact on Indian chemical industry with specific reference to the following factors:

- R&D intensity, investment and exports
- Growth of MSME sector
- Generation and protection of intellectual property and its utilization
- Linkage with universities and R&D institutions
- Utilization of government funded R&D and the benefits of innovation policies
- Fostering new entrepreneurs and start-up ventures
- Human capital and its turnover

The dynamics of Indian chemical industry in terms of creation of new knowledge, growth of new ventures, better allocation of its resources, generation of more efficient processes and products and modernization of its infrastructure and human capabilities greatly depend on its R&D absorption and utilization capabilities. It is, therefore, the major objective of this project to look into the chemical industry growth as impacted by R&D.

For the purpose of analysis, the Indian chemical industry has been classified into **basic chemicals** (organics, inorganics, fertilizers, petro and gas-based chemicals and intermediates), **specialities** (colorants, coatings, sealants, additives for pharma, food, construction, oil well drilling, plastic and allied products, catalysts etc.,) and **knowledge chemicals** (pharmaceuticals, agrochemicals, bioproducts and other high end specialities).

1.2 Scope of the Study

R&D Intensity (R&DI) and Related Issues

In the present studies, R&DI has been evaluated for important segments of Indian Chemical Industry and its direct or indirect effect on exports / imports, FDI and company size and turnover has been assessed.

Industry – Academic Linkages

In the present study, the Indian successes achieved in specific cases and the overall status of the industry linkages with state, central and deemed universities and Indian Institutes of Technology have been assessed. The medium and long term research priorities of universities and R&D institutions, joint research endeavours with industry, exchange of personnel, industry sponsored R&D programmes establishing startup companies through technology / business incubators, creation of major infrastructure at Universities and R&D institutions for developing services have received attention.

Generation, Protection and Utilization of Intellectual Property

The present study focussed on vital issues pertaining to intellectual property generation and protection in chemical sector, product versus process oriented R&D, and its internationalization as well as R&D trend analysis based on scientometric data. The broad implications of the internationalization of intellectual property have been examined. The contribution of Indian industry and scientific community to the product patenting in India have also received attention since it is a recent phenomena in Indian patenting system.

Utilization of Government Supported R&D Programmes by the Industry

The Government of India through the Departments of S&T, Scientific and Industrial Research, Biotechnology, Environment and Forests, Electronics, Space, Atomic Energy, Ocean Development, Information Technology and others and major R&D institutions like CSIR, ICAR and ICMR and the state governments have been offering a range of R&D support initiatives. They include NIMITLI, TDDP, SBIRI and others support programmes. Many of them promote industry – academic or inter R&D institutional partnerships. Some of the vital issues pertaining to the operation of these programmes and extent of participation by the industry have been examined:

Human Capital and Turnover

Investment in human capital is crucial for a nation's innovation and R&D. Proactive actions at government and industry levels are very essential for mobilising investment for creating new research infrastructure, S&T parks, industry relevant R&D projects, financing of education and training facilities, better integration of education and employment promotion policies and advanced training in overseas institutions. This project has investigated the growth of human capital specifically in R&D of Indian Chemical Industry and its turnover and mobility.

1.3 Structure and contents of the INAE Report

The INAE project is sponsored by the office of the Principal Scientific Adviser to the Government of India on 27th May 2009 (**Annexure-1.3.1**). Keeping the broad scope as indicated above, the INAE Report presents the subject of R&D Impact on Indian chemical industry in seven chapters with following titles:

- Current Status of Indian Chemical Industry
- R&D Intensity, Investment and Export/Import Trends
- R&D and Growth Dynamics of MSMEs
- Intellectual Property Generation, Protection and Utilization
- Utilization of Government Funded R&D initiatives
- Industry – Academic Linkages, Technology Incubation and
- Establishment of New Startups
- Human Resource for R&D and its Management Issues
- Environment Impact on Future Growth and R&D

The Chapter 10 focuses on major recommendations emanating from INAE Study. Each chapter covers subject specific implementable actions.

1.4 Information Sources for INAE study on Indian Chemical Industry

The INAE project team made extensive use of reported information from diverse sources pertaining to Indian chemical sector. It is the objective of the team to share its experiences on the strengths and deficiencies of the available information sources for undertaking such a study. The details are presented hereunder:

Annual Performance Reviews

The INAE study team made use of the annual reports published by the Departments of chemicals and Petrochemicals, Fertilizers, Pharmaceuticals, Biotechnology and Science and Technology of Government of India on the status of concerned sectors of Indian chemical industry with reference to production, exports / imports and annual growth rates. Priced publications from Industrial consultants, advertised on internet, provide company level information. Their authenticity is rather difficult to establish.

The INAE study team employed the recent reviews on the status of Indian chemical industry published by the KPMG, FICCI and EXIM Bank of India. On S&T inputs to Indian chemical sector, the Report of the Steering committee on Science and Technology, Planning Commission, Government of India for 11th five year plan has been used extensively. The INAE team has noted the lack of initiative on the part of Indian professional bodies in chemical sector to publish periodic reviews of Indian chemical industry development as brought out by overseas journals like C&EN.

Performance of Small, Medium and Large scale chemical units

The INAE study team has employed the 'PROWESS' database published by the Centre for Monitoring Indian Economy (CMIE), Mumbai for obtaining financial and non-financial information on Indian medium and large scale chemical companies. It is a powerful database covering vital information on more than 22,000 Indian companies in various industrial sectors viz., financial statements, fund flows, product and raw material profiles and allied data pertaining to these companies. The main source of data on SSIs in organised sector has been provided by the reports published from time to time by the Department of MSME, Government of India and Directorate of Industrial Statistics for SSIs registered under the Indian Factories Act 1934. There is no such data available on MSMEs in unorganised sector either on regional or on All India basis. The information on chemical MSMEs is rather scanty.

Indian Speciality Chemical Sector

Open literature pertaining to the number of companies, their products and production, turnover, R&D expenditure and exports / imports in various subsegments of this sector is very scanty and diffused. It is surprising that this sector is not covered by the Annual Reports of the Departments of chemicals, petrochemicals, fertilizer, food processing and pharmaceuticals of the Government of India eventhough they are the controlling ministries. The INAE project team has to rely on the brief web based information on speciality chemical sector published from time to time.

Intellectual Property

The INAE team relied on ISI Web of Knowledge for accessing scientific information on research publications and patents. In case of patents, Derwent Innovations Index has been employed under chemical (A to M) and engineering (P-Q) sections. In addition, the INAE study team employed national and international data on patent filing trends as reported in the Annual Reports of the World Intellectual Property Organisation (WIPO) and its Indian counterpart. For assessing the patenting landscape in India and other countries, the white papers published by Evalueserve (www.evalueserve.com) have been used. The INAE team has also made use of the report of WIPO Standing Committee on the Law of Patents held in Geneva published in June 2008 while dealing with subjects like support structures for the patent system, global patenting trends and international patent treaties.

Industry – University Linkages

The INAE study team extensively used web based information on Indian Institute of Technology, state, central and deemed universities and institutes of national importance. The WIPO report on Technology Transfer, IP and effective University – Industry partnerships published in 2007 has been used to ascertain the experiences of India, Japan, China and Republic of Korea.

Human Resource Development

The DST information on S&T Manpower, a special report on HR and skills requirements in chemical and pharmaceutical sectors published by the National Skill Development Corporation (NSDC) of India and other sectoral HR reports have been consulted by the INAE team. It has noted the severe information deficiency on HR for R&D in chemical and allied sectors.

Government funded R&D schemes in chemical sector

The Department of Science and Technology (DST), Scientific and Industrial Research (DSIR) and Biotechnology (DBT) and Council of Scientific and Industrial Research (CSIR) of the Government of India provide information on number of projects, their sectorial affiliation, and quantum of support provided and duration of these programmes. However, information on the extent of success achieved by these programmes and benefits actually accrued to the industry is, however, not readily available.

Industry concern on Information Deficiencies

The INAE team discussed the information management aspect during the ICC-INAE Brainstorming Workshop held at Mumbai held on 8 November 2010. The industry representatives expressed concern at the lack of adequate information on R&D developments of Indian chemical industry in the open literature.

During the Chief Executives Conclave held on the same day, it was recommended that suitable institutional mechanism has to be evolved for development of vision and foresight for various segments of Indian chemical industry. The need for technology forecasting for evolving future R&D roadmap was also stressed.

1.5 Surveys and Special Studies

The Principal Scientific Investigator of INAE project has launched opinion surveys and special studies in areas where open literature information is rather scanty. The details of these studies are highlighted below:

Opinion and Sample Surveys

The following subjects have been covered by the surveys conducted by a two member expert team from ASCI, Hyderabad.

- Chemical industry's perceptions on R&D Utilization
- Patent utilization in Indian chemical sector
- Technology transfer mechanisms adopted in Indian chemical sector
- Quality and mobility of human resource in Indian chemical sector

The INAE teams has also conducted sample studies based on the data collected from public domain information in following areas:

- The Current status of production, turnover, investments and exim trade of Indian chemical sector
- Sectoral growth trends of R&DI (R&DI) in Indian chemical sector
- R&DI relationship with company turnover and size in chemical industry subsectors
- Cluster concept for growth of R&D in chemical MSMEs
- Internationalization of chemical R&D utilized in India
- Citation Analysis of Indian Patents in chemical sector
- Government funded R&D commercialization initiatives and their outcome
- The status of Industry – Academic linkages in Indian chemical sector
- HR utilization in chemical R&D
- Long term impact of environment on the growth of Indian chemical sector.

Special Studies carried out by the INAE Team

The basic objective of these studies is to obtain expert opinion on specific subjects with wider implications on R&D growth in Indian chemical sector. The following subjects have been selected for carrying out special studies:

- R&D impact on Indian petrochemical sector by Dr M O Garg, Director, Indian Institute of Petroleum, Dehradun
- A case study on the linkage between industry and Institute of Chemical Technology, Mumbai by Prof A N Maitra, Retd Professor, Delhi University

- Publication and patenting trends in the fields of Chemical Engineering and Nano Technology by Dr(Mrs) Annapurna Jetty, Retd Scientist, IICT, Hyderabad.

- Role of Project engineering companies in R&D commercialization in Indian chemical sector by Sri D P Misra, Director, Tata Consulting Engineering, Mumbai

- Impact made by government funded R&D commercialization programmes by Dr D Yogeswara Rao, Scientist G, IICT, Hyderabad.

1.6 Major Events Organised / Participated by the INAE Team

The INAE arranged major events in association with external agencies during the project execution period to solicit specific opinion on vital issues pertaining to INAE study. Special interaction sessions were also held with professional bodies and national institutes to ascertain the views of experts on Indian chemical sector on issues of specific interest to INAE study. The Principal Scientific Investigator, Project Consultants and Advisors visited few industry association offices, SME sites and academic institutions to interact with the senior executives on subjects of critical importance to the INAE studies. The details are presented in **Table.1.6.1**.

Two ICC-INAE Workshops were held at Mumbai to interact with the senior representatives of Indian chemical industry at the beginning and at the end of the INAE project period to seek industry's considered views on the issues covered in the INAE project and their feedback on the draft findings of the report. A CEO's Conclave was also held on 8 November 2010 to seek the opinion of the Senior Executives of Indian Chemical sector on the policy issues being covered in the INAE study. The considered views of the senior representatives of Indian chemical industry were also ascertained at various stages of the INAE project through the above modes of contact. They have been covered at appropriate places in various chapters of this report.

1.7 Analysis of Recent Chemical Industry Memoranda to Government

The INAE study team examined the nature of issues covered in the recent chemical industry memoranda to Government of India from time to time. They cover:

- Import and excise duty revisions on feedstocks, intermediates and capital goods
- Reduction of direct taxes
- Special support to industry during global melt down
- Tax exemptions for SEZs
- Enhanced depreciation allowance for investments on energy efficient and green technologies
- Exemption of Carbon Emission Reduction Credit (CER) from Income tax
- Creation of a technology upgradation fund for SME sector
- Financial incentives for R&D
    - Soft loans at reduced interest rates
    - Zero duties on R&D specific capital goods

- Extension of IT exemption of 150% of R&D expenditure beyond 2012
- Income tax benefits to R&D commercialization including new product launches

- Government commitment to Free Trade Agreements (FTA)

The topics highlighted above shows that the Indian Chemical industry has recognized R&D as a priority area for special fiscal incentives from the government and identified technology upgradation of SMEs as an urgent need. The industry has also responded positively to long term environmental issues covering green energy technologies and acquisition of carbon credits. The INAE team is encouraged by the Indian chemical sector's concern on environment protection, low R&D investment / expenditure and adverse global implications of free trade agreements.

Table.1.6.1 Major Events Organised / Participated by the INAE Team (2009-11)

1. EXTERNAL PROJECT MONITORING

S.No	Event	Theme	Date	Venue	INAE Participant(s)
1.1	**PRMC-1**	**Objectives, scope and time targets (Annexure 1.6.1a)**	**3 November 2009**	**Vigyan Bhavan Annexe, New Delhi**	**PSI, Project Consultants and President, Vice President and Secretary, INAE**
1.2	**PRMC-2**	**Activity progress review and Extension of time (Annexure 1.6.1b)**		**-do-**	**-do-**
1.3	**PRMC-3**	**Draft findings and recommendations (Annexure 1.6.1c)**	**10 January 2011**	**-do-**	**-do-**

Ref: Annexure 1.6.1.

2. INTERNAL PROJECT MONITORING

S.No			*Date*	*Venue*	*INAE Participant(s)*
2.1	**Project Consultants Meeting-1**	**Finer aspects of Project Scope and Activity Scheduling (Annexure 1.6.2a)**	**17 July 2009**	**IICT, Hyderabad**	**PSI, Project Consultants and Team Members**
2.2	**Project Consultants Meeting-2**	**Identification of critical findings of INAE study (Annexure 1.6.2b)**	**23 June 2010**	**IICT, Hyderabad**	**-do-**

Ref: Annexure 1.6.2.

3. ICC-INAE WORKSHOPS

S.No	*Workshop*	*Theme for Discussions*	*Date*	*Venue*	*INAE Participant(s)*
3.1	***R&D Impact on Indian Chemical Industry***	***Important Issues for INAE study (Annexure 1.6.3a)***	***4/5 December 2009***	***Mumbai***	***PSI and 3 Consultants***
3.2	***Brainstorming on R&D Impact on Indian Chemical Industry; CEO's Conclave***	***Feedback on Major Findings of INAE Project Study Annex 1.6.3b)***	***8 November 2010***	***Mumbai***	***-do-***

FIRST ICC-INAE WORKSHOP ON "R&D IMPACT ON INDIAN CHEMICAL INDUSTRY"
At Mumbai on 4/5 December, 2009

Workshop Sponsors

Welcome by Sri DP Misra,
INAE Project Consultant

Inaugural address by Prof M M Sharma,
Former Director, UDCT

Project Presentation by Dr K V Raghavan,
PSI, INAE Project

Distinguished Speakers

Sri R Parthasarathy
Vice President,
ICC

Prof G D Yadav
Director,
ICT

Sri Surendra Kulkarni
Director,
Dow Chemicals

Dr Hameed Bhombal
Sr President
Aditya Birla Group

SECOND ICC-INAE WORKSHOP OF R&D IMPACT ON INDIAN CHEMICAL INDUSTRY
at Mumbai on 8 November 2010

Welcome by
Sri H S Karangle, Director General, ICC

Inauguration by
Dr R Chidambaram, PSA to Govt.of India

Keynote Address by
Prof M M Sharma, Former Director, UDCT

INAE Project Findings by
Dr K V Raghavan, PSI, INAE Project

Address by
Dr M O Garg, Project Consultant

Valedictory Address by
Dr P S Goel, President, INAE

Distinguished Speakers

Sri D P Misra
INAE Consultant

Sri S R Lohokare,
Chairman, T&EC, ICC

Sri Prakash Trivedi,
Adviser, Solvay

Dr D Yogeswara Rao
Scientist 'G', IICT

4. INTERACTION MEETINGS TO SOLICIT EXPERT OPINION

S.No	Meeting with	Theme	Date	Venue	INAE Participant(s)
4.1	20th Meeting of the Scientific Advisory Committee to the Cabinet, GOI	Highlights of INAE Project studies and draft recommendations (*Annexure 1.6.4*)	7 September 2010	Vigyan Bhavan, New Delhi	• Dr K V Raghavan, PSI • Dr Zarabi, VP, INAE
4.2	INAE Annual Convention	INAE Project Draft Findings (*Annexure 1.6.5*)	17 December 2009	IGCAR, Kalpakkam	Dr KV Raghavan, PSI
4.3	INAE Governing Council	Project Overview	30 July 2010	New Delhi	-do-
4.4	Institute of Engineers India	Growth Dynamics of Indian Food Processing sector		Karnataka Regional Centre, Bangalore	Dr K V Raghavan, PSI
4.5	Indian Institute of Chemical Engineers	Major Findings and Recommendations of INAE Report	17 March 2011	Chennai Regional Centre, Chennai	-do-
4.6	Dr R Chidambaram, Principal Scientific Advisor, GOI	Major Findings and Recommendations of INAE Report	18 January 2011	Vigyan Bhavan Annexe, New Delhi	PSI and President INAE
4.7	Dr T Ramasami, Secretary, DST, GOI	Major Findings and Recommendations of INAE Report	-do-	New Delhi	Dr K V Raghavan, PSI

5. *INTERACTIONS WITH TECHNICAL EXPERTS*

S.No	Meeting with	Theme	Date	Venue	INAE Participant(s)
5.1	ICC-INAE Interaction meeting with Vapi Industries Association	R&D Support to SMEs in Industrial Clusters (Annexure 1.6.6)	17 .11.2010	Mumbai	• Dr K V Raghavan, PSI • Sri DP Misra, Project Consul tant
5.2	Dr Samir Somaiya, VP, ICC	Government R&D commercialization programmes – Recommendations	3 .02. 2011	Mumbai	Dr KV Raghavan, Sri DP Misra Dr D Yogeswara Rao
5.3	Bulk Drugs Manufacturers Association	R&D Support to bulk drugs units in clusters	16.07.2010	Hyderabad	Sri G A Reddy, Project Advisor
5.4	Andhra Pradesh Industrial Technical Consultancy Organisation, (APITCO)	R&D Impact on SME Clusters	23.12.2010	Hyderabad	-do-
5.5	District Industry Centre, Ranga Reddy	Status of chemical / Drug industries in Hyderabad	03.12.2010	Hyderabad	-do-
5.6	MSME-New Delhi	Cluster Development in SME Sector – R&D Impact	20.04.2010	MSME, New Delhi	-do-
5.7	MSME-Indore	Visit to SME cluster	09.08.2010	Indore	-do-
5.8	Senior Official of Industries Dept., Govt of AP	Drugs & Pharma / Chemical Industries in A.P.	14.12.2010	Hyderabad	-do-
5.9	DST and DSIR of Government of India	R&D Commercialization Programmes	2009-10	New Delhi	1. Sri Neeraj Atrey, Scientist, IIP, Dehradun 2. Dr.D.Yogeswara Rao, Scientist 'G', IICT, Hyderabad

6. VISITS

S.No	Meeting with	Theme	Date	Venue	INAE Participant(s)
4.1	Vapi Industrial Estate	Familiarization with industrial cluster activities	16 .11.2010	Vapi	Dr K V Raghavan, PSI
4.2	Chemical SME cluster at Indore	-do-	09.08.2010	Indore	Sri G A Reddy, Proj Advisor
4.3	Biotech Incubation centre, Hyd	-do-	03.03.2011	Shamirpet	-do-
4.4	CFTRI, Mysore	Interaction with senior scientists on R&D in Indian food processing Sector	26 .09.2010	Mysore	Dr K V Raghavan, PSI
4.5	Institute of Chemical Technology, Mumbai	Industry – Academic linkages in chemical sector (**Annexure 1.6.7**)	8-9.11.2010	Mumbai	Prof A N Maitra and Sri A Narasimha Rao, Proj Asst
4.6	SMEs in Taiwan	Promotion of R&D and innovation in SME sector	January 2010	Taipeh 2010	Dr K V Raghavan, PSI, IICT, Hyderabad

Dr K V Raghavan, PSI, INAE Project Delivering CFTRI Foundation Day Lecture on R&D Impact on Indian Food Processing Sector on 26 September 2010

CHAPTER – 2 STATUS OF INDIAN CHEMICAL INDUSTRY AND ITS R&D

An attempt is made in this chapter to evolve the current profile of Indian chemical industry based on the latest information reported in national and international literature. A broad picture of global chemical industry is also presented to understand its overall growth dynamics and sectoral performances.

The second part of this chapter broadly deals with the current R&D scenarios of global and Indian chemical sectors with reference to their productivity, innovation content and extent of investments made. This is followed by a presentation on the export-import performance of Indian chemical industry, technology intensiveness of Indian exports and exim policies of Government of India.

A detailed presentation has been made in the third part of this chapter on the subsectoral performances of the Indian chemical industry. The special report on R&D impact on Indian petrochemical sector prepared by the INAE team is also discussed. The Indian Science and Technology Policies and their impact on R&D and innovation in Indian chemical sector has received attention in the 4th part of the report.

The information contained in this chapter provides a valuable base data for assessing the future growth prospects for Indian chemical industry and its R&D.

2. STATUS OF INDIAN CHEMICAL INDUSTRY

2.0 Preamble

The chemical industry worldwide is undergoing significant changes. Many companies including established ones are readapting themselves to the rigours of globalized economy by leveraging their core strengths and human capabilities with system positives. The demand growth of the sector is shifting to Asia Pacific region particularly to China, India and a number of southeast Asian countries. The global chemical sales are now distributed in Asia (38%), European Union (29%) and NAFTA (21%). It is interesting that China accounts for almost half of the chemicals sales in Asia followed by Japan and India. Inspite of limitations, the Indian chemical players are reasonably well positioned with government responding positively to most of their medium and long term needs. The present study considers this development as a reasonably good starting point for evolving a roadmap for future growth with a much better outlook for the Indian chemical industry.

2.1 Global chemical Industry

The chemical industry is one of the largest and most diversified industries in the world with a turnover of USD 3.4 trillion and an annual growth rate of approximately 9%. Due to global economic downturn, it has seen in 2009 a decline of around 5% of its turnover over that in 2008. On the market front, the basic chemicals have a share of 45% followed by pharmaceuticals and specialty chemicals with 27 and 22% shares respectively. During 2008-13, the global chemical industry is expected to grow at around 5.3% CAGR. The current growth trends can be best described as follows:

- The petrochemical segment is slowing down with an upswing in polymer and resin prices
- The pharmaceutical segment is witnessing reduced R&D spending due to slowing down of US and European markets.
- Specialty chemical sector is showing its vulnerability to economic cyclicality

2.1.1 Sectoral Performance

Basic Chemical Segment

It is characterized by high volume and low value added products with limited product differentiation across the manufacturers. The basic chemicals have high entry barriers to new comers due to high capital investment, tight regulations and low profitability. Globally inorganic, organic, petrochemical, fertilizer and other industrial chemicals constitute this segment. It accounts for 45-50% of the chemical industry turnover of USD one trillion. The petrochemicals and their derivatives account for more than 80% of its own turnover. Raw material and energy costs form the largest cost component of basic chemical manufacture.

Logistics play a key role in basic chemical industry worldwide with handling and transportation of voluminous raw materials being the principal cost contributing factor. The major driving force for the growth of this segment is provided by the optimization of capacity utilization and operational efficiency and designing a suitable product mix to match the market demand. Amongst petrochemicals, the global ethylene and propylene annual production capacities are around 130 and 90 million tones respectively in 2009. The global market size of petrochemicals is around USD 320 billion and is expected to reach USD 385 billion in 2014. The major producers are North America, Western Europe and East Asia.

The global fertilizer consumption is around 157 million tones of nutrients and is expected to grow at 3% CAGR till 2015. Increasing foodgrain consumption (around 2.28 billion tones in 2010) and biofuel production using cereals, sugarcane and oilseeds as feedstocks provide the major driving forces for its global expansion. Its consumption pattern in two large fertilizer consuming countries viz., China and India is becoming a major factor for its future expansion.

The Inorganic chemical sector is the oldest and largest in size in the world. The typical production capacities achieved in 2009 for Caustic soda, chlorine and soda ash are 78.6, 55.4 and 44 mmtpa respectively. The major demand of caustic soda arise from chemicals, paper, aluminium, textile, soaps and detergent industries. The key end users of chlorine are PVC and organic chemicals. The soda ash demand is mainly attributed to glass, chemicals and detergent industries.

Speciality Chemical Segment

The global speciality chemical market is around USD 400 billion accounting for nearly 25% of global chemical industry. It is characterized by high product differentiation and value addition endowed with typically smaller production units with high flexibility in product mix and low capital investment. It is a product knowledge driven industry with raw material cost component much lower than that of the basic chemical industry. The typical success factors for speciality chemical industry lie in understanding the customer's needs and new application development.

Speciality chemical sector in the developed countries has higher than the average chemical industry growth rate and is closer to highly customer oriented sectors like automobiles and civil constructions. The European speciality chemical segment has a much lower dependence on raw materials than basic chemicals. Its size is 10 times that of Indian speciality chemical sector and is worth Euro 150 billion. It nearly accounts for 40% of total chemical sales in Europe. The global developments in emerging fields like nano, pharma and biotechnologies are likely to broaden the landscape for higher end speciality chemicals. The environmental friendly products like biopolymers and advanced action additives for fuel systems will provide new opportunities in ecosensitive market segments.

Knowledge Intensive Chemical Segment

It employs differentiated chemical and biological substances with specific outcomes related to human and animal health, plant protection and sustainable growth of other forms of life. It is a knowledge driven industry characterized by high investment and expenditure on R&D and marketing. It is the fastest growing segment (6 times that of basic chemicals) of the global chemical industry with pharmaceutical, agrochemicals and biotechnology as its major constituents.

The global pharmaceutical market is placed at USD 837 billion in 2009 with 8% growth over 2008. It is expected to grow at 6% CAGR to reach USD 100 billion in 2014. The top 10 players account for over 42% of total global sales.

The global agrochemical industry has grown at 9% per annum rate since 2001 to reach USD 51 billion in 2009. Europe provides the bigger market for agrochemicals with 32% share recorded in 2008. The top six companies account for 70% of the total market. The global biotechnology market is estimated at USD 200 billion in 2009 with 10.2% CAGR from USD 136 billion in 2001. By 2014, it is expected to reach USD 320 billion level. Medical products account for 66% of global revenues with bioservices market accounting for 14% of value in 2009. Americas and Asia Pacific countries accounted for more than 70% of the global market in 2009.

2.1.2 R&D in Global Chemical Industry

Despite declining R&D Intensity, global chemical industry continues to place adequate priority for investing in R&D. Its spending touched USD 27.33 billion in 2007. The focus areas are biobased processes, novel catalysts, sustainable chemistry, smart materials and alternatives to oil based feedstocks.

The global speciality chemical companies have recorded higher R&D intensity over basic chemical companies. It is estimated (**1**) that 80% of global R&D expenditure is in Europe, 17% in Americas, 3% in Asia-Pacific region. In the knowledge intensive chemical sector, their R&D activities are not confined to their geographical boundaries since international cooperation, outsourcing R&D to other countries and establishing R&D centres in developing economies have made them boundary less.

R&D Productivity

The productivity of R&D in US chemical companies was studied by DAboody and B Lev (**2**). Their study revealed that R&D in USA yielded an average return of 26-27% (before tax) on the investment made in late 1990s. It is substantially above the cost of capital employed by the chemical companies. The ratio of R&D to operating earnings was around 56% indicating the serious constraints on achieving substantial increases in R&D budgets. The economies of scale of US chemical R&D are pronounced indicating the higher level of sustainability of their large chemical companies

Factors Governing R&D Innovation

The top innovations in global chemical sector are predominantly governed by short term goals and for meeting urgent regulatory requirements (**3**). The use of renewable energy as well as materials provides the second important priority for innovation. The process innovations are more concerned with emissions trading and pollution prevention through clean technologies. The product innovation is influenced by the therapeutic concerns over health and safety of living systems. While the process research is governed by a closed system of innovation, the product research is based on a more cognitive system of innovation.

2.1.3 Anticipated Changes in Global Chemical Industry

The Management Centre Europe (MCE) brought out an Executive Issue (**4**) in 2010 to prepare the chemical industry managers to deal with the changes anticipated in the industry in the coming years. If provides useful leads to Indian chemical industry to plan its future roadmap for growth. The following important parameters have been identified as having high impact on the future growth of global chemical industry.

Natural Resources and Environment

Redesign of chemical processes to reduce water usage will receive high priority. Carbon dioxide emission reduction is likely to manifest itself in business and consumer markets in a much bigger way in order to promote trade with green companies.

Cross border Investments

Cash rich companies in MiddleEast and Asia are likely to invest in European and American companies to acquire their knowledge base, special expertise and brands.

Shifts in Consumption Patterns

By 2020-25, 80% of middle income consumers will be from outside of North American, European and Japanese economies. Alongwith this, there will be a shift in end user choices for products with special properties.

International Regulatory Intensity

Regulation will continue to influence the development of global chemical industry with more rigorous regulations like REACH to come into force for handling and use of hazardous chemicals / compounds.

Demographic Distortions

Demographic shifts in manufacturing activities to Middle East and Asia can devoid western companies of experienced middle managers to take up supervisory roles due to their migrations and in Asian countries with high percentage of young people with inadequate development capabilities getting opportunities to take up senior management positions in the speciality and knowledge intensive chemical segments.

Twin Advantages of Asset Ownership in Middle East

World's largest asset driven players are in Middle East as far as petrochemical sector is concerned. They are likely to become major global petrochemical producers in the next decade or so. They will get a competitive advantage globally due to their access to significantly large discounted oil and gas reserves. They get further market advantage in view of their proximity to user markets in Asia. It is forecasted that 86% of world's petrochemical capacity will be built in Middle East and Asia. As a result, western petrochemical producers may like to seek mergers, joint ventures, partnerships or alliances with Middle East an Asian companies.

Speciality chemical sector reaching higher innovation levels

The future success in this sector will be governed by higher level of innovation, greater degree of customer satisfaction and ability for complexity management. Globalization of supply chain capability will drive its business development.

The above developments are expected to have significant influence on the future growth of Indian chemical industry.

2.2 Indian chemical industry

The Indian chemical industry is highly heterogeneous in structure with diversified manufacturing bases and markets. It is rather difficult to make a holistic analysis of such a complex industry in order to draw generalized conclusions. An attempt, however, has been made in this section to make a sectoral analysis of Indian chemical industry to identify factors which have significant bearing on the its growth and R&D performance. F**ig.2.2.1** highlights the growth trends of basic, speciality and knowledge intensive chemical markets. While highest growth is anticipated in the latter, lowest growth has been projected in basic chemical segment.

2.2.1 Reviews on Performance

Two important surveys have been published during the first decade of the 21st Century. The first survey was done by M/s. KPMG, India, (**5**) in 2002-03 in association with the CHEMTECH Foundation, Mumbai and the second survey by the Chemicals Division of FICCI, New Delhi in 2010 (**6**) in association with Tata Strategic Management Group, Mumbai and M/s. Roland Berger, the strategic consultants. The KPMG study focused on the development of vision 2010 to showcase the industry's potential to grow at a faster rate and the key imperatives. Based on aspirational growth scenario, the industry was projected to attain a turnover level of USD 60 billion by 2010 implying an annual growth rate of 15.5% and contribution to Indian GDP to the extent of 12.1%. The KPGM study classified the chemical industry into three broad segments viz., basic, speciality and knowledge intensive chemical sectors. The study identified key parameters including growth strategies, consolidation, R&D, cost reduction and collaborations for the future growth of these segments.

The FICCI sponsored study focused on attracting potential overseas and domestic investors to exploit the vast investment opportunities available in Indian chemical industry. It classified the Indian chemical industry into 5 segments viz., basic, speciality, pharma, agro and bioindustrial chemicals. The total size of the Indian chemical industry in 2010 is estimated as USD 83 billion with basic chemicals constituting 53% followed by pharmaceuticals with 24%. The study identified the key factors of advantage to Indian chemical industry in terms of feedstocks cost, their availability, value chain access, technology adaption ability, pooling resources for capital investment, strong local players and rapidly growing domestic market. The study saw India as a growth driver for chemicals among many advanced economies in the world.`

The INAE study, as presented in this report, views R&D as the most probable growth engine for Indian chemical industry to meet the global challenges of the next two decades. It has also classified the Indian Chemical industry into 3 segments as was done in the case of KPMG studies. The impact of R&D intensity, intellectual property generation and protection, technology upgradation of SMEs in clusters, industry-academic linkages and environment / safety on the current growth of chemical industry has been examined.

Table 2.2.1 shows the turnover growth projections made by the KPMG, FICCI and INAE studies. The overall figures projected by the KPMG and INAE studies agree well, eventhough their percentage distribution amongst BC, SC and KI sectors differ.

2.2.2 INAE Analysis on Performance

Industry Structure

The Indian chemical industry is highly heterogeneous in terms of the composition of its constituent units. Since, precise data is not available about their numbers and distribution in its three major segments. The INAE team compiled relevant data from a number of information sources (**5 to 15**). **Fig. 2.2.1** shows that the large chemical companies constitute less than 3% and medium scale companies less than 20% of total chemical companies. Their overall distribution within SC, BC and KI chemical secors is given in **Fig.2.2.2**. The SSI units in organized and unorganized sectors dominate (77%) the Indian chemical sector. The maximum number of medium and large scale units exist in knowledge intensive chemical sector. The total number of companies of all sizes in Indian chemical sector touches 69,000. These statistics may not be highly accurate but are indicative of chemical industry's heterogeneous structure.

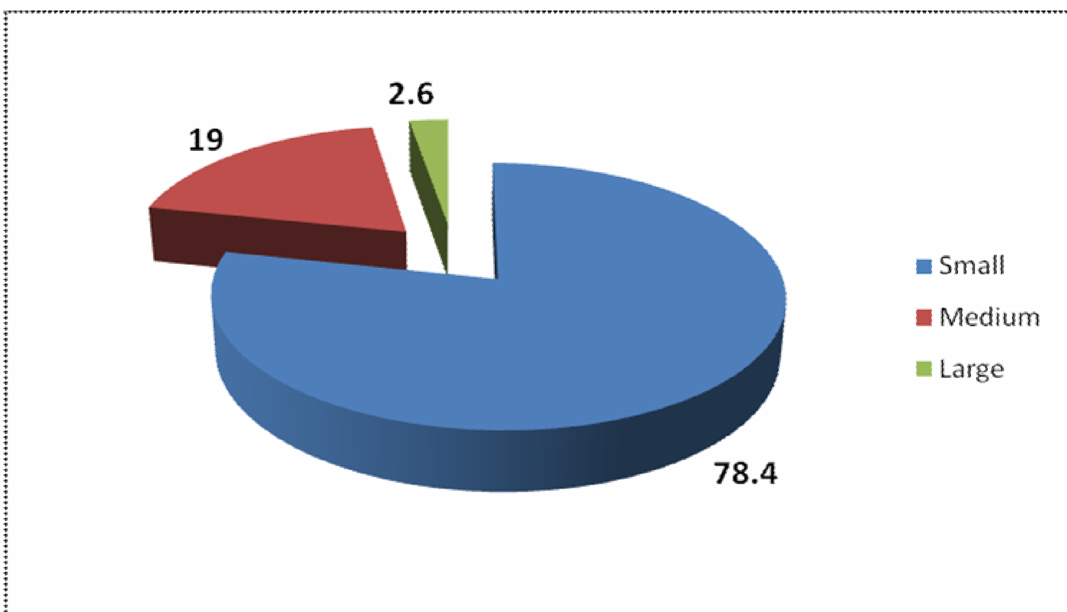

Fig. 2.2.1 : Broad Distribution of Small, medium and large units in Indian Chemical sector

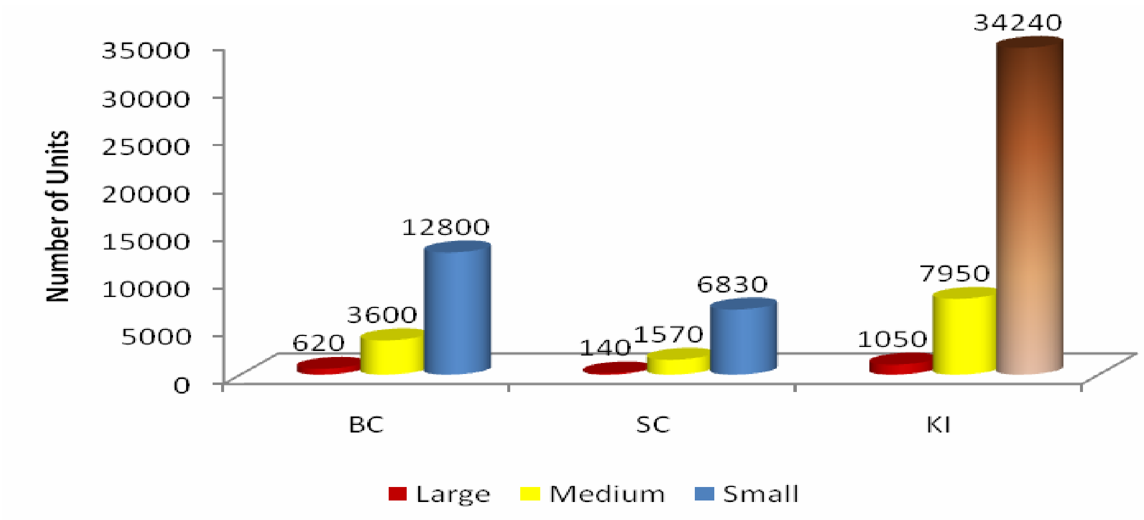

Fig. 2.2.2 : Distribution of Large, Medium and Small Scale units in BC, SC and KI Chemical Sectors (2010)

Investments

During 2002-07, the Indian manufacturing companies (domestic and foreign subsidiaries) have added around 27% to their capital stock. More than 60% of it was new investments. In 2005-06, the turnover of the chemical industry was reported (**15**) as Rs 1,52,600 crores while its total investment stock was around Rs 2,61,600 crores. The information compiled by the INAE team suggests that the cumulative investment made by the chemical industry during 1991-08 is around Rs 110,300 crores with 72% contribution from the basic chemical sector. Nearly, 85% of its is from petrochemical investments. India has not set up a green field petrochemical complex since 2001. However, there has been incremental capacity increases for debottlenecking purposes. During 1991-08, the Indian private sector is reported to have contributed more than 50% of the Indian petrochemical investment. Recently Government of India approved investments worth Rs 1,54,512 crores under PCPIR scheme. A higher investment growth rate is therefore, expected during the next decade.

Table 2.2.1 : Turnover Growth Projections of Indian chemical sector

Turnover, USDB

	KPMG Study				**FICCI Study**		**INAE Study**	
	2002		**2010***		**2009**		**2009**	
	USDB	***%***	***USDB***	***%***	***USDB***	***%***	***USDB***	***%***
Basic Chemicals	**16**	**57**	**31**	**51.7**	**44**	**53**	**30.2**	**47**
Speciality Chemicals	**7**	**25**	**14**	**23.3**	**14.9**	**18**	**11.7**	**18.3**
Knowledge Intensives	**5**	**18**	**15**	**25**	**24.1**	**29**	**22.3**	**34.7**
	28	**100**	**60**	**100**	**83**	**100**	**64.2**	**100**
% of GDP	**6.7**	**2008-09**			***USDB***		**5.14**	
% World Chem	**1.3**	***Indian GDP***			**1250**		**3.7**	
% Indian Exports	**10.0**	***Indian Exports***			**165**		**12.4**	
Trade Balance (USDB)	**-ve (1.5)**	***World Chemical Trade***			**1698**		**+ve (7.98)**	

USDB: USD billion

The Research and Information system (RIS) for the nonaligned and other developing countries had brought out a Research Monograph (**7**) on Indian chemical industry in 2004. It examined the international competitiveness of Indian chemical industry, its sectoral innovation system, its policies and institutional framework. One of the interesting studies reported in this monograph is the relationship between company size, turnover and R&D intensity for selected Indian chemical companies in 2002. It shows that 50% of 385 companies sampled in the study belong to the turnover below Rs. 50 crores and nearly 55% companies had reported no R&D expenditure. The INAE study has made use of this data to compare the situation in 2005 and 09.

An attempt has been made in this section to quantity the overall technical and financial performance of Indian chemical industry during 2008-09. Such information is not available from a single information source. The INAE team, again studied several reports (**5 to 15**) to build an overall picture of Indian chemical industry performance. **Table 2.2.2** provides the size and performance of Indian chemical sector. **Table 2.2.3** provides 'at a glance' information on the important performance indicators of Indian chemical industry based on the data presented in the previous Table. **Table 2.2.4** provides the sectoral contributions to commercially important performance indicators like production, turnover, exports, imports, capital and R&D investments, FDI accruals and intellectual property generation / protection. It provides the sensitivity and relative importance of various subsectors of chemical industry for enhancing the industry performance.

It can be seen that more than 85% of Indian chemical industry production is accounted by the basic chemical sector with fertilizers (43%) and petrochemicals (30%) providing the major contributions. The share of Knowledge intensive chemical sector is extremely low in view of its low production volume and high value feature. The overall contribution of speciality chemical sector is around 14% with nearly 50% of it is contributed by the food processing subsector. The growth in production of organics has been very sluggish during 2003-09 and whereas the growths of food processing, drugs / pharmaceuticals and biotech / product subsectors have been very impressive. The capacity utilization in fertilizers and petrochemicals subsectors has been higher than 88%. **Fig.2.2.3** provides the subsectoral contributions to the turnover of Indian chemical industry for 2008-09. It shows that the contribution of petrochemicals and drugs/ pharma subsectors exceed 66%. Except for fertilizers, organics, lipids and household / personal care products and biotechnology based products, the contribution of no other chemical subsector crossed 4% of total chemical industry turnover.

Table 2.2.3 : Performance indicators of Indian chemical industry (2008-09)

Item	Size	BC	SC	KI
		Percentage		
• Cumulative Investments: (1991-08), Rs Crores	111,280$^+$	72	19	9
• Total Production, MMTPA				
• Total Turnover, Rs Crores	69$^+$	85$^+$	14$^+$	<1
• Exports, Rs Crores	2,85,000$^+$	46	20	34
• Imports, Rs Crores	89,440	28	18	54
• Trade Balance, Rs Crores	56,440	74	6	20
• FDI Attracted, Rs Crores (2000-10)	33,000	-ve	+ve	+ve
• R&D Expenditure, Rs Crores	30,120	42	20	38
• Research Papers, Number (03-07)	7,860	13	3	84
• Patent Families Applied (03-07)	31,480	44	25	31
• Patents / Publications	10,360	39	14	47
	0.33	0.30	0.18	0.5

2.3 Export and Import Performance

India is becoming more competitive in export of knowledge intensive services, specialities and high tech products. The INAE study considered the export-import performance of Indian chemical industry as a measure of its global competitiveness in traditional and high tech manufacturing segments.

2.3.1 Global and National Trends in all S&T sectors

Globally, macroeconomic policy reforms initiated by the governments in developed countries have facilitated significant growth in exports. The studies reported by Lee (**16**) for USA, M.J.Robert (**17**) for Columbia, S.Hirsch (**18**) for Israel, L.Wilmore (**19**) for Brazil, K.Ito (**20**) for Japan, A.Bernard (**21**) for Germany, G.Wingnaraja (**22**) for Sri Lanka and Kenya and R.H.Dholakia (**23**) for India have shown that company size exerts a positive influence on exports. Employing a Pabel Tobit Model, R.H.Dholakia et al., (**24**) analyzed the export performance of Indian companies in general. They arrived at following conclusions:

- Large companies perform better in export activities
- Liberalization of imports in itself is export promoting
- The level of risk taken by a company will have a positive influence on export performance
- Product R&D undertaken by firms has a positive influence on export performance
- Companies which have been consistently performing well in their sales have achieved better export performance.

Indian exports and imports have been growing much faster than GDP over the past two decades for eg., exports grew 11% per annum while GDP growth is around 5% during 1970-98. Their growth has become more pronounced since then. Several factors have contributed to this improved peformance, the notable amongst them are competitive pricing, improved quality, ability to attract sizeable FDI inflows, the initiatives taken to acquire modern technologies as well as larger scale contract manufacturing outsourced from the global companies.

The overall Indian export market for 2007-08 was around USD 163 billion. Over a period of 7 years, the Indian exports rose by 370% with a CAGR of 24.5% during this period. The overall Indian imports (CAGR of 30.3%) stood at USD 251 billion in 2007-08 as compared to USD 51 billion in 2001-02. It is interesting to note that Asian countries account for 51.7% of global chemical exports, followed by Europe (22.9%) and North America (13.5%).

2.3.2 EXIM Performance of Indian chemical sector

The per capita consumption of chemicals in India is very low compared to several industrialized nations and there are signs of its increase. Indian chemical sector is exporting several of its products to both developed and developing countries. These are classified under following four categories as defined by the Indian Trade Classification based on harmonized ITC (HS) Code:

Table 2.2.2: Size and Performance of Indian Chemical Sector (2008-09)

S.No	SECTOR	Cumulative Investments* (91-08)	Production (08-09)	CAGR (01-09)	Turnover (08-09)	Cap Utilizn	Exports (08-09)	Imports (08-09)	FDI (00-10) Cumulative	Research Exp (08-09) (PVT)	RDI	Research Papers (03-07)	Patent family Applications* (03-07)
		Rs Crores	000' Tons	%	Rs Crores	%	Rs.Crores	Rs.Crores	Rs Crores	Rs Cr	%	Number	Number
1	**BASIC CHEMICALS**												
1.1	**CHLOR ALKALI/INORGANICS**	**3,896**	**5,960**	**2.6**	**5,057**	**72**	**440**	**630**	**NA**	**25**	**0.5**		
1.2	**FERTILIZERS**	**4350**	**29,760**	**-0.73**	**17,211**	**90**	**94**	**13,670**	**545**	**46**	**0.3**		
1.3	**ORGANICS**	**1,576**	**2,411**	**12**	**16,297**	**81**	**709**	**3,726**		**210**	**1.3**		
1.4	**PETROCHEMICALS/ INTERMEDIATES**	**70,268**	**20,790**	**1.82**	**92,897**	**88**	**24,226**	**24.020**	**11,949**	**720**	**0.8**		
	Sub-Total of (**1**)	**80,090**	**58,921**		**1,31,462**		**25,469**	**42,046**	**12,494**	**1001**	**0.74**	**13,867**	**4.088**
2.	**SPECIALITY CHEMICALS / PRODUCTS**												
2.1	DYES/INTERMEDIATES	269	32.0	4.24	4,425	58	2,750	540	67	20	0.5		
2.2	FOOD PROCESSING	6,101	2,365	9.0	7,198		9,947	NA	4969	25			
2.3	LIPIDS/HOUSEHOLD/ PERSONAL CARE PROD	8,815	5,372	8.0	22,497	90	1,888	1711	780	101	0.9		
2.4	PAINTS/COATINGS	968	1,600	28	13,045	65	39	616	NA	80	1.9		
2.5	CHEMICAL AUXILIARIES	2,952	400	10.0	3,923	NA	335	171	258	28	0.7		
2.6	ADHESIVES AND SEALANTS	1,935	133	20.0	3,500	85	441	310	40	16	0.4		
2.7	ADDITIVES	273	127	NA	1,308	NA	NA	NA		10	0.8		
	Sub Total of (**2**)	**21,313**	**10,029**		**55,896**		**15,400**	**3,348**	6114	280	0.8	**7,954**	1,441
3	**KN OWLEDGE INTENSIVES**												
3.1	**DRUGS/PHARMA**	**3,295**	**34**	**17.8**	**81,433**	**60**	**38,433**	**8,552**	**8125**	**3963**	**4.8**		
3.2	**AGROCHEMICALS**	**486**	**85**	**0**	**5,009**	**58**	**2,985**	**597**	**NA**	**116**	**2.3**		
3.3	**BIOTECH/PRODUCTS**	**6,099**	**7**	**40.0**	**12,137**	**79**	**7,152**	**1,900**	**3388**	**2500**	**20**		
	Sub Total of (**3**)	**9,880**	**126**		**98,579**		**48,570**	**11,049**	**11,513**	**6579**	**6.7**	**9,657**	4,835
	GRAND TOTAL(1+2+3)	**1,11,283**	**69,076**		**2,85,937**		**89,439**	**56,443**	**30,121**	7860	2.9	**31,478**	10,364

*Traditional Investment

Table: 2.2.4 : Overview of Performance Indicators of Indian Chemical Industry (08-09)

percentage

S.No	SECTOR	Cumulative Investments (91-08)	Production (08-09)	Turnover (08-09)	Exports (08-09)	Imports (08-09)	FDI (00-10) Cumulative	Research Exp (08-09) (PVT)		Research Papers (03-07)	Patent family Applications* (03-07)
									RDI		
1	**BASIC CHEMICALS**										
1.1	CHLOR ALKALI/INORGANICS	3.52	8.62	1.78	0.49	1.11		0.31	0.5		
1.2	FERTILIZERS	3.92	43.08	6.02	0.01	24.23	1.81	0.59	0.3		
1.3	ORGANICS	1.42	3.50	5.71	0.80	6.6		2.67	1.3		
1.4	PETROCHEMICALS/ INTERMEDIATES	63.14	30.10	32.49	27.08	42.57	39.67	9.16	0.8		
	Sub-Total of (**1**)	**72.00**	**85.30**	**46**	**28.48**	**74.51**	**41.48**	**12.73**	**0.74**	**44.05**	**39.45**
2.	**SPECIALITY CHEMICALS / PRODUCTS**										
2.1	DYES/INTERMEDIATES	0.24	0.05	1.55	3.08	0.95	0.22	0.25	0.5		
2.2	FOOD PROCESSING	5.48	3.42	2.52	11.13		16.50	0.32			
2.3	LIPIDS/HOUSEHOLD/ PERSONAL CARE PROD	7.92	7.78	7.87	2.11	3.03	2.59	1.28	0.9		
2.4	PAINTS/COATINGS	0.87	2.32	4.56	0.04	1.09		1.02	1.9		
2.5	CHEMICAL AUXILIARIES	2.65	0.58	1.37	0.37	0.30	0.86	0.36	0.7		
2.6	ADHESIVES AND SEALANTS	1.74	0.19	1.22	0.49	0.54		0.2	0.4		
27	ADDITIVES	0.24	0.18	0.45	NA		0.13	0.13	0.8		
	Sub Total of (**2**)	**19.14**	**14.52**	**19.54**	**17.22**	**5.91**	20.30	3.56	0.8	**25.27**	13.90
3	**KN OWLEDGE INTENSIVES**										
3.1	DRUGS/PHARMA	2.95	0.05	28.47	42.97	15.23	26.97	50.42	4.8		
3.2	AGROCHEMICALS	0.44	0.12	1.75	3.33	1.05		1.48	2.3		
3.3	BIOTECH/PRODUCTS	5.47	0.01	4.24	8.00	3.36	11.25	31.81	20		
	Sub Total of (**3**)	**8.86**	**0.18**	**34.46**	**54.30**	**19.58**	**38.22**	**83.79**	**6.7**	**30.68**	46.65
	GRAND TOTAL(1+2+3)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**2.9**	**100.00**	**100.00**

HS28 : Inorganic chemicals, organometallics and others

HS29 : Organic chemicals

HS36 : Explosives, pyrothechnic products and combustible preparations

HS38 : Miscellaneous chemical products

The maximum exports growth has been recorded by HS29 category products and the lowest growth has been registered by HS36 category.

From the available statistics, the Indian chemical exports and imports stood at USD 20.5 billion and 12.5 billion respectively in 2008-09 with a positive trade balance. The percent share of various subsectors of Indian chemical industry including food processing, drugs / pharmaceutical and biotechnology is shown in **Fig.2.3.1**. The drugs / pharma and biotech sectors are the fastest growing export sectors.

The sectoral growth trends of chemical exports during 1996 – 2009 have been shown in **Table 2.3.1** based on the data compiled from RIS (**7**) and INAE studies. It shows a fall in export of inorganics and organics during 2002 – 09 and steep increase in exports of pharma sector during the same period.

Table 2.3.1 : Export Growth Trends in Indian chemical sector (1996 – 2009)

USD billion

Sector	1996	1998	2000	2002	2009
Inorganics	0.23	0.16	0.24	0.4	0.1
Organics	0.99	1.14	1.73	2.11	0.16
Dyes	0.44	0.39	0.52	0.61	0.63
Soaps/ Cosmetics	0.18	0.18	0.25	0.3	0.43
Pharma	0.67	0.73	0.95	1.4	8.81
Overall industry	**NA**	**3.44**	**3.34**	**6.31**	**20.5**

Source: RIS and INAE Studies

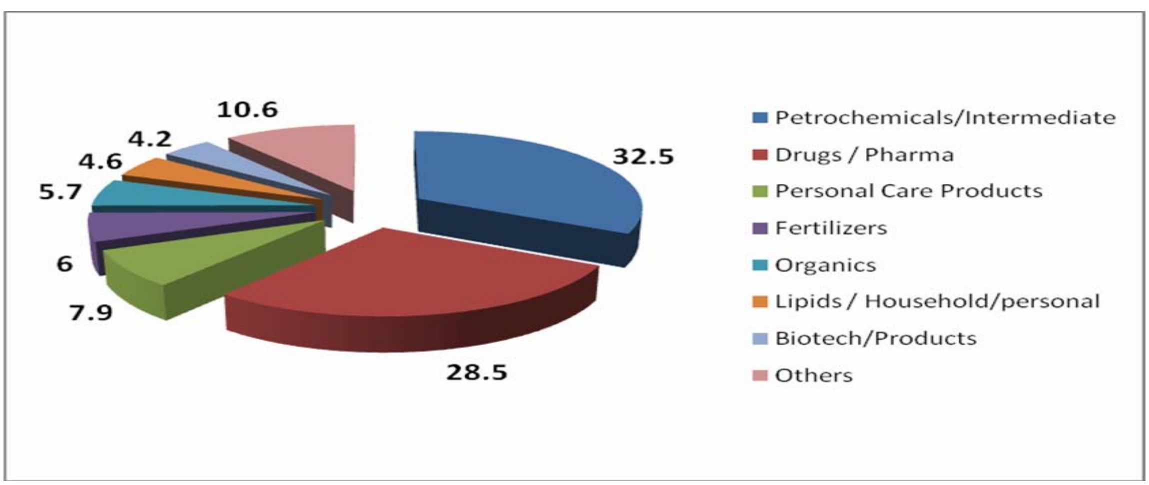

Fig. 2.2.3 : Sub-sectoral Contributions to Turnover of Indian Chem Sector (2008-09)

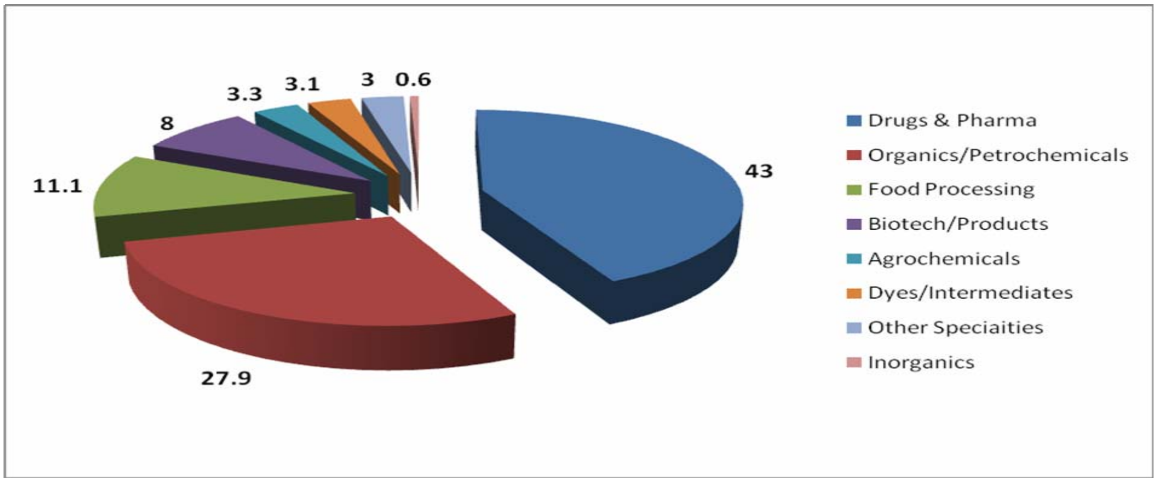

Fig.2.3.1: Percent share of subsectors in Indian chemical Exports (2008-09)

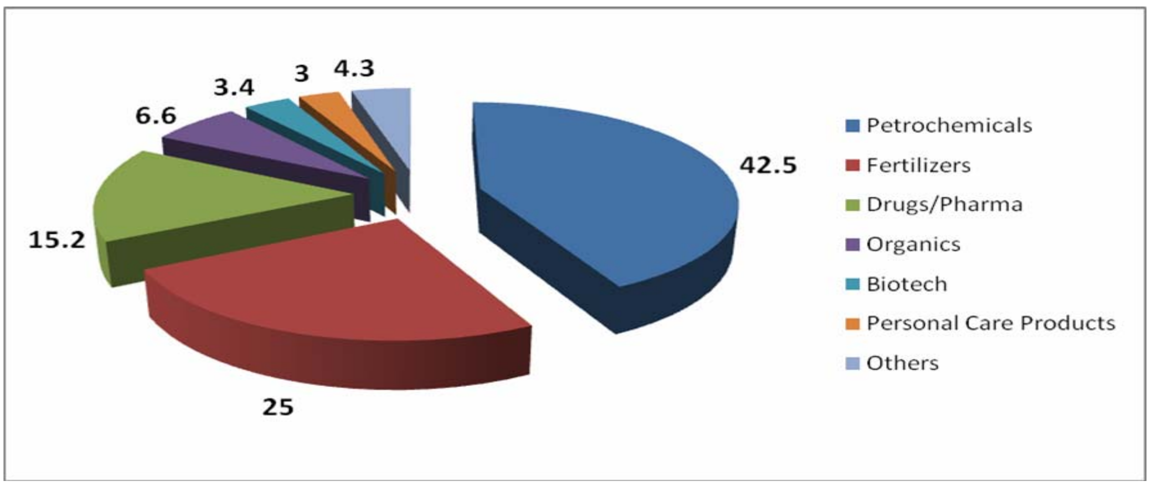

Fig.2.3.2: Percent Import Demands of Indian chemical subsectors (2008-09)

With regard to the imports during 2008-09, the Indian Chemical sector accounts for USD 12.5 billion. The % share of various subsectors of Indian chemical industry including food processing, drugs / pharma and biotechnology is given in **Fig.2.3.2**. The organics / petrochemicals, fertilizers and drugs/pharma sectors accounted for nearly 90% of Indian chemical based imports. **Fig.2.3.3** provides the normalized growth trajectory of Indian all industry and chemical exports with 1990-91 as the base year with growth index =100. It shows the chemical based exports followed similar growth trajectory till 2004-05. Thereafter, it lagged behind the general trend. The Indian chemical segments which have positive trade balance in 2008-09 are speciality chemicals (USD 2.76 billion) and Knowledge Intensive chemicals (USD 9 billion). The basic chemicals sector has a negative trade balance of USD 3.8 billion. The subsectoral contributions to positive and negative trade balances in 2008-09 are given in **Table 2.3.2**.

Indian chemical industry was a net importer in early 1990s but has now become a net exporter due to reduction in its imports, significnat growth in its exports in drugs / pharma and biotech sectors and higher share of high tech product manufacture. The basic chemical sector continues to be a net importer with large negative trade balance mainly due to petrochemical and fertilizer subsectors. R&D driven approach to enhance its productivity and energy utilization efficiency and export oriented management policies may transform the situation for the better in the coming years.

2.3.3 Technology Intensiveness of Indian Exports

India's high technology trade has increased from USD 1.02 billion in 1995 to USD 4.5 billion in 2006. During the same period, the export of high technology products from Brazil has increased 8 times while that of China has increased by 25 times. The share of high technology trade in India's GNP is around 0.49% in 2006. During 1995-06, India's share in global high technology trade has increased marginally from 0.14 to 0.23%. Its share of high technology exports in its own total manufactured exports has hardly changed during 1995-04. On the other hand, India's high technology imports have increased dramatically from USD 2.63 to 23 billion in 2006. This corresponds to a share of 1.16% in world's high tech imports in 2006 as compared to 0.36% in 1995. A major reason for its insignificant role in global high tech trade is India's virtual absence in several high tech products / manufacturing areas.

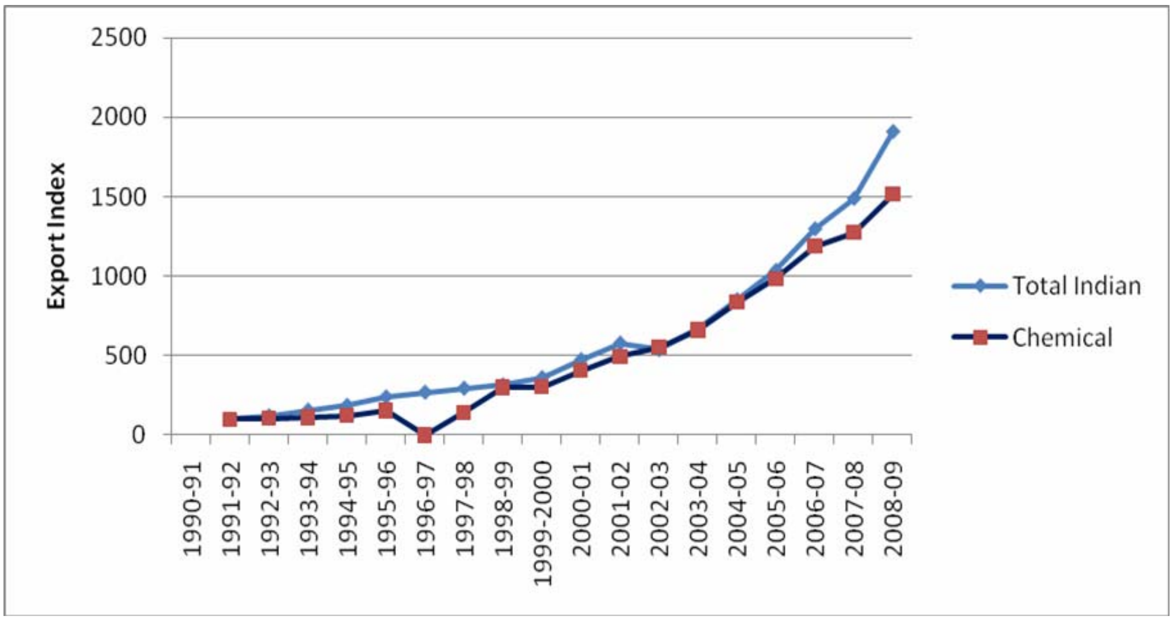

Fig.2.3.3: Growth Trajectory of Indian all products and Chemical Exports (1990-09)

Table 2.3.2: Contributors to Positive and Negative Trade balances (2008-09)

No	Positive Trade Balance		No	Negative Trade Balance	
	Sector	**USD million**		**Sector**	**USD million**
1	Drugs/Pharma	6850	1	Fertilizer	3135
2	Food Processing	2000	2	Organics	692
3	Biotech/Produces	1205	3	Paints / Coatings	132
4	Agrochemcials	547			
5	Dyes	506			
6	Other Specialities	108			
7	Petrochemicals	47			

In such a gloomy scenario, it is heartening to note the stellar performance of Indian drugs / pharmaceuticals sector. It has also a marked presence among the developed countries of the world with its share of global exports around 5% in 2006, the highest among developing countries (except china) and is more impressive than OECD countries like Japan and Canada. In contrast, Indian share of global pharmaceutical import is less than 1% in 2006 mainly due to higher level of self reliance of Indian pharmaceutical sector.

Recently DSIR has brought out (**25**) a report on the technology intensiveness of Indian exports. It states that the world high technology based exports have increased 6.8 times from USD 207 billion in 1988 to USD 1419 billion in 2006 with high technology product exports constituting 21% of the total global exports. **Table 2.3.2** gives the share of high technology based exports pertaining to India, China and Thailand. Though India has more than doubled the quantity of high technology based exports during 2001-06 period, it share in the manufactured product exports remains at 5% in 2006 as compared to 30% and 27% achieved by China and Thailand respectively.

Table 2.3.3: High Technology Exports by India, China and Thailand

Year	India	China	Thailand
2001	1.68 (6)	49.43 (20)	15.29 (31)
2002	1.79 (5)	68.18 (23)	15.23 (31)
2003	2.29 (5)	107.54 (54)	18.20 (30)
2004	2.84 (5)	161.60(30)	18.20 (80)
2005	2.84 (5)	214.25 (31)	22.48 (27)
2006	3.51 (5)	271.17 (30)	26.95 (27)

Source: DSIR Compendium on Technology Exports, Vol IX Jan 2010

Note: *Numbers in parantheses indicate % share of high tech exports*

The composition of Indian exports in 2007-08 comprises of resource based and low, medium and high technology products. The low technology products are those from textile, leather, chemicals, gems / jewellery and allied sectors. They dominated the Indian exports till 2002-03 and their share come down to 39% in 2007-08. The medium technology products include engineering goods, machinery, transport equipments, metals etc. Their share in Indian exports stood at 17% in 2003-03 and increased to 21% in 2007-08. The growth trends of resource and technology based Indian exports during 2002-08 are shown in **Fig.2.3.4**.

Royalty and licence fee payments not only indicate the growth of technology exports but also the intensity in the Indian technology trade. **Table 2.3.4** shows the receipts and payments of royalty and licence fee of India, USA, China and Brazil during 2002-06. It shows the better record of India in growth terms but not in quantum when compared with China and USA.

Table 2.3.4 : Receipts and Payments of Royalty / Licence Fee

USD million

Country	2002		2004		2006		R/P Ratio
	Receipts	Payments	Receipts	Payments	Receipts	Payments	
USA	44.14	19.25	52.64	23.9	63.38	26.43	2.36
China	0.13	3.11	0.24	4.5	0.21	6.63	0.03
Brazil	0.10	1.23	0.11	1.2	0.15	1.66	0.09
India	0.012	0.35	0.025	0.42	0.11	0.95	0.12

R/P = Receipts / Payments

India has a much better receipt / payment ratio as compared to China and Brazil. However, China and Brazil have much higher level of royalty payments as compared to receipts in view of their more aggressive efforts to acquire world class technologies.

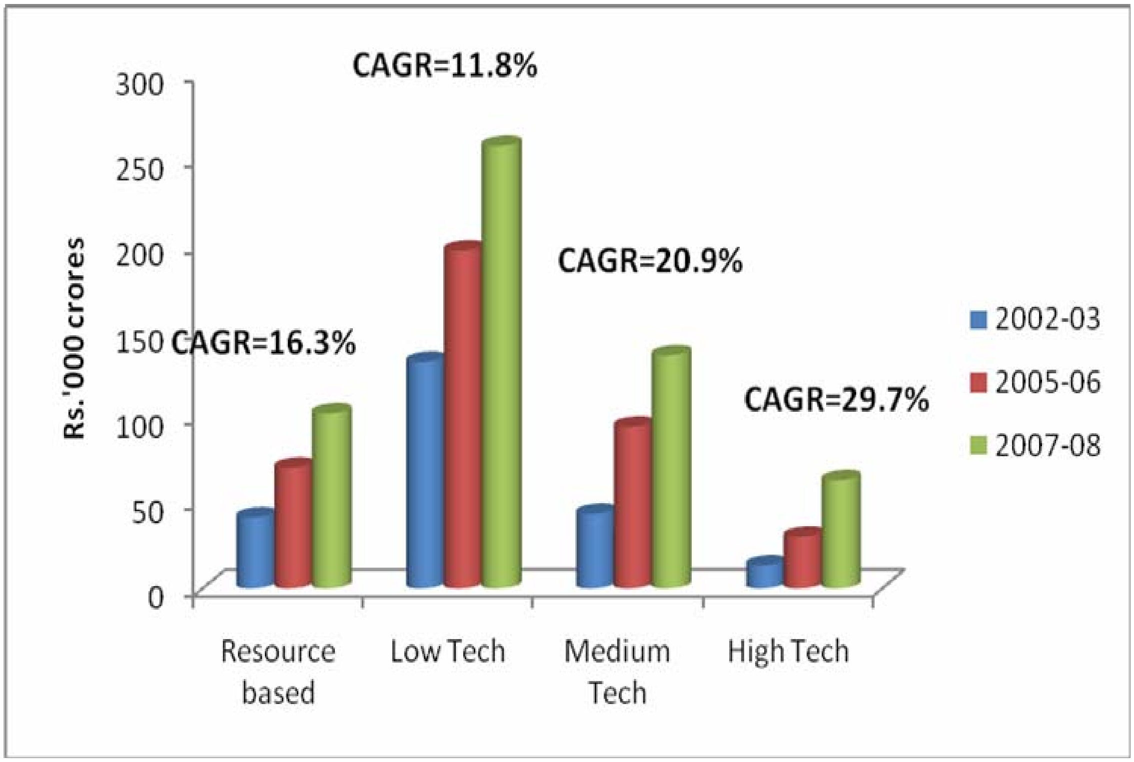

Fig.2.3.4: Growth Trends of Indian Technology Based Exports (2002-08)

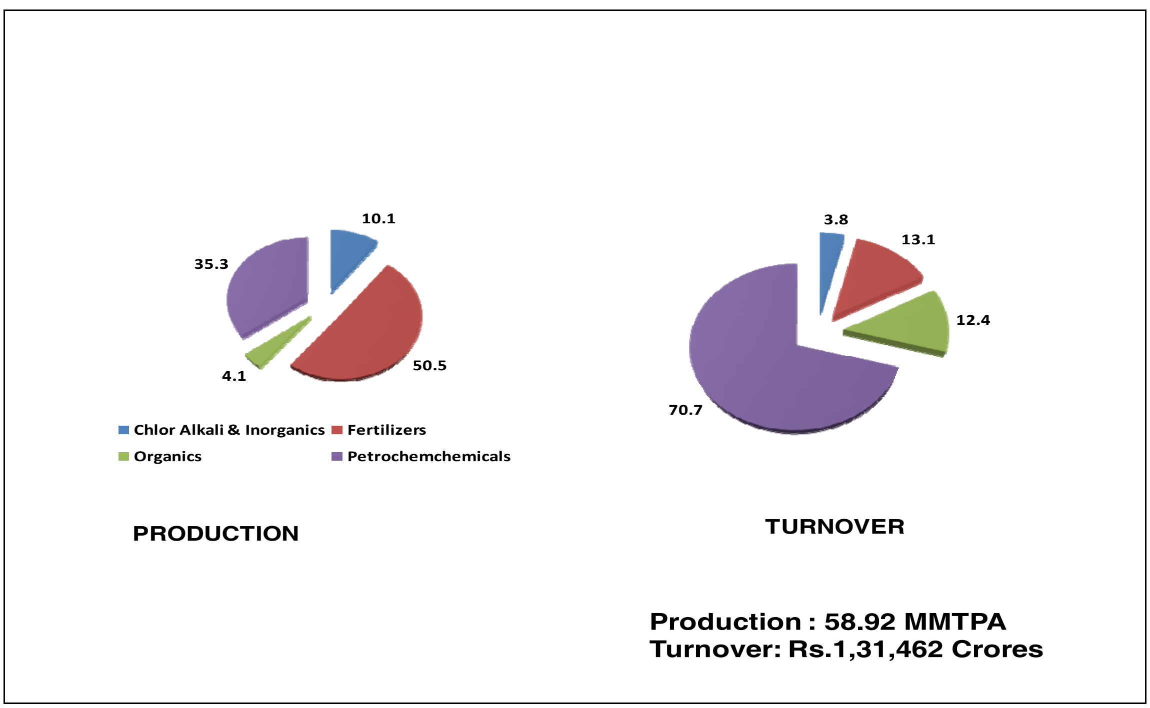

Fig.2.4.1 Indian Basic Chemical Production and Turnover Breakups (2008-09)

2.3.4 EXIM Policies of Government of India

The EXIM policies of the Government of India in vogue during 2004-09 are endowed with incentive driven Export Promotion Capital Goods (EPCG), Export Oriented Units (EOUS), Special Economic Zones (SEZS), Duty Exemption (DES), Duty Entitlement Pass Book (DEPBS), Project Import (PIS) and allied Schemes. From R&D point of view, SEZ schemes have indirect relevance since they encourage new startups or expansion of existing units some of which may have been R&D driven. The Project Import Scheme (PIS) provides for import of equipments and instruments with a concessional duty of 20% for R&D, testing and qualty control programmes. The DES policies provide for import of fuels upto 3-5% of FOB value of export in case of dyes / intermediates, organic chemicals, pesticides and inorganic chemicals.

2.4 Performance Analysis of India Chemical Subsectors

2.4.1 Basic Chemical sector

The basic chemical sector continues to dominate the Indian chemical industry in cumulative investment (57%), production capacity (85%), turnover (47%) and FDI attraction (41%). It also contributes to 77% of Indian chemical imports with a –ve trade balance mainly due to organic chemical and fertilizer sectors. In terms of R&D expenditure, its share is around 13%. The constrained performance of this sector is partly due to preliberalization era infrastructure and work practices. **Fig.2.4.1** shows the contributions of its constituents in production and turnover. **Annexure 2.4.1.1** provides subsector specific information.

The KPMG study (**5**) evaluated the Herfindah Index (HFI) for the Indian basic chemical sector to assess the extent of its fragmentation. HFI provides a measure of the concentration in an industry with its value at unity implying 100% market share is held by a single player and its value at zero indicates a situation where large number of players exist and each of them have a very small fraction of the total market. The study has shown that the basic chemical sector has a HFI of less than 0.3 indicating a high degree of fragmentation and internal competition. The other findings of the KPMG study are:

- Basic chemical companies focus mainly on developing domestic market
- Non competitiveness of their processes are due to their low economies of scale
- Cost disadvantages are due to high taxes are unattractive cost of financing
- Unhelpful labor laws, inefficient processing and low level of automation are other constraints

2.4.1.1 Petrochemicals

Petrochemical industry with turnover crossing Rs 92,000 crores and exports to the tune of Rs.24,226 crores in 2008-09 is the most important component of Indian basic chemical sector. It has significant growth potential due to higher GDP growth of India, low percapita consumption of petroproducts in the country and increased application potential to fuel downstream demand in polymers and fibre intermediates. At less than 2.5% of the global ethylene and polymer production, the size of Indian petrochemical industry is insignificant from global standards. With the discovery of new natural gas offshore reserves, the gas based petrochemicals is likely to receive big boost in the coming years. There is a strong need for government to create an economic environment for competitive positioning of Indian petrochemical players particularly in the light of petrochemical industry growth in middle east countries.

PCPIR Policy Initiatives of Government of India

The Government of India has notified the petroleum, chemcials and Petrochemcial Investment Regions (PCPIR) Policy in April 2007. Its basic objective is to develop global scale industrial clusters in India in an integrated and environmental friendly manner. The focus is on bringing synergy for value-added manufcturing, research and development. The PCPIRs encourage co-siting, networking and greater efficiency through the creation of common infrastructure and support servies. They would also provide world class infrastructure and working environment conducive for setting up new businesses.

Each PCPIR will be a specially delineated investment region with around 250 square kms of developed area for setting up manufacturing facilities for domestic and exported production in the above sectors. At each PCPIR site, a combination of production projects, public utilities, logistics, environmental protection, residential areas and administrative services will be established. The main purpose is to encourage global scale investment in above sectors to accelerate industrial and economic growth.

Each PCPIR will identify refineries and feedstock companies as anchor tenants to encourage downstream units to establish their manufacturing activites. Given the large size of India, more than 5 or 6 PCPIRs are likely to come up in different states by 2020. The Department of Chemicals and Petrochemcials will be the nodal department of Government of India for the PCPIR policy. A high powered committee has been constituted under the chairmanship of the Cabinet Secretary for its implementation. Empowered Committees are being setup by the interested state governments to supervise, monitor and appraise the functioning of a particular PCPIR participated by it. The first batch of PCPIRs are being established in AP, Gujarat, West bengal and Orissa in their coastal areas for better environmental management.

The INAE team is of the opinion that PCPIR policy of Government of India will greatly benefit the basic chemical sector in general and petrochemical and organic chemical sectors in particular. Considering the significant level of success achieved in international ventures like Jurong chemical complex in singapore which was established under similar framework, there are good prospects for the success of PCPIR in India. There is a need to establsih special R&D support programmes under PCPIR scheme to encourage process technology upgradation and downstream product development for future growth of basic chemical sector in India. The Project Engineering Companies and R&D institutions have to network with industry to undertake specific R&D commercialization and technology development programmes. This aspect has been covered in Chapter 10 under major recommendations.

INAE Special Study on Petrochemical R&D

The INAE team led by Dr MO Garg, Director, Indian Institute of Petroleum, Dehradun made a special study on Indian petrochemcial sector basically to find ways and means of enhancing its R&D impact. The Study Report is provided as **Annexure 2.4.1.4**. The study examined the global and Indian petrohemical industry scenarios, current status of its constituents, projected future trends, government R&D funding, ongoing R&D projects of major petrochemical agencies, R&D impact on the Indian petrochemical sector and ways and means of strengthening R&D.

The study has concluded that Indian R&D is vital in areas like alternative feedstocks, environment friendly process options, enhancing process energy efficiencies and use of nano and biotechnological options for intrinsically safe and high efficiency petrochemical processes and downstream products. It also recommended to establish (a) Petroleum R&D fund to focus specifically on R&D on technology upgradation, development of biodegradable feedstocks /

products and waste management, (b) Plastics Development Council for inventing new applications for Indian and overseas consumers and (c) Centres of Excellence in polymer technology with R&D thrust on engineering polymers, alternative feedstocks and novel downstream products.

It has also identified following priority areas for Indian petrochemical sector:

- Strategic investment decisions based on twin objectives of meeting domestic and overseas market demands
- Tariff and Export Incentives with rationalization measures to counter global price cyclicability and import duty reduction on fuels
- Concenssional funding for infrastructure modernization through inhouse R&D programmes
- Enhancing new product development opportunities in downstream sectors
- Matching government funding for technology upgradation through process intensification and zero waste concept implementation

2.4.1.2 Inorganics

The chloralkali and inorganic chemical industry with its production touching 6 million tonnes per annum and its annual turnover crossing Rs.5000 crores is characterized by a high degree of fragmentation, high energy costs, higher imports and infrastructural deficiency. The Indian producers also face threat of cheap imports from China inspite of anti-dumping duties being levied on Chinese products.

2.4.1.3 Fertilizers

Indian Fertilizer sector continues to face growth limitation due to price regulation. India is a net consumer of fertilizers. Six companies produce 64% of nitrogen fertilizer and two companies manufacture 44% of phosphatic fertilizer. The investment policy 2008 of Government of India is encouraging brownfield expansion of fertilizers. Recently Oman has agreed to invest around USD 5 billion for revival of closed fertilizer plants and expanding the existing capacities. For expansion of gas based fertilizer plants in India, natural gas requirement of 42 mmscmd was envisaged in 2009 against the actual availability of 28 mmscmd. With therecent growth in gas production in Krishna-Godavari basin, new gas based fertilizer plants likely to come up in AP and adjoining states.

2.4.1.4 Organics

The organic chemical sector with 2.4 million TPA production level and annual turnover of Rs 16,300 crores is expected to grow at 5% per annum to 3.53 million tonnes by 2014. The key segments to grow are methanol and phenol. The major challenges faced by this sector are nonavailability of cheaper raw materials, large global capacity additions and relatively low capacity utilization. Key opportunity areas are wider product portfolios, forward integration and overseas opportunities to set up greenfield projects.

India has achieved reasonable level of success in developing alcohol based organic chemical industry. **Table.2.4.1** shows the current capacities of this industrial sector as reported by Tata Consulting Engineers.

Table. 2.4.1: Indian Alcohol based Chemical Industry

Alcohol based chemicals	Capacities (TPA)
Acetic acid	450000
Acetic anhydride	78000
Vinyl acetate monomer	25000
Pyridines, picolines and other derivative	30000
Ethyl acetate	160000
Mono ethylene glycol	260000
Monochloro Acetate	42000
Ethylene Dichloride	35000

2.4.1.5 Role of Project Engineering Companies in R&D Commercialization

The INAE team led by Sri DP Misra, Diretor, Tata Consulting Engineers, Mumbai studied the current role of Projet Engineering Companies (PEC) in setting up commercial process plants in basic chemcial and other sectors, the type of knowledge base and expertise available with them and the future role to be played by them in R&D commercialization in Indian chemcial sector. The report is attached as **Annexure.2.4.1.5.**

The above study was necessiated on account of following:

- The process of R&D commercialization is not straight forward or easy for chemical companies without adequate support from project engineering companies.

- Major barriers are encountered by the Indian R&D / academic institutions in chemical sector in commercializing their research outcomes since most of their research outcomes fall under early stage technology category endowed with a high degree of technological / market uncertainties.

- Very limited availability of either government or private funding for transforming a process knowhow into a basic design engineering package.

- Limited capabilitie exist in Indian project engineering companies to develop basic design packages for complex process technologies involving catalysis, reactive separations, biotransformation etc.,.

  This special study has enabled the INAE team to offer appropriate recommendations in Chapter 10 and other sections of this report. It has established the need for:

- Industry-R&D-Project Engienering agency networks for R&D commercialization for development of technology packages along with commercial guarantees

- Apart frtom TDB, provision to be kept for seeking support from other Government R&D commercialization programmes for preparation of basic design engineering packages from knowhow of complex processes.

The current competitive advantage acquired by certain segments of Indian chemcial sector endowed with low cost skilled manpower, domestic resource availability and government incentives may not last long if no efforts are made to create new driving forces for R&D commercialization.

2.4.2 Speciality Chemical Sector

Speciality chemicals are a group of relatively high value and low volume products designed for specific end use applications. They provide required solutions to meet the customer specific needs. **Fig.2.4.2** shows the important constituents of Indian speciality chemical sector and their approximate production capacities. This sector is characterized by the low capital intensity, high profit margins and existence of a large number of SME players in organized and unorganized sectors. The cost advantage enjoyed by the latter has been the barrier for the entry of organized players into this segment.

Indian speciality chemical sector recorded a positive trade balance around Rs 12,000 crores in 2008-09. The R&D expenditure incurred by the speciality chemical sector is hardly 4% of the entire Indian chemical sector eventhough its turnover share is as high as 20%. This sector is greatly benefitted by the ready availability of moderately skilled manpower. The KPMG studies revealed that the low cost base of speciality chemical sector has been its strongest growth factor contributing to its competitiveness in global market. The study also identified lack of modern infrastructure, inadequate marketing structure and poor access to common R&D facilities as its growth hindrance factors. The Datasheets of speciality chemical sector are given in **Annexure 2.4.1.2**.

Its contribution of 30% to the cumulative investments made by the chemical sector during 1991-08 and its 15-20% share in production, turnover, exports and FDI of chemical sector during 2008-09 are quite impressive. It caters to a large number of end use industries including construction, automobile, dyes, polymers, personal care products, water treatment, textile, leather, paints, coatings, soaps, cosmetics and others.

Though the speciality chemical sector has been registering growth rates higher than the overall Indian chemical industry, its R&D intensity has remained stagnant during the last 10 years. The FICCI study (**6**) has projected its growth at 14-15% per annum to reach Rs 2,18,000 crores turnover by 2015. Its turnover in 2008-09 is estimated by INAE study team as Rs 55,896 crores. There looks to be a big gap between projected and the existing turnover. This is possibly due to lack of information from unorganized segment of Indian speciality chemical sector and also the more number of subsectors considered by FICCI study under this category.

The KPGM study (**5**) has shown that Indian Speciality chemical industry is largely driven by robust domestic demand with export driven growth in select segments. The future Indian growth in this sector is likely to be driven by three factors viz., (a) the performance of higher than the overall GDP growth rate of consumer industries viz., textiles, automotive and construction (b) emerging customer needs of product performance driven segments like wrinkle free textiles, reflective glasses, novel cement admixtures etc., and (c) progress in process and equipment upgradation driven segments like paper, electronics, textile, cosmetics and plastics.

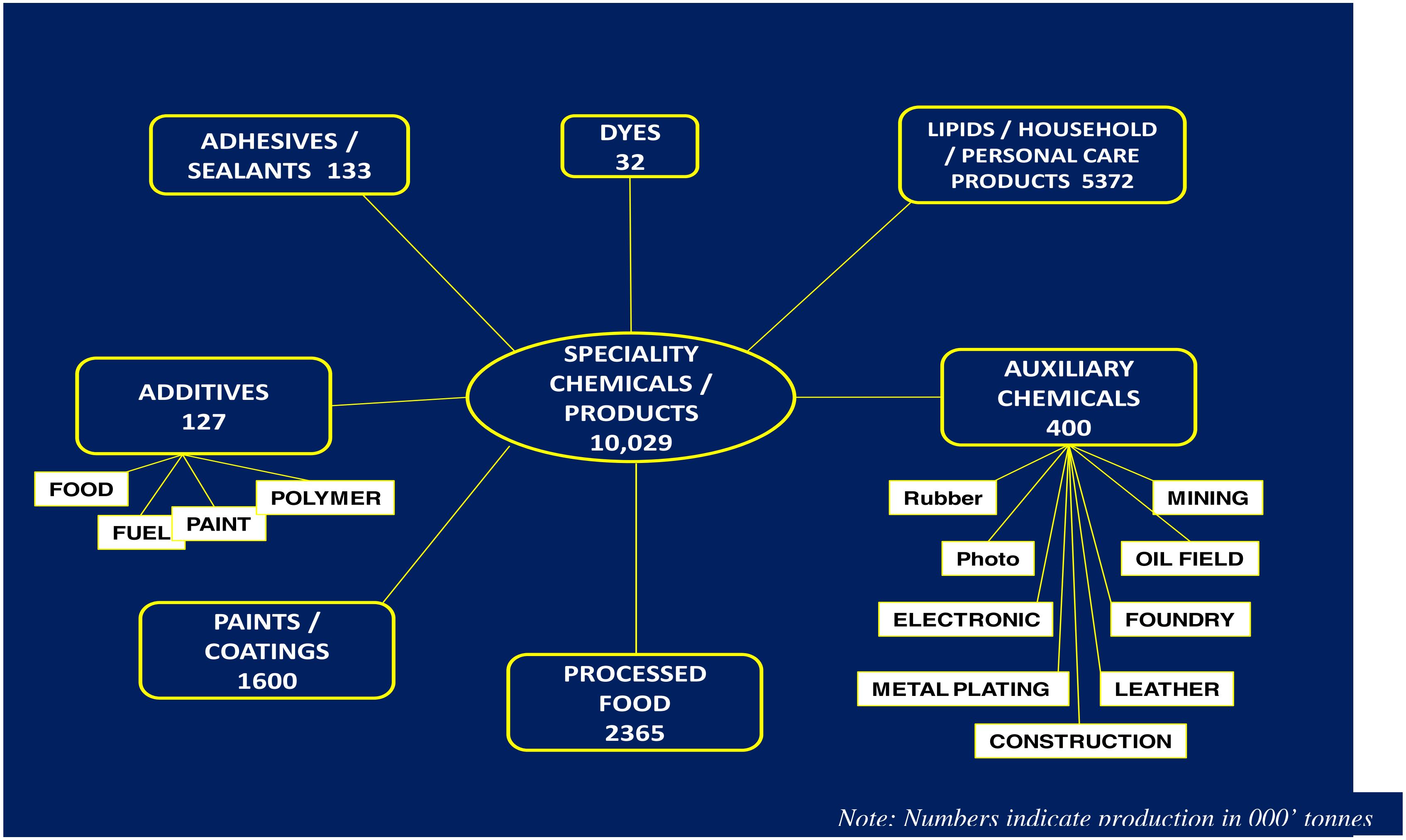

Fig. 2.4.2 : Subsegments of Indian Speciality Chemical Sector

The Indian strengths which can contribute to the future growth of its speciality chemical sector are:

- The Indian consumer industries have created a large domestic market in excess of USD 20 billion. It provides the critical market size for sustainability.
- Indian automotive, construction and textile industries provide unique opportunities for customized application development
- The establishment of PCPIR policy in India has strengthened the future prospects for creating suitable docking points for the new startups of the Indian speciality chemical sector.

2.4.2.1 Lipids / Personal Care Products

The turnover of lipids / personal care product industry constitutes over 40% of the speciality chemical sector followed by paints / coatings (23%), food processing (13%) and dyes / intermediates (8%).

The personal care products business in India is flourishing with their per capita consumption growing at the rate of 15-20% per annum. This segment is witnessing a large scale foreign entrants to the market which consists of talcum powders, color cosmetics, deodorants and perfumes. A ASSOCHAM study has indicated the significant growth potential of this sector in rural and semiurban areas in India. There is tremendous scope for innovative technology application to meet the increasing customer demand for natural product based cosmetics.

2.4.2.2 Food Processing

In terms of exports, food processing industry tops the Indian speciality chemical sector with nearly 65% contribution followed by dyes / intermediates (18%) and lipids / personal care products (11%). The INAE study has considered the processed food segment of Indian food sector as part of Indian speciality chemical industry in view of its technological and process affinities. There is an increasing demand in India for processed food on account of rising urbanization and growing income levels of Indian middle class.

The Government of India has been taking several initiatives since 2000 for the growth of food processing sector. The notable amongst them are:

- Enhancing the outlay of Indian Food Processing sector beyond USD 41 million and enhancing its investment beyond USD 23 million by establishing atleast 10 mega food parks in India with 100% FDI and income tax benefits..
- Establishing Special Economic Zones (SEZs) with flexible fiscal and foreign exchange procedures.
- Identifying food processing sector as a thrust areas for exports by offering

➢ Free trade and export processing zone facilitation with export linked duty free import of capital and other goods and customs duty concessions and retaining upto 50% foreign exchange receipts.

➢ All profits from export sales are exempted from corporate taxes and Minimum Alternate Tax (MAT)

➢ Special customs clearance procedures for food items with shorter shelf life.

2.4.2.3 Paints / Surface Coatings

This Industry is over 100 years old with the first Indian coating unit established in1902. Indian industry is worth 4% of global coatings market. The current turnover is Rs.15,400 crores and approximate production capacity is around 1.5 million TPA. The industry is growing at 7.5% during the last 5 years. The large scale manufacturers, (about 15) who have a market share of 58%, produce about 9,20,000 TPA of architectural (78%) and industrial coatings (22%). There are more than 1500 units in SME sector with a total production capacity of 6,80,000 TPA with architectural (88%) and industrial (12%). The products manufactured by this sector are enamels (36%), exterior emulsions (14%), interior emulsions (13%), primers and thinners (12%), distempers (11%), precoats and special cements (10%) and other (4%). Most of the Indian industrial coatings are predominantly solvent based except in high end automotive refinishes.

The non-technical growth drivers are 100% FDI, booming housing sector, recent thrust of state governments on nonresidential schemes and development of satellite towns in rural and semiurban areas. The technical growth drivers are increased sophistication in finishes and refinishes, shift towards powder coating technology, increased coating needs for high end construction segment.

Most of the traditional technologies for paints / coatings are developed indigenously and modern coating and application technologies often transferred from overseas collaborators. The main weakness of this sector is inadequate R&D support and because of this, the sector has difficulties to comply with international regulatory and environmental norms. Due to pricing pressures, the increasing dependence on overseas partners for new technologies and due to unfavourable economies of scale, the R&D expenditure in this sector is very low viz., less than 1% of its turnover. R&D is very important for development of high class water based coatings. The lack of manpower with required skills and educational qualifications are other factors hampering the growth of this sector.

2.4.3 Knowledge Intensive Chemical Sector

Indian companies in this segment have attached relatively higher importance to R&D as a means to achieve product leadership as well as competitive process technologies with demonstratable savings in chemicals and manufacturing costs. Leading companies in this segment have been making R&D investments to the extent of 5-15% of their sales. Indian knowledge intensive companies are also making effective use of bio and information technologies for developing ecocompatible products and processes. At CAGR of 12.3%, this segment industries are the fastest growing components of Indian chemical sector.

The main constituents of this segment are drugs / pharma, agrochemicals and biotechnology. The INAE study shows that Indian knowledge intensive chemical sector accounts for 34+% turnover, 54% exports, 38% FDI inflows, nearly 30% research publications and 47% patents filed in Indian chemical sector as a whole. A very attractive performance record indeed. Its EXIM trade balance of more than USD 9 billion is one of the highest in the country's manufacturing industries. Nearly Rs 10,000 crores have been invested by this segment during 1991-08. This level of Indian investment is, however, less as compared to Rs 11,513 crores FDI attracted by this sector during 2000-10. A special mention need to be made of this segment in terms of its ability to make a R&D expenditure of Rs 6579 crores during 2008-09. It is nearly 84% of the entire R&D expenditure made by the Indian chemical industry. The fact and data sheets of its sector are given in **Annexure 2.4.1.3**.

2.4.3.1 Drugs / Pharmaceuticals

The drugs / pharmaceutical sector is the key component of Indian knowledge intensive chemical sector since it accounts for 92% of its imports, 83% turnover, 79% exports, and 60% R&D expenditure of it during 2008-09. Its cumulative investment (1991-09) is 33% of the knowledge intensive chemical sector and FDI inflows (2000-10) are 71% of all Indian industrial sectors. It is the foremost Indian sector to have taken full advantage of the product patenting facility under WTO regime. Nearly 42% product patents filed at IPO during 2002-10 are from this sector with CSIR, Dr Reddy's, Dabur Research and NATCO leading the table.

Indian drugs / pharma sector is ranked 3rd in the world in terms of production volume and 14th in terms of domestic consumption value. Formulations account for 65% and bulk drugs for the balance 35% in value terms. As per FICCI study, its turnover is expected to reach Rs 1,90,000+ crores in 2014 from its present value of Rs 81,400+ crores. It is important to note that Indian pharmaceutical sector meets 95% of the Indian health care needs. Indian drugs / pharma companies manufacture a wide range of generic drugs (branded and non branded), intermediates, bulk drugs and Active pharmaceutical Ingredients (API). India exports pharmaceutical products to more than 200 countries in the world. Bulk drug export accounts 90% of Indian production with USA as its single largest export market. It is reported that 95% of India's pharmaceutical market has demand for second and third generation drugs whose process technologies have become offpatent in developed countries.

Low production costs and a very large talent pool provide India a clear edge over several developed and developing countries in the world. The substantial part of Indian global investments are in the generic manufacturing field. Indian pharma companies now account for over 30% of all US Abbreviated New Drug Applications (ANDA) filings submitted to FDA. India has the largest number of US FDA approved manufacturing sites (100+) outside USA. The manufacturing activities are concentrated primarily in Andhra Pradesh, Maharashtra and Gujarat states.

Contract Research, Manufacture and Allied Services (CRAMS)

The declining R&D productivity of global pharma majors has contributed to skyrocketing of new drug development costs. Added to this, nearly USD 130 billion worth of drugs will become offpatent by 2013. Both these factors have put pressure on profit margins of global drug companies to outsource the drug manufacture to countries like India. This provides good opportunity for Indian pharma companies to undertake contract research, manufacture and allied services along with wide ranging joint marketing alliances, outsourcing clinical research and 'time to market' system for new drug development and their small scale manufacture. They require GMP facilities, FDA approved manufacturing centres and high level quality control systems.

CRAMS help to service the high value global markets with an opportunity to become part of their value creation. Indian pharma and biotech companies have already made a mark in CRAMS in the manufacture of generic drugs and bioproducts. They need to sustain their competitive advantage by focusing on cost reduction and develop capabilities to meet the critical end to end needs of innovative MNCs.

The current Indian contract manufacturing predominantly focusses on low value and high volume intermediates, APIs and carrying out clinical trials. Strong domestic and international competition has already brought down profit margins significantly in recent times. It is time that Indian

CRAMS players look at new opportunities areas including high potency APIs, antibody drug conjugates and allied products.

Indian R&D Companies

India has made reasonable progress in establishing R&D companies in knowledge intensive chemical sector. More than 20 companies have been formed during last 10 years whose main business is R&D. For example, in pharma sector, such companies offer drug discovery and development, knowledge intensive services, clinical research and collaborative research partnerships. There companies are well equipped with state of art facilities for lead optimization, preclinical and clinical research, custom synthesis, formulation development, micro analysis and process scaleup. They invest even upto 30% of their profits on R&D investment and expenditure.

Virtual R&D Concept

By 2020, the R&D process in global pharma sector may be shortened by more than 60% to dramatically increase the drug discovery success rates and substancially cut clinical trial costs. Computer based technologies are likely to create a great understanding of disease biology to predict the effects of new drug candidates before they are tested on human beings. Indian pharma companies are gearing themselves to derive the full benefits of such novel concepts.

Other Major developments in offing

The Indian pharma companies are graduating from reverse engineering of generic drugs to development of new drug entities and their delivery systems. Adoption of new biotechnology and IT tools will enable them to participate more proactively in global drug development programmes. Increasing number of global acquisitions have been made by Indian pharma companies to get strategic advantages in global sales. This trend is likely to gain momentum in coming years.

Government Support to Drugs /Pharma Sector

Considering the new challenges faced by the industry from time to time on account of liberalization and new obligations undertaken by India under the WTO, the Government of India has taken following initiatives for Indian drugs / pharma industry:

- Modification of Drug Policy (1986) in 1994 to promote accelerated growth and to enhance the global competitiveness of the industry.
- Recognition of the industry as the most important knowledge based industry
- Abolition of industrial licensing except for bulk drugs produced by the recombinant DNA and related technologies
- 100% foreign investment through automatic route
- Extending the facility of 150% weighted deduction of R&D expenditure under section 35 (2AB) of Income Tax Act till 31 March 2012.
- Second Amendment to the Indian Patent act to allow product patenting in India from 1st January 2005

- Pharmaceutical policy 2002 (a) to improve incentives for R&D (b) further reduce the rigors of drug price control (c) strengthen the quality control system (d) provide incentive framework for attracting new investment into the pharma industry and new technologies and (e) reduce trade barriers for pharma exports.

- Setting up Pharmaceutical Research and Development Committee (PRDC) for

  - Investing atleast 5% of its turnover per annum in R&D and Rs.10 Crores / annum in new drug development through innovative R&D

  - Employing atleast 100 research scientists in India pharma sector

  - Setting up Drug Development Promotion Foundation (DDPF) and Pharma Research and Development Fund

- Setting up a chain of National Institutes of Pharma Research and Education (NIPERs) to achieve excellence in Indian pharmaceutical sciences and technologies. A centre of excellence on bulk drugs will be established at Hyderabad by the NIPER in the near future.

2.4.3.2 Agrochemical Sector

India is world's fourth largest producer of agrochemicals after USA, Japan and China. India's agrochemicals consumption per hectare (0.58 kg) is, however, one of the lowest in the world as compared 4.5 kgs in USA and 11 kgs in Japan. Paddy accounts for the maximum share (28%) of pesticide consumption in India followed by Cotton (20%). Agrochemicals are manufactured in India by 125 technical grade product manufacturers including 10 multinationals, 800^{+} formulators and over 1,45,000 distributors. Nearly 60 technical grade pesticides are being manufactured in India.

The Indian agrochemical market is characterized by low capacity (58%) utilization. The industry suffers from high inventory and long credit periods to farmers making our agrochemical operations working capital intensive. Its exports (Rs 2985 crores in 2008-09) form nearly 60% of its own turnover. Its contribution to Indian knowledge intensive chemical sector itself is marginal viz., <7% of its investment and turnover, 6% of its exports and less than 2% of its R&D expenditure. The Indian agrochemical sector is constrained by its negative image from environmental considerations. The current and future focus for this sector has to be the development of environmentally safe products and crop application options. The R&D has to play a major part in this endeavour.

The Indian agrochemical sector is expected to attain a turnover of Rs 8500^{+} crores by 2014 from Rs 5000^{+} crores in 2008-09. The key market drivers are higher demand for food grains in India, growing export demand and future growth in nonconventional application areas in horticulture and floriculture. The key challenges are high R&D costs, competition from GM crops and plant based pesticides favoured through Integrated Pest Management (IPM) concept.

2.4.3.3. Biotechnology Sector

Indian biotech sector accounts for nearly 2% of the global market and its turnover has more than doubled during the last 5 years to reach Rs $12{,}000^{+}$ crores in 2008-09. It is growing at a rate 21^{+}% per annum, the highest recorded by any industrial sector in India. The key segments of Indian biotech sector are biopharma (62%) bioagro (19%) and bioservices (14%). Others are bioinformatics, bioagri and bioindustrials. India's inherent strengths in biotechnology are high skills, lower cost of clinical trials, moderate labor costs and reverse engineering expertise. The government support, as in the case of pharmaceuticals, is very strong and responsive. A full-fledged department of biotechnology (DBT) was established by the Government of India as early as in 1980s. Formation of a Biotechnology Regulatory Authority (BRAI) is in the offing.

The Indian growth of biotech sector is expected to accelerate further on the back of high demand for vaccines, clinical investigations, biopesticides and fertilizers, biosimilars for pharmaceutical applications, biofuels and biopharmaceuticals. The biotech sector is benefitting significantly from the establishment of new startup ventures through biotechnology incubators.

2.5 Systemic Deficiencies in Indian Chemical Sector

2.5.1 Important Issues

The Indian Chemical Industry has evolved in a phased manner from 1950 onwards. Following five phases can be broadly identified:

Phase 1 (1950-72)	:	Basic need fulfillment phase with focus on health and agriculture
Phase 2 (1992-80)	:	Downstream product development
Phase 3 (1980-92)	:	Consolidation in speciality chemical sector
Phase 4 (1992-95)	:	Major investments in post globalization
Phase 5 (1995 onwards):		Growth of knowledge intensive segments

The preglobalization policies of the government have led to the noncompetitive growth of basic chemical sector with suboptimal scales of operation, reverse engineering centred approach for the growth of even knowledge intensive chemical segments and indigenisation focus for speciality chemical segments. The protectionist policies pursued for SME growth have reduced their competitive abilities in global markets. All these factors created inherent deficiencies in Indian chemical sector with reference to its performance under globally competitiveness environment in the post globalization period. The international competitive in several sectors of Indian chemical industry is price based with companies endowed with global scale manufacturing operations possessing definite advantage in meeting the challenges of international markets. Another problem which confronts several segments of Indian chemical industry is the operational bottlenecks leading to suboptimal manufacturing capacity utilization. This has significantly minimized the cost benefit of several basic and speciality chemical sector units. The third important deficiency is with reference to meeting the rigorous international environment norms without sacrificing substantial cost advantage. There appears to be very few viable options to get over these deficiencies in the long run without resorting to increase in operation scales, technology upgradation and infrastructure modernization. R&D plays an extremely important role in achieving these goals.

2.5.2 Economic Performance Driven Chemical Industry Classification

The classification of chemical units as micro, small, medium and large may not be very convenient to use while implementing S&T performance driven strategies for their development. The boundaries between them are very hazy and many times development programme implementation meets roadblocks at their interface.

The INAE team has found the economic performance oriented classification of Indian chemical companies in the six turnover zones as identified in Chapter 3 is much more convenient in evolving new growth strategies. The turnover data of more than 1600 chemical companies listed in CMIE-PROWESS Database has been employed in a sample survey to generate information on the revised distribution pattern of Indian chemical companies as indicated in **Fig.2.5.1**. Nearly 75% of Indian chemical companies exist in first two turnover zones viz., below Rs 50 crores. Only 6% of them have turnovers exceeding Rs.500 crores. **Fig.2.5.2** shows the number of companies in BC, SC and KI sectors in the various turnover zones. It shows the dominance of KI sector companies in all turnover zones except that of Rs 500 crores and above. The BC sector has a slight edge in this zone. A sizeable number of SC sector companies exist in turnover zones below Rs 50 crores. It has nearly as many companies as those in BC sector. In broad terms, companies in less than Rs 50 crores turnover can be classified as small enterprises, Rs 50 to 500 crores as medium and large medium and Rs 500 crores and above as large companies. The INAE team suggests that their technoeconomic performance can be the guiding factor for evolving future growth strategies

2.5.3 Performance of MNCs vis-à-vis Domestic Companies

Employing the data from CMIE 'PROWES" database (2005), there were a total 4612 companies in India in all industrial sectors out of which 94.6% are Indian companies and the rest are multinational companies. **Table.2.5.1** shows the distribution of MNCs in engineering, chemical and textile fields.

Table 2.5.1 : Distribution of MNCs and Domestic Companies (2005)

	MNCs		**DOMESTIC Co.,**		
SECTORS	No.	%	No.	%	TOTAL
• ENGINEERING	125	7.8	1,479	92.2	1604
• CHEMICALS	80	6.2	1,207	93.8	1287
• TEXTILES	22	2.8	760	97.2	782

Source: CMIE Prowess Database (2005)

The engineering companies have relatively higher number of MNCs as compared to chemical sector companies. From the studies reported by P Katiyar (14) on the performance of MNCs vis-à-vis Indian companies in the above sectors, there is no significant difference between MNCs and domestic companies in R&D performance, return on net worth and export intensity. However, in case of chemical MNCs, the return on capital employed is quite significant and in case of engineering MNCs, the import intensity is quite high. The textile MNCs have significant level of sales to capital ratio.

2.6 Indian Chemical sector Ability to Attract New Investments

2.6.1 Foreign Equity

The drugs / pharma sector accounts for highest number of companies with foreign equity participation whereas it is the lowest in the case of explosives. **Table.2.6.1** shows the relative foreign equity participation in various chemical subsectors.

Table 2.6.1 : Foreign Equity Participation in various chemical subsectors

	0%	0-10%	10-25%	25-50%	>51%	Total
Drugs & Pharmaceuticals	73	5	1	6	8	93
Cosmetics, Soaps & Detergents	11	0	0	0	3	14
Paints & Dyes	22	0	1	1	2	26
Industrial Chemicals	56	3	0	1	1	61
Agrochemcials & Fertilizers	34	4	1	7	1	40
Speciality Chemicals	46	1	1	1	7	57
Petrochemicals	19	3	1	1	2	26

2.6.2 New Investments

The statistics (**26**) released by the DIPP, Government of India from time to time provide an idea on the extent of investments attracted by the various sectors of the Indian industry. The chemical sector is the second most attractive industry in India for new investment proposals. The details are provided in Section 3.5 in Chapter 3 of this report. The Indian chemical sector attracted new investment proposals worth Rs 3,61,000 crores during 1991-05.

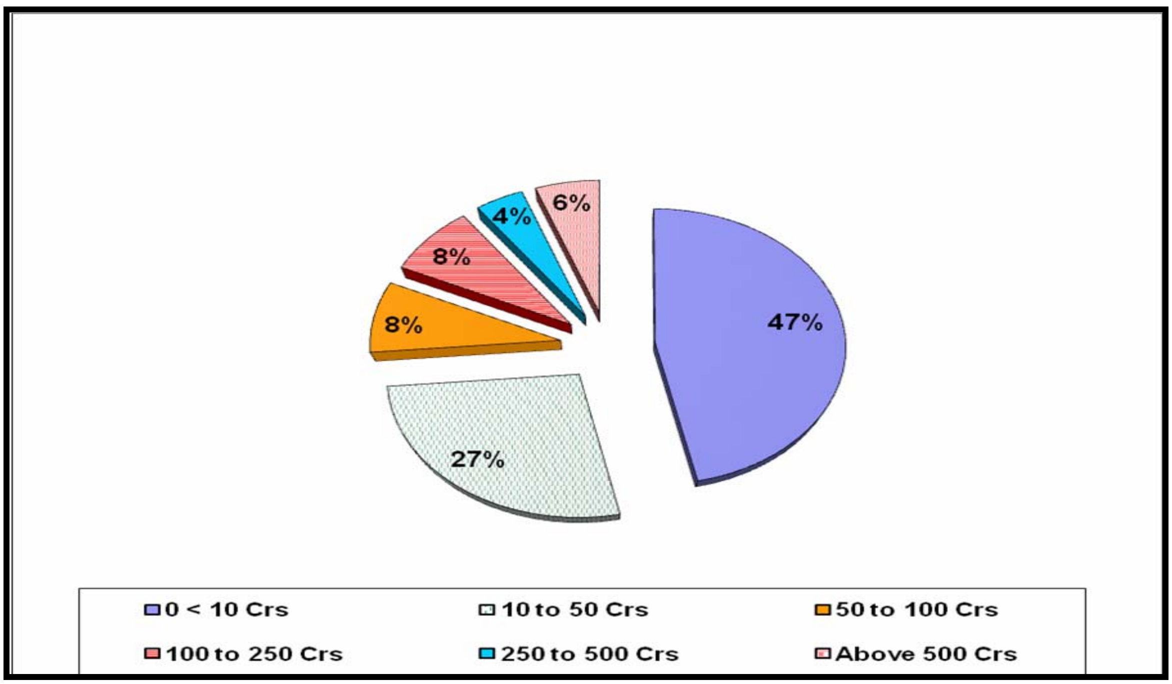

Fig. 2.5.1 : Percentage Distribution of Chemical Companies in various Turnover Zones (2009)

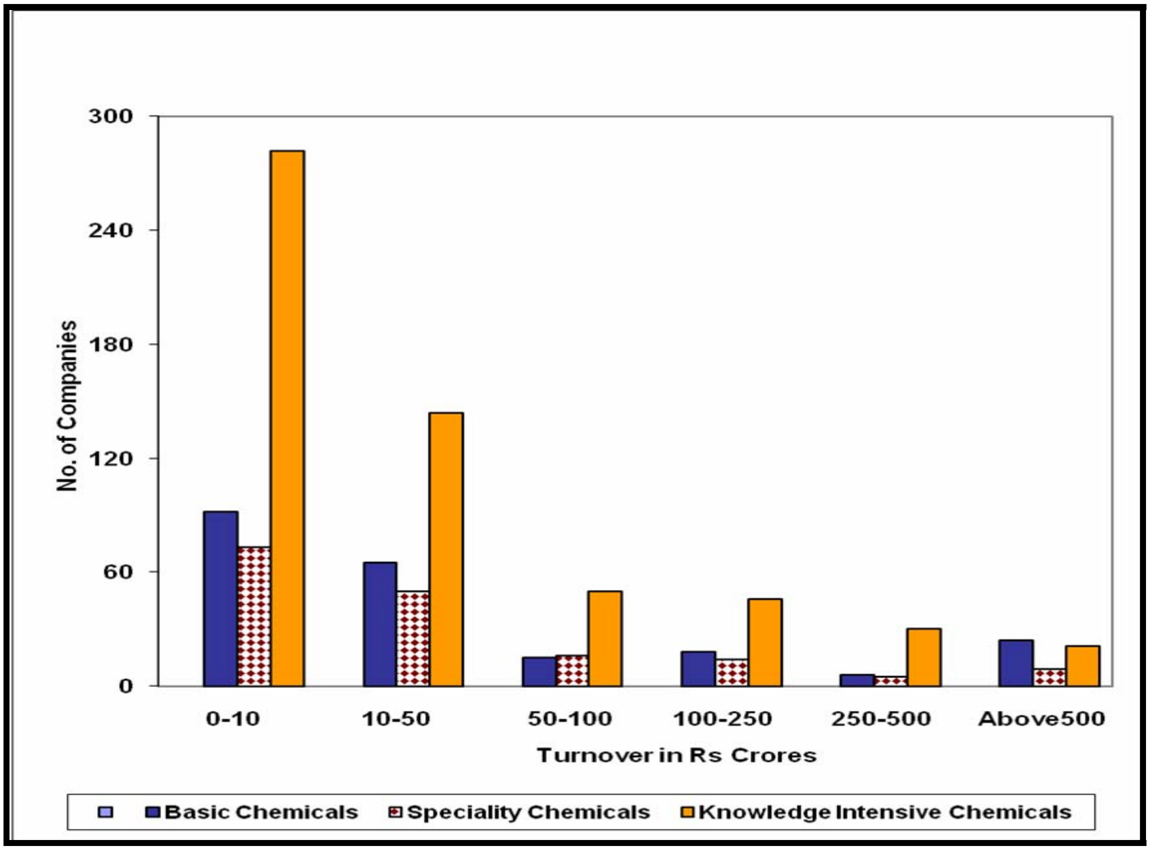

Fig. 2.5.2 : BC, SC and KI sector companies in various turnover zones

2.7. R&D in Indian Chemical Sector

2.7.1 Nature of R&D Inputs

The Indian chemical sector, right from its inception, has regarded S&T as a major source of its growth. The pool of scientific knowledge actually applied in its production activities, however, varies from sector to sector. In smaller chemical companies, the technological sources are mainly inhouse whereas in several medium and large scale companies, the technologies are being brought in through transfer from external including overseas agencies.

The total R&D expenditure made by the Indian chemical companies in both public and private sectors in 2008-09 is estimated to be Rs 7860 crores. It works out to be 3% of national R&D expenditure. This does not include the research grants provided by the government to R&D, academic and industrial establishments. Nearly 84% of chemical sector R&D expenditure has been incurred by the companies in knowledge intensive chemical sector with drugs / pharma accounting for nearly 60% of expenditure. The share of basic chemical sector is less than 13% and the speciality chemical sector accounting for less than 4%.

The major R&D expenditure made by the knowledge intensive chemical sector is on account of increased market power of drugs / pharma and biotech companies. Modern S&T application through R&D requires team work in well equipped laboratories under the umbrella of large number of research projects. Generally large medium and large companies have the necessary capability and strength to undertake such tasks.

The basic chemical sector requires R&D for its manufacturing process improvements to reduce costs and to boost downstream application demand. This sector had not made much headway in utilizing R&D for process intensification to achieve green processing. The speciality and knowledge intensive chemical sectors requires R&D for product improvement as well as orchestrate process innovations for cost savings. The Government of India has taken several initiatives to promote quality and quantity of Indian speciality chemical products. They include tax relaxation of upto 200% to industry if it outsources projects to academic institutions. The effect of such initiatives on Indian speciality chemical sector has been marginal.

2.7.2 Determinants for R&D Expenditure in Indian manufacturing sector

The decision to invest in R&D by Indian manufacturing companies depends upon several factors including their short or long term goals, viability and gestation period of their ongoing projects, profitability levels of their manufacturing activities and the market structure. The studies reported by D.A.Hay and D.J.Morris (**27**) have indicated the preferred route for R&D funding as the retained earnings of the companies rather than debt financing. They further stated that undertaking several projects in parallel by the companies may lead to a steady flow of innovations to undertake high risk R&D. K.Arrow (**28**) expressed the view that the competitive environment is a major factor for R&D promotion. While these studies are relevant to industries in developed countries, their applicability to developing countries is open to question. K.S.Sujit (**29**) analysed R&D investment under Indian context in 2004 and came to following conclusions:

- Most of the Indian R&D is of adaptive in nature and less innovative. The latter provides technological independence and strength in an increasingly competitive global environment.

- The factors that contribute to R&D investment varies with different industrial sectors. Industries in which products are differentiated by the market are generally high spenders of R&D.

- The manufacture appropriability is quite significant in Indian chemical sector. The R&D growth rate is slower upto a point and then rises faster than the rate of growth of its revenue. The probability of undertaking R&D in this sector is much higher as compared to other manufacturing industries in India.

- The R&D expenditure increases with size upto a certain point and then falls in Indian food processing sector. However, the probability of conducting research in this sector is relatively less as compared to other chemical subsectors. The advertisement intensity is very significant in this sector.

2.7.3 Technology Choices

The policies pursued by the Government of India in the post economic liberalization period have significantly enhanced the technology choices of Indian chemical companies. R. Basant (**30**) examined this issue and arrived at following conclusions:

- R&D and foreign technology licensing are neither perfect complements nor substitutes of each other.

- The firm size has the most significant impact on the choice of doing only R&D in chemical sector.

- Adaptive R&D induced by imports is not very significant in Indian chemical sector.

- Imports seem to significantly reduce the need to license technologies to produce them domestically by Indian chemical companies.

- Foreign Equity participation has improved the chances of licensing foreign technologies and combining them with their R&D efforts.

H.Katrak (**31**) examined whether import of technology by the Indian enterprises encourage or inhibit their in-house R&D efforts. Employing enterprise level data and analyzing through Chi-square Probit and multiple regression tests, he concluded that (a) R&D expenditures are higher among the technology importers than non importers and (b) the larger enterprises have proportionately lower R&D expenditure. A.B.Deolalikar et al., (**32**) made an econometric analysis of technology production and purchase in Indian industry. They concluded that use of overseas technology and local inventive activity are complementary to each other and the need to have a liberal technology import policy. The above studies are relevant o Indian chemical sector.

2.8. The Innovation Environment in India

Innovation, from industry viewpoint, has been defined (**33**) as an effort that needs the synergetic use of cumulative creative abilities of private enterprises, universities, research institutes, individual think tanks and the government agencies.

2.8.1 Innovation Climate in India vis-à-vis other countries

S.Mani (**34**) made a comparative analysis of the impact made by national S&T policies (fiscal and non-fiscal) of Singapore, South Africa, Malaysia, India and Brazil on the innovation in manufacturing companies considering various components of their knowledge generation systems. The fiscal measures consist of tax incentives to encourage R&D investments and grant in aid for research projects of industrial relevance. The non fiscal measures include promotion of human resource development and industry-academic linkages. Giving cognizance to the density of R&D scientists, high tech content of their exports and content of their innovation policies, he concluded that Singapore has an effective innovation policy which has continuously raising its research intensity. Eventhough South Africa and Malaysia have established a variety of research grants to stimulate R&D projects, they have not succeeded in making significant impact on account of shortage of appropriately qualified manpower. Typical data is given in **Table 2.8.1**. Though India and Brazil have a large pool of S&T manpower and research infrastructure, they are not readily and adequately available to manufacturing companies for doing R&D. They need to finetune their non-fiscal measures. As far as India is concerned, following observations as applicable for 1978-99 period are still relevant:

- Though a variety of direct and indirect tax incentives for R&D are available, they are poorly administered

- Research grants are aimed at technological self reliance and not global competitiveness

- Reasonably well articulated public policies exist for the development of venture capital programmes

- Non-fiscal instruments need to be strengthened.

The creation of innovation ecosystem is a complex issue from implementation angle since it requires coordinated efforts of various stakeholders in order to function effectively.

Table 2.8.1 : Innovation Ecosystems in 5 countries (1996)

		Singapore	Malaysia	India	South Africa	Brazil
1	**Density of R&D Scientists (No per 10,000 labor)**	56.3	5.1	8.24	20	7
2	**US patents granted**	54 (37)	7 (0)	22(50)*	67 (28)	37 (35)
3	**Hightech Exports (%)**	55.7	44.4	6.9	5.7	6.25

Note: Numbers in paranthesis indicate % share of local companies

**: Local companies + R&D institutes*

2.8.2 Key Elements and Corporate Perspectives

C.Herstatt et al., (**35**) studied the India's national innovation system in 2008, its key elements and corporate perspectives. They acknowledged the singularly positive role played by the Government of India in the formation of its innovation system. They identified major bottlenecks related to infrastructure and bureaucratic hurdles. Inspite of excellent credentials in S&T education, its fruits do not translate into industrially relevant R&D. A booming economy is also leading to shortage of qualified and experienced skilled workforce. India is also expressing inflationary wage growth and relatively high attrition rates. The massive investments being made by the Government of India in education and research is expected to resolve long standing bottlenecks in R&D. The Indian industry's positive attitude toward R&D is expected to aid this process.

Many positive steps have been taken in India in the recent past to promote long term growth of innovation. The liberal economic and government policies together with global and local competitions are sharpening the Indian innovation system which is still in nascent stage. In India still 75-80% of R&D is undertaken with government support, 20-25% by the private sector and around 3% by the Universities. Private R&D investments grew from USD 0.8 billion to USD 4.1 billion in 2004. Indian cities such as Bangalore, Delhi, Hyderabad, Pune and Mumbai have emerged as innovation clusters due to presence of high quality academic and R&D institutes, innovative companies, favourable state government policies, availability of specialist knowledge and improved infrastructure and financial resources.

2.8.3 Innovation Environment in Indian Chemical Sector

The Indian chemical industry is basically a S&T driven sector to develop a range of chemical building blocks and new and modified products for specific end uses and has the ability to execute quite complex chemical and biological transformations in an innovative fashion to synthesize them. Indian chemical industry, over a period of time, has developed the necessary technological skills and innovative practices to face the global challenges particularly in knowledge intensive sectors. This is inspite of the weaknesses in achieving R&D commercialization through industry – academic / R&D linkages. Major part of the SME sector has very limited access to high tech R&D. The globalization process has started in right earnest to integrate Indian economy with the world economy and WTO driven patent system has changed the demand side of Indian chemical innovation system. An integrated approach to infuse new dynamism is required in the supply side of the innovation system.

P.K.Sen and S.J.Chopra (**36**) studied the business driven innovation in chemical industry. They have observed that innovation in the chemical industry is more of a networking process. Maintenance of dynamic downstream linkages viz., marketing and customers and upstream linkages viz., and global research base are critical to the speed of innovation implementation process during a project execution. The speciality chemical sector illustrates the importance of networking for innovative knowledge generation.

The National Knowledge Commission (NKC) in its report (**37**) published in 2007 has made following observations which are relevant to Indian chemical sector:

- There is a clear indication that collaboration between industry and academic institutions enhances the innovativeness of the resulting outcome
- The small proportion of large companies and SMEs which partnered with government agencies for R&D commercialization have a significantly higher innovation intensity as compared to those without such partnerships
- Innovation intensity has an inverse relationship with the size of the firm i.e., SMEs have higher innovation intensity than large firms.
- Intellectual Property (IP) is a means of increasing innovativeness and large companies with 10-20 patent filings can be competitive with leaders on the global scale.

The recommendations made in this report have a strong bearing on the above observations of the NKC.

2.9 Indian S&T Policies and their impact on Indian Chemical Sector

An attempt has been made to broadly analyse the impact of Indian S&T policies on R&D and innovation of Indian chemical industry. India, after independence had recognized that S&T holds the key to the national prosperity and the effective combination of technology, feedstocks and capital provides the impetus to its industrial growth. The Government of India made three important contributions to the creation of a robust S&T policy framework viz., Science Policy Resolution (1958), Technology Policy Statement (1983) and Science and Technology Policy (2003). The dominating feature of Indian S&T policy framework has been the intense cultivation of S&T on a large scale and their application to meet the growing requirements of the common man.

2.9.1. Science Policy Resolution (1958)

The main objectives of this policy resolution is a) to promote, foster and sustain the cultivation of science through pure, applied and educational research (b) to ensure human resource development through training (c) to employ creative talent of Indian people in scientific activities and (d) to secure for people of India all benefits of science. It has enabled the establishment of scientific institutions of national eminence and promotion of HRD in chemical and allied sciences.

2.9.2. Technology Policy Statement (1983)

Its basic objective is to develop Indian technological capabilities through indigenous S&T development as well as efficient absorption and adoption of imported technologies appropriate to national priorities and resources. Provision has been made for attaining technological self reliance to reduce Indian vulnerability in strategic sectors, maximizing gainful employment to all strata of society, facilitating the use of traditional skills and capabilities of Indian artisans to make them commercially competitive, modernization of technology and infrastructure, priority to technologies with high export potential products and preservation of ecological balance.

The Indian chemical sector derived significant benefits from the above measures of Government of India in terms of strengthening its technological and R&D base in drugs / pharma, biotechnology, food processing and other sectors, establishment of centres of excellence in chemical and engineering sciences, strengthening project engineering capabilities of consulting agencies, recognition to inhouse R&D units of private sector companies, easier access to imported technologies in basic chemical sector and special efforts to enhance the diffusion of technology to the small and medium scale chemical companies.

2.9.3 Science and Technology Policy (2003)

Having come a long way since the enactment of above S&T policy resolution, the Science & Technology Policy (2003) of Government of India has been designed to make India a continuous innovator and creator of S&T intensive products and the Indian industry in a stronger position to engage itself with the global knowledge economy.

The policy provides for fostering scientific research and attracting bright talent for S&T careers, establishing centres of excellence of global standards, empowerment of women in all S&T activities, providing autonomy and freedom for academic / R&D institutions, use of S&T for national strategic needs, evolving mechanisms for technology development from concept to utilization and establishing IPR regime which maximize the incentives for IP generation, protection and utilization in public interest, using IT for S&T development, promoting international S&T cooperation in critical areas and integrating S&T knowledge in national governance.

The policy has helped to strengthen R&D commercialization systems, enhancing Indian contribution to patenting new knowledge in knowledge intensive sectors and in recognizing the need for innovation in R&D in Indian chemical sector. It has helped the chemical sector in deriving the benefits of product patenting.

2.9.4 New S&T Policy in offing

The Financial Express (**39**) reported that India is planning to develop a more suitable S&T policy to provide explicit encouragement to innovations. The Government may adopt a new strategy at the end of 11th Five year plan to enhance the economic impact of R&D and innovation led S&T growth during the 12th plan period. It is learnt that Gross R&D investment will form an important indicator of India's global competitiveness. The above report is based on the keynote address delivered by the Union Minister of S&T and Earth Science during the 97th Indian Science Congress.

Viewed from the above context, the findings of the INAE study will be of great value to the Government of India in formulating an innovation led S&T policy for enabling Indian industry to become an important contributor to global knowledge economy.

2.9.5 Ramification of Indian S&T Policies / Strategies in Post Liberalization Era

T.Jayaraman (**29**) surveyed the implications of science, technology and innovation policies pursued by India under the economic reform environment. In the pre-economic liberation era, S&T was one of the key elements of Indian economic growth. India developed it together the paradigm of self reliance for more than four decades after the independence. By 1980s, India had developed a strong S&T establishment with few parallels among the developing countries. The first science policy resolution of Government of India had little recognition of technology's complex interplay with economic factors as well as creation of our own knowledge base. At the later half of 1980s, certain degree of technological advance had taken place in India in areas where industrial growth had slowed down significantly. In areas like semiconductors, integrated circuits, pharmaceuticals and biotechnology, Indian innovation capabilities were found to be totally inadequate as compared to global technological advances.

The onset of economic reforms in early 1990s introduced a series of significant shifts in S&T policy framework and promotion of innovation. The concept of self reliance was set aside and initial thrust of reforms was directed towards the dismantling of control regime and licence raj. The integration of Indian patent system with WTO brought in a major growth in the IP through the process of internationalization. The onset of declining trend in Indian inventor contribution to its growth has become evident. A need has now arisen to take effective measures to enhance the Indian inventor contribution to IP being employed by the Indian chemical industry on par with some of the industrially advanced countries.

2.10 Overall Findings on the Current Status of Indian Chemical Industry

2.10.1 The past industrial surveys and present study undertaken by INAE have shown that Indian chemical industry has a turnover exceeding USD 60 billion, its total production touching 70 million metric tonnes / annum, a positive international trade, moderate FDI attraction capability and suboptimal overall R&D expenditure. The Indian drugs / pharmaceuticals is the only high technology sector where India has a marked presence (>5%) among the developed countries in the world. Its foreign equity participation is relatively higher than other chemical subsectors.

2.10.2 The economic performance based distribution of Indian chemical companies has shown that nearly 75% of chemical companies in organized sector have turnover less than Rs 50 crores. A sizeable number of them belong to speciality chemical sector category. Hardly 6% of Indian chemical companies have turnover greater than Rs 500 crores.

2.10.3 The major factors contributing to the suboptimal performance of Indian chemical subsectors have been identified as low economies of scale, inefficient processing, cheap imports, low capacity utilization, large global capacity additions, limited government funding for technology commercialization, lack of modern infrastructure, poor access to R&D facilities by SMEs and overdependence on imported speciality products due to their high development costs in India.

2.10.4 The chemical sector has been the second most attractive Indian industry for new investment proposals eventhough its ability to convert them into tangible assets is somewhat low. The R&D expenditure of Indian chemical sector is around 3% of national R&D expenditure. The drugs / pharma and biotechnology segments have contributed more than 84% to it. There is a strong need to enhance R&D expenditure in several segments of Indian chemical sector.

2.10.5 The S&T policies being pursued by the Indian government have benefitted the chemical industry in R&D commercialization, enhancing its innovation level and modernization of its infrastructure. The patent policy of the Government of India has boosted the internationalization of Indian R&D and patented IP. The worrying factor is the falling content of Indian invented IP.

2.10.6 Major changes are anticipated in the global chemical industry in terms of natural resource utilization and environment. Cross border investments, shifts in consumption patterns, changes in international regulatory intensity and demographic distortions. They have a strong bearing on the future growth of Indian chemical industry. R&D has to be the major player for propelling the Indian chemical industry to higher levels of innovation and creativity in the coming years.

2.10.7 Special studies are required on the following subjects to take appropriate measures to improve R&D performance of Indian chemical sector:

- ***Nature of government incentives and policies to promote the growth of R&D companies in speciality and knowledge intensive chemical sector***
- ***Improving R&D and innovation environment in Indian chemical SMEs***
- ***Type of driving forces needed for forging sustainable industry-academic linkages for product development in speciality chemical sector***

The studies may be sponsored to academic and / or management institutes in the country.

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Chapter 3 R&D INTENSITY, INVESTMENT AND FDI TRENDS

The R&D Intensity (R&DI) provides the key metric for assessment of business outcomes, innovation ability and capacity to change as per competitive market demands of an industrial sector. Adequate attention has not been given to R&DI studies in the Indian chemical industry.

An attempt has been made in this chapter to study R&DI growth trends of Indian chemical industry and its subsectors and its impact on technology intensive exports / imports, FDI inflows and firm size and turnover. A survey of recently reported literature has also been made to assess the state of knowledges on this subject.

In the second part of this chapter, the INAE team made a R&DI study based on reported Indian chemical company performances in various turnover zones during 2000-09. It shows that except for drugs / pharma and organic chemical companies, R&DI is moderately sensitive to company sizes and their turnovers. Mobility of companies from lower to higher turnover zones has been noticed during the above period indicating a positive growth trend. Areas which require further studies have been identified

The third part of this chapter covers the extent of R&D expenditure made by the various subsectors of Indian chemical industry and its impact on their overall growth. It also traces the FDI growth profiles of Indian chemical sector vis-à-vis other industrial sectors, its FDI economy links and the role played by MNC-R&D centres in the growth of Indian chemical industry.

3. R&D INTENSITY, INVESTMENT AND TRENDS

3.0 Preamble

In a globalized economy, R&D Intensity (R&DI) at industry as well as firm levels provides the key metric for the assessment of business outcomes, innovation ability and capacity to change as per competitive market demands of an industrial sector. In simple terms, the R&DI is the ratio (in percentage) of a manufacturing or service company's R&D expenditure to its turnover or revenue. The reported evidence suggests that R&DI within an industry is remarkably consistent and can be employed as a strong tool for attracting Foreign Director Investment (FDI), for enhancing its competence in high tech international trade and for acting as a driving force for higher performance levels. The INAE team has noted the inadequate attention being given to R&DI studies in Indian chemical sector. An attempt is, therefore, made in this chapter to study R&DI and its growth trends in Indian chemical sector at overall industry and sectoral levels, its influence on international chemical trade and generating necessary resources to enhance their productivity and R&D investing abilities. Efforts have also been made to assess the Indian chemical industry's ability to attract FDI in view of its importance on the capitalization of Indian chemical market.

3.0.1 Reported Studies on R&DI and Company Size, Age and Performance

The relationship between R&DI and company performance attributes has been studied by several researchers through emperial and semiemperical analysis. H.Itami and Numagami (**1**) studied the dynamic interaction between R&D strategy and technology and concluded that the technological capabilities created by R&D provide the main driving force to gain competitive advantage as dictated by the growing markets. N.Capon et al., (**2**) discussed the positive relationship between R&D expenditure and a company's growth and profits. On the other hand, M.A.Hitt et al., (**3**) discovered a negative relationship between them quoting examples of successful firms taking lower risks by investing less in R&D. Interestingly, not many studies have been reported on the relationship between R&D intensity and technological success achieved by SMEs.

O.J.Borch et al., (**4**) employed empirical studies to emphasize the relevance of company age and size for technology and growth strategies. The company life cycle can play a significant role for formulating technology strategies. Their studies also suggested that the different stages in the development of technology based companies call for specific levels of R&D intensity to sustain growth and profitability. It means that R&D portfolios may have to be suitably tailored for different outcomes. Recently R.Wohr et al., (**5**) assessed the interaction between R&D intensity and the company age with evidence from technology based German companies. A curvilinear relationship between R&D Intensity and company growth was suggested since high growth companies have a very low R&D intensity. They concluded that over the time, the positive effect of R&D on sales growth decreases and even turns negative. For the technology driven companies, at a median age of 15 years, they experience their second or third growth phases.

Generally higher R&D intensity will have a positive impact on trade balance. The higher R&D investment will contribute to better quality products which in turn can propel higher sales. At the same time, due to increased technological capability of the company, it reduces imports. **Fig 3.0.1** shows the positive impact of R&DI of Indian pharma sector on its trade balance. A significant increase in surplus trade balance has occurred during 1990-03 when R&DI increased from 0.3 to 4.0.

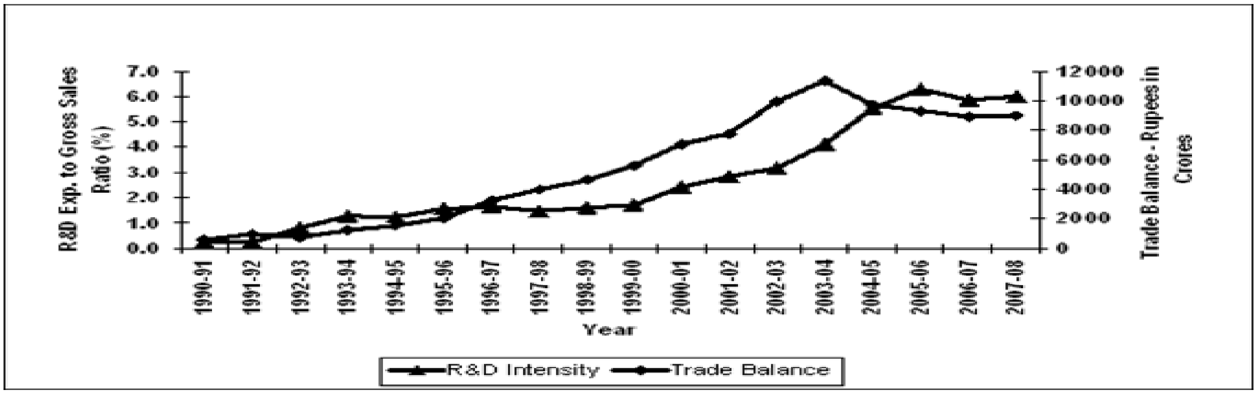


Figure 3.0.1 : R&DI vis a vis Trade Balance of Indian Pharma Sector

Technology as Determinant for R&DI

R&DI of high tech industries is reported (**6**) to be distinctly higher than that of their low tech counterparts. **Table 3.0.1** compares the R&D intensity of industrial sectors at four technological levels in high (Sweden) and moderate R&D spending countries (Spain and Ireland). It clearly shows the increase in R&DI as the industry becomes more advanced technologically. It also shows that R&DI of companies in different countries in the same industrial sector may vary according to the relative importance enjoyed by them at national level and the technological status prevailing in the concerned industrial segment.

Table 3.0.1: R&D Intensity of Industrial Sectors at Various Technological Levels

Industry Segments	**Countries**		
	Sweden	**Spain**	**Ireland**
High Tech			
• Aerospace	13.6	12.7	-
• Pharma	19.2	3.4	2.1
• Telecom	9.4	4.7	4.6
• Medical Instrumentation	8.1	1.7	1.6
Medium – High Tech			
• Electrical	2.5	1.1	2.1
• Auto	5.6	0.6	1.9
• Chemicals	2.1	0.7	0.2
• Machinery	3.6	1.1	1.4
Medium – Low Tech			
• Rubber / Plastics	1.2	0.6	1.1
• Non metallics	0.6	0.2	0.5
• Metals / Products	0.9	0.2	0.5
Low Tech			
• Paper	0.6	0.1	0.1
• Food	0.4	0.1	0.3
• Textiles	0.5	0.2	0.5
TOTAL	**3.9**	**0.6**	**0.8**

D.L. Deeds (**7**) examined the relationship between R&DI of a high tech venture and its technology absorptive capacity with pharma sector as an example. He identified three distinct components of S&T capabilities viz., internal S&T, technical development and interactive capabilities with external scientific community as important factors for technology absorption. It has long been acknowledged that a company's ability to access external knowledge sources is critical to enhance its ability to innovate. His studies showed that the market rewards based on R&D during the early stages of technology development provide the foundation for the later stage wealth generating outcomes. Technology absorptive capacity enhances the productivity of a company's R&D investment. It enables it to readjust its portfolio of R&D projects to avoid repetition of failures.

The subject of R&DI impact on new product development is relevant to knowledge intensive segments of chemical sector like pharmaceuticals, bioproducts and agrochemicals. R.O. Chao etal., (**10**) studied R&D Intensity and its relationship with NPD portfolios. They concluded that a proper alignment between R&D intensity and NPD portfolio strategy determines a company's competitive performance.

Effect of Foreign Acquisitions on R&DI

The 1990's witnessed a new wave of mergers and acquisitions in all industrial sectors which was unprecedented in terms of its size and coverage. It enhanced the magnitude of crossborder operations and nearly 80% of FDI was acquired in many countries during this period. The relationship between foreign acquisitions and R&D was examined by O.Betrand (**8**) with respect to overseas R&D of multinational enterprises. He concluded that increasing internationalization of R&D activities will reflect in a shift in the role of overseas R&D viz., from the local production support role to adjusting their products and technologies to the global and regional market needs. He also found that the foreign acquisitions can have long term impact on R&D budgets of the local units to undertake higher level of inhouse as well as contract R&D by networking with local research institutes and universities.

3.1 Chemical R&DI in Advanced and Emerging Economies

Globally, more than 80% of chemical R&D occurs in just five countries viz., USA, Japan, Germany, France and U.K. Their overall R&D intensity is around 3.5% of sales. The R&D expenditure in OECD countries has kept pace with their GDP growth since 2001. It stands at about 2.75% of overall GDP.

Europe: The R&DI for all Industrial Sectors in Europe has remained fairly stable at 1.8 – 1.9% during 1995 – 05 (**9**). Its performance is below its main competitors such as USA (2.67%) and Japan (3.17%). It is interesting to note that public sector in EU has invested on much higher scale than that of Japan and 20% less as compared to USA. The R&DI related to GDP is similar in Europe and USA. However, there is a marked difference in the structure of EU industrial companies as compared to those from USA. They are endowed with much lower number of high tech companies and accordingly lower R&DI levels. Their SME's spend 50% lower R&D expenditure as compared to those from USA.

The chemical research in R&D centres and universities in EU leads in number of scientific publications but have less number of citations in science disciplines as compared to USA. However the citation value of their chemical engineering publications is similar to that of USA. In Europe, venture capital is not utilized enough for early stage financing of startups. More has to be done to improve the mechanism of technology transfer through public – private partnerships.

USA**:** The average R&DI of all companies in USA reached its highest reported level of 4.2% in 2001. Since then R&DI has varied between 3.5 – 3.9%. The US chemical industry incurred R&D expenditure of USD 43 billion in 2005. Little of R&D in the US chemical industry is funded by the government. In terms of R&D performance, the largest industry within the chemical sector is pharmaceuticals (USD 34.8 billion). A sizeable amount of biotechnology R&D serves the pharmaceutical industry.

Japan: The R&D in Japan is both inventive as well as adaptive in nature with more emphasis on design and development while most of the other developed countries deal with innovative R&D through basic or applied research. The data presented below shows the Japanese R&D expenditure and intensity of their overseas subsidiaries. It is quite in contrast with the domestic R&D utilization pattern. The numbers in parantheses indicate adaptive R&D component.

Year	**R & D Expenditure billion Yen**	**R & D Intensity %**
1996	268 (138)	0.23 (0.12)
1998	402 (256)	0.32 (0.21)
2001	499 (349)	0.28 (0.20)

Comparison of R&DI in EU, USA and Japan

The relative R&Di performance of EU, USA and Japan has been reported by the EU industrial R&D investment score board (**11, 12**), as reproduced in **Table. 3.1.1,** shows that the pharmaceutical sector registered the highest R&DI (15.7%) in all the countries followed by the software and IT services (9.8%) in EU and USA. The other high growth R&DI sectors are technology hardware (8,6%), leisure goods (6.5%) and health care equipments / services (6.8%). The R&DI of European basic chemical industry is much higher than that of USA and equivalent to Japan. It has been decreasing marginally in the last 10years. Basic Chemicals, which require a rather low investment in research, represents almost 60% of sales of the European chemical Industry. Due to large multinational presence along the value chain, the corporate R&D is more concentrated in the large companies.

The R&DI growth trends for EU, USA and Japan are shown in **Fig.3.1.1**. While Japanese industry has been showing a declining R&D growth during 2003-08, the EU and US companies have shown a flat profile during 2006-08. The US consistently maintained higher R&DI as compared to EU and Japan in all S&T sectors.

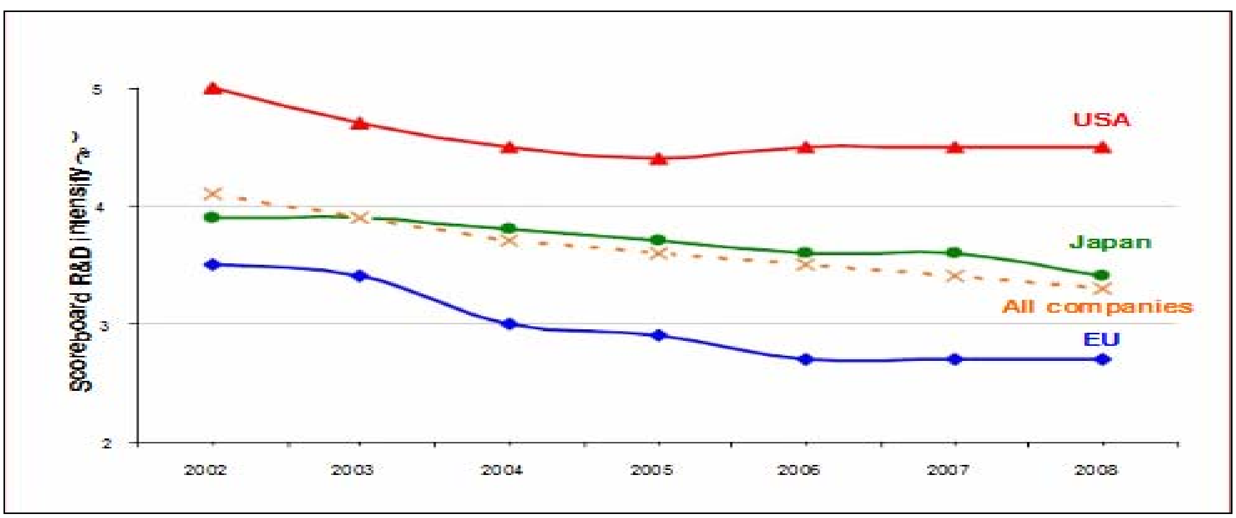


Fig.3.1.1: R&DI growth trends in EU, USA and Japan (2002-08)

Table 3.1.1: **R&D Intensity of Various Industrial Sectors in EU, USA and JAPAN**

Sl.No.	Sector	R&D Intensity, %		
		EU	USA	JAPAN
1.	**Pharma**	**15.7**	**16.7**	**15.9**
2.	Software IT	9.8	10.6	4.8
3	Tech Hardware	8.6	9.6	5.3
4.	Health Care	6.8	7.8	5.0
5.	Electricals / Electronics	4.4	3.8	5.3
6.	Automobile	4.1	3.9	4.1
7.	**Basic Chemicals**	**3.1**	**2.4**	**3.2**
8.	Industrial Engineering	2.7	2.4	2.7
9	**Food Processing**	**2.2**	**0.9**	**2.3**
10.	**Oil / Gas Production**	**0.3**	**0.2**	**0.2**

China* and *South Korea

S Korea is known for its openness to knowledge and Korean companies rapidly adapt themselves to global technology changes to compete in fast moving markets. It has been reported (**13**) that R&DI of S Korea in 2006 was 3.2% as compared to 1.5% achieved by China. The reported weaknesses of S Korea are in establishing inter-institutional linkages and its ability to internationalize S&T activities. The R&DI as a percentage of GDP in China has increased from 0.6% in 1995 to 1.35% in 2005 and is expected to reach 2% in 2020. The government is investing heavily in S&T related infrastructure for basic research, technology incubation and knowledge clusters. The weaknesses of its system are in interinstitutional and industry-university linkages, technology transfer mechanisms and venture capital funding.

Global R&D Spending Trends

The 2010 Global R&D forecast made by Battalle Analysts (**15**) foresees an increase in the global R&D by 4% largely driven by China and India (**Table 3.2.1**) which in turn contribute to a 7.5% increase in Asian R&D. They have also foreseen that the increasing amount of debt burden being faced by the USA and Europe is likely to limit their general economic and R&D growth capabilities. Viewed from this background, the future R&D contribution of India and China are likely to be on the ascending path particularly in case of knowledge intensive and speciality chemical sectors.

Table 3.2.1 : Global R&D Spending Trends(2008-10)

Country / Region	R&D as % of GDP		*GERD, USDB*		Govt's R&D Contribution, %
	2008	**2010**	**2008**	**2010**	
• USA	2.79	2.85	397.6	401.9	30
• Brazil	NA	0.91	18.1	18.6	NA
• China	1.28	1.50	102.3	141.4	24
• Japan	3.41	3.41	147.8	142.0	18
• India	0.80	0.9	26.7	33.3	80
❖ Americas	2.28	2.32	448.1	452.8	
❖ Europe	1.69	1.69	278.8	268.5	
❖ Asia	1.91	1.95	359.0	400.4	
❖ Rest World	1.21	1.23	35.9	34.8	

GERD: Gross Domestic Expenditure on R&D; USDB: USD Billion

3.2. R&DI of Indian Chemical Sector

S.Bhattacharya etal., (**17**) analysed Indian economic performance since 1991 to assess the growth of knowledge intensive entrepreneurship in the post liberalization period viz., 1991-2007. The Indian private sector has become more dynamic in the globally competitive markets as indicated by:

(a) The export intensity of Indian private firms increased from 8 to 25%

(b) Notable progress has been achieved in overseas acquisitions

(c) Emergence of significant number of Indian knowledge intensive firms in IT, BT and PT sectors.

3.2.1 R&DI Growth Profiles

The INAE project team compiled extensive chemical company performance data from **CMIE-PROWESS** Database to assess the overall and sectoral R&DI growth trends over a long period. **Fig.3.2.1**. shows the average R&DI growth profile from 1980 to 2008. It shows a fall in R&DI from 0.95% to 0.52% during 1980-02 possibly due to uneven growth experienced by Indian domestic companies and initial adverse impact of Indian globalization efforts. From 2003 onwards, the R&DI maintained a steady growth to reach 0.89% by 2007-08.

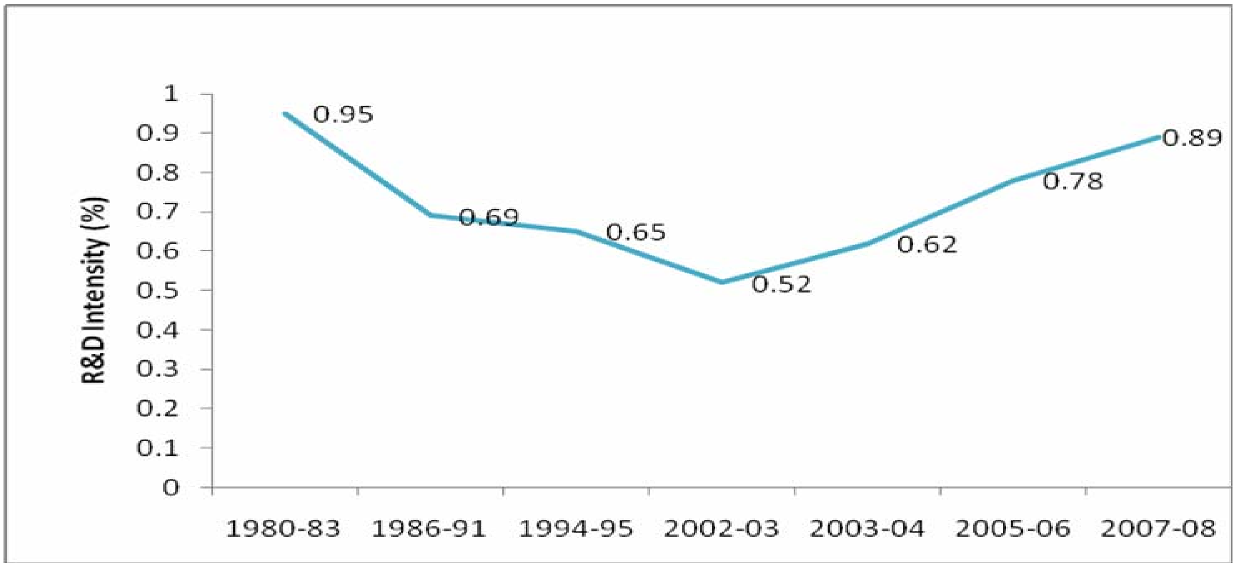


Fig. 3.2.1 : Overall R&DI Growth Profile of Indian Chemical Sector (1980-08)

Table 3.2.2 : R&DI of Chemical and Pharmaceutical Sectors in India, EU, USA and Japan (2008-09)

Percentage

Sector	EU	USA	JAPAN	INDIA
Chemical	3.1	2.4	3.2	0.9
Pharma	15.7	16.7	15.9	4.5

The major contribution to its growth is from the knowledge intensive chemical sector. **Table 3.2.2** shows the R&DI of chemical and pharma sector units from EU, USA, Japan and India during 2008-09. It indicates the relatively poor Indian R&DI performance in both sectors as compared to the above countries. Apart from technological factors, the R&D cost structure and low level of R&D investment to turnover of Indian units are responsible for this trend.

Fig.3.2.2 shows the sectoral R&DI trends of Indian chemical industry. The wide differene between R&DI of knowledge intensive and other two segments is very much evident. The R&DI of Indian speciality chemical companies has maintained a moderate growth during 2001-08 around 1% value. The basic chemical sector has shown higher growth during this period though at a lower R&DI base value.

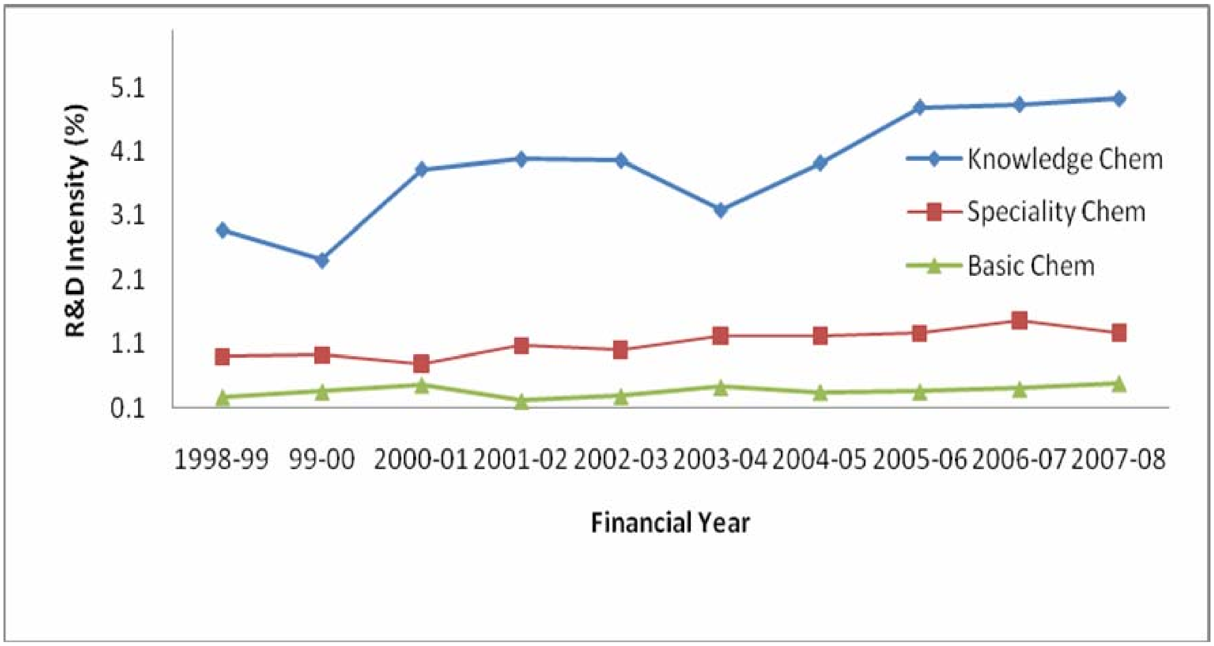


Fig. 3.2.2 : R&D Intensity of Knowledge, Speciality and Basic Chemical Sectors (1998-08)

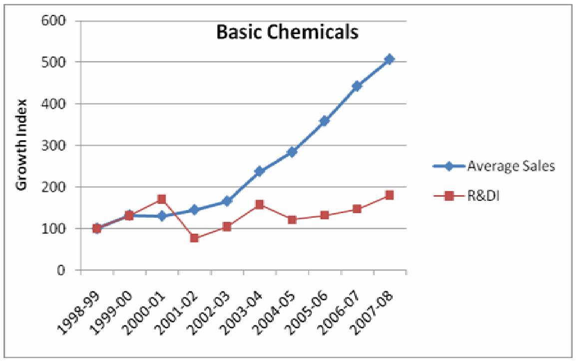
3.2.2. R&DI of Top Performing Chemical Companies

Employing CMIE-PROWESS Database, the INAE team has selected 61 top Indian chemical companies **(Table 3.2.3)** in basic, speciality and knowledge intensive chemical sectors to assess their R&DI performance. It is characterized by steep R&D expenditure per company in basic and knowledge intensive chemical sectors as comapred to speciality chemical sector.

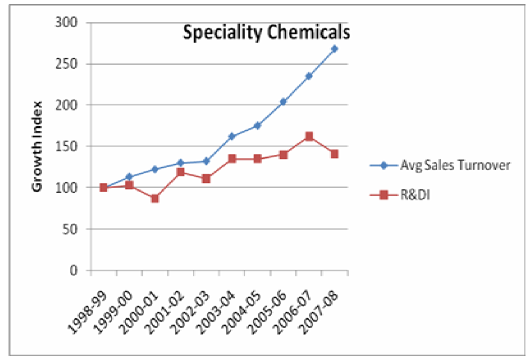
Table 3.2.3 : Average Sales and R&D Expenditure of the selected Companies

Sector	No.of Companies	Sales / Co., Rs. crores		R&D exp/ Co Rs. crores	
		1998	2008	1998	2008
Basic	18	795	4,041	2.16	18.30
Speciality	16	538	743	4.85	7.44
Knowledge Intensives	27	363	726	9.93	32.74

Fig.3.2.3 provides R&DI profiles for top performers in these sectors for 1998-08.



(a)



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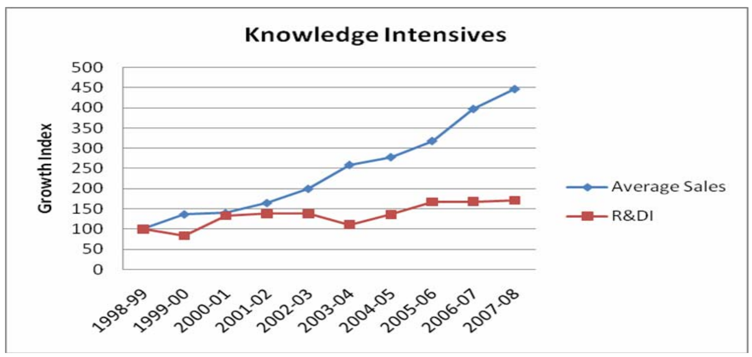


(c)

Fig. 3.2.3: Sectoral R&DI Growth Trends in Indian Chemical Sector

Basic Chemical sector:

The overall R&DI of this segment has risen gradually over the last ten years except for a spike in 2001-02 to become double by 2008. The low level of R&DI is due to the fact that only a fraction of the total sales is spent on research and development (R&D). The growth indices of average sales and R&DI as shown in **Fig.3.2.3a** indicate the widening gap between them from 2003-04 onwards with the average turnover maintaining a steep rise during 2003-08. It indicates the comfortable resource position for investing in R&D but lack of adequate driving forces to achieve it.

Speciality chemical sector

The R&D intensity of this segment has increased within a narrow band during 2001-08. This shows that even the top performers in this segment have not invested adequately in R&D eventhough the speciality chemical sector demands significant level of product oriented R&D. Regarding its R&DI growth index as shown in **Fig.3.2.3b** relative to that of sales turnover, the widening gulf between them is noticeable from 2003-04 onwards. The recent global meltdown had a major impact on the growth of this sector.

Knowledge Intensive Chemical sector

This is the fastest growing segment of the Indian chemical industry contributing to more than 25% of the turnover of the Indian chemical industry. Pharmaceutical, agrochemical and biotechnology companies are the main players with a CAGR of 13-14% during 2008-09. **Fig.3.2.3c** indicates the impressive R&DI growth of this sector. It climbed significantly from 2003-04 to 2005-06. However, a slower R&DI growth is observed during 2006-08. The R&DI during 1998-08 varied from2 .73 to 4.15%. Even, in this segment, the R&D expenditure has not maintained a growth rate commensurate with the high growth observed in turnover of the top performing companies.

It can be broadly concluded from the above analysis that Indian chemical companies have just started investing in R&D after 2000. The widening gap between the growth indices of R&DI and turnover is a common feature in all three segments of Indian chemical industry. The gap in R&DI between India and industrially advanced countries continues to be substantial in all of them.

3.3. Turnover - R&DI Relationship in Indian Chemical sector

VK Kaul (**19**) analyzed the relationship between company size, turnover and intensity in case of 385 Indian chemical companies for the period 1997 - 02. His overall findings were:

- The companies with turnover exceeding Rs 500 crores have doubled
- Approximately 55% of companies have not reported any R&D Expenditure
- Less than 5.45% companies incurred R&D expenditure exceeding 3% of sales.

The above studies did not examine the sectoral performances of chemical companies. An attempt is, accordingly, made in the present study to examine this aspect with 2009 as the reference year. To facilitate this, 251 chemical companies affiliated to basic, speciality and knowledge intensive segments have been selected from CMIE's Prowess Database. Their turnovers range from less than Rs 10 crores to greater than Rs 500 crores. For convenience, they have been placed in six turnover zones as was done by V K Kaul.

The **Tables 3.3.1 and 3.3.2** present the turnover and R&D expenditure data pertaining to 251 Indian companies covering fertilizers, organics, paints and dyes, cosmetics, agrochemicals and drugs / pharmaceutical areas for 2000, 2005 and 2009 spread over six turnover zones. The main focus of the R&DI analysis is on differentiation of company performances in various turnover zones, the relationship between company size and R&D intensity and the mobility of the companies within the six identified turnover zones. The term 'mobility' is used to indicate the enhancement of a company turnover.

3.3.1 Subsectoral Performances

Fertilizers**:** It is one of the less R&D intensive sectors of Indian chemical industry. More than 50% of the 26 selected companies have reported turnovers greater than Rs 500 crores in their Annual Reports in 2009. The R&D intensity is extremely low even in companies with turnover exceeding Rs 100 crores per annum. There is no reported R&D expenditure by the companies with less than Rs 100 crores turnover. There is no appreciable forward movement of fertilizer companies to the higher turnover zones during 2000-09.

***Organics** :*

The 41 selected companies in this sector have low to moderate R&D intensity. Very negligible or no R&D expenditure has been reported for companies having less than Rs.10 Crores / annum turnover. Several companies have shown positive trends in R&D Intensity during 2000-09 period. There is a definite forward mobility of companies from lower to higher turnover ranges. For example, in the year 2000, 29 companies were in less than Rs 100 crores turnover bracket and their number has come down to 15 in 2009 since 14 of them have advanced to higher turnover zones. All companies with annual turnover greater than Rs 250 crores in 2009 have exhibited positive growth in R&D intensity.

***Paints and Dyes**:*

The 28 companies which were selected for the study fall under the speciality chemical sector. More than 55% of them have annual turnover exceeding Rs 100 crores. The lack of R&D spending is evident in companies with turnover less than Rs 10 crores per annum. The R&D performance indicators have shown positive values in all the listed companies with turnovers exceeding Rs 250 crores. There is, however, no significant forward movement of these companies from lower to higher turnover zones during 2000-09.

***Cosmetics**:*

This is a sector with relatively low R&D intensity. Even in 2009, most of the top performers in this sector have not made much R&D expenditure eventhough their turnover touched Rs 50 crores. More than 50% of the selected companies have annual turnover greater than Rs 250 crores in 2009. The companies whose annual turnover exceeding Rs 500 crores during 2000-09 have maintained a stagnant R&DI. No forward mobility has been noticed in this class of companies into higher turnover zones.

Table: 3.3.1: A Sectoral Analysis of Firm Size and R&DI Growth

TOP RANGE Rs Crore / YEAR	**<10**				**10-50**				**50-100**				**100-250**				**250-500**				**>500**			
	NU	TOR	RDE	RDI	NU	TOR	RDE	RDI	NU	TOR	RDE	RDI	NU	TOR	RDE	RDI	NU	TOR	RDE	RDI	NU	TOR X10^{-3}	RDE	RDI
1. FERTILIZERS	**BASIC CHEMICAL SECTOR**																							
(26 Units)																								
2000	1	4.2	0	0	7	221	0	0	2	135	0	0	1	115	0	0	1	294	1.4	0.46	14	22.6	22	0.1
2005	1	1.4	0	0	8	241	0.1	0.04	1	72	0	0	2	354	0.8	0.2	-	-	-	-	14	32.7	30	0.09
2009	2	7.0	0	0	2	39	0	0	3	218	0	0	3	410	0.8	0.19	3	1018	2.6	0.25	13	75.8	43	0.06
AVERAGE/UNIT 2000 VIS A VIS 2009		-VE				-VE				+VE				+VE		St		+VE		-VE		+VE	+VE	-VE
2. ORGANICS	**BASIC CHEMICAL SECTOR**																							
(41 Units)																								
2000	7	45.5	0.05	0.11	18	555	3.4	0.62	4	346	4.6	1.3	7	1188	6.8	0.57	3	1067	5.7	0.53	2	1.16	0.3	0.03
2005	3	10.3	0	0	11	309	0.9	0.28	11	848	1.6	0.19	5	816	8.0	0.97	3	1070	3.9	0.36	8	6.21	41.5	0.67
2009	4	22.6	0	0	6	191	0.33	0.17	5	345	0.66	0.19	10	1661	12.6	0.76	7	2640	27	1.02	9	9.42	167	1.7
AVERAGE/UNIT 2000 VIS A VIS 2009		-VE	-VE	-VE		-VE	-VE	-VE		-VE	-VE	-VE			+VE	+VE		+VE	+VE	+VE		+VE	+VE	+VE
3. **PAINTS AND DYES** (28 Units)	**SPECIALITY CHEMICALS SECTOR**																							
2000	3	20.3	0.01	0.05	9	270	0.94	0.35	2	156	0.52	0.33	7	1169	7.73	0.66	2	751	1.5	0.2	5	3.77	23.9	0.63
2005	4	30.9	0.07	0.22	7	204	0.8	0.39	3	185	0.05	0.02	4	616	2.8	0.45	4	1338	10.3	0.77	6	6.97	37.5	0.53
2009	5	29.5	0	0	6	196	0.53	0.27	1	55	0.04	0.07	7	1505	3.9	0.26	2	854	7.8	0.9	7	12.97	87.3	0.67
AVERAGE/UNIT 2000 VIS A VIS 2009		-VE	-VE	-VE		+VE	-VE	-VE		-VE	-VE	-VE		+VE	-VE	-VE		+VE	+VE	+VE		+VE	+VE	+VE

4. **COSMETICS** (15 Units) **SPECIALITY CHEMICALS SECTOR**

2000	1	3.4	0	0	2	56	0.38	0.68	4	246	0.03	0.01	2	215	0	0	2	856	6.4	0.75	4	12.11	43.8	0.36
2005	2	13.1	0.43	3.28	2	49.4	0.07	0.14	2	145	0.17	0.12	3	541	0.65	0.12	-	-	-	-	6	13.27	45.9	0.35
2009	1	6.5	0	0	1	35.4	0	0	3	232	1.77	0.76	2	388	0.08	0.02	1	375	0	0	7	25.8	96.3	0.37
AVERAGE/UNIT 2000 VIS A VIS 2009		+VE	-VE	-VE		+VE	-VE	-VE		+VE	+VE	+VE		+VE	+VE	+VE		-VE	-VE	-VE		+VE	+VE	St

5. **DRUGS /PHARMA** (120 Units) **KNOWLEDGE INTENSIVE CHEMICAL SECTOR**

2000	27	108	0.79	0.73	38	903	5.85	0.65	18	1335	5.93	0.44	18	2786	52.4	1.88	13	4794	123	2.56	6	5.2	142	2.73
2005	21	89.5	0.14	0.16	35	872	16.7	1.91	11	723	7.07	0.98	23	3643	89.1	2.4	13	4243	134	3.16	17	18.5	1599	8.65
2009	22	76.6	0.44	0.57	26	697	15.17	2.17	10	805	7.66	0.95	16	2206	44.6	2.02	15	4959	165	3.32	29	38.5	3593	9.33
AVERAGE/UNIT 2000 VIS A VIS 2009		-VE	-VE	-VE		+VE	+VE	+VE		+VE	+VE	+VE		-VE	-VE	+VE		-VE	+VE	+VE		+VE	+VE	+VE

6. AGRO-CHEMICALS (21 Units)	**KNOWLEDGE INTENSIVE CHEMICAL SECTOR**																							
2000	3	16.9	0.09	0.53	6	178	0.23	0.13	3	195	0.61	0.31	4	533	1.46	0.27	2	854	8.1	0.94	3	2.8	19.8	0.7
2005	1	3.9	0.06	1.53	7	157	0.12	0.08	2	129	0.04	0.03	4	715	4.12	0.57	4	1328	4.35	0.32	3	1.95	18.0	0.92
2009	3	10.2	0.1	0.98	5	70	0.33	0.47	1	90	0.49	0.46	2	332	1.54	0.46	6	2164	14.2	0.65	4	4.26	18.2	0.42
AVERAGE/UNIT 2000 vs 2009		-VE	+VE	+VE		-VE	+VE	+VE		+VE	+VE	+VE		+VE	+VE	+VE		+VE	-VE	-VE		+VE	-VE	-VE

TOR : Annual Turnover, Rs Crores NU: No. of Units RDE: Annual R&D Expenditure, Rs Crores St: Stationary RDI: R&D Intensity, %

Source : CMIE's PROWESS Data Base

Table 3.3.2: Turnover Zones in Indian Chemical Sector with Positive R&DI Growth

	<10			10-50			50-100			100-250			250-500			>500		
Fertilizers	-Ve			-Ve			-Ve			136.6	0.19	3	-Ve			-Ve		
										13.55	-0.005 St	1						
Organics	-Ve			-Ve			-Ve			166.1	0.76	10	377	1.0	7	1046	1.7	9
										3.4	2.9	7	9.48	6.76	3	23.29	49.73	2
Paints & Dyes	-Ve			-Ve			55	0.07	1	-Ve			427	0.9	2	1852	0.67	7
							*-21.54	28.47	3				1.29	16.23	2	13.15	0.006	5
Cosmetics	-Ve			-Ve			77.3	0.76	3	194	0.02	2	-Ve			3686	0.37	7
							-0.006	4.42	4	-6.43	7@	3				7.85	0.002	4
Drugs/Pharma	3.48	0.51	22	26.8	2.17	26	80.5	0.95	10	137.8	2.02	16	330.6	3.32	15	1327	9.33	29
	-3.06	28.92	21	-02.5	12.81	38	-04.9	08.00	18	-02.3	0.007	18	0.003	02.6	13	22.16	13.07	6
Agrochemicals	3.4	0.98	3	14	0.47	5	90	0.54	1	166	0.46	2	360.6	0.65	6	-Ve		
	-4.9	6.3	3	-8.9	13.7	6	-7.4	5.7	3	-4.6	5.47	4	10.25	15.22	4			

@ = Arithmetic average

LEGEND

Avg Turnover Rs.Crores	*R&DI (2009)%*	*No.of Units (2009)*
CAGR % (2000-09)	*CAGR % (2000-09)*	*No. of Units (2000)*

Yellow: **2005-09**

White: **2000-09**

Drugs and Pharmaceuticals

This is one of the best performing sectors in the Indian chemical industry and the present analysis confirms this. All selected companies with less than Rs 10 crores to greater than Rs 500 crores turnover have incurred R&D expenditure during 2000-09. They have registered positive R&D performance indicators. Nearly 50% of the selected companies have registered more than Rs 100 crores turnover in 2009 as against Rs 50 crores in 2000. There is a very strong forward mobility of pharma companies to higher turnover zones with number of companies in Rs500+ crores turnover range nearly trebling. They have registered very impressive rise in R&D intensity compared to all other Indian chemical companies.

Agrochemicals

As in the case of drugs and pharmaceuticals, companies covering all six turnover regions have made R&D expenditure eventhough their R&D intensity is relatively low with somewhat sluggish growth. Nearly 50% of the selected agrochemical companies have annual turnover exceeding Rs 100 crores. A moderate forward movement is noticeable with doubling of the companies with Rs 250+ crores turnover. It is interesting to note that the companies in Rs 50-250 crores regions have registered better performance indicators as compared to their counterparts in higher turnover regions. The major concern in agrochemical sector has been the slow growth in R&D intensity as compared to drugs / pharma and biotechnology subsectors in knowledge intensive chemical segment.

3.3.2 Overall Growth Comparisons (1997-09)

The **Table 3.3.3** compares overall growth registered by the Indian chemical companies during two specific period viz.,1997-02 and 2000-09. It shows that the significant drop in number of companies which have not incurred any R&D expenditure during 2000-09 period. It also shows the significant increase in the growth of companies which have incurred R&D expenditure exceeding 3% over sales.

Table 3.3.3: Chemical Companies Then and Now (1997-09)

S.No	Item	Studies by Kaul etal., (1997-2002)	Present Studies (2000-09)
1	Companies with Turnover >Rs 500	Doubled	Doubled
2	Cos which have not incurred any R&D Exp	55%	7
3	Companies which incurred R&D expenditure of 3% over their sales	5.45	17.5%
	No. of companies analysed	385	251

3.3.4 Sensitivity of R&DI to Turnover Increase

Fig.3.3.1 presents the R&DI vs turnover profiles for fertilizers organics, paints / dyes, cosmetics, drugs / pharma and agrochemical sectors of the Indian chemical industry. It clearly shows that except for drugs / pharma and to some extent organic chemical sector, R&D intensity is moderately sensitive to turnover increase. The earlier studies reported in Section 3.0.1 highlight the need to study the above behavior pattern in terms of the role of company life cycle, R&D portfolio selection, R&D relationship with company age and its growth profile. Such a study can be sponsored.

3.3.5 Upward and Downward Movement of Indian Chemical Companies on Turnover Scale

Fig.3.3.2 shows the status of 251 companies in 2000 and 2009 in three consolidated turnover zones. **Table.3.3.4** provides the relevant data on upward and downward movement of these companies on turnover scale. It is preferably read in conjunction with **Table 3.3.2**. It shows that: (i) among the 251 selected chemcial companies belonging to basic, speciality and knowledge intensive sectors, nearly 20% i.e., 49 companies have entered the three higher turnover zones covering Rs.100 crores and above from lower turnover zones. The two biggest gainers among the companies in turnover zones are those in Rs.500 crores and above and Rs.100-250 crores.

The mobility of companies from lower to higher turnover zones indicates their growing economic stature. On the other hand, their downward movement points to their declining turnover performance level.

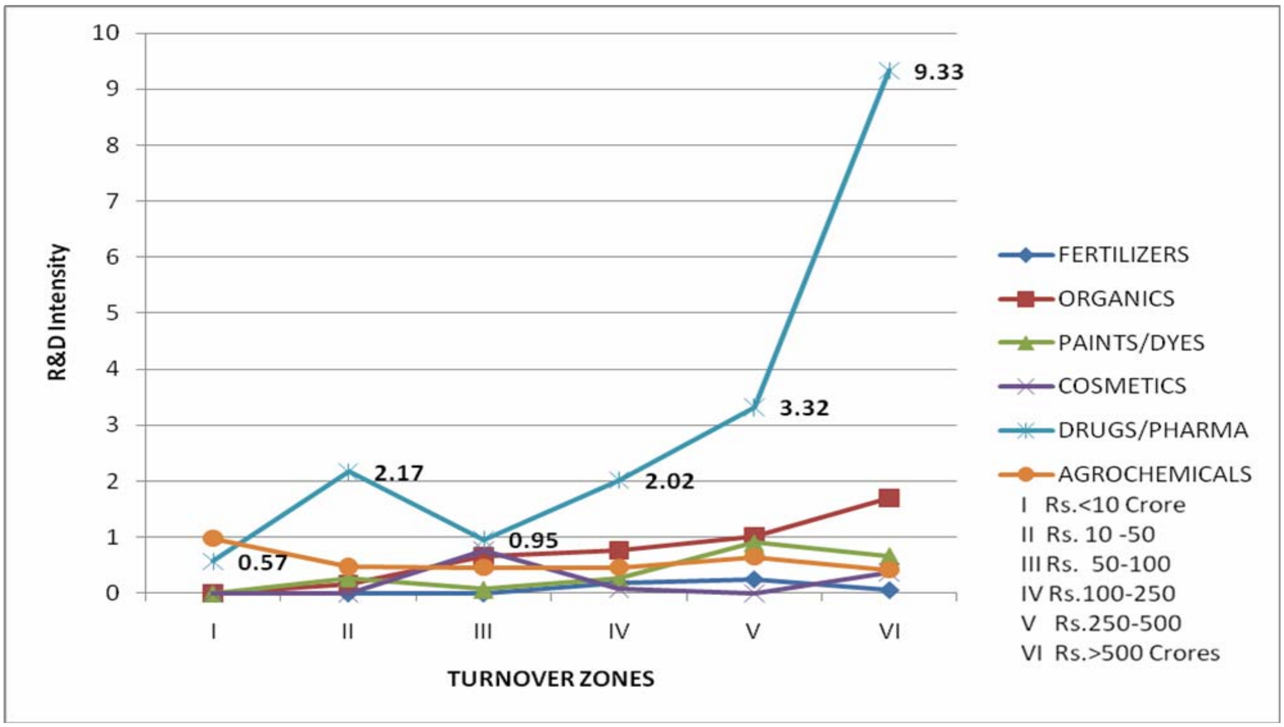


Fig.3.3.1: R&D Intensity in various turnover zones

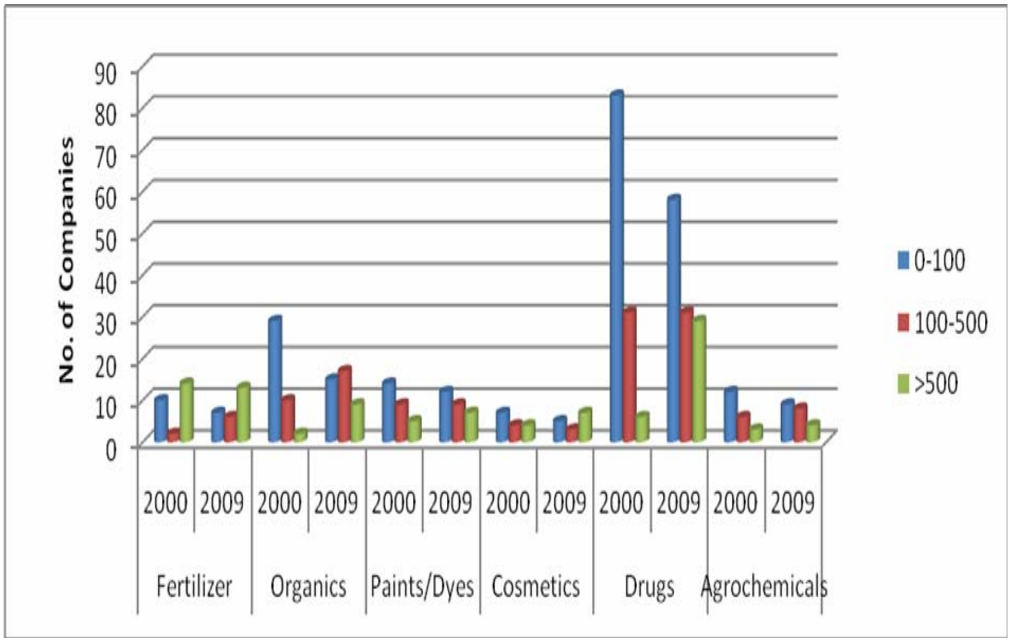


Fig.3.3.2: Status of Chemical Companies in 2000 and 2009 in 6 subsectors

The cumulative effect of the data presented in **Table 3.3.4** shows:

- Significant increase in number of companeis in 3 top turnover zones with biggest gains noted in Rs 100-250 and Rs >500 crore zones.
- No. of chemical companies in the three lower turover zones have declined by 12-42%
- The speciality chemical sector companies have shown negative growth trends in four turnover zones.

Table 3.3.4 : Forward and Backward Mobilities of Chemical Companies (2000-09)

Sl.No.	No. of Companies in 2000	**Turnover Zones (Rs. Crores)**					
		<10	10-50	50-100	100-250	250-500	>500
1	• BC (67) • % increase (+) / decresase (-) in 2009	8 25 (-)	25 68 (-)	6 33 (+)	8 63 (+)	4 150 (+)	16 38 (+)
2	• SC (43) • % increase (+) / decrease (-) in 2009	4 50 (+)	11 36 (-)	6 33 (-)	9 0	4 25 (-)	9 55 (+)
3	• KI (141) • % increase (+) / decrease (-) in 2009	30 17 (-)	44 30 (-)	21 48 (-)	22 18 (-)	15 40 (+)	9 267 (+)
4	• Chemical Sector • % increase (+) / decrease (-) in 2009	42 12 (-)	80 42 (-)	33 30 (-)	39 97 (+)	23 18 (+)	34 103 (+)

3.4 R&D Spending in Indian Chemical Sector

3.4.1 Indian Potential

R&D represents creative S&T work undertaken to generate new knowledge and relevant S&T competencies to produce industrial products which can enhance the quality of life of people. The common factor of Industrialized economies in the world is their ability to mobilize attractive R&D investments from private sector for developing innovative products and processes for the global markets. The situation is, however, quite different in developing economies with almost 70 – 80 % of R&D investments provided by the government. As far as India is concerned, the protectionist barriers that existed till late 1990's did not provide any driving force in real terms for the private sector to invest significantly in R&D. Also Indian manufacturing companies operated in a much smaller scales of operations as compared to MNC's in developed nations. Their size has not permitted them to invest substantially till 1990's.

There has been significant change in Indian Industry since last 15years. With the liberalization of economy and the policy measures which were initiated in the 1990's, greater integration is being made with world economy and global footprints of several Indian companies are becoming visible. Indian companies in sectors like electronics, pharmaceuticals, bio-technology and specialities have started investing larger proportion of their profits in R&D.

A report on the S&T progress made in India was recently published by NISTADS, (**16**) covering S&T trends, human resources, financing, infrastructure, resource inputs and patents, inclusive growth of rural Indian sector and allied subjects. The present study has drawn relevant information from this document. The factors which can drive the Indian chemical industry towards larger R&D investment and expenditure are:

- The Indian economy, the 4th largest after USA, Japan and China, has fared rather poorly on R&D spending but has the potential to create higher value for their technologies.

- The increase in R&D growth and intellectual property gains being made in China and India are not likely to show any declining trend in the near future.

- Growing realization on the need to strengthen R&D further for the very survival of the industry under intense global competition, to meet huge domestic market demand potential, to develop alternatives to not easily available imported technologies and to meet the higher percapita consumption of public utility chemical products

- The MNC established R&D centres in India can provide useful benchmarks for Indian R&D groups to adopt. The case in point are the R&D centres of DuPont, GE, Dow Chemical's etc.,

3.4.2 Major Sources of Support for Indian R&D

The Government continues to be the major source of R&D funding in India as compared to many developed / developing countries. The nominal and real GERD growth rates have declined in India since liberalization of its economy in 1991. The statistics presented in **Table 3.4.1** show the overdependency of Indian industry on the government for R&D funding as compared to a developing country like Brazil. The situation is gradually transforming in India as far as the private investment is concerned.

Table 3.4.1: Distribution of R&D Sources *percentage*:

	Government	Industry	Others
India	74.7	23.0	2.3
Brazil	60.2	38.2	1.6
China	33.4	56.6	6.3
Japan	17.7	74.5	7.5
Germany	31.1	66.1	0.4
USA	31.2	63.1	5.7

Employing Prowess database (CMIE), S. Bhattacharya etal., (**17**) evaluated the R&D investments made by overseas companies in India in all R&D disciplines during 1990 – 2006. It shows that the R&D expenditure incurred by Indian Companies registered a sharp increase during 2000 – 05 followed by a fall during 2005 – 06 and the R&D expenditure by foreign companies in India during 1997 - 06 has been more or less stagnant.

Fig.3.4.1 shows the R&D expenditure incurred by Indian chemical companies and their ownership during 2006-07. The Business groups lead both in terms of their numbers and quantum of R&D expenditure. In terms of ownership, the Indian business groups have established nearly 62% of the Companies alongwith R&D facilities followed by Indian private (16%), public (16%) and overseas private (6%) investors.

3.4.3 Growth of Chemical Companies Served by R&D Units:

S. Bhattacharya etal., (**17**) sampled and analysed 1055 Indian Companies in all S&T sectors having their own R&D facilities from a population of 10,000 Companies that had made R&D investments during 2006 – 07. He noted that chemical companies (349) constituted nearly 33% of them. **Table 3.4.2** shows their distribution as a function of incorporation year. The period 1981 – 90 witnessed the establishment of maximum number of chemical companies which undertook their own R&D. However, their growth rate fell in subsequent years. In terms of regional distribution of Indian Companies in all sectors, the western region in India accounts for 40% followed by south 25%, north 23%, and east 12%. It will be interesting to study their long term impact on R&D budgets of domestic companies.

Table 3.4.2: Growth of R&D driven Indian Chemical companies:

Incorporation year	No. of Companies from all sectors	% share of Chemical Companies	Growth
1900 and before	20	30	**Low**
1901 – 50	163	30	**High**
1951 – 60	102	23.5	**Moderate**
1961 – 70	128	25.0	**- do -**
1971 – 80	152	32.9	**- do -**
1981 – 90	278	40.3	**High**
1991 – 95	128	38.4	**- do -**
1996 – 2000	66	30.3	**Moderate**
2001 – 2005	18	33.3	**Low**
2006 – 2007	3	66.7	**- do -**

The Indian private sector has started displaying necessary dynamism in investing in new expansions/ventures to meet the global market demands. The following are indicators:

- R&D investment by business enterprises now accounts for 28% of GERD as compared to 14% in1991.

- 8 to 25% increase in the export intensity of Indian private companies
- Good progress was made (**40**) in overseas acquisitions as indicated in **Fig.3.4.2**
- Emergence of significant number of Indian knowledge intensive firms in IT, BT and PT sectors.

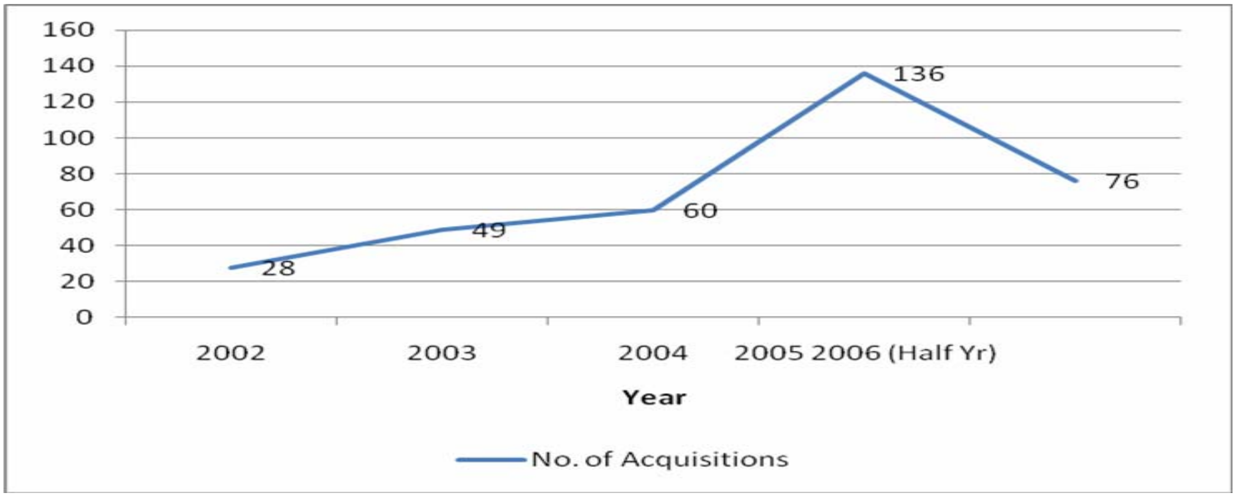


Fig.3.4.2: Overseas Companies acquired by Indian Chemical Companies

3.5 Investment Growth Pattern in Indian Chemical Sector

Several manufacturing industries in the world are growing faster in emerging economies than elsewhere. This has created a greenfield opportunity for new assets creation for manufacturing, design engineering, R&D, marketing and human capability enhancement. During 2003-08, Indian manufacturing companies both domestic and foreign based multinationals have added about 27% to total capital stock. Due to depreciation and technical obsolescence of property, plant and equipments, more than 60% of total capital stock in Indian manufacturing sector is due for new investments that did not exist five years earlier. A Chaudhuri etal., (**14**) reported the worth of greenfield investments in Indian manufacturing industries as Rs 300,000 cores in 2004-05 with nearly Rs 200,000 crores as the present worth of old investments. The greenfield investments were of the order of Rs.30,000 crores in 2000-01. The manufacturing output of Indian industry maintained an annual growth rate in the region of 8-12% during 2001-07. They also reported that investment growth rates lag behind revenue generation in India in several Indian industrial sectors since they are sacrificing long term growth prospects to gain short term profitability and cashflows. Limited access to external finance, land, infrastructural bottlenecks and allied factors are also responsible.

The total investment stock of Indian Chemical sector is reported (**18**) to be approximately Rs 2,61,600 crores and the total employment around one million during 2005-06. **Table 3.5.1** shows the annual investment vis a vis sales growth in Indian chemical sector during 2002-06. A downward trend can be noticed during 2002-05. Firm size and capital productivity and its intensity account for the variation in investment growth in this sector. Currently, the per capita consumption of chemical products in India is about 10% of the world average, highlighting the potential for further growth in domestic demand. It is projected that if all chemical companies with their growth below the chemical industry average level achieve the industry average level, their annual average investment growth will touch 40%. Even this projection looks modest if the projected annual average investment growth of Indian electronics sector of 72% is compared.

Table 3.5.1:Turnover vs Investment in Indian Chemical Sector (2002-06)

	Investment Rs Crores	Turnover / Investment	% Annual Growth
2002	12,600	0.72	NA
2003	13,140	0.71	4.3
2004	12,770	0.64	-2.8
2005	14,140	0.56	10.8
2006	17,700	0.68	25.2

From the chemical industry investment statistics collected from various sources, the INAE team estimated the cumulative investment made by the Indian chemical industry including food processing, pharmaceutical and biotechnology sectors as per 110,000^{+} crores during 2000-10. **Fig.3.5.1**. shows the percentage share of its subsectors.

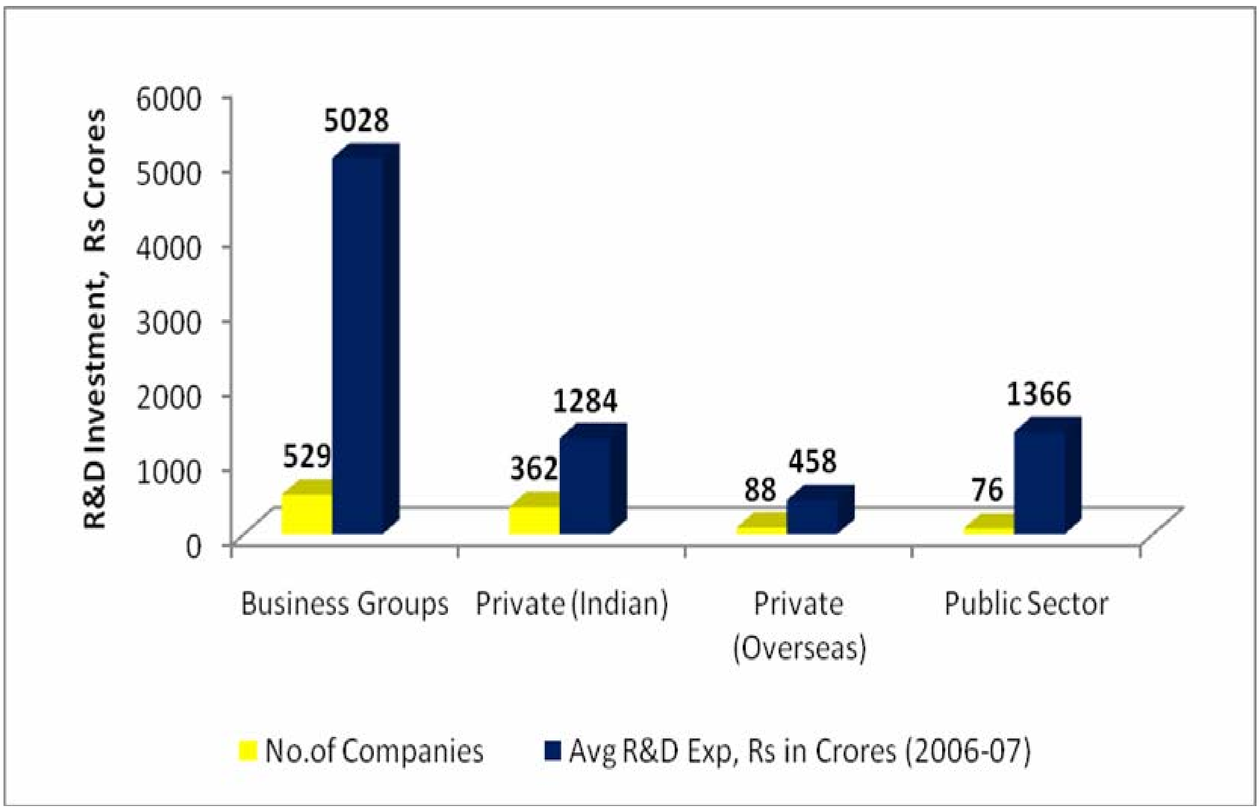


Fig.3.4.1: R&D Expenditure / Ownership of Indian Chemical Companies (2006-07)

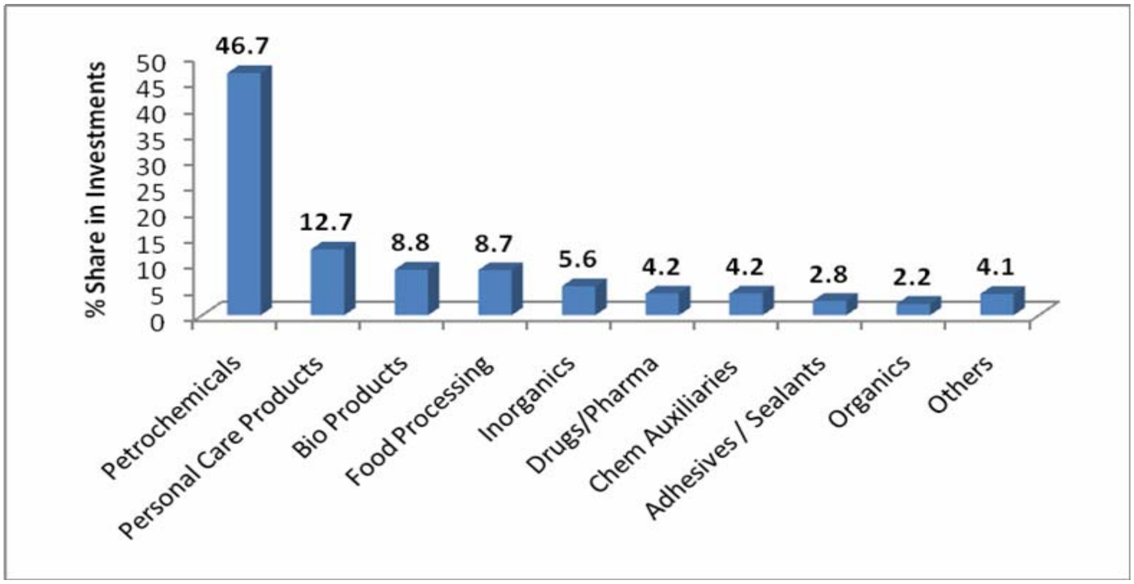


Fig.3.5.1.Percent Share of investments made by the indian Chemical sector (2000-10)

Attractions of New Investments

From the statistics made available by the DIPP, Government of India, the Indian chemical industry attracted 24.8% of total Indian investment proposals during 1991-05. These include the Industrial Entrepreneur Memoranda (IEMS), Letters of Intent (LOIs) and Direct Industrial Licenses (DILs). The chemical sector performance is shown in **Tables 3.5.2 and 3.5.3**. The basic chemical sector attracted the maximum (69.3%) while the knowledge intensive chemical sector attracted the least (11.1%). However, the Indian chemical sector had attracted less than 3% share in Indian investment projects implemented through loans from banks and financial Institutions (FI) during 2004-05. It is further dropped to 1.5% in 2006-07 eventhough the quantum of investment increased by 46%. The infrastructure sector had attracted the maximum share.

There is a need to study the factors responsible for low capitalization of Indian chemical industry in general and three sectors in particular.

Table: 3.5.2 : New Investment Proposals from the Indian Chemical Sector (1991-05)

Sector	IEMs	LOIs+DILs	Total	Share %
Basic Chemicals				**Rs Crores**
• **Chemicals**	1,91,051	34,048	2,25,099	
• **Fertilizers**	25,374	Nil	25,374	
Sub Total	2,16,425	34,048	2,50,473	**69.3**
Speciality Chemicals				
• **Food Processing**	38,209	2,246	40,455	
• **Vegetable Oil**	22,439	96	22,535	
• **Soaps/Cosmetics**	6,320	120	6,440	
• **Glue & Gelatin**	833	0	833	
• **Dye Stuffs**	440	51	491	
Sub Total	68,241	2,513	70,754	**19.6**
Knowledge Intensive				
• **Pharma**	16,432	5,804	22,236	
• **Fermentation**	16,321	1,271	17,592	
Sub Total	32,753	7,075	39,828	**11.1**
Total	**3,94,227**	**57,103**	**3,61,055**	**100**

Table 3.5.3 : **Distribution of Indian Investment Projects**

Sectors	2004-05		2006-07		
	Project cost, Rs. crores	% Share	Project cost Rs. crores	% Share	Growth %
• **Infrastructure**	31,294	33.3	101,744	35.9	225
• **Metals / Products**	27,331	29.1	39,876	14.1	46
• **Textiles**	7,458	8.0	25,933	9.2	247
• **Transport(s)**	4,201	4.5	1,561	0.5	-ve
• **Cement**	3,642	3.9	10,567	3.7	190
• **Chemicals**	2,822	3.0	4,136	1.5	85

3.6. Foreign Direct Investment (FDI) in Indian Industry

Foreign Direct Investment (FDI) plays an important role in the globalization process of a country. While domestic investments add to the capital stock in an industrial economy, FDI plays a complementary role in overall capital formation. While the quantity of FDI is important, equally important is its quality. Two important studies (**26,30**) in the recent past have shown the growing attractiveness of India as an overseas investment destination with Indian economy expected to grow at a rate greater than 5% till 2050. India, accordingly, ranks as the second most attractive destination after China with USA at number three. The total FDI inflows into India stood at USD 33 billion in 2008 showing a healthy growth rate of 43% over 2007. It is the objective of INAE study to assess the contribution of Indian chemical sector in attracting FDI and the nature of its utilization. To place the analysis in proper perspective, the FDI acquisition of Indian chemical sector is compared with that from other Indian industrial sectors. The Indian FDI performance in relation to other developing and developed countries is also examined to assess its global dimensions.

3.6.1 *Determinants for FDI Growth in Indian Industry*

The most prominent aspect of globalization in India since 1990 has been the integration of production and financial markets with trade and investment as the prime moving force. Attracting Foreign Direct Investment (FDI) has been one of the core features of Indian globalization process. R.K.Sahoo (**20**) studied FDI and its influence on the growth of manufacturing sector during post reforms period in India. He saw the potential of food, chemicals and drugs / pharma sectors for attracting sizeable FDI stocks as well as inflows. S.Chatterjee (**21**) made a sectoral economic analysis of FDI in India. Very recently G.P.Sharma (**22**) analyzed FDI inflows, its basic determinants and the nature of investors. His analysis clearly shows the suboptimal performance of India in attracting FDI. S.K.Safiuddin (**23**) made an assessment of opportunities and benefits of FDI inflows into India. He identified the high potential of Indian pharma sector in attracting FDI in view of its varied functions covering contract manufacturing, clinical research, vaccine and drug development and medical diagnostics. J. W. Cho (**24**) identified following important determinants of FDI: Stable macroeconomic and political environment

- Availalbility of physical / technical infrastructure and industrial clustering
- Human Resource availability in quality and quantity

- Development of SME Capabilities
- Adequately addressing environmental and social concerns
- Reducing restrictive business practices
- Investment incentives
- Larger market creation through regional and bilateral collaborations
- Protection of investment and intellectual property rights.

In highly competitive global markets, the ability to attract high quality FDI needs a variety of niche investment products. Development of differentiated and efficient industrial clusters that offer real and identifiable locational advantages to international investors is very essential. The typical Indian examples are Bengaluru IT cluster and Genome Valley biotech cluster near Hyderabad city. To set up such technology intensive clusters, highly coordinated policies (single window type) across administrative and political level are required.

N.S.Siddhartan et al (**29**) studied the technology transfer and import of capital goods in chemical, electrical and electronics, automotive and machinery industries in India covering 294 companies. They concluded that:

- Intrafirm transfer of technology through FDI is preferred in cases in which while technology licensing is preferred when technology can be transferred through designs and drawings.
- The Indian chemical industry did not adequately derive the benefits of FDI in importing capital goods as in the case of electrical, electronics and automobile sectors.

3.6.2 Indian FDI and Export Growth Profiles

The INAE team assessed the normalized growth profiles of FDI and Indian exports / imports to understand their inter relationship. **Fig.3.6.1(a)** shows the growth indices of Indian FDI and exports from all Industrial sectors for 1990-09 with 1993-94 as the base year. While FDI growth profile nearly rose by 16 times during 1993-06, the Indian exports rose by 7 times during the same period. The divergence between these profiles increased much more steeply during 2006-09. The impact of FDI on Indian exports can be gauged by the change in composition of Indian exports (**Figs.3.6.1(b))** as reported by the DSIR-IIFT report on Technology Exports (**25**). It clearly shows that Indian medium and high technology intensive exports as a percentage of total manufactured exports grew from 22.2% in 2002-03 to 40.4% in 2007-08 with total exports registering 130% growth during the same period. It also shows that FDI is being mainly channelled into manufacturing sector with a fairly large share (**Fig.3.6.1C**). It increased from USD 1.64 billion with a share of 17.6% in 2006-07 to USD 4.78 billion in 2008-09 with a share of 21%. A spurt in FDI outflows is also noticed during this period as Indian companies started establishing production, marketing and distribution, major R&D investments in knowledge intensive industrial sectors and joint industry – academic initiatives in high tech areas. The routes adopted for FDI inflows into India are highlighted in **Table 3.6.2**.

Indian FDI Performance Indicators

Following indicators are employed to assess a country's openness to FDI:

i. Percent FDI/GDP ratio

ii. FDI as a percent of Gross Fixed Capital Formation (GFCF)

iii. Inward FDI Performance Index(IFPEI)

iv. Inward FDI Potential (IFPOI)

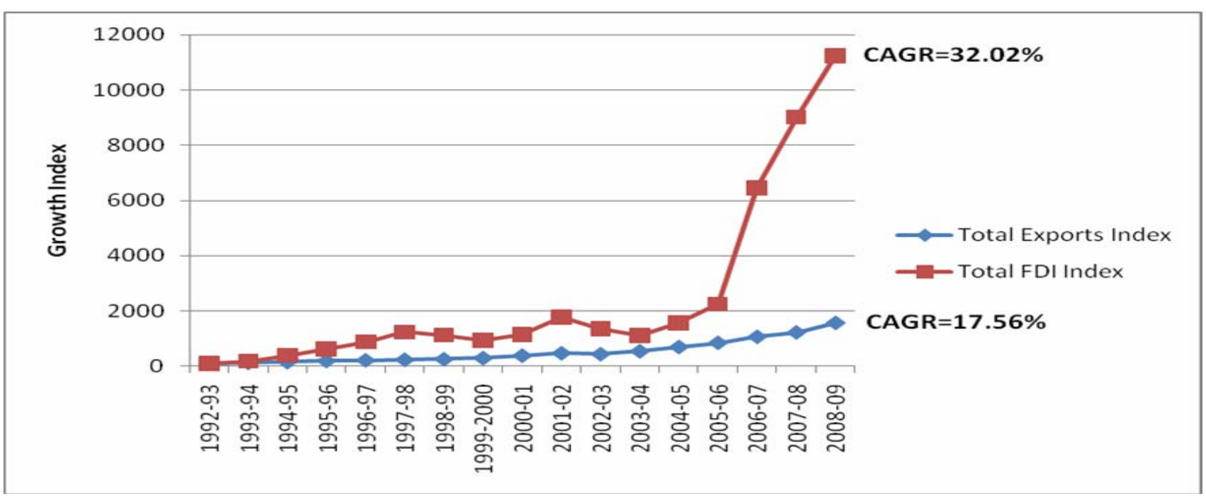
Table 3.6.1 : Routes adopted for FDI inflows into India (2008-09)

		%Share
a)	FIPB / RBI / Acquisition Route	77.7
b)	Equity Capital of Unincorporated Bodies	1.9
c)	Reinvested Earnings	18.3
d)	Other Capital formation routes	2.1

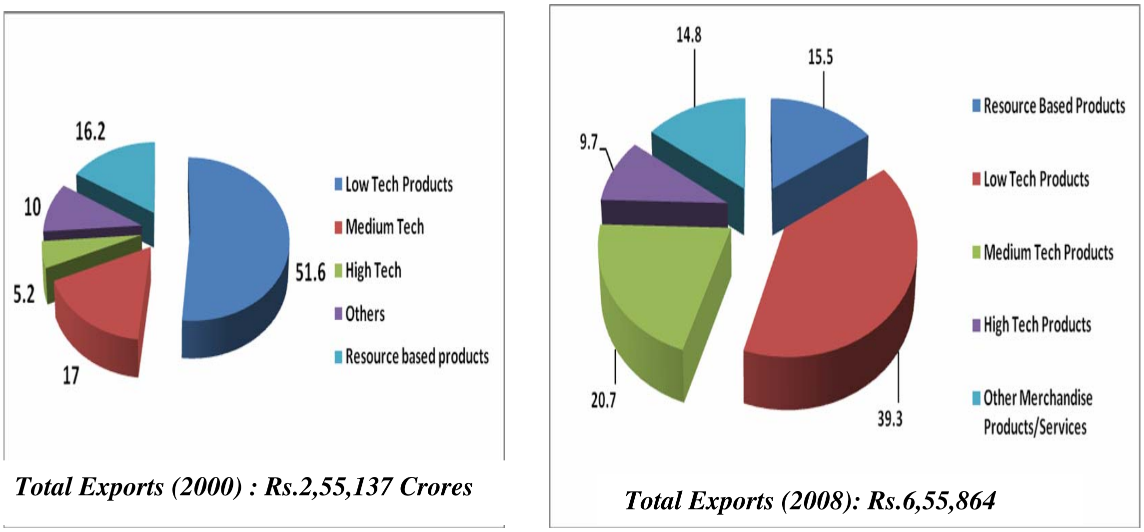
Table 3.6.2: Magnitude of Indian FDI Performance Indicators (1998-09)

FDI Parameter	1998-99	2000-01	2008-09	Remarks
FDI/GDP, %	0.86	0.77	2.24	Increasing buoyancy in FDI Inflows
FDI as % *GFCF*	2.4	3.5	9.5	Increasing FDI role in capital formation
IFPEI (*UNCTAD*)	0.155 (1.198)	0.215 (1.331)	NA	FDI is less compared to economy size
IFPOI (*UNCTAD)*	0.156 (0.255)	0.159 (0.273)	NA	Moderate ability to attract FDI inflows

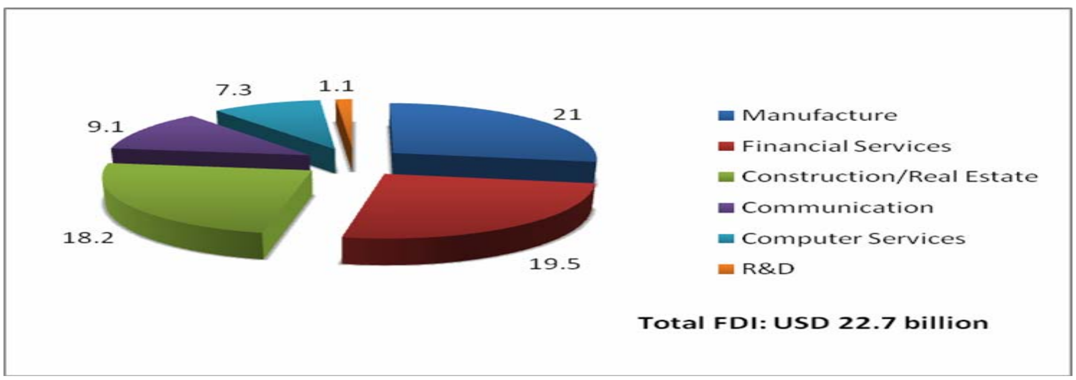
Note: Numbers in parentheses indicate corresponding Chinese FDI indicators



(a) Indian FDI vs Exports related to all Industrial Sectors (1990-2009)



(b): Transformation in the Composition of Indian Exports (2002-08)



(c): Sectorwise Breakup of FDI Inflows into India (2008-09)

Fig.3.6.1: Indian Exports and FDI Growth Profiles and their Compositions

India is an underperformer as compared to China in attracting FDI till 2004 since the overseas investment received by India (USD 5.77 billion) remained weak (0.8%). However, d by 2008-09, Indian FDI rose to USD 29.36 billion/annum level. **Table 3.6.1** shows the reported (**21**) FDI performance indicators for India during 1998-09. They broadly indicate increasing byoyancy in FDI inflows and their importance in capital formation. However, their magnitude is much less compared to Indian economy size.

3.6.3 FDI Inflows into Indian chemical sector

The Indian chemical sector including pharmaceutical and food processing segments had attracted more than 15% of Indian FDI inflows in 2005-06. **Fig.3.6.2** provides the breakup of other industrial sector's contribution relative to chemical sector. The intra-sectoral FDI inflows into Indian chemical sector during 2000-10 is given in **Fig.3.6.3.** It shows the dominance of petrochemical, pharmaceutical, food processing and biotechnology subsectors in attracting foreign investments.

It will be interesting to examine the relative growth of FDI attracted by all Indian Industrial sectors vis a vis chemical sector in India. **Fig.3.6.4** provides their normalized profiles with 1990-91 as the base year. The growth profiles show a similar growth trajectory for chemical and other industrial sectors during 1990-05. Thereafter, FDI growth for all Industrial sectors exhibited much steaper rise the chemical FDI. This indicates the need for the Indian chemical industry to attract much higher level of FDI inflows in order to enhance its ability to access global capital.

Fig.3.6.5 shows the normalized growth profiles of chemical sector FDI and its exports during 1992-09 with 1992-93 as the base year. While the chemical export growth remained more or less steady with a CAGR of 17%, the FDI growth profile has been somewhat erratic eventhough it recorded a CAGR of 13.9%. It maintained a higher growth profile as compared to chemical exports till 1999-00 and exhibited a lower growth profile from 2000-01 onwards with 2 dips followed by 2 recoveries. This trend indicates that the Indian chemical sector is yet to stabilize its FDI inflows.

3.6.4. Market Capitalization of Foreign Equity

The DIPP, Govt. of India made an estimate of the market capitalization of foreign equity in various industrial sectors. The estimates are based on perceived future prospects, economic and monetary conditions. The market capitalization of foreign equity in the Indian manufacturing sector is around Rs 24,620 Crores in the case of FDI enabled companies and Rs.1,890 Crores in the case of the foreign equity component of the domestic companies. **Table 3.6.2**. indicates the market capitalization of foreign equity component in Indian chemical and other industrial sectors for comparative purposes. The chemical products top the list due to attractive performances of pharma, bio and speciality other products sectors.

Table 3.6.2.: Capitalization of Foreign Equity in Indian Industry (2009)

Sector	FDI	Domestic	Total
• Chemical Products	51,178	682	51,859
• Metals	30,357	28	30,385
• Electrical	27,318	--	27,318
• Automobile	13,472	180	13,652
• Iron & Steel	6,939	639	7,578
• Basic Chemicals	1,316	18	1,334
• Food Processing	1,911	47	1,958
• Synthetic Fibres	--	6	6
• Petroleum Refining	3,472	12,325	15,797

3.6.5. FDI - Economy Linkages in Indian Chemical Sector

The gains expected from FDI inflows into Indian Chemical sector is to bring in new skills, new products and technologies and productive linkages with the economy. A FDI inflow can strengthen both forward and backward linkages to the economy. The former benefits increased production of an upstream industry to meet the requirement of the downstream industry and the latter increases the output of a downstream industry. The chemical industry linkages with the Indian economy can be classified as relatively strong forward-backward linkages in certain sectors and strong backward linkage in other sectors. **Table 3.6.3.** provides (**24**) the Hirschman-Ramussen index (**HRI**) as applicable to various chemical sub-sectors to provide an idea of the demand pulls (backward linkages) and supply pushes (forward linkages). A HR Index of greater than unity indicates stronger linkage.

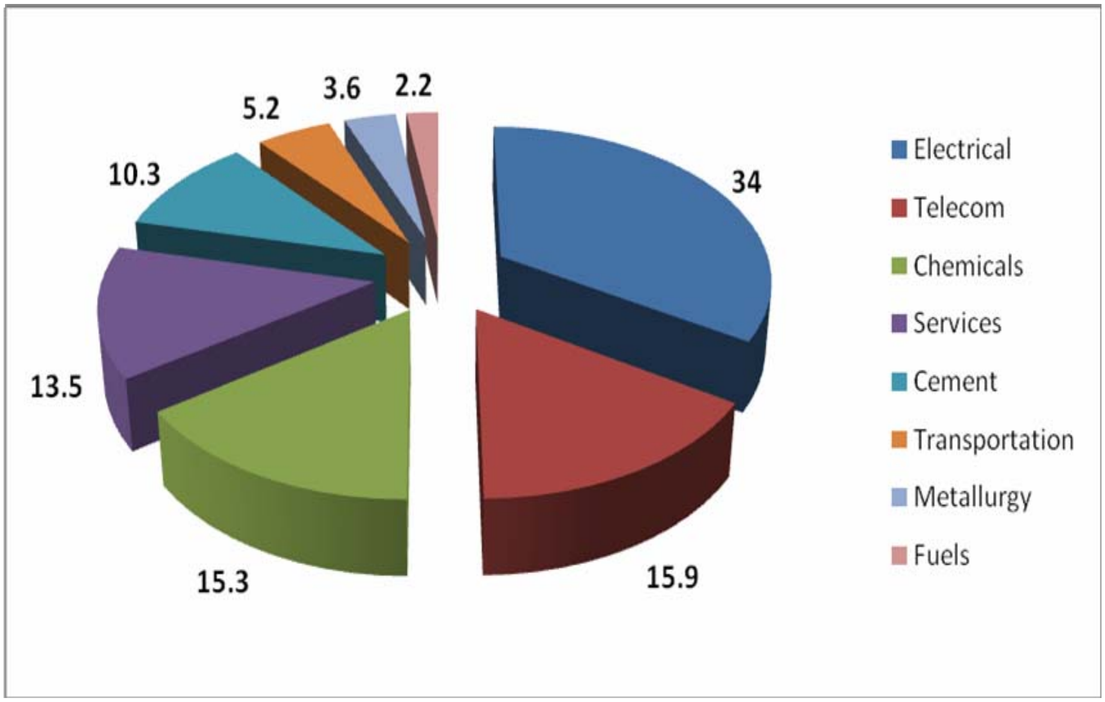


Fig.3.6.2: Industrial Sectorwise FDI Inflows into India (2005-06)

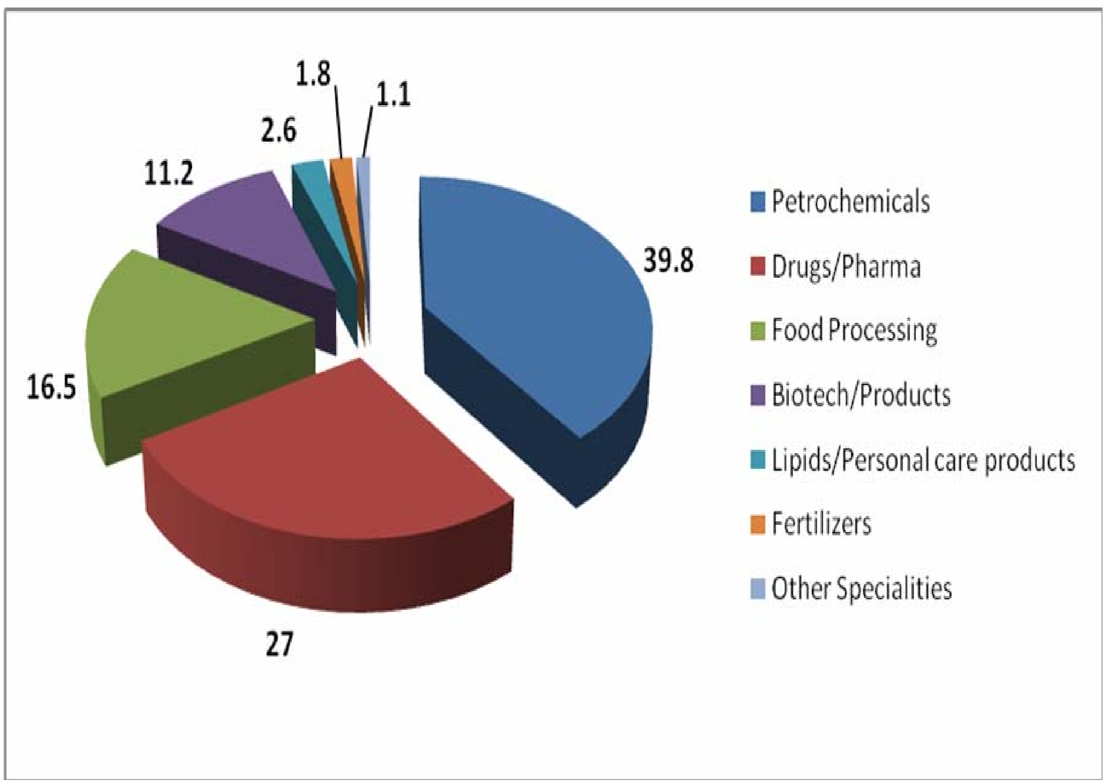


Fig.3.6.3 Intrasectoral FDI Inflows into Indian Chemical sector (2000-10)

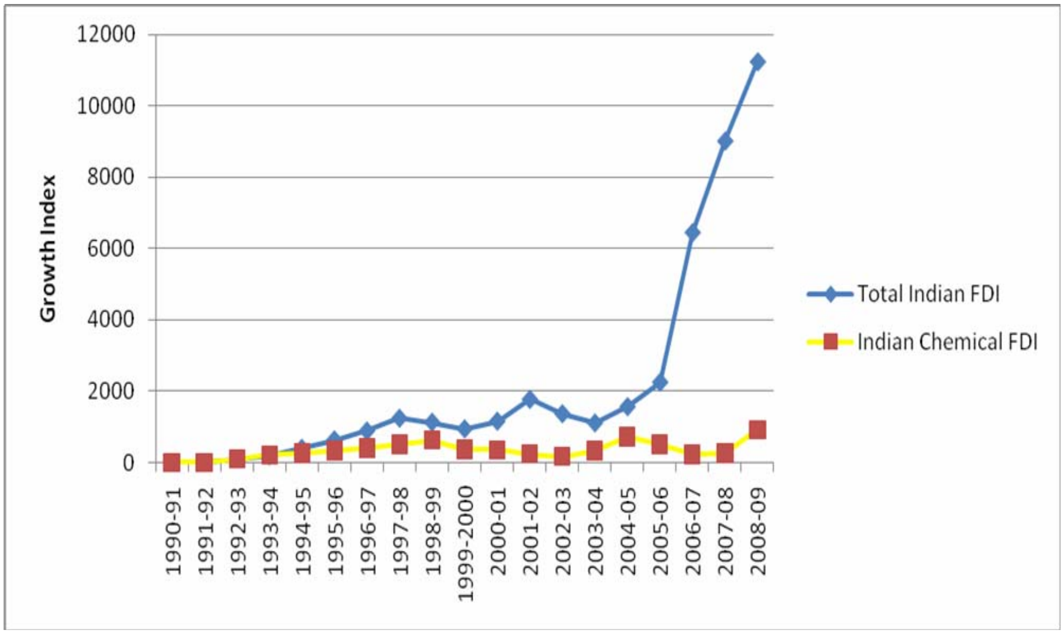


Fig. 3.6.4: Relative Growth of FDI attracted by Indian Industry and its chemical sector (1990-09)

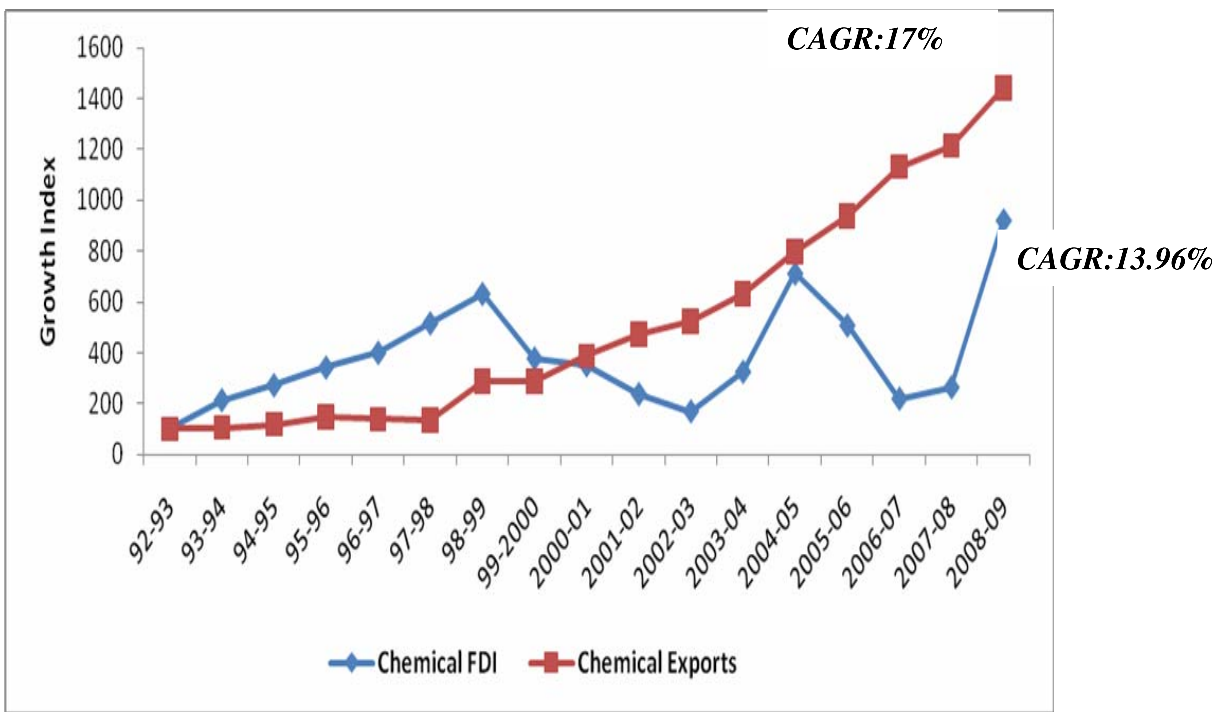


Fig.3.6.5: Growth Profiles of FDI and Exports pertaining to Indian Chemical sector (1990-09)

Table 3.6.3: Forward and Backward Linkages of some chemicals sectors

	Sector / HRI	BWL	FWL	BWL+FWL
1	**Equally strong Forward – Backward Linkages**			
	• Inorganics	1.19	1.82	3.01
	• Organics	1.18	1.81	2.99
	• Syn Fibres/Resins	1.20	1.66	2.86
	• Fertilizers	1.22	1.43	2.65
	• Other Chemicals	1.17	1.97	3.14
2	**Stronger Backward Linkages**			
	• Soaps/Cosmetics	1.18	0.55	1.73
	• Beverages	1.16	0.55	1.71
	• Agrochemicals	1.15	0.94	2.09
	• Drugs/Pharma	1.12	0.84	1.96

**Hirschman – Rasmussen Index (HRI) for forward (FW) and Backward (BW) Linkages*

3.6.6 FDI for Establishing chemical oriented MNC-R&D Centres in India

R&D internationalization in Indian chemical sector has been one of the major contributions of FDI. According to TIFAC Report (**27**), over 70 MNCs have opened more than 100 R&D centres and outfits in India during post economic liberalization period with Bengaluru, Hyderabad, Delhi, Mumbai and Chennai attracting sizeable numbers of scientific manpower. The details are given in **Table 3.6.4**:

Table 3.6.4 : MNC-R&D Centres established in India in all Disciplines

	Location	Number	Prior to 1995	1996-00	2001-06
1	Bengaluru	47	14	18	15
2	Hyderabad	13	3	4	6
3	Delhi	19	4	8	7
4	Mumbai	18	3	6	9
5	Chennai	9	4	3	2
6	Kolkata	2	1	0	1
7	Kochi	1	0	1	0
		109	29	40	40

It is interesting to note from the Economists Intelligence unit Survey (**28**) that India has emerged as the most preferred destination for location of their R&D centres followed by USA and then China. The survey conducted by them in 2004 with 500 company executives as respondents had provided a greater insight into destination of FDI into India. **Table.3.6.5** provides the choices favoured by the respondents for directing their FDI destination. India scored much higher than China and Brazil with regard to access to highly skilled manpower, new outsourcing opportunities and R&D capabilities. China scores better than India and Brazil in providing access to new customer markets, low cost manpower and acquisition opportunities. The USA and India have been placed on equal footing with reference to new customer markets, R&D capabilities and new partnership prospects.

Table 3.6.5:The Choices favouring FDI Destination

Choices	China	India	Brazil	USA
• **New Customer markets**	49	9	4	7
• **Low Cost Manpower**	50	29	3	1
• **Access to highly skilled manpower**	6	30	2	14
• **New Outsourcing opportunities**	16	46	4	7
• **R&D Capabilities**	11	24	3	22
• **New Partnership Prospects**	20	12	3	14
• **Acquisition Opportunities**	15	8	9	13

Chemical Oriented R&D Centres

During 1998-2003, 24 chemical oriented R&D centres were established in India by MNCs from USA, UK, Germany, France, Switzerland, Canada, Mauritius and The Netherlands with a planned investment of USD 1.7 billion. The details are given in **Fig.3.6.5.** The actual investment made till 2003 is hardly 17.7% of the planned investment.

Table 3.6.5 : Chemical Oriented MNC-R&D Centres in India

	Investment Rs. Crores	R&D Manpower	No.of Centres
USA	3215	2619	9
Germany	3727	380	4
UK	82	629	3
France Switzerland, Canada	130	552	6*
Mauritius Netherlands	280	355	2**
	7434	**4525**	**24**

*2 Centres by each country **1 Centre by each country

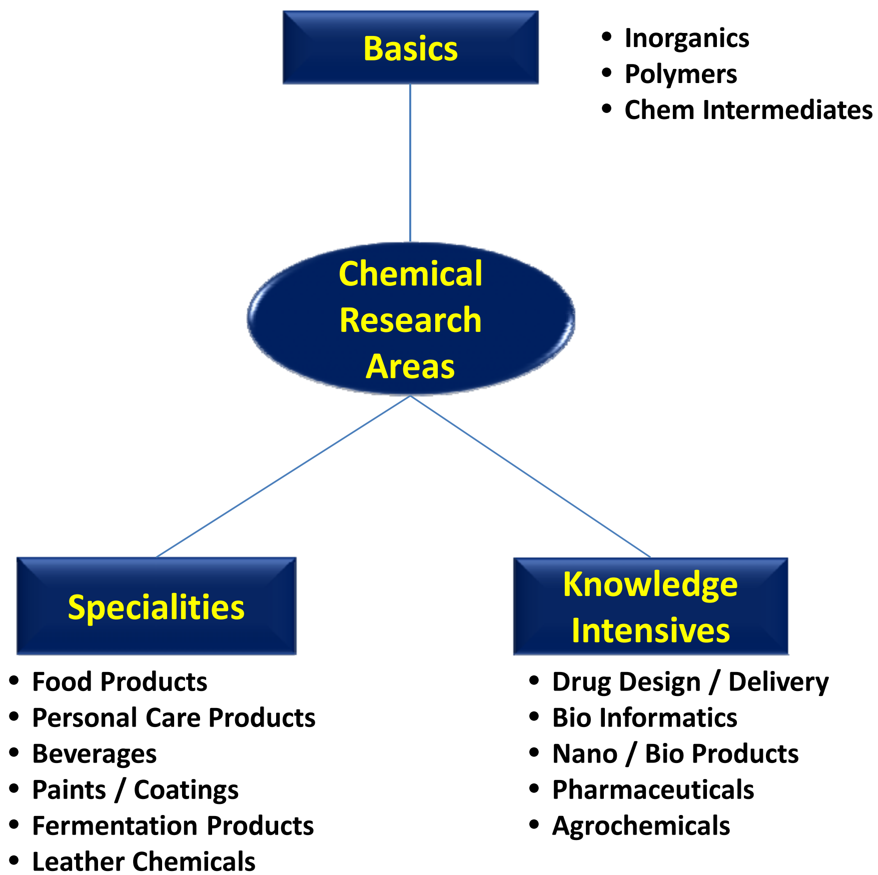


Fig. 3.6.6 : Research Areas pursued by the MNC-R&D Centres in India

It is interesting to note the range of research subjects covered by the MNC-R&D Centres in India under basic, speciality and knowledge intensive chemical segments. The forces of global market competition are such that MNCs are trying to cut costs by outsourcing the R&D in highly competitive research areas as indicated in **Fig.3.6.6**. In terms of their outputs, around 100 patents were filed at US-PTO during 2001-03 and their R&D outputs were predominantly or overseas markets. Around 30-40% of the MNC-R&D Centres have established linkages with Indian institutions for complementary inputs.

Nearly 50% of the planned investment is accounted by Germany followed by 43% by the USA. Around 4500 R&D personnel with requisite qualifications and skills have been employed in the 24 centres established by them in India and six other countries. The molecular modeling based R&D dominates the research on drugs / pharma and biotechnology areas.

3.6.7. FDI Policies and their relevance to Indian Chemical Sector

Most of the chemicals and their products fall under the RBI automatic approval route for FDI investment upto 100% except in case of (a) activities / items that require an industrial licence (b) proposals in which a foreign collaborator has previous or existing venture in India in the same or allied field (c) proposals relating to acquisition of shares in an existing Indian company by a foreign / NRI investor and (d) proposals falling outside notified sectoral policy / caps or under sectors in which FDI is not permitted. 100% FDI under automatic route within 30 days has been permitted for all chemical manufacturing activities with certain exceptions in SEZs. Further details on FDI policy with reference to Indian chemical industry is available on the website of DIPP, Govt. of India (**http://dipp.nic.in**).

The FDI can serve as a vehicle for carrying tacit knowledge as well as assisting enterprises at the threshold of generating commercializable intellectual property. X.Liu and C.Wang et al (**26**) analyzed the FDI facilitation for technological progress with evidence drawn from the Chinese industries. These studies have shown that a country like India, with tremendous potential to develop intellectual property in knowledge intensive areas like pharma, biotechnology and allied fields can attract and gain significantly from FDI by promoting global knowledge networks. A stronger link between national S&T innovation and FDI policies will provide the way forward. This aspect will be discussed further in Chapter 10.

3.7 Chemical Industry's Perceptions on R&DI Related Issues

The two brainstorming workshops held at Mumbai in 2009 and 2010 generated high level of interest amongst the participants from the Indian chemical industry to explore ways and means of increasing R&D intensity in subsectors where the current level of research activities are inadequate for their sustainable growth. The Chief Executives expressed similar sentiments.

Innovation

The industry is keen to implement innovations in product and process technologies employed in their manufacturing plants. The following suggestions were made to promote innovation culture in majority of the chemical companies.

- Appointment of a Chief Innovation Officer in each medium and large scale company particularly in speciality and knowledge intensive chemical sectors.
- Board of Directors of companies to monitor and promote innovative idea implementation in highly competitive areas
- Collaborative innovation to be promoted in solving green processing and energy minimization problems
- Avoiding repeated import of technologies in petrochemical and fertilizer sectors by developing technology and design engineering packages for Indianized process knowhow for subsequent commercialization.
- Equity participation of academic and R&D institutes in the chemical companies will contribute new ideas to solve technological problems encountered by the industry

R&D

The industry is equivocal in committing itself to conduct R&D on a much larger scale to compete with fast moving economies of Asia Pacific countries including China. The need for multidisciplinary R&D has been stressed for petrochemical sector to tackle problems associated with productivity improvement, process intensification, energy minimization and novel downstream products.

Middle East Expansion in Petrochemicals

The Indian chemical industry has identified both positive and negative aspects of the current efforts of middleeast countries to expand their production capacities in petrochemicals. The prospects for joint ventures, technology transfers and outsourcing their R&D to Indian institutions need to be examined not only for enhancing Indian contribution to their growth but also to get access to their feedstocks and intermediates at competitive rates.

3.8 Summary of the Major Findings and Implemented Actions

3.8.1 Major Findings

Inspite of Indian Chemical Sector taking a lead over other industrial Sectors in promoting and utilizing R&D, it has to take many more significant steps in future to attain a comparative level of R&D intensity with industrially emerging economics in Asia, Latin America and Europe. From this angle, following findings are important:

1. ***The relative R&DI growth profiles of basic, speciality and knowledge intensive chemical sectors indicate the need (a) to break the moderate growth of R&DI of speciality chemical sector and (b) significantly enhance the R&DI of basic chemical sector.***

2. ***The positive impact of R&DI on chemical company size and turnover is shown by the significant drop in chemical companies in lower turnover zones which have not incurred any R&D expenditure and significant increase in their number in higher turnover zones in making greater than 3% R&D expenditure over sales. The studies have also shown that except in case of drugs / pharma and organic chemical sectors, R&DI has not shown significant influence on the company size on its turnover. The Indian chemical sector has 34% share in Indian technology oriented new industrial ventures.***

3. ***The Multinational Companies from USA, Germany, UK, France, Switzerland, Canada, Mauritius and the Netherlands have established 24 chemical oriented R&D centres during 1998 – 03 with a total planned investment of USD 1.7 billion. Their R&D focus is on 3 areas in basic chemicals, 6 areas in speciality chemicals and 5 areas in knowledge intensive chemicals. Predominantly their R&D outputs are tailored to global markets. FDI inflows through chemical oriented MNC-R&D Centres in India is estimated to be Rs 1340 crores (USD 0.3 billion) since their establishment at different periods of time from 1975. This is hardly 17.7% of planned investment till 2003.***

4. ***The Indian chemical sector, with 15.3% of total FDI inflows in 2008-09, stands third amongst the Indian industrial sectors. The petrochemical, pharma, food processing and biotechnology subsectors are its major contributors. Though the chemical FDI followed a similar growth trajectory as in the case of other industrial sectors during 1990-05, thereafter it could not keep pace with the steep growth trajectory recorded by the other sectors. The chemical sector has an attractive market capitalization of foreign equity component of FDI as compared to other industrial sectors. The chemical FDI-Indian economy linkages has been relatively strong with basic chemical segments showing equally strong forward and backward linkages and speciality and knowledge intensive chemical sectors exhibiting stronger backward linkages with downstream sector.***

3.8.2 Implementable Actions

The R&DI is the core issue in enhancing the technological status of Indian chemical industry. The analysis presented in this chapter has clearly established the need for taking multidirectional actions to achieve the basic objective in a highly heterogeneous chemical industry. The following three important recommendations have emanated from the above study. They are presented in Chapter 10 adequately.

- ***Enhancing R&DI and investment in three prioritized turnover zones***
- ***Technology innovation centres for R&D commercialization in Frontier Areas***
- ***Incentive driven policies to make transnational R&D and FDI as vehicles for innovation***

There are no further recommendations on implementable actions in this chapter. However, following special studies have been suggested for a better understanding of the prevailing situation in Indian chemical industry:

- ***Relevance between R&DI and company structure and age in three segments (BC, SC and KI) of Indian chemical industry***
- ***Technology Absorptive capacities of various chemical industry subsectors***
- ***Role of new product development portfolios in enhancing R&DI of Indian speciality chemical sector***
- ***Factors responsible for enhancing capitalization of Indian speciality and knowledge intensive chemical sectors.***
- ***Indian role in expansion of petrochemical sector in middleeast.***

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Chapter 4 R&D AND GROWTH DYNAMICS OF MSMEs IN INDIAN CHEMICAL SECTOR

The main focus of this chapter is on R&D and growth dynamics of Indian micro, small and medium scale enterprises (MSMEs) in chemical sector. To enable to understand the environment and support systems relevant to these enterprises, the situation in Indian MSMEs in all S&T sectors is briefly reviewed. Lack of information on R&D growth, innovation and external linkages of MSMEs in chemical sector has been a major bottleneck in making any objective analysis.

Most of the Indian chemical oriented MSMEs exist in 80 clusters spread over 20 states with Andhra Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Orissa and Rajasthan leading the list. The recent success achieved by Vapi Industries Association in establishing a centre of excellence through a public-private partnership has been examined as a model for propagation to other clusters.

The R&D intensity of chemical MSMEs, their knowledge flow channels and their R&D determinants are broadly discussed in the last part of this chapter. A special effort is made to present the experiences of Asia Pacific countries in terms of government policy support, one stop window approaches, technology development through incubation and cluster development programmes to emulate some of them in India.

4. R&D and Growth Dynamics of in Indian Chemical Sector

4.0 Preamble

The micro, small and medium scale enterprises (MSME) in an emerging economy like India can no longer rely on reverse engineering and other conventional methods for the development of modern process technologies under the new technology policy regime. They also cannot take total refuge under government policy protection as current Indian policies have somewhat moderated the special privileges provided to MSMEs in terms of product reservation, preference in government procurement and exemption from price controls. The Indian MSMEs have to gradually develop or acquire new technological skills to compete with large national firms, foreign multinationals and cheap imports. Rapidly changing Indian customer preferences, shorter product lifecycles and growing quality consciousness of Indian people have already started putting pressure on Indian MSMEs to upgrade technologies.

Against this background, the INAE study concentrates on ascertaining the R&D status of MSMEs in the chemical sector and their growth dynamics. Given their limited financial and intangible resources, the enhancement of their R&D intensity has been a very difficult issue.

4.1 Growth Dynamics of Indian MSMEs

The impact of MSMEs on the Indian industrial economy is quite substantial. The Indian industry is served by more than 14 million MSMEs as per the statistics provided by the Government of India during the global SME Technology Summit-2010 held at Mumbai. They produce more than 8000 products and create 1.3 million jobs / annum and contribute to 40% of Indian exports. K Das (**1**) studied the growth of SSI units, their production and employment apart from other growth factors relevant to Indian MSMEs during 1990-07. P.Banerjee (**2**) studied the innovation and other state of affairs of MSMEs in India. **Fig.4.1.1** shows the growth trends of SSI units and their employment potential during 1990-07. However, the normalized growth profiles as reported by K Das and reproduced in **Fig.4.1.2** shows that the production growth has not been able to significantly enhance either their employment potential or number of units. These studies have further shown that the pace of capital productivity growth has far outstripped that of the labour productivity. This has been the hallmark of economy globalization effect on Indian SMEs.

Fig.4.0.1:

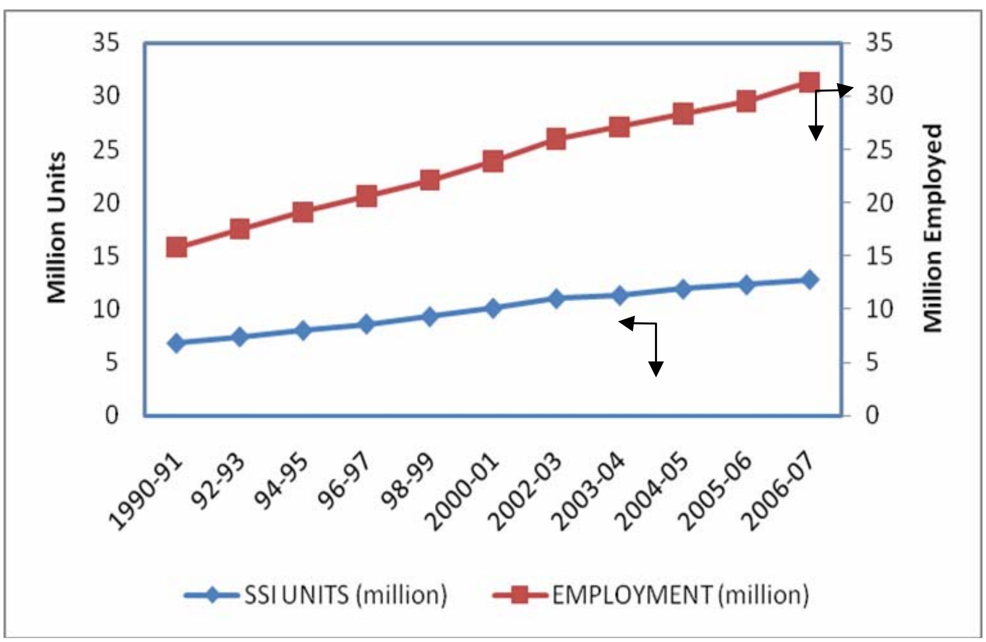


Fig. 4.1.1 : Growth versus Employment Potential in Indian SSI units (1990-07)

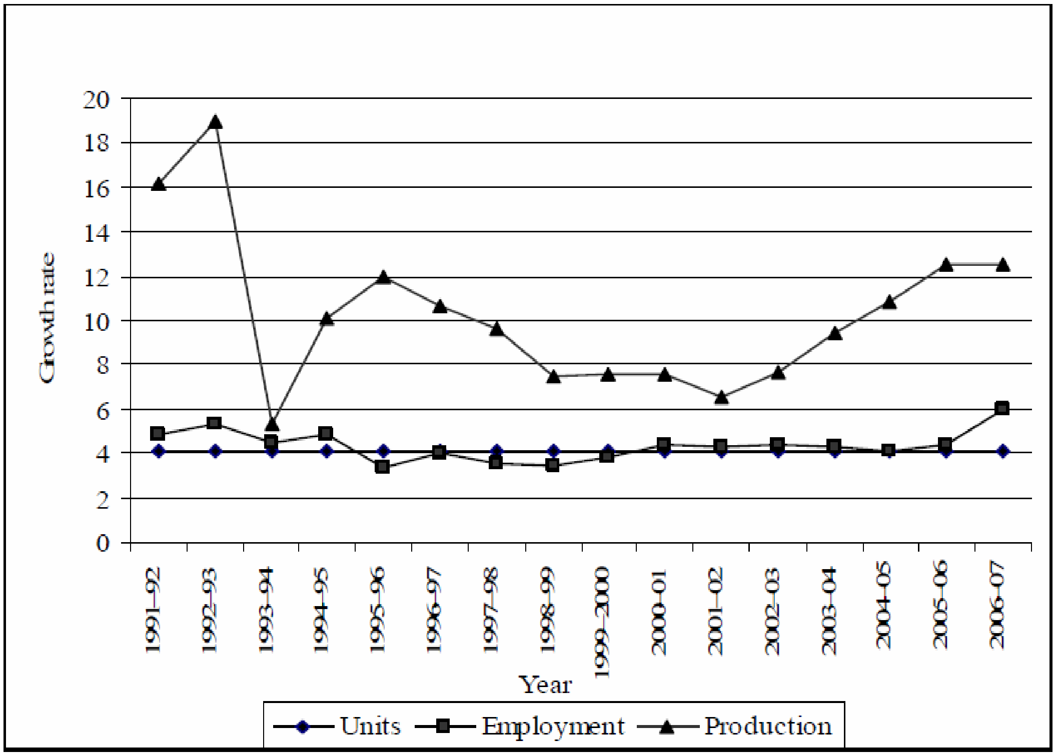


Fig.4.1.2 Normalized Growth Profiles of SSI Units (1990-07)

4.2 The Structural Aspects of Indian MSMEs

Based on the third All India Census of SSIs held in 2001-02, the breakup of MSMEs under organised and unorganised categories has been reported and the details are given in **Fig.4.2.1**. The breakup of their commercial activities are provided in **Fig.4.2.2** and their broad organisational structure is given **Fig.4.2.3**. It is interesting to note that inspite of their small size and resource limitations, 32.4% of units survived for about 2 decades, 1.2% for five or more decades, 11.2% units for 25 years and 30.7% for a decade or so. However, their growth profile is dismal with firms with 100 years of existence not having any sizeable increase in their gross output. The trend of MSME closure during 1991-01 is indicated in **Fig.4.2.4**. It shows downward trend in 2001. There are very few examples of microenterprises becoming small and medium scale companies in course of time. The major reasons quoted for this poor record are deficiencies in government SME policies, lack of institutional as well as organised market finance support and negligible impact of innovation and technology on their growth.

4.3 Cluster Centred Development of MSMEs

India has approximately 350 SSI and 2000 rural / artisan based clusters contributing to almost 60% of the manufactured exports and 40% of the manufacturing industry employment. They are in existence for several decades. The chemical industry's share of these clusters is around 23%.

4.3.1 Cluster Concept

Technically, a cluster represents a spatially limited critical mass of industrial or R&D entities that have some systemic relationships to one another based on their complementarities. The major stimuli for establishing a cluster are the availability of raw materials, proximicity to user markets, R&D facilities and knowledge centres, availability of skilled workforce, a culture of proactive entrepreneurship aided by a suitable geographical or climatic zone. The growth of a cluster depends on the availability of venture and other means of acquiring capital, technical infrastructure, access to academic and R&D inputs, entrepreneurial drive, proactive government policies etc,. The cluster approach is integrative in nature and can bring coherence to diverse activities and use the interdependencies for techno-economic benefits. It has also been well established that clusters drive innovation and this in turn drive productivity.

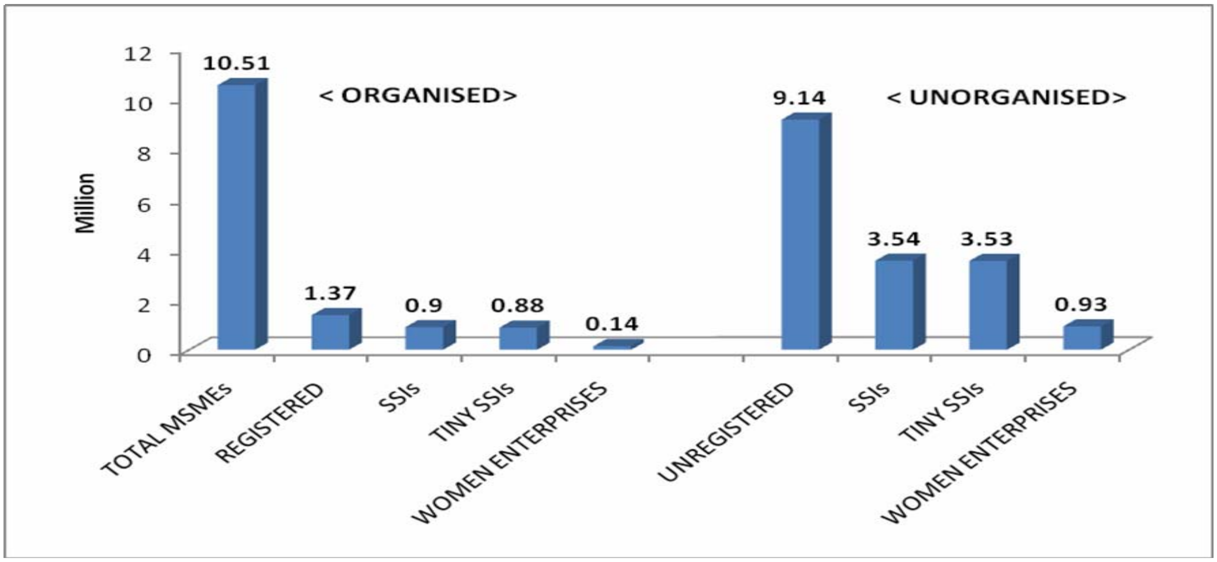
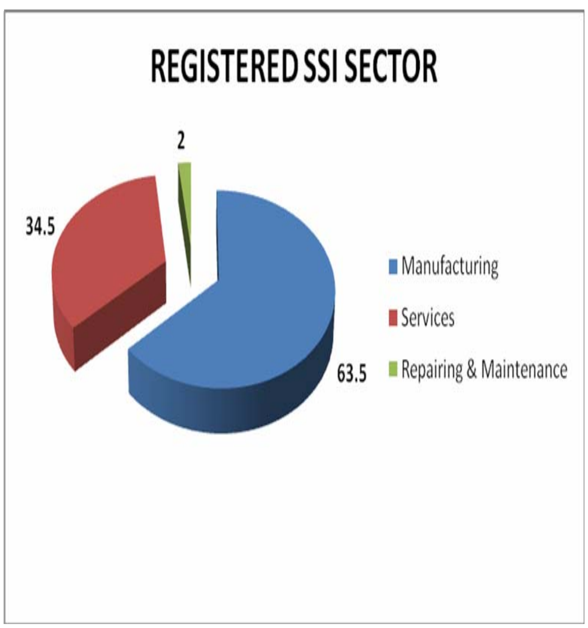


Fig.4.2.1 ; MSME Census Statistics (2001-02)



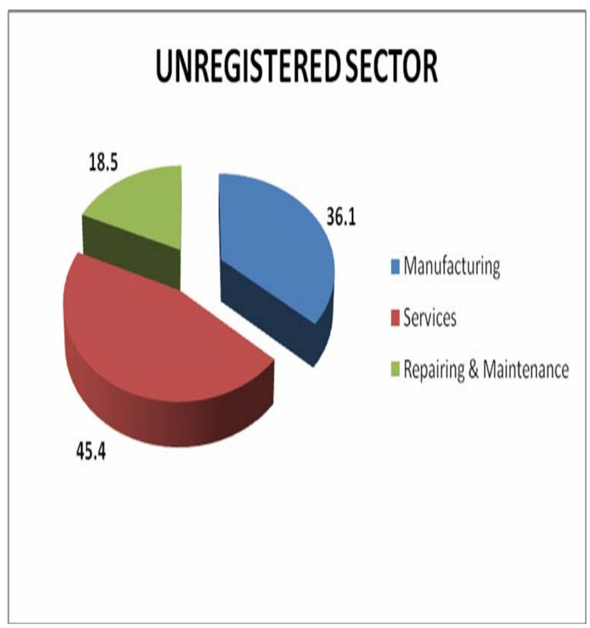


Fig. 4.2.2 : Commercial activity breakup of Indian MSMEs

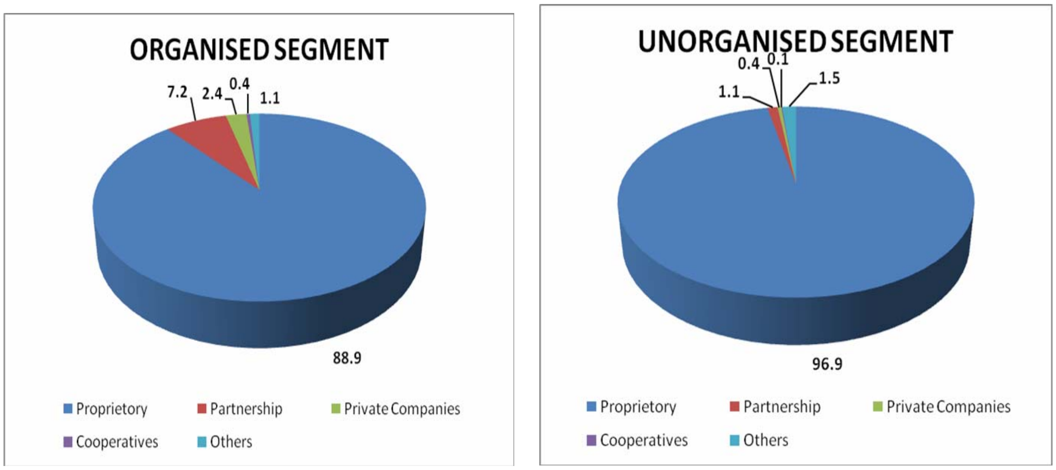


Fig. 4.2.3 : Organisational Structure of MSME Units (2001-02)

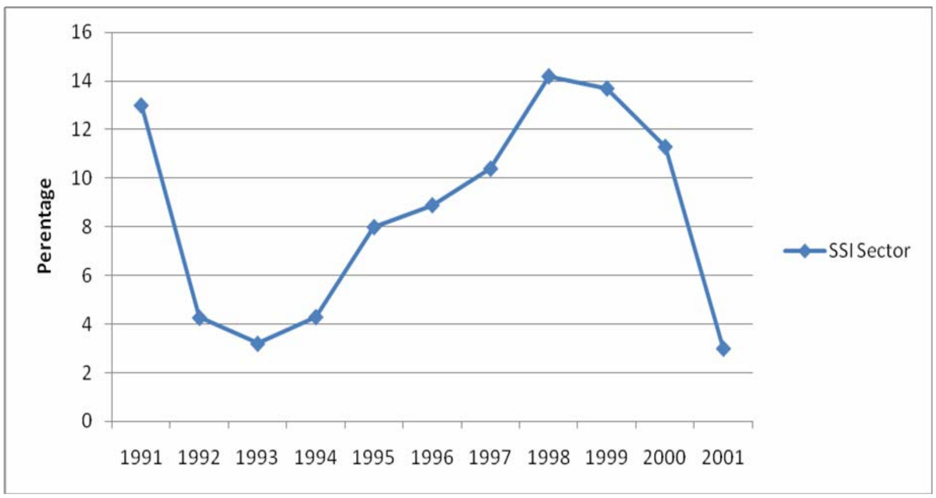


Fig. 4.2.4 : Trends in Closure of MSME Units (1991-01)

The cluster based industry and R&D development models have been explored by both developed and developing nations in the world. There is a growing realisation that if the cluster based approach is properly organized and managed, it can provide a strong foundation for sustainable MSME growth. The cluster concept has accordingly been receiving substantial interest from policy makers, business leaders and industrial development agencies. It has been established that government agencies, multinational and large national companies, R&D and academic institutions and consulting agencies have, so far, not contributed substantially to the creation of a knowledge driven environment in industrial clusters.

4.3.2. Government Planning and Policy Initiatives for MSME Clusters

4.3.2.1 India to Develop 1150 SME Clusters

The Government of India is planning to promote 1150 more SME clusters by employing successful growth models for their technological innovation, enhanced employment opportunities and boosting economic growth. These clusters will be looked after and nurtured by specialized agencies in the relevant areas. There are proposals to undertake a programme for twinning of Indian SME clusters with their counterparts in Italy. Efforts will also be made to learn from the experiences of Asian and European countries in cluster development.

The Government of India has also announced in February 2011 the creation of a Rs 2500 crores corpus for technology modernization of MSMEs. At present such benefits are availed by the textile sector under Technology Upgrade Fund Scheme (TUFS) wherein the MSMEs will get 5% subsidy on loans for upgrading their technologies. The benefits of the proposed programmes will be significantly enhanced if MSMEs improve their infrastructure, innovation, marketing initiatives and human skills.

4.3.2.2 Government Policy Framework

There is no exclusive policy framework for the development of MSME clusters in India. The industrial policy related to small scale sector is a minor component of the Indian Industrial Policy announced in 1991. The state governments provide support to the clusters through schemes based on technology upgradation, infrastructure provision and training through various state and national institutions.

As per the provisions of Indian Industrial Policy – 1991, the following investment ceilings have been proposed for MSMEs:

	Investment Level
Micro enterprises	< Rs 25 Lakhs
Small Enterprises	> Rs 25 Lakhs but
	< Rs 5 Crores
Medium Enterprises	> Rs 5 Crores but
	< Rs 10 Crores

The Indian large scale enterprises and foreign investors are allowed 24% equity participation in small scale units.

4.3.3 Abid Hussain Committee Recommendations on SSI Clusters

In December 1995, the Department of SSI and Agro & Rural Industries and the Ministry of Industry of the Government of India constituted Dr Abid Hussain Committee on Small Enterprises. The Committee, in its report (1997), advocated cluster development approach for the growth of Indian SSIs. It recommended public – private partnership (PPP) for setting up support systems for small scale enterprises. The PPPs can be joint ventures between the State Governments or local authorities and business associations.

4.3.4 UNIDO Study on Indian SME Clusters

The study was conducted in 1999 with the objective of developing sustainable Indian capabilities to promote SME networking and cluster development by assessing their competitiveness, benchmarking them at national and international levels and implementing a sustainable national cluster programme.

The outcome of UNIDO studies is as follows:

i. Cluster development is essentially about bringing change in the way firms, institutions, government authorities and NGOs interrelate among each other to promote a more conducive business environment and effective management of their development processes.

ii. Conventional technological and fiscal supports provide the necessary complements to cluster development if the relationship between the enterprises and the expertise providers are optimized.

iii. Conventional evaluation criteria are not sufficient to assess the impact of R&D programmes on SME sector and their cost effectiveness. Factors like culture of cooperation, emergence of local technology leadership, improvement in the quality of work, nature of institutional linkages and impact of local government policies have to be taken into account.

iv. Technological interventions have to be tailormade in each cluster to meet their specific needs.

v. Benchmarking with successful clusters will be effective for improving lower performers.

vi. Cluster development is a long drawn process requiring a minimum of 3-4 years to become sustainable.

4.4 Innovative Abilities and Drivers for SMEs

4.4.1 Innovative Abilities of Indian SMEs

The National Knowledge Commission in its report (**11**) published in 2007 made very interesting observations on the innovative abilities of Indian SMEs. It had observed that the Innovation Intensity (% revenue derived from product / services which are less than 3 years old) has increased in large and SMEs in India with the latter registering a greater increase in innovation intensity than large enterprises. It was also observed that 42% of large firms and 17% of SMEs in India are innovative. This is based on their ability to introduce "New to World" innovations during their business in 2002-07. It is also interesting that for less than 30% of SMEs, the motivation to innovate is driven by the entire firm whereas more than 60% claim that it is primarily driven by top and middle management.

The commission has also made following important observations with respect to Indian SMEs and their innovation:

- Only 3% of SMEs have filed more than 5 patents during 2002-07

- A sizeable number of SMEs agree that lack of strong industry – academic linkage is an important barrier to innovation.

  The major external barriers are

  - Lack of interfirm collaborations
  - Skill shortage due to education shortfalls
  - Long time to market for innovations
  - Lack of government incentives for SME innovations
  - Insufficient domestic market pressure to innovate

The internal barriers for SMEs to innovate are:

- Lack of vision from firm leadership
- Priority for short term gains
- Lack of effective inhouse staff training programmes
- Lack of sustainable efforts to innovate
- Failure to keep pace with technological changes
- Poor understanding of customer needs and market dynamics

• A small proportion of SMEs employ bank loans as an additional source of funding for innovation

• Innovative SMEs have achieved greater competitiveness, profitability, market share and reduction of costs due to innovation

The National Knowledge Commission has found that creation of an innovation ecosystem in any enterprise is a complex exercise requiring the synergistic use of cumulative energies of the industry, government, education system, R&D environment and consumer preferences.

The INAE team feels that a comprehensive effort is needed to address the innovation issues pertaining to chemical SMEs. The future goal is to promote innovation led growth by employing the cluster centred approach. This forms an important component of the recommendations made in Chapter 10 of this report.

4.4.2 Drivers for SME Innovation

M H B Subramanya etal., (**6**) studied the drivers, dimensions, achievements and outcomes of technological innovations carried out by SMEs in auto components, electronics and machine tool sectors. Khalid and Schmitz (**5**) have shown that clustering helps SMEs to overcome growth constraints and compete in international markets. Their studies have shown that a substantial portion of SMEs in above sectors are informally innovative due to (a) firm level technological capability accrued through self motivation, technical qualification / knowledge / experience and individual innovative ideas and (b) market pressures due to external factors. The major objectives of their innovations are quality improvement, cost reduction, extension of product range, replacement of phased out products and desire to penetrate international markets. Their studies have conclusively proven that the innovative SMEs registered higher growth relative to non innovative SMEs in terms of sales turnover, employment and investment. The importance of R&D for their growth is therefore established beyond doubt.

4.4.1 Launching of UPTECH Programme for SME Clusters

The recommendation of Abid Hussain Committee and the UNIDO Studies have prompted the Ministry of Industry, Government of India to launch UPTECH programme designed to foster technological upgradation at the cluster level through R&D / academic – industry linkages. Inspite of all these efforts, challenges still exist in India to develop an effective and sustainable technology driven cluster development programme.

4.4.2 Knowledge Sharing in Industrial Clusters – Indian, German and Italian Experiences

The current globalized knowledge economy demands the Indian chemical SMEs to harness their human capabilities through the process of enhanced communication, cooperation and sustainable knowledge linkages both within and outside the industrial clusters. Globally, it is well accepted that the cluster environment is conducive for knowledge sharing in areas of common interest and transfer because of the proximity, mutual trust and shared development goals.

V.P. Kharbanda(**4**) studied the issue of knowledge sharing, transfer and cooperation in industrial clusters in India, Germany and Italy. The studies have shown that knowledge and information sharing in Indian clusters take place through informal channels that too within narrow groupings with very little academic-industry linkages. The strong feature of German and Italian clusters has been the innovative knowledge transfer through strong academic-industry linkage. The work sharing in Indian clusters is practically not seen since most of the units fight for the same customers and same markets. Indian clusters are basically formed to solve mostly production related issues and very few of them handle marketing issues. On the other hand, German and Italian clusters assist SME's in capturing markets even with severe MNC competition.

It is important to note that Italian clusters operate on a model where all aspects from raw material access to marketing are taken care of by the industrial consortia. Such support from production to marketing are not available to Indian SME's in industrial clusters. The collaborative and collective work environment need to be improved in Indian clusters to enable SME's to face current and future challenges of globalized markets much more effectively.

4.5 Indian MSMEs in Chemical Sector

4.5.1 Census Data

As per the 3rd Census of SSIs carried out by the Government of India in 2001-02, there were around 1.11 lakh chemical manufacturing units (MSMEs) in the country in organised and unorganised sectors employing nearly 6 lakh persons. In terms of numbers, they constitute nearly 10% of Indian MSMEs in all disciplines and in terms of employed persons, their contribution is less than 3%. The registered units constitute nearly 38%. Of the total registered units, around 680 are exporting companies. Unlike other sectors, several small enterprises in chemical sector have grown to become medium scale players riding the value chain in a growing domestic and export markets. As far as the reserved products for SMEs in chemical sector are concerned, their number (166) in 1980s was the highest and accounted for 20% of total reserved products. In the post liberalization period, this number was brought down to 36 products till January 2007. **Table. 4.5.1** provides the list.

Table 4.5.1 : Reserved Products for Chemical MSMEs

PRODUCT NAME	PRODUCT CODE
Dyestuff Basic Dyes	31220301 - 31220307, 312203308
Azo Dyes	31220701 - 31220745
Acid Dyes	31220761 - 31220782
Naphthols	31220801 - 31220811, 31220901
Reactive Dyes	31221001 - 31221045
Fast Colour Bases	31221101 - 31221115
Potassium Citrate	3106290
Diethyl Phthalate	310645
Diocytyl Phthalate	310646
PVC Compounds	316204
Alkyld Resins	316206
Potassium Nitrate (produced from salt petre)	31010101
Barium Carbonate	31011
Sodium Silicate	319704
Copper Sulphate*	310306
Zinc Sulphate*	310337

4.5.2 Subsectoral Distribution

Authentic statistics on this aspect are not available and therefore an attempt has been made by the INAE project team to compile the information from the diverse information sources. The subsectoral distribution of Indian chemical clusters are given in **Fig.4.5.2.** indicating the dominance of food processing (44%) followed by bulk drugs / pharma (15%) and dyes / intermediates (12%) subsectors.

4.5.3 Chemical MSMEs in Clusters

The factors like reduced power tariffs, relatively superior quality utility supplies, easier access to imported fuels and feedstocks at competitive price levels and better infrastructure facilities like road and rail transport are the main driving forces for chemical MSMEs to adopt a cluster based approach to their development. As per the available statistics, 80 chemical clusters exist in 20 Indian states as per the distribution given in **Fig.4.5.1**. More than 10 clusters each exist in Andhra Pradesh, Maharashtra and Uttar Pradesh and 7 clusters each in Gujarat, Orissa and Rajasthan. The total number of MSME units in these clusters may be between 6000 to 8000.

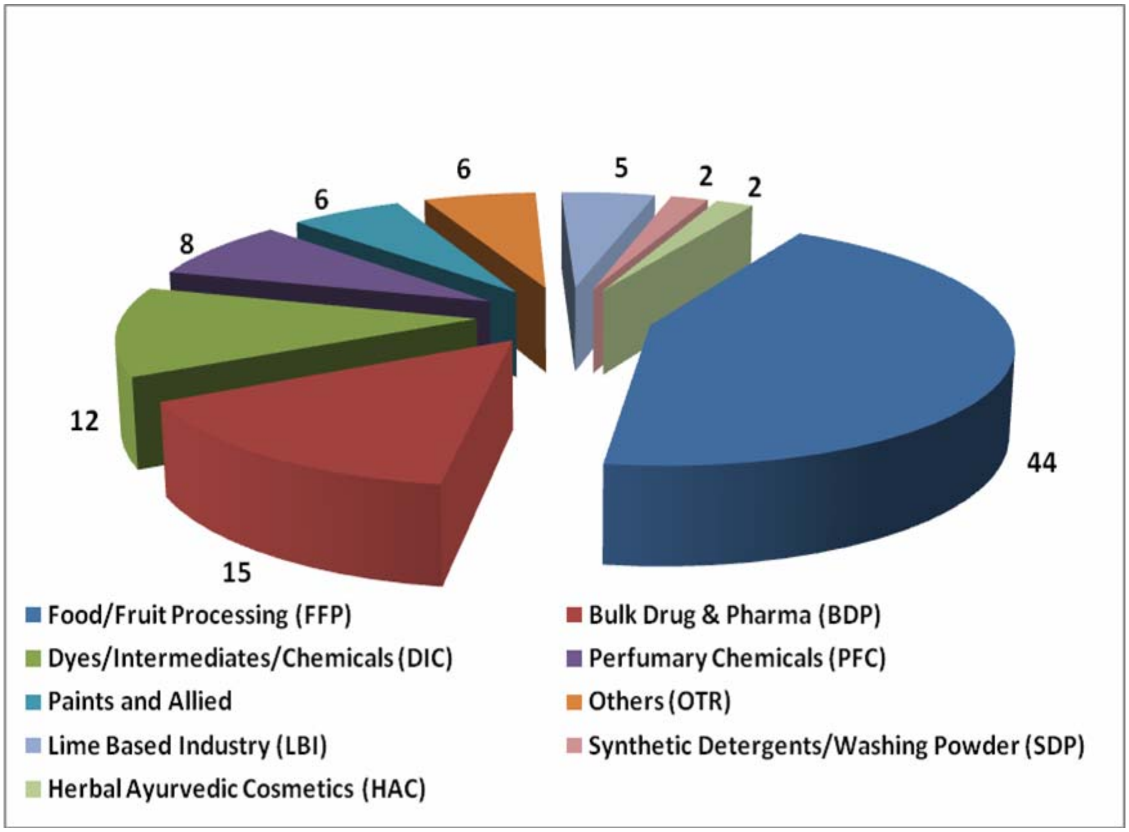


Fig.4.5.2: Subsectoral Distribution of Chemical MSMEs

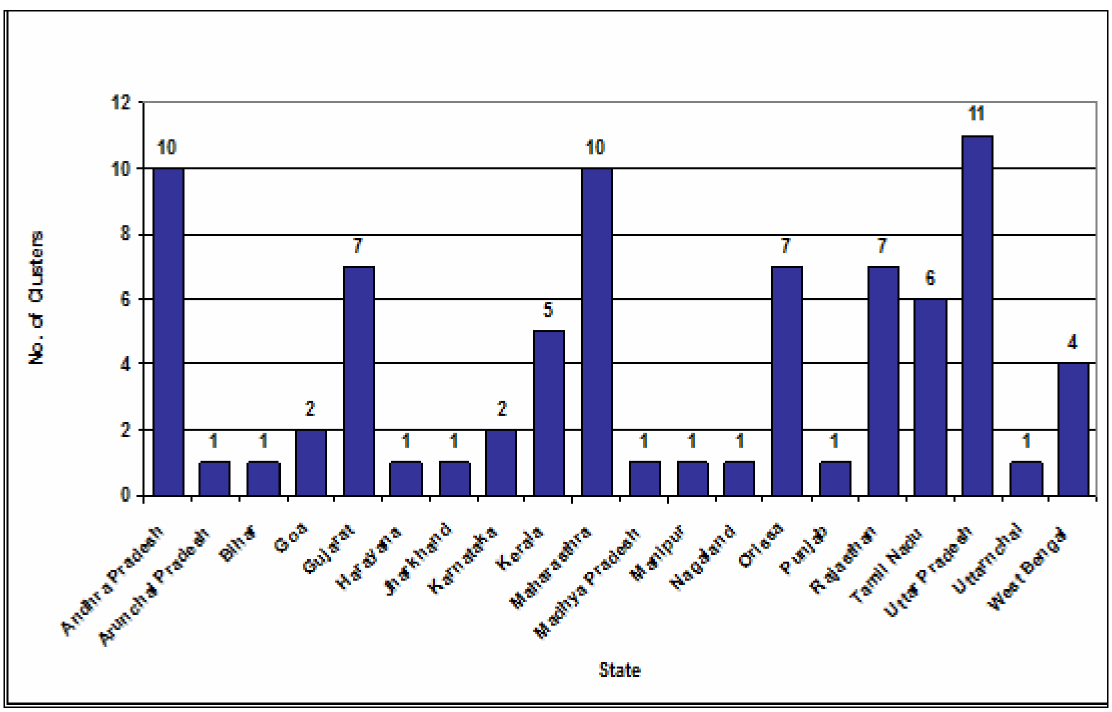


Fig.4.5.1: Chemical MSME Clusters in 20 States

A Unique Venture of Vapi Industries Association (VIA)

The VIA came into existence in 1971 with a membership strength of around 1500 chemical and allied industrial units located at GIDC estate at Vapi. The VIA has rendered valuable services to its constituent units by adoping a catalytic role in implementing various promotional policies and programs of the government. It regularly conducts seminars and symposia, business meets, HRD programmes and industrial exhibitions. It has set up an emergency control centre to provide timely services including ambulance facility to its constituent units in chemical emergencies under the chairmanship of the Collector, Valsad District. VIA started a two year diploma course on industrial safety. One of the India's large Common Effluent Treatment Plant has been in existence at Vapi managed by Vapi Water and Effluent Management Company Ltd., (VWEMCL). Recently, it has established a Centre of Excellence (COE) under the Industrial Infrastructure Development Scheme (IIDS) of the Ministry of Commerce and Industry, Government of India at a cost of Rs 43 Crores. A 30 member staff manages an analytical laboratory, a multipurpose pilot plant for scale up of process technologies and an information technology centre for the benefit of 700+ SME units at Vapi.

A two members INAE Team consisting of Dr K V Raghavan, Principal Scientific Investigator and Sri D P Misra, Consultant held extensive discussions with the Senior Representatives of VIA at Mumbai on 17th November 2010 to understand the objectives, organisational structure and areas of support to SMEs of the COE being commissioned at Vapi. The INAE team appreciated the efforts of VIA in undertaking this unique initiative. It felt that the COE's scope can be further extended by establishing laboratory workspace which can be leased to SMEs, to operate the pilot plant, analytical facilities and the suggested laboratory workshop as a Technology Business Incubator and establishing formal linkages with universities and R&D institutes for providing R&D support. Organisations like National Cleaner Production Council (NCPC) can be associated to promote R&D in ecofriendly technologies of relevance to Vapi industrial cluster.

The Centre of Excellence at Vapi Industries Association

A General View of Vapi Industries Cluster

The Centre of Excellence

Analytical Facilities at the Centre

Other Facilities at the Centre

4.2.7 Knowledge Intensive Biotechnology Clusters in India

Clusters have been found to be advantageous in Indian knowledge based sectors like biotechnology, medical and life sciences and information technology (**8**). This is mainly due to the fact that knowledge that creates competitive advantage often requires face to face interaction and interdependency in several manufacturing activities. The critical mass effect attracts manufacturers, service companies, investors and suppliers into the cluster. While the large companies are able to capture above requirements internally, the biotech SMEs need clusters to access them. Five major bioclusters exist in India at Hyderabad, Chandigarh, Delhi, Bangalore and Pune. The concerned state governments have been taking several initiatives including biotech park development, enacting biotech policies for their growth and creating venture capital fund. There is a growing demand from the biotech industry to develop "Niche Clusters" in fields like genomics, proteomics and drug discovery and design.

The biotech cluster development is largely responsible due to sector friendly national and state level policies and their impact on intra-cluster collaborations and setting up R&D support facilities by S&T organisations in public and private sectors. The Indian biotech industry is keen that government launches more cluster driven innovation schemes wherein R&D centres set up by the industry could be nurtured by the government by providing appropriate research grants and financial assistance to new start-ups. It is heartening to note that the Indian biotechnology clusters at Bangalore, Hyderabad and New Delhi are considered to be on par with their counterparts at New York, Philadelphia, Baltimore DC and North Carolina in USA.

German Experiences of Chemical Clusters

The Commission of the European Community Enterprises and Industry Directorate General had launched in 2008 a European Cluster Mapping Project (**7**) titled "Identification, Analysis and Monitoring of business clusters in Europe". The Programme described clustering as a priority area in support of innovation since it has helped to move the German chemical companies towards new market and knowledge generation institutions.

The German clustering process started at the beginning of 1990 with focus on SME networking. Two chemical sector projects in plastics and polymers were created during 1997-2000 through the joint efforts of industry, local political leadership and scientific institutions. The SME investments and innovation capacities were increased along the respective chemical value chain. The challenges faced by the German chemical SMEs include bringing fundamental changes in their structure, improving poor entrepreneurship qualities, deficiencies in venture capital acquisition and small market shares, overcoming cross regional and cross sectoral barriers and difficulties in attracting bright young talent to their units.

4.5.4 Chemical SEZs Approved by the Government of India

To provide a major thrust to the growth of Indian chemical sector, the Ministry of Commerce and Industry, Government of India approved in 2006, the establishment of 5 chemical SEZs whose details are given in **Table 4.5.2.** They are expected to provide new impetus to the growth of large, medium and small scale chemical companies with modern infrastructure, better supply chain management, better access to global value chains and new opportunities to adopt modern technologies and new product ranges. The R&D support system for SMEs has to be given high priority in these SEZs.

Table.4.5.2. Chemical SEZs Approved

Developer	Location	State	Type of SEZ
Hetero Infrastructure SEZ Limited	Visakhapatnam	Andhra Pradesh	Pharmaceuticals/Chemicals/ Chemical engineering ancillaries
Meditab Specialities Pvt Ltd	Tal-Ponda	Goa	Pharmaceuticals and Chemical Products
Jubilant Infrastructure Ltd	Baruch	Gujarat	Chemical
Jayant Oils and Derivatives Limited	Baruch	Gujarat	Chemicals (agrobased)
New Kolkata International Development Private Limited	Purba Medinipur	West Bengal	Chemicals

4.5.4 Export Performance of Chemical SMEs

The Indian exports (**1**) from its SSI sector has increased from Rs 7593 crores in 1990-91 to Rs.1.24 Lakhs crores during 2005-06. The chemical sector SSI units have a share of 27.8% in the latter. Internally, the share of chemicals and allied products, food processing, pharma and cosmetic segments is around 34.5, 32.7 and 32.8% respectively.

Among the SMEs benefitted from the globalization effects are those from the food processing, garments, engineering goods and pharmaceutical sectors. The impact of globalization of Indian economy on SMEs is also evident from their export performance. The results are presented in **Table 4.5.3**. The SME sector has accounted for over 33% of the total Indian manufacturing exports and the ratio of exports to production has also been on the rise during 1990-06. It is interesting to note the impressive percent share of chemical and processed food segments of Indian SMEs during this period.

Table 4.5.3: Export Share of Chemical and allied sectors

Year	SSI Exports Rs. Crores	% Share	
		Chemicals, pharma and cosmetics	Food Processing
1990-91	9,664	17.9	4.1
2002-03	86,013	13.1	10.0
2005-06	1,50,242	18.7	9.1

4.5.5 Knowledge Flow Channels for Indian Chemical SMEs

P.Banerjee (**2**) reported three prominent knowhow sources for SSI units viz., overseas agencies, domestic collaborating companies in the logistics chain and Indian R&D / academic institutions. Their impact on technological changes, innovation, quality improvement and adoption of best practices by the chemical SMEs has been broadly assessed as:

- Insignificant impact of large corporate houses on any of the above areas
- R&D Institutional Inputs in many cases proved to be expensive for SSIs.
- Few units benefitted from Government R&D funding channelled through NGOs eventhough there is potential for their wider propagation.
- Cluster based approach has not focussed on R&D propagation through a localized institutional mechanism. It has not been employed for monitoring innovation and technological changes in chemical industrial estates.
- Public-private partnership mode of technology transfer through industry associations has, to some extent, provided inputs related to best process practices, product efficacy evaluation and safety measures. They suffer from the delink that exists between technology and financial supports.

Given the vastness of MSME segment of Indian chemical industry, meeting the general and specific needs of innovation, technology upgradation, process / product troubleshooting etc., of individual units provide the most challenging task to government, R&D and academia.

4.6 R&D Intensity of Indian Chemical SMEs

J P Pradhan (**1**) drew upon the Prowess Database of CMIE (2009) for assessing SME R&D Trends. He identified 5237 SMEs in the total sample of 9200+ manufacturing companies listed in the above database. The outcome of his analysis is presented in **Table.4.6.1.** They make an interesting reading.

- A large proportion of small companies are not doing R&D and their average R&DI is very low viz., less than 0.1 and remained stagnant during 1995-08. On the other hand, smaller companies doing R&D had shown significant increase in their R&DI during corresponding time periods. Their R&DI, accordingly, increased from 0.48 in 1995 to 1.5 in 2008.
- The R&DI of medium scale companies (R&D and non R&D) remained stagnant during 1995-08 with a low base value whereas those doing R&D, a 40% growth was observed from relatively higher R&DI value of 0.95.
- The large companies have been pushing up their R&DI for most part of 1995-08 period. The R&D performing large companies performed much better.

The data clearly shows that R&DI of small companies, which are doing R&D are consistently higher than that of large companies for most of the study period. This is in line with NKC's findings. It also shows that Indian SMEs have lower probability of incurring R&D expenditure, but once they adopt R&D, they spend more resources relative to their sales than large companies.

The higher R&DI of SMEs are those from technology intensive chemical segments. The following are the R&DIs (given below) of chemical companies reported by Pradhan during 1995-02 vis a vis SMEs in G7 countries

	India	**G7 Countries**
Chemicals	4.0	2.89
Pharma	10.5	10.75
Food Processing	0.3	0.38
Soaps / Cosmetics	0.3	0.30

It shows good parity in R&DI registered by R&D doing SMEs from India and G7 countries

Table 4.6.1: R&DI of three segments of Indian Manufacturing Companies

percentage

	1995	**2000**	**2005**	**2008**
	1. All Companies			
Large	0.27	0.28	0.48	0.42
Medium	0.20	0.11	0.11	0.18
Small	0.11	0.10	0.09	0.08
	2. R&D Performing Companies			
Large	0.42	0.4	0.61	0.6
Medium	0.95	0.75	1.1	1.4
Small	0.48	0.50	0.88	1.5

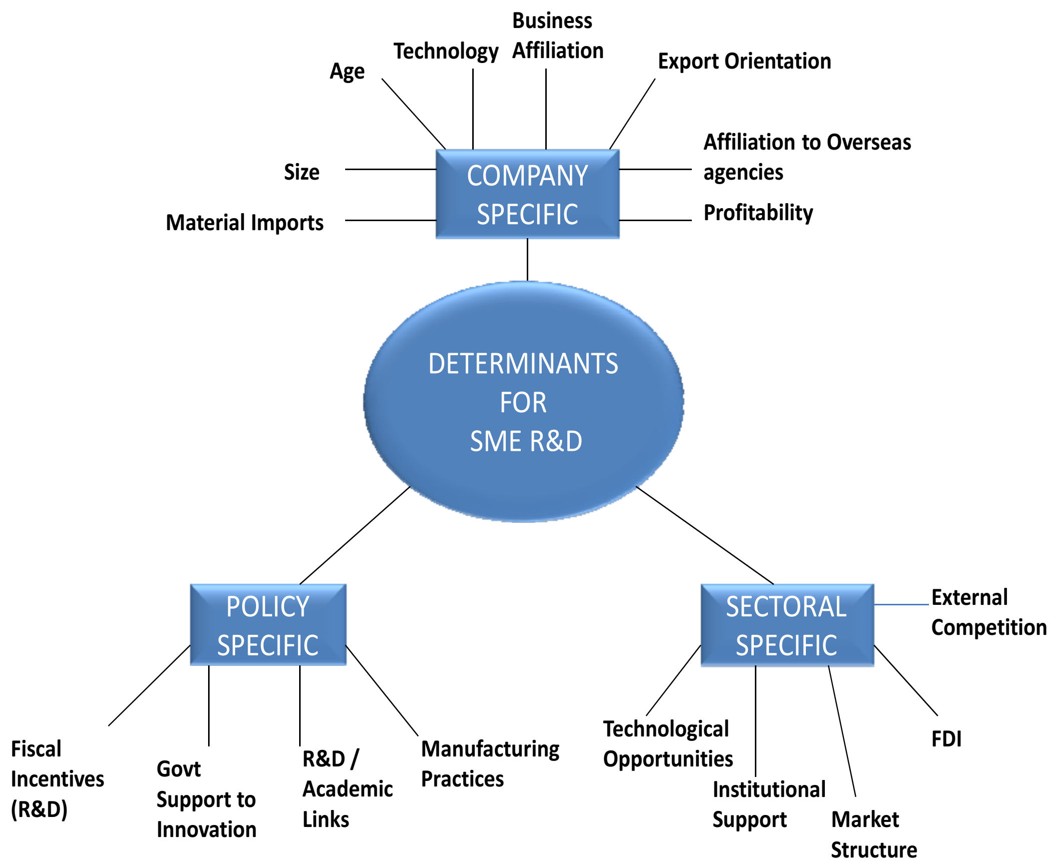


Fig. 4.6.1 : Determinants for SME R&D

4.6.1. Determinants of SME R&D

Pradhan (**1**) identified company, policy and sectoral specific factors that determine the R&D investment / expenditure incurred by SMEs in India. It is generally found that SME's preference for R&D increases as they grow up in their age, expand their size, engage in exports / imports, receive strategic investments and enjoy higher profitability. Creating conditions for overcoming their size limitation is of vital importance for achieving their full R&D potential. Promoting cluster concept is reported to be one of the best options to minimize their size constraint for undertaking R&D. Providing fiscal incentives for R&D is another option for enhancing their R&D potential.

4.6.2 Experiences of Asia Pacific Countries in adopting New Technologies by SMEs

A White Paper on SMEs (**9**) was brought out by the Government of Taiwan in 2009. It covered the experiences of Asia Pacific Countries and its own SME sector. Many of their experiences are relevant to Indian SMEs since the socioeconomic conditions and the structure of R&D / academic institutional systems have several parallels in India.

Japan has made significant use of industry clusters to achieve SME development. The Japanese government has defined the boundaries of an industry cluster by covering a group of enterprises, universities, research institutes, industry guidance agencies, technology transfer organisations and group of experts available in geographical proximity. The close linkage between them within the cluster facilitated the rapid transmission of technology, specialist knowhow, new ideas, proven knowledge and information exchange. The fusion and innovation that have taken place within such clusters are due to mediation from competition and coordination mechanisms.

The South Korea has identified specific industrial activities for SME development. A 5 year R&D investment strategy is formulated to enhance the country's technological competitiveness in the respective fields. Model enterprises are identified for promoting their growth to facilitate early commercialization. The infrastructure needed for their steady growth has been put in place making use of public and private sectors capital. The government also created mechanisms to promote the concerned industry's R&D efforts.

The Principal Scientific Investigator of INAE project visited Taiwan in January 2010 under a Government of India programme. **Annexure 4.6.1** provides the overall findings. He noted that 97.7% of Taiwan's enterprises are SMEs. The government identified 14 key technology groups including agricultural biotechnology, nanomaterials and environmental management for developing future plans for effective utilization of key technologies. Government's direction coupled with entrepreneurial spirit of Taiwanese industrialists has made its SME sector as one of the most technologically advanced in the world. Taiwanese SMEs have learnt number of lessons from their past practices. The excessive focus on their own interests as compared to customer needs resulted in steady decrease in volume of orders and falling profit margins. Their short term thinking has also posed problems in implementing their value addition plans. They have shown that even if a neighbouring country has developed a particular brand of technology, the government and industry have examined whether such a technology is really suited to Taiwanese industry or not. The government has also redefined its own role in SME development. It now focuses on providing SMEs with a fair and supportive business and technology development environments leaving the industry to develop their future plans and appropriate innovation strategies.

The experiences of Asia Pacific countries in SME development have shown that both government and industry need to reassess their roles and strategies from time to time and if needed collaboration driven innovation strategy be adopted by the SMEs. The enlarged scope and the size of the geographical area of SME clusters have enabled them to integrate the efforts of government, industry, universities and R&D centres to engage themselves in innovation activities based on their shared vision and minimize the negative impact of new technologies on SMEs.

4.6.3. Novel SME Experiences of Asia Pacific Countries relevant to India

The inherent constraints under which SMEs operate in Asia Pacific countries had made it difficult for them in the past to compete on a level playing field against large national and multinational companies during 1980s and 1990s. They were often not fully aware of the range of national, regional and international technological assistance and facilitation programmes in vogue. Realizing these constraints, the governments in these countries have evolved several innovative practices and systems to provide support to SMEs. The INAE team has identified following as very relevant to SMEs in Indian chemical sector.

The Multifaceted Role of Government

The national and provincial governments have employed a variety of tools and support systems to bring technological benefits to a large number of SMEs in a variety of industrial sectors. They cover legal, regulatory, strategic planning guidance, fiscal incentives, subsidies, tax benefits and consultancy support through experts and elite institutions. The single-most objective has been to handhold SMEs firmly to face upto global technological challenges of today and tomorrow.

STUDY TOUR TO TAIWAN ON INNOVATION IN SMEs (17-22 January 2010)

A Model of Hsin Chu Science Park

Indian Delegation with Sri Pradeep Kumar Rawat, Director General, Indi-Taipeh Association

Nanking Incubation Centre Complex

At Technology Transfer and Service Centre, ITRI, Hsinchu

SPECIAL MEETINGS

SME Administration, Taipeh

R&D Office Taiwan University of S&T, Taipeh

Indian Delegation
Dr K V Raghavan (INAE)
Dr Rajeev Anantram (ICRIER)
Sri B K Sahu, NRDC at Nankang Software Park, Taipeh

One Stop Service Window Approach

Like India, an industrial sector in these countries may be under the administrative control of more than one ministry / department of the government. In all such cases, a "One Stop Service Window" approach is invariably adopted for SME development. The service windows are well equipped with local help desks, hotlines, dedicated websites, local service centres and link agencies to knowledge generating institutions. All government resources have been channelled through such systems to make effective use of available resources and knowledge base in the country. More help is given to those SMEs whose activities are in line with the national vision on industry development.

Sponsored Research to meet SME Development Strategies

The complexities under which SMEs operate in most of the Asia Pacific countries have made it difficult to implement straight jacket solutions. Operational research oriented projects are sponsored in specialized institutions to seek possible solutions to their complex problems. Typical research areas are development of emerging markets for speciality products, SME brand development strategies in specific areas, overhauling the SME finance systems and procedures, SME-Large chemical companies collaboration for jointly exploiting overseas markets, to cope with rising cost of limited resources and enhancing SME visibility in national and international markets.

Formation of Inter SME Networks

There are several interdisciplinary technological areas in which SMEs have to cross their sectoral boundaries to develop integrated process or product technologies. In such cases, inter SME Networks are encouraged by the government with appropriate incentives. Such networks are also favoured in the development of cleaner process options, energy conservation, finding renewable source options and coping with tough international environment, health and safety regulations.

Multifaceted SME Technology Support Programmes of Government

A number of SME support programmes are launched in Asia Pacific countries by the respective governments to cover a wide range of technology related activities. They include:

- Technology development schemes to encourage key technology adoption
- Innovative technology application programmes to promote innovative application and high tech services and modernization of existing technologies
- Small business Innovation Research Initiative (SBIRI) for covering all phases of concept to commercialization of new technologies with phase I activities focussed on research and evaluation of innovative concepts for commercial prospects, phase 2 activities for promoting R&D for process / product development and phase 3 programmes directed towards application of technology and process scale up aspects.
- Technology services development schemes focussed on knowledge intensive services, value additions to existing services and global marketing of competitive services.
- Enterprise upgradation guidance schemes to enable SMEs to upgrade and modernize their infrastructural facilities.
- Business plan formulation support initiatives for marketing innovative products and processes.

- Programmes to strengthen R&D management in SME sector with focus on HRD and institutional capability enhancement.

- Attractive initiatives to forge and strengthen industry – university / R&D collaboration in high tech areas.

- Subsidy programmes for Technology consultancy services with respect to rapid technology guidance, trouble shooting, developing mechanisms to create appropriate environment for innovation etc.

Government's Special Overseas business Assistance Programmes

Most SMEs have very limited experience of international marketing. The governments in Asia Pacific countries arrange business exchange activities for SMEs by integrating official and private sector channels within and outside their countries. They have achieved significant level of success in achieving new international business opportunities for their SMEs.

Incubation Support to SMEs

Some of the Asia Pacific Countries have established public funded incubation support systems with focus on SMEs to cultivate new generation of entrepreneurs in emerging industrial sectors. The universities and R&D institutes have been given the anchor roles for starting the incubations systems. By 2007, 100 incubation centres were established in Taiwan (**10**) in which 3 of them are directly managed by the Ministry of SME Administration.

Human Resource Quality Improvement Programmes

While formulating domestic and foreign labour policies, the governments in Asia Pacific countries take into consideration the manpower needs of SMEs to help them to relieve the shortage of skilled and qualified personnel. The governments support the implementation of manpower cultivation programmes and special high-tech talent recruitment from overseas under national service system. The governments also offer subsidies through their Ministry of Labour Affairs for individual SMEs to arrange training programmes for their personnel. It is interesting to note that the number of persons from SMEs participating in professional training programmes touched one million mark in 2005 in Taiwan itself.

Online Job banks established by some of the national universities constitute the most widely used channel for recruitment of new employees. The SMEs provide attractive subsidies to their employees to undergo higher education and training programmes. Under an interesting scheme titled "Lifelong Learning Passports" Taiwanese SMEs provide their employees time off to take part in training activities.

4.7. Summary of Findings and Implementable Actions

4.7.1 Overall Findings on Indian Chemical MSMEs

1. ***Around 1.11 lakh Chemical MSMEs exist in India employing nearly six lakh persons, out of them 38% are registered units. From the available statistics, 80 chemical oriented clusters exist in 20 Indian states with Andhra Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Orissa and Rajasthan as the lead states. Five major biotechnology clusters exist at Hyderabad, Chandigarh, Bengaluru and Pune.***

2. ***The Government of India has plans to develop 1150 SME Cluster for all industrial sectors and approved the establishment of 5 SEZs in chemical sector in Andhra Pradesh, Goa, Gujarat and West Bengal.***

3. *Inspite of several facilities provided to SMEs by the Government of India and State Governments, the challenges still exist in enhancing R&D capabilities of Indian SMEs.*

4. *The other important findings of INAE team on Indian chemical MSMEs are highlighted below:*

- *Innovative SMEs registered higher growth relative to non-innovative SMEs in terms of sales turnover, employment and investment. Inspite of this, the R&D inputs to SMEs are not adequate in view of their large number and lack of adequate resources for access and absorption of technologies through a localized institutional mechanism.*

- *The reported studies that the cluster centred approach is the best option for a large number of Indian chemical SMEs to gain access to R&D facilities. There is a strong need to revisit the current cluster concept employed by the Government of India and various facilitation programmes offered to SMEs in order to extend R&D facilities under the existing umbrella. The Japanese concept of an industrial cluster as a group of SMEs, local universities, R&D institutes, industry guidance agencies and individual experts is novel and inclusive in terms of providing R&D access to multiple SME units.*

- *The establishment of R&D and Technology Innovation Centres in SME Clusters will enable centralized R&D facilities to be brought to the doorsteps of the SMEs. No such attempt, so far, has been made in India except the recent effort at Vapi Industrial Estate.*

- *The experiences of Asia Pacific Countries in general and Taiwan and South Korea in particular are valuable for India. Many of them can be replicated with appropriate modifications.*

4.7.2. Implementable Actions

The INAE team has identified following implementable action for chemical MSMEs in India:

1. *Formulating and implementing an Integrated Approach for R&D Capacity Building in Chemical MSME Clusters. Details are provided in Section 10.2 of Chapter 10 under major recommendations.*

2. *Following experiences of Asia-Pacific countries can be emulated in India*

   - *The government role has to be multifaceted with a firm hand holding to enable chemical MSMEs face upto global challenges effectively*

   - *A truly one stop service window approach for R&D propagation is highly essential*

   - *Promotion of inter SME networks for development and adoption of generic clean process options, energy conservation and meeting the challenges of international environment regulations*

   - *Evolving Small Business Innovation Research Initiative (SBIRI) specifically for chemical MSMEs in clusters and outside with generous funding. The existing DST and DBT programmes need to be expanded in their scope as well as their reach. The uptech programme of Government of India can be integrated into this scheme.*

   - *Special Assistance Programme to SMEs for overseas business development*

   - *Establishment of Technology Incubators in pharma, food processing, agrochemcials, selected speciality chemicals, dyes / intermediates and allied fields. Priority to be given to speciality chemical sector.*

- ***Creating necessary driving forces and changes in university acts for forging industry – university linkages***

3. ***Special studies are required in following areas***

- ***Assessment of Emerging Markets for SMEs in speciality chemical sector***
- ***Identification of driving forces and methodologies for forging SME-large chemical company collaborations in speciality chemical sector***
- ***Driving forces for formation of inter SME networks for development and utilization of cleaner processes / products options***

4. ***The Government of India is planning to establish new MSME clusters and increasing the financial support for technology upgradation and R&D during the 12th Five Year Plan. An integrated approach for R&D capacity building to be one of the pillars of new clusters. The SBIRI initiative to form an important component of the proposed financial support programme envisaged by the Government of India.***

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Chapter 5 INTELLECTUAL PROPERTY GENERATION AND PROTECTION IN INDIAN CHEMICAL SECTOR

This chapter deals with the various facets of Intellectual Property (IP) management in Indian chemical sector. The first part of the presentation deals with IP generation and protection trends in chemical and allied S&T sector in post WTO period. The global dimensioning of Indian IP is examined in both qualitative and quantitative terms.

The internationalization of IP employed in India in various modes has been covered in the second part of the chapter. Its ramifications on the competitiveness of Indian inventions are broadly analyzed.

The third part of the chapter deals with the institutional sources for IP generation in Indian chemical sector and their performance in post WTO period. Their ability to convert chemical research into commercializable products and processes is examined.

The last part of the chapter focuses on the product patenting trends in Indian chemical sector during 2005 onwards. The application potential of bibliometry for forecasting the emerging chemical technologies and their pathways has been demonstrated through a sample study conducted by the INAE team.

5. Intellectual Property (IP) Generation and Protection in Indian Chemical Sector

The main theme of this chapter is to assess the global and national trends in IP generation and protection in chemical and other S&T sectors as influenced by the knowledge globalization in post WTO period. In order to provide proper perspective for IP management in Indian chemical sector, the status of Indian IP management in all S&T sectors is discussed in Section 5.1. Adequate subject coverage has been given to Indian chemical IP quality, Indian top institutional performance, Indian ability to generate protected IP, product patenting trends, prediction of technological growth paths in various disciplines and positive and negative effects of internationalization of chemical IP being protected in India. It is for the first time that such a comprehensive coverage has been given to the IP management related issues in Indian chemical sector.

5.1 IP Generation Trends in All S&T Sectors

5.1.0 Global Trends

The research publication output of the world in all S&T discipline is around 1.7 million in 2007 (**1a**). The percent share of Europe (43.6), Americas (35.4), Asia (16.9), Oceania (2.77) and Africa (1.2%) indicates the publication intensity in important world regions. Globally, around 146 countries contribute to research publications with 48 of them are developed countries and the rest are developing countries. The combined share of developed countries in research publications during 1993-03 is around 87% accounting for 94.74% of world citations. In the developed world, the top 7 countries account for 64% of world research papers in 19 disciplines. Among the developing countries, material science, agriculture and chemistry have the top 3 ranks.

During 1980-90, the number of worldwide patent filings was relatively stable at an average of one million patent filings per year. However, since 1995, the global patent filings have grown at a rapid rate. In 2005, it crossed 1.6 million. Approximately half of the worldwide patent filings originated from Japan and USA. The shares of China and S Korea significantly increased during this period. **Fig.5.1.0(a)** provides the global trends in patent filings in pre and post WTO periods. The distribution of worldwide patent filings by resident and non resident applicants shows the significant increase in non resident patent filings which reached 38% of the worldwide patent filings in 2005. The details are given in **Fig.5.1.0(a).**

The geopolitical and economic priorities have undergone significant changes after 1990 in industrially advanced countries in the world including India. The internationalization of R&D had become an important component of this transformation. Large MNCs enhanced their R&D investment from 45% to 66% by establishing their R&D centres in various developing countries including China and India. They are now emerging as major R&D destinations for MNCs.

5.1.1 Growth Profile of Indian IP in various S&T Disciplines

India had adopted the policy of economic liberalization in 1990 and from then onwards, is making sustained efforts to open up its economy for Foreign Direct Investment (FDI). India accessed itself to WTO in January 1995 to enter into a new regime of intellectual property management. The post WTO developments and their impact on Indian patenting activity was well documented in a NISTADS Report (**2**). This section provides the growth trends of two important components of Indian intellectual property viz., research publications and patents during 1990-2009. **Fig.5.1.0(b)**. provides the overall growth trend and growth indices of SCI research publications and patents filed in Indian Patent Office (IPO) covering all S&T disciplines.

Pre WTO period (1990-94)

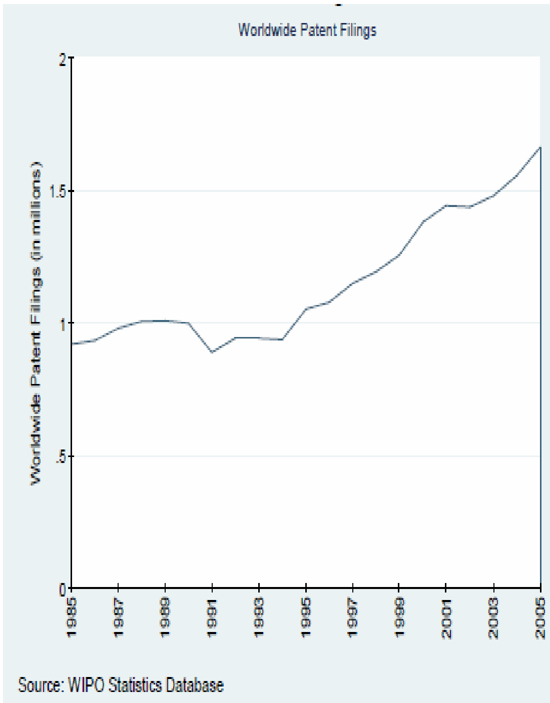
The growth profile of Indian research publications during this period was somewhat flat. However, the patent filing at IPO had experienced a more moderate growth with more than 70% of them contributed by overseas agencies and non resident inventors. Since there was no product patenting facility in India during this period, majority of the Indian inventors preferred to work in collaboration with their non resident counterparts for patented inventions (**3**).

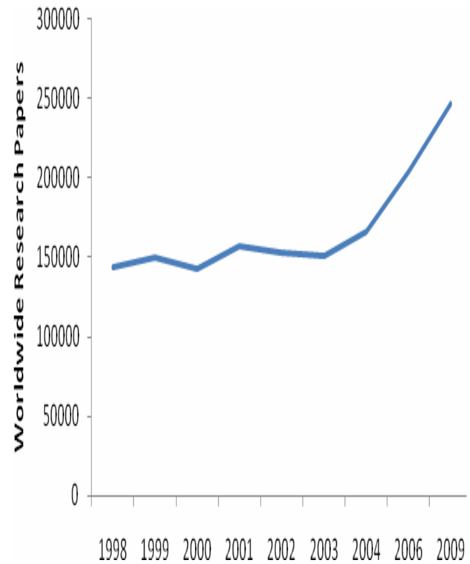
Post WTO Transition Period (1995-98)

India's accession to WTO in January 1995 and particularly its status as a TRIPS signatory, facilitated it to harmonize many provisions of its patent system in line with the standards prevalent in the developed nations. Since significant wave of TRIPS compliant amendments towards achievement of came into force in 1999 followed by further amendments in 2002 and 2003 with many retrospective changes, the years 1995-98 is appropriately termed as post WTO transition period. The Indian research publications in all S&T disciplines registered a significant increase during 1995-97 after near stagnancy experienced earlier. The Indian Patents also registered fairly steep increase during 1995-98 predominantly due to overseas contribution. The share of Indian inventors fell from 25 to around 19% during the period.

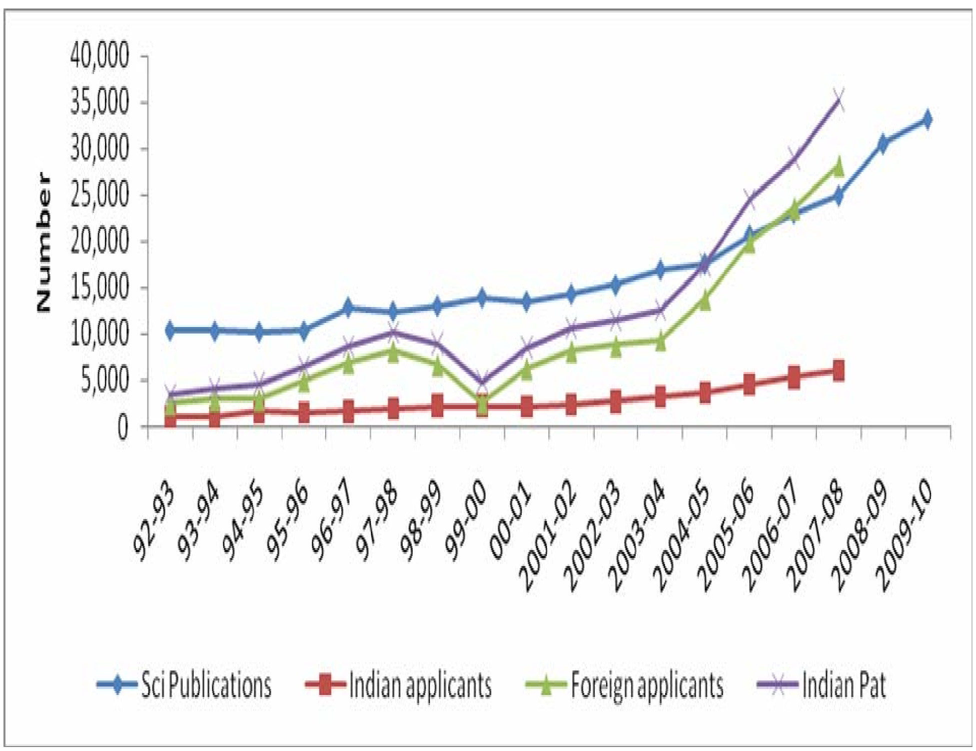
Post WTO period (1999 onwards)

Several Interesting developments took place during this period. The Indian research publications in all S&T sectors grew by 25% during 1999 to 2005 and by 50% during 2006-2009. On the other hand, patent filing experienced a fairly steep fall during 1997-00 mainly due to significant drop in patenting at IPO by overseas inventors. For the first time during the post liberalization period, the patent contribution from Indian and overseas inventors were almost equal during 1999-2000. The patents filed by Indian inventors, however, did not registered any fall during the post WTO period. The growth trajectory of Indian patents after 2000 was on a fast track with overseas patent contribution registering an exponential growth and Indian inventor's contribution treading a moderate growth path. As a result, more patents were granted by the IPO to overseas inventors than to resident Indian inventors in 2005. At present, more than 80% of patents filed at IPO are from overseas inventors.





(a) World Patenting Trends (1985-05) **(b) World Publication Trends (98-2009)**



(b) Relative Growth of S&T Publications and Patents in India (1992-09)

Fig. 5.1.0 : Indian Intellectual Property Generation at Global and Indian Levels

5.1.2. Global Dimensioning of Indian IP Generation

Research Papers

Around 3.04 lakh research papers were published in India in all S&T disciplines during 1992-00. It ranked 10th among the top twenty countries in science and technology development. Its global publications share was 2.11% as computed from cumulative world publications data for 1995-09 (**1b**). **Fig.5.1.1** provides the relative growth of research publications in India vis a vis USA, Japan, China, Germany and China during this period. The growth rate of research papers from USA, Japan and Germany had declined during this period as compared to those from China and India. The performance of China has been outstanding with its world ranking jumping from 8th to 2nd position due to six fold growth in its publications as compared to two fold growth achieved by India to raise its global ranking from 13th to 10th position. In terms of total number of research papers in all S&T disciplines, the record of USA is equally outstanding with a 23.44% global share.

The world's annual average growth rate of research papers has been reported (**1a**) as 5.64% during 2003-07. While India and other developing countries with impressive S&T record have attained higher than the world average growth rate, and several top performers in developed world recorded less than the world average. **Fig.5.1.2** provides the details. Though Indian average research papers growth rate is above the world average, the countries like Brazil, Taiwan and S Kores have achieved much higher growth rates.

Patents

A total of 1.17 lakhs patent applications were filed at IPO during 2003-08. **Fig. 5.1.3** shows the disciplinewise distribution of Indian patents during this period. The patents from chemical related fields dominate (42.2%) over those from other disciplines. It shows the relatively higher importance attached to the protection of intellectual property in the Indian chemical sector. The Mechanical Engineering sector comes next in protecting its intellectual property. The growth pattern of patents filed in chemical, mechanical, computers / electronics and electrical sectors during 2003-08 is presented in **Fig. 5.1.4.** The mechanical sector recorded relatively higher growth rate as compared to chemical sector.

B.M.Gupta etal., (**1b**) reported the subject coverage of S&T publications from India, China, S Korea and Brazil. While India has the largest share (16%) of chemistry publications, China has a major share in engineering (30%), Brazil in medicine (27%) and S.Korea in physics (19%) amongst their respective national S&T publications. This shows the variations in their discipline focus and S&T strengths. India has the largest global publication share of 4.53% in case of chemistry as compared to its other disciplines. China's share of chemistry in global publications is 9.67%. It has 11.86% share in global engineering publications as compared to 1.71% achieved by India.

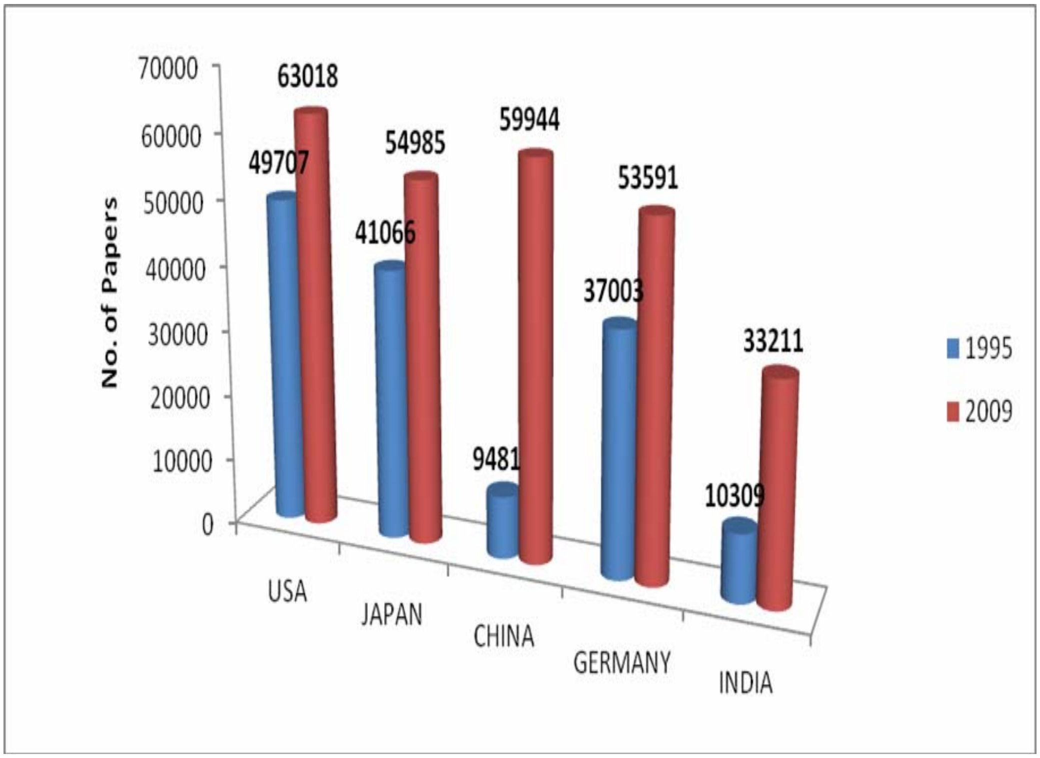


Fig. 5.1.1 : Growth of Research Papers in India vis a vis other countries 1995-09

Fig. 5.1.2 : Annual Average Res Publication Growth Rates of Selected Countries (2003-07)

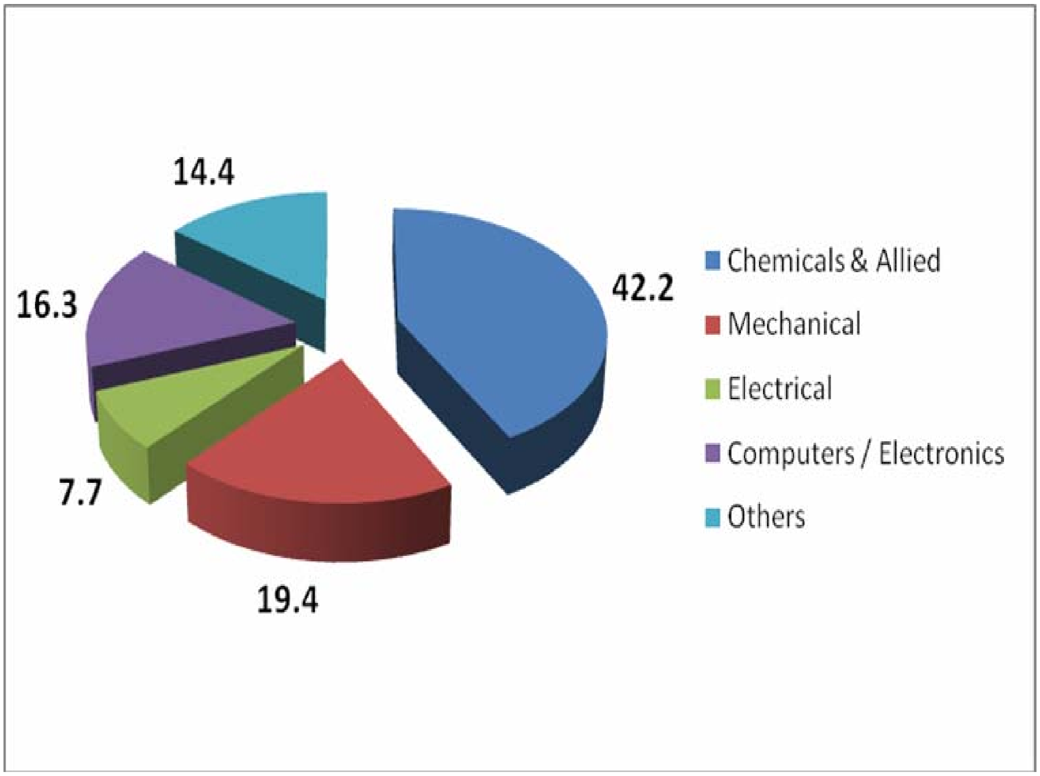


Fig. 5.1.3: Discipline wise Breakup of Indian Patent Applications (2003-08)

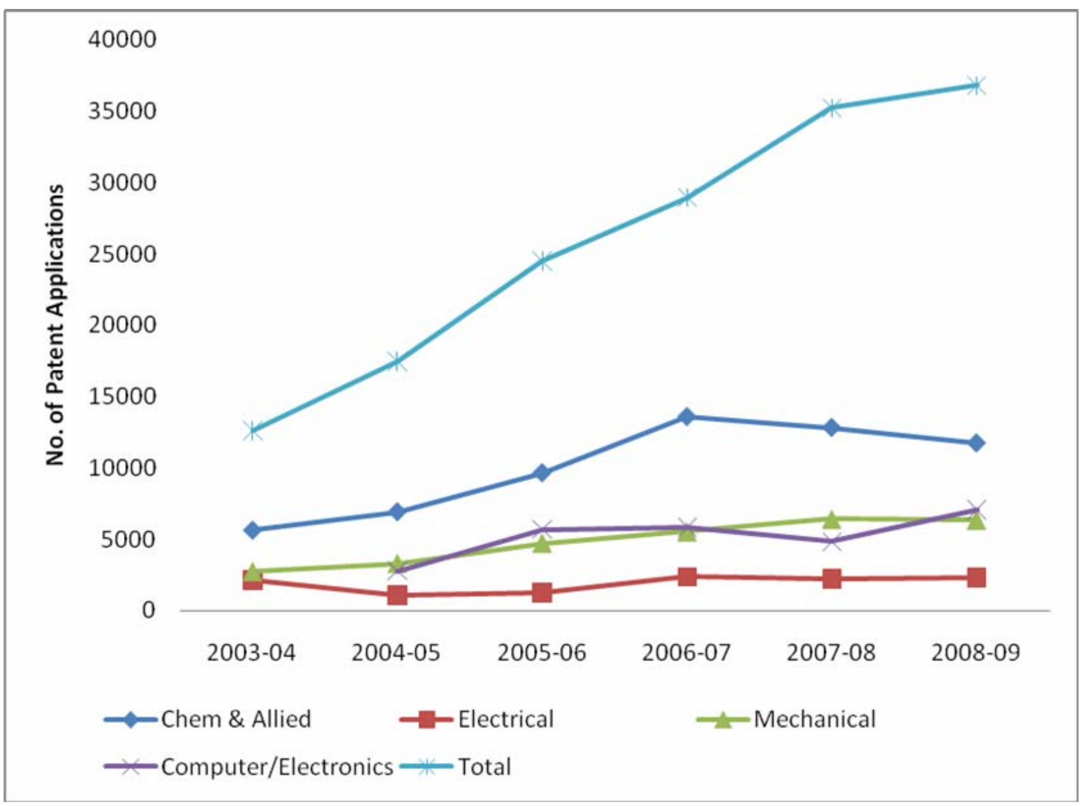


Fig. 5.1.4 : Growth of Indian Patents filed in Four S&T Disciplines During 2003-08

5.1.3 Internationalization of IP Employed in India

The studies of A Chakrabarti & Bhowmik (2009) etal., (**3**) have indicated that the multinational companies are rapidly driving the growth of patents filed at IPO in the post WTO period. Their ability to transfer and exploit S&T knowledge across borders has been their major success factor. The effect of knowledge globalization on intellectual property generated as well as employed in Indian industry is an interesting subject for study. In this section, the globalization phenomena with reference to Indian inventors patenting in other countries and overseas inventors filing patents at IPO are examined.

5.1.3.1 Indian Inventors Filing Patents in Other Countries

The filing of patents by India, China, Japan, USA and Germany in EU as reported by EPO (**4**) is highlighted in **Fig.5.1.5**. The Indian contribution, eventhough very less as compared to other countries including China, its growth is significant. It rose from less than 0.1% of patents filed at EPO in 1998 to around 1.4% in 2008.

Table 5.1.1 shows the Indian public and private sector contribution to the filing of patents in India, USA and Europe during 2005-07. While Indian patents constitute 69% of total patents filing in India and abroad in case of public funded agencies, the private sector industrial agencies have much less (55%) contribution to total patents filed by them. However, they filed much higher number of PCT applications. Nearly 85% of their patents pertain to pharmaceuticals. Amongst the Indian public sector agencies, the CSIR contribution (72.5%) to both Indian and overseas patents is praiseworthy.

Indian Patent filing per Million Population

Wong and Singh (**12**) recently shown that the Indian patents filed per million of population viz., 0.01 (1981), 0.03 (1990) and 0.13 (2000) are much lower than that of Malaysia (0.07-2.02), Thailand (0.04-0.49) and South Korea (0.46) – 73.44). A substantial increase in R&D expenditure and increased rate of patenting along can improve Indian situation.

5.1.3.2.Overseas Inventors Patenting at IPO

The ownership of Indian inventors in patents filed at IPO in all S&T fields never exceeded 30% during 1992 to 2008 except on two occasions' viz., 1994-95 and 1999-2000. **Fig.5.1.6** provides the details. The Post WTO period had witnessed a significant drop in Indian inventor's share indicating the strong internationalization effect on Indian patent ownership. However, for a country like India with its high S&T strengths, it is indicative of the declining share of Indian inventiveness in nationally marketable products and processes. It is relevant for India to study the strategy followed by USA which has enabled it to maintain its domestic inventors contribution around 50%.

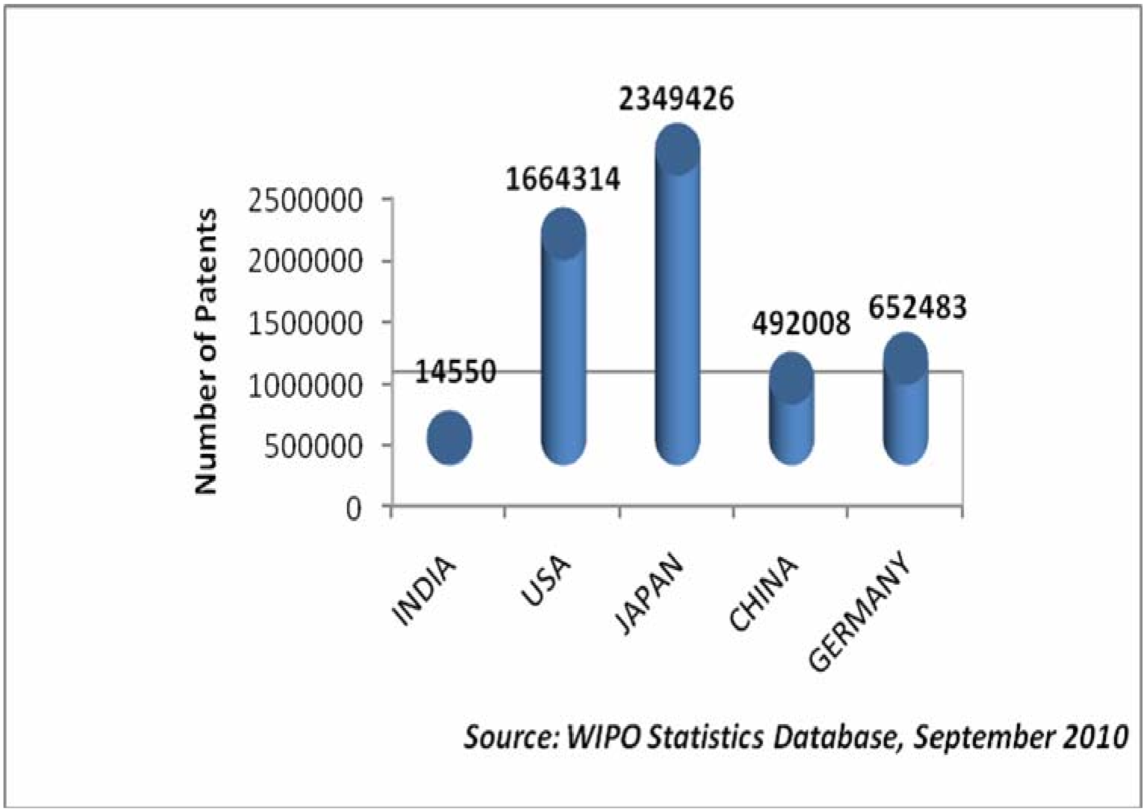


Fig. 5.1.5 : Indian Filings at European Patent Office (EPO) during 2003-07

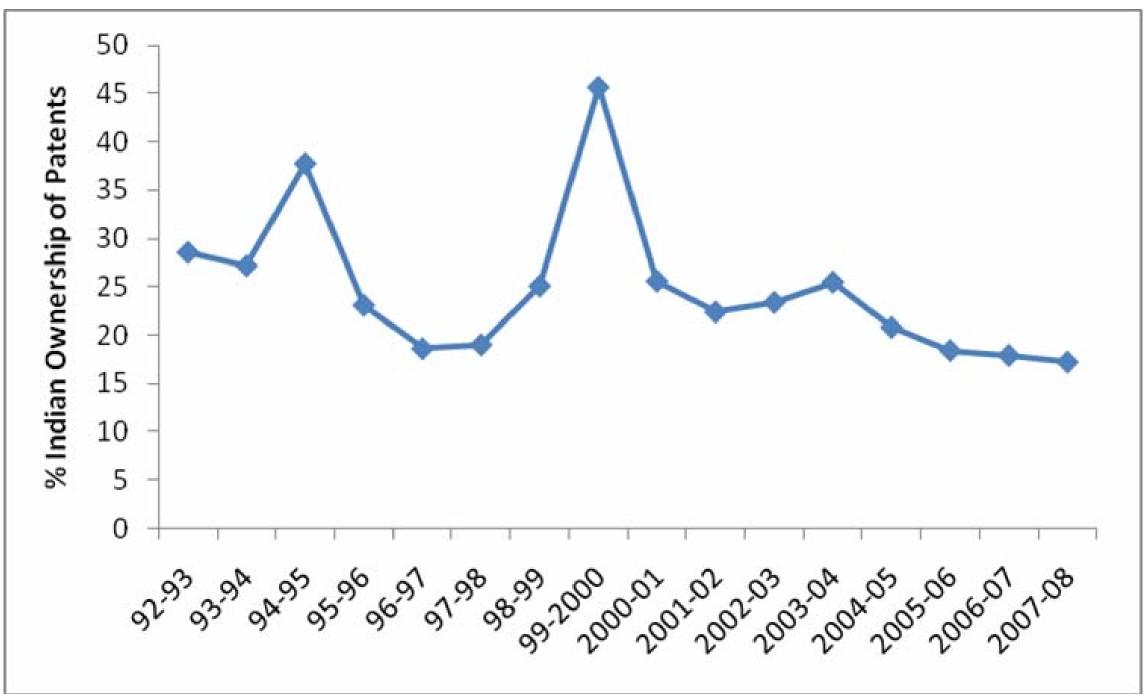


Fig. 5.1.6 : Indian Ownership of Patents filed at IPO in all S&T disciplines

Table 5.1.1 : Indian and Overseas Patents from Indian Public and Private Sector Agencies (2005-07)

PUBLIC SECTOR AGENCIES						PRIVATE SECTOR COMPANIES					
Agency	**IPO**	**USPTO**	**PCT**	**EPO**	**Total**	**Agency**	**IPO**	**USPTO**	**PCT**	**EPO**	**Total**
1. R&D Institutes						**1. Pharma**					
CSIR	1523	356	381	240	2500	RANBAXY	320	108	458	194	1080
DRDO	83	3	11	4	101	Dr.Reddy	315	27	113	39	494
ICAR	82	-	1	1	84	Orhid	149	17	47	11	224
ISRO	67	1	1	1	70	Cadila	148	17	67	23	255
						Others	440	55	267	72	834
Sub Total	**1755**	**360**	**394**	**246**	**2755**	**Sub Total**	**1372**	**224**	**952**	**339**	**2887**
2. Academic Institutions						**2. Automobiles**					
IIT's	237	19	25	6	287	TVS	121	-	-	-	121
IISc	51	3	13	5	72	TATA	66	-	-	-	66
Sub Total	**288**	**22**	**38**	**11**	**359**	**Sub Total**	**187**	**-**	**-**	**-**	**187**
3. Industry						**3. Fabrication / Construction**					
BHEL	189	3	6	-	198	L&T	123	2	2	-	127
SAIL	136	--	--	-	136	TATA Steel	119	1	10	3	133
						OTHERS	52	0	0	1	53
Sub Total	**325**	**3**	**6**	**-**	**334**	**Sub Total**	**294**	**3**	**12**	**4**	**313**
Total	**2368**	**385**	**438**	**257**	**3448**	**Total**	**1853**	**227**	**964**	**343**	**3387**

The Annual Report of IPO for 2007-08 shows (**5**) that the major overseas patents filed at IPO are from thirteen European countries (11.909), followed by USA (10,653) and Japan (2,453). They nearly constitute 81% of the 27,749 patents **(Fig.5.1.7)** filed at IPO by overseas inventors in 2007-08. The European countries in order of their contribution are Germany, Switzerland, France, The Netherlands, UK, Sweden, Italy, Finland, Belgium Denmark, Austria, Spain and Norway. Amongst Asia-pacific countries, S. Korea has a significant contribution (920) after Japan. The overseas inventors have filed Indian patents through three routes viz., normal (2.4%), Convention (13.6%) and PCT national phase (84%) application filings. The normal patent applications are directly filed in India whereas the others are routed through worldwide PCT facilitation units.

5.2 The IP Generation Trends in Chemical Sector

The versatility of chemical and allied sciences lies in their ability to form overlap regions with adjacent disciplines like biology, medicine, physics and engineering to develop a useful multidisciplinary product/process for diverse industrial applications. The significant R&D growth in chemical and allied sciences in advanced nations is mainly attributed to this versatality.

5.2.1 Global Trends

Research Publications

The world chemical research papers is of the order of 1.66 lakhs in 2004 (**6**). They registered a 15% growth during 1998-04. The top publishing nations are USA (25.4%), China (11.72%), Japan (10.04%) and Germany (8.03%). India stood at 9th position with 7,387 research papers in 2004. Globally, the subject coverage of chemical research papers has grown to diverse fields like molecular structure and synthesis, process dynamics, catalysis, supramolecular assemblies, biochemistry, microbiology, advanced materials etc. In addition, there are overlap regions with several other disciplines including, medicine, biotechnology and nanotechnology.

Fig.5.2.1 shows the chemical research papers output in India vis a vis USA, Japan and China. During the period, the Chinese chemical research grew 6 times whereas those from India grew 2.4 times eventhough both countries had a similar trend in 1995.

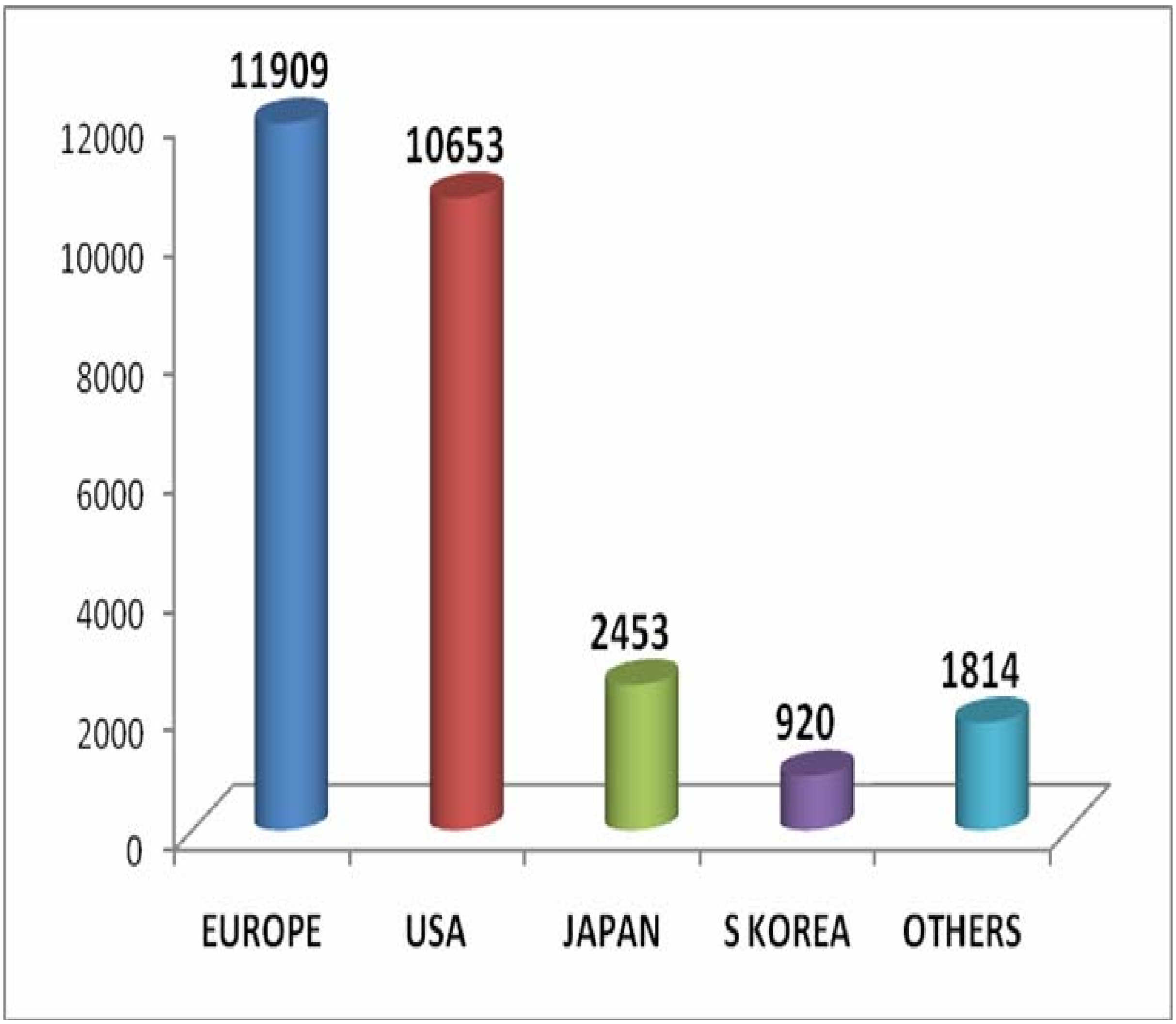


Fig. 5.1.7: Overseas Sources for Indian Patents (2007-08)

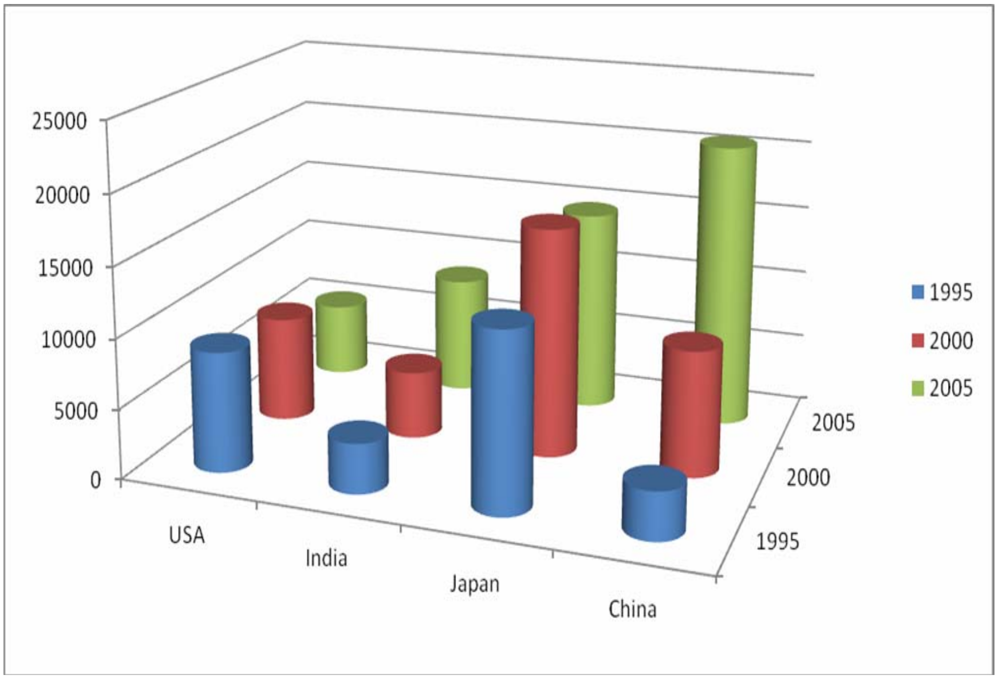


Fig. 5.2.1: Research Publication output in chemistry and allied areas in India, USA, Japan and China

While China has achieved the top spot in chemical research publications. USA and Japan had experienced negative growths during 2000-05. Interestingly, USA has lower number of chemical research papers in 2005 as compared to India, China and Japan.

The cumulative aggregate growth rates of Indian chemical research papers in various sub disciplines are given below:

Discipline	***PSC***		***CAGR***	
		1995-99	**2000-05**	**2005-09**
Organics	9.7	10.03	12.70	01.06
Biotech	10.00	09.25	02.33	**15.85**
Pharma	10.0	18.23	08.01	**16.50**
Polymer	8.4	03.37	08.00	04.93
Food	5.7	10.21	0.7	08.20
Materials*	12.1	03.62	06.93	**15.20**
Coatings**	9.1	0.65	15.75	09.06
Nanotech	9.31	05.22	22.42	**19.03**
Chem Engg	8.0	04.60	07.87	07.69
Env Sc/Engg	17.7	0.26	11.33	**15.62**

PSC: Percentage Share of Citations *Basic Materials (ceramics and metallurgy)
**Basic Materials (Coatings and films)

The fastest growing sub-disciplines are nanotechnology, pharmaceuticals, biotechnology, environment science / engineering and materials. The growth rate of organic chemistry research papers has significantly fallen during 2005-09 and so is the case with polymer science.

Patents

The data presented in this section is based on the WIPO reports (**7-9**). With knowledge driving innovation and economic growth worldwide, IP rights have become central to achieving global leadership in IP generation. As per WIPO classification, the technology patents have been categorized under electrical engineering, instruments, chemistry, mechanical engineering and other fields. The chemistry discipline is subcategorized as organic chemistry (**OC**), biotechnology(**BT**), pharmaceuticals(**PH**), polymers(**PL**), food chemistry(**FP**), materials chemistry and metallurgy(**MS**), surface technology / coatings(**MC**), nanotechnology(**NT**), chemical engineering(**CE**) and environment technology(**EE**). U.Schmoch studied the distribution of international patent applications in 2005 in various technological fields. Pharmaceutical patents covered more than 6.5% of global patents as compared to any S&T discipline. This is based on revised technology classification as adopted by ISI-OST-INPI (2005).

Around 22.14 lakhs patents were filed in the world in 11 chemical sub-disciplines during 2002-06 (**7**). The details are provided in **Fig.5.2.2**. Their average annual growth is around 2.8% and cover interdisciplinary application areas like biotechnology, food processing and material science and technology, pharmaceuticals and nanotechnology. Except pharmaceuticals, food chemistry, materials, coatings and nanotechnology, negative growth was observed in patent applications in other disciplines during this period. Nanotechnology recorded the highest growth rate (5.2%) followed by pharmaceuticals (3.1%).

Foreign Oriented Patent Families in Chemical Sciences

The Foreign Oriented Patent Family (FOPF) is defined by WIPO as a set of patent applications inter-related by either priority claims or PCT national phase entries normally containing the same subject matter. The FOPF concept also eliminate double counts of patent applications filed in multiple patent offices for the same invention. The latest data from WIPO shows that approximately 8.76 lakh FOPFs were filed in 2005 with Japan and USA accounting for the largest share (58.3%). In recent years, there has been an increase in FOPFs filed by China, Brazil and India eventhough their combined share is less than 1%. Approximately 0.44 million FOPFs were filed during 2002-06 by various countries in the world. On an average, a FOPF consists of 5 patents in chemical and allied sciences. Globally, chemical sector contributed nearly 23% of the FOPFs filed during 2002-06 (**Fig.5.2.3**). The electrical engineering field has the highest share (32%) of FOPFs as compared to other disciplines.

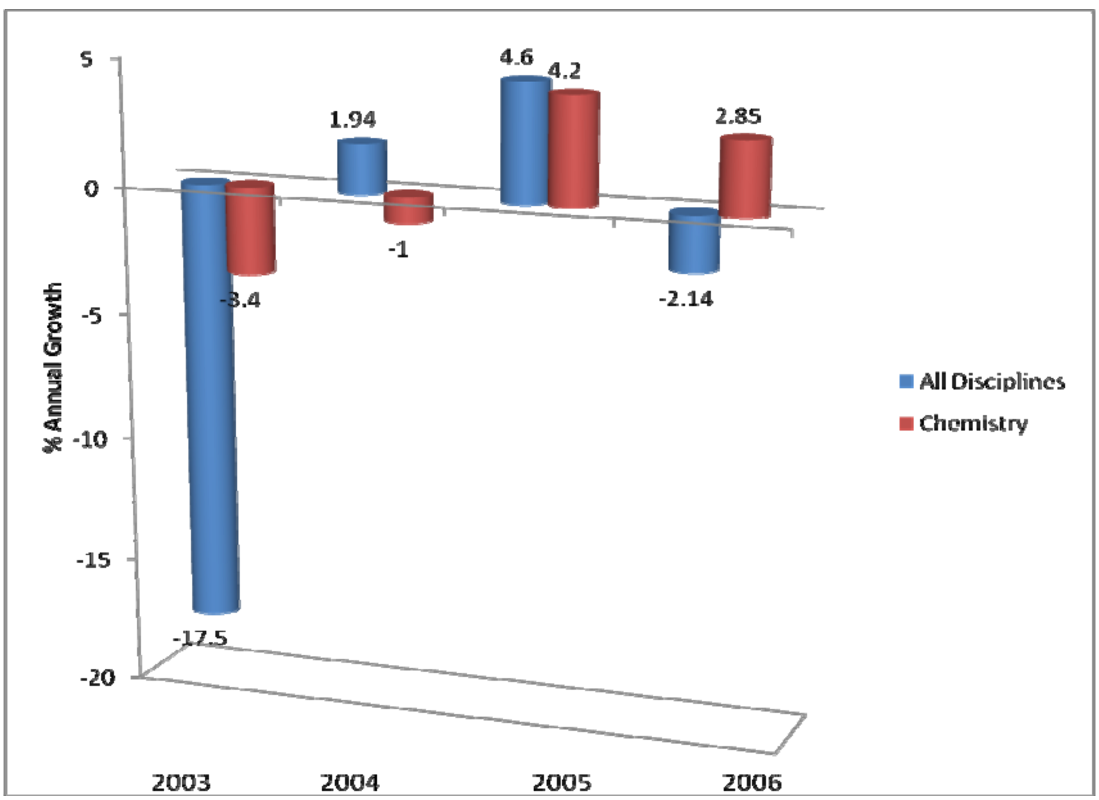


Fig.5.2.2.: Growth of Patent Filings in Chemistry and other Disciplines (2003-06)

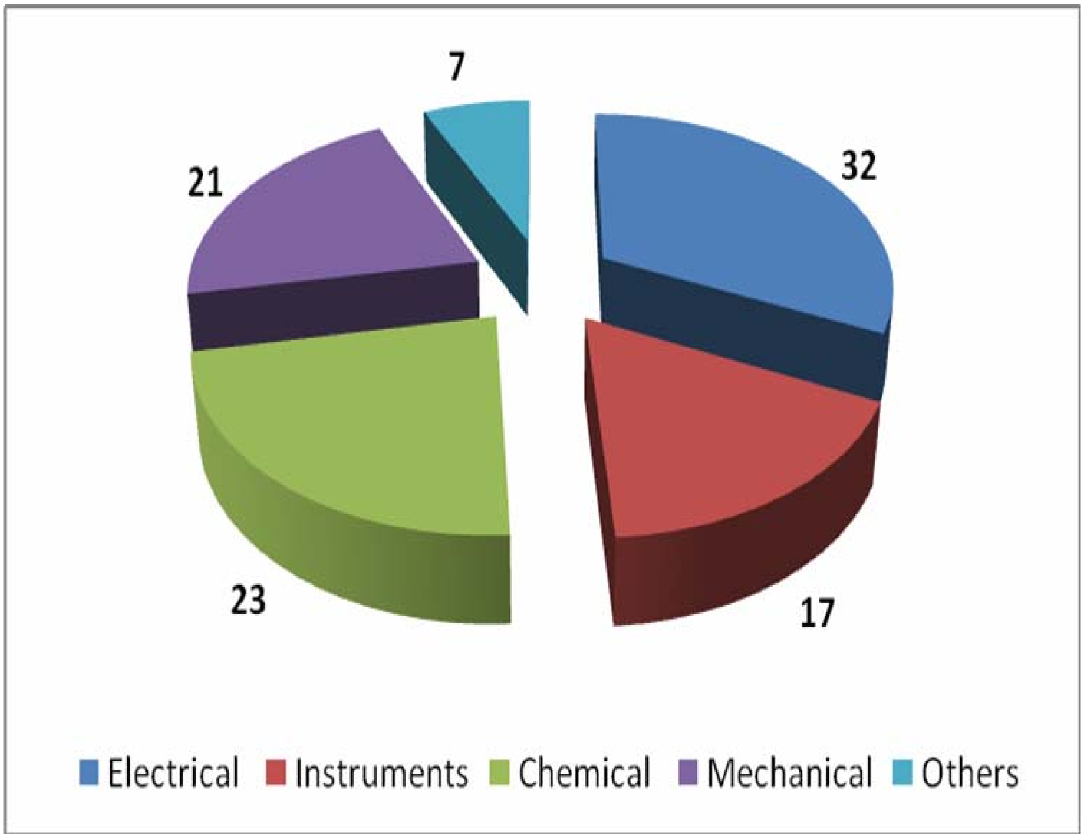


Fig. 5.2.3 : Disciplinewise breakup of FOPFs (2002-06)

PCT Applications

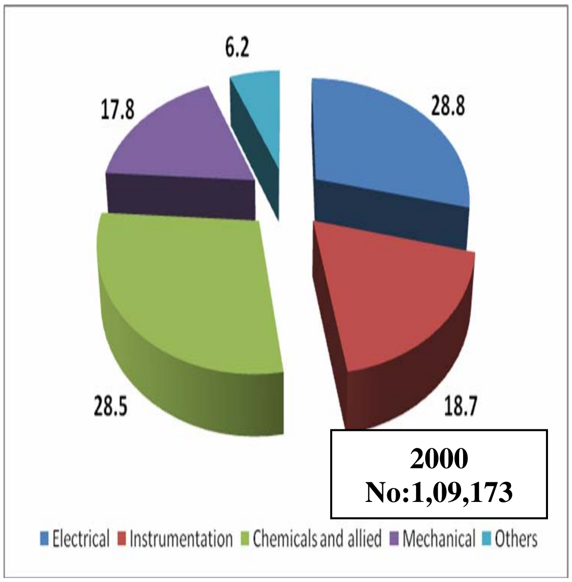
The Patent Cooperation Treaty (PCT) administered by the WIPO, facilitates patent protection for an invention simultaneously in a large number of countries through a single patent application from a single patent office. The PCT international application process starts with international phase and concludes with national phase.

The PCT applications in all technological fields registered an impressive growth (**9**) from 1.09 Lakhs applications in 2000 to 2.23 Lakhs in 2008. The robust growth rates have been recorded by the Republic of Korea (12%), China (11.9%) and Sweden (12.5%). In the technological fields, the largest proportion of PCT applications in 2008 is from medical technology (12%) followed by Computer technology (8.5%) and pharmaceutical (7.9%) sectors. The residents from following countries are the leading foreign inventors named in PCT international applications in 2008. The Indian contribution is quite significant.

- USA : 6187
- GERMANY : 5746
- CHINA : 5221
- UK : 4773
- **INDIA : 4071**
- FRANCE : 3104

The subdisciplinewise breakup of PCT applications in 2000 and 2008 is shown in **Fig.5.2.4**. It demonstrate the growing domination of chemical sector PCT filings as compared to other discipline filings. **Fig.5.2.5** shows the percent share of various chemical sub-disciplines in PCT applications. The dominance of PCT filings in pharma, materials and organics can be seen. A broad chemical industry sectoral affiliation of PCT applications is shown in **Table 5.2.1.** Globally, the speciality chemical sector recorded an impressive 110% growth during 2000-08.

As per the statistics released by WIPO in 2008, the PCT facility was utilized by 139 countries in 2006 with a significant heterogeneity amongst them in terms of its utilization. The WIPO distribution of the PCT filings based on user type (**Table 5.2.2**).



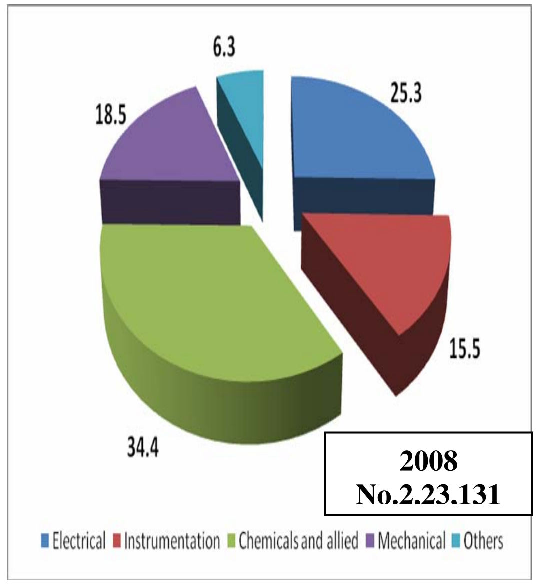


Fig.5.2.4: PCT Applications in Technological Sub-disciplines in 2000 and 2009

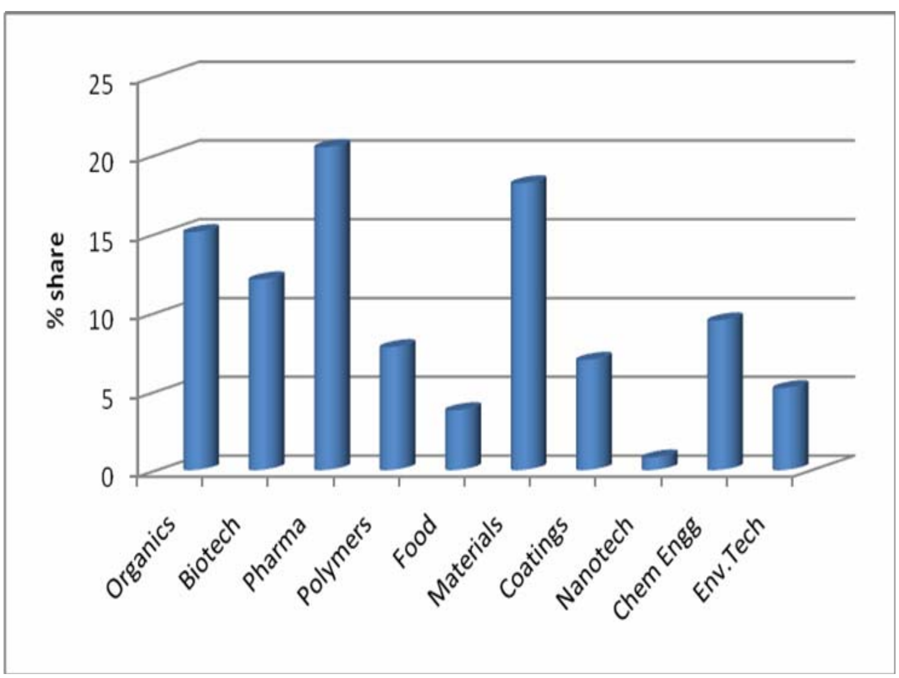


Fig. 5.2.5 : World PCT Applications in Chemical sub-disciplines

Table 5.2.1: Breakup of PCT Applications as per Chemical subsectors

	2000		2008		Growth (2000-08)
	No	%	No	%	%
Basic Chemicals					
❖ Organics	5641		9621		
❖ Polymers	3139		4955		
❖ Chem. Engg	3681		6000		
❖ Env. Tech	1568		3321		
Sub total	**14,029**	**38.4**	**23,897**	**37.6**	**71**
Speciality Chemicals					
❖ Food	1212		2423		
❖ Coatings	2208		4410		
❖ Materials	5380		11,608		
Sub total	**8,800**	**24.1**	**18,441**	**29.0**	**111**
Knowledge Intensive					
Chemicals	6789		12,967		
❖ Pharma	6798		7,698		
❖ Biotech	86		518		
❖ Nano					
	13,673	37.5	21,183	33.4	77
Grand Total	**36,502**	**100.0**	**63,521**	**100.0**	

Table 5.2.2 : Distribution of PCT Filings by User Type (2006)

	"Intensive" User[1]	"Medium" User[2]	"Low" User[3]
Number of Countries	18	26	76
Number of PCT Filings	141 369	6 812	656
Average Annual Growth Rate (1995-2006, %)	12.6	14.4	18.8
Share in Total PCT Filings (%)	94.8	4.6	0.4
Change in Share of Total PCT Filings (1995-2006)[4]	-0.9	0.7	0.2

1. Intensive users: more than 1000 PCT Filings in 2006.
2. Medium users: between 50 and 1000 PCT Filings in 2006.
3. Low users: less than 50 PCT Filings in 2006.
4. Percentage points.

India falls under "Medium User" category with less than 1000 PCT filings / annum capacity. It is bracketed along with small open economics like Austria, Ireland and Norway and larger economies like Brazil, Russia and South Africa. India stood second under medium user category with 800^{+} PCT filings / annum.

Ownership Pattern of PCTs

The composition of applicants varies across countries. WIPO reported (**7**) the distribution for 30 leading PCT filings (in all S&T disciplines) countries in the world based on 2009 statistics. **Fig.5.2.6** shows the reported distribution for PCT applications filed in patent office in India, China, USA, Japan and S.Korea. In all these countries, industry filed majority of PCT applications with Japan registering 93.6% applications from industry. India, S.Korea and China attracted larger % of individual applications from industry. The university contribution has been less than 10% in all these countries. The government R&D institutions contributed 10% or more in India and S.Korea. WIPO has reported that Ireland, Spain and Singapore attracted more than 13-26% applicants from Universities.

5.2.3 IP Growth Trends in Indian Chemical sector (1997-08)

The growth trends of Indian research publications and patents in chemical and allied sciences during 1997-09 are given in **Fig.5.2.7(a)**

Post WTO Transition Period (1995-98)

The research publications in chemical oriented discipline during this period recorded a moderate growth whereas the patents filed at IPO have registered a near flat profile followed by a downward trend. This is in contrast with the trend of total Indian patents in all S&T disciplines.

Post WTO period (1999 onwards)

Indian Research Publications in chemical and allied disciplines grew by about 70% during 1999 to 2005 and subsequently by 43% till 2008. The overall growth is very impressive as compared to Indian research papers published in other disciplines. The growth of Indian patents in chemical sector has shown a totally different trend. During 1999-2002, the growth profile is practically flat possibly due to wait and watch policy adopted by the overseas inventors with reference to patenting at IPO. The Indian chemical patent growth during 2002-06 has been spectacular with a six fold increase. The effect of internationalization of IP could be seen clearly. The share of Indian chemical patents among the total Indian patents covering all disciplines rose from 18 to 49%. Surprisingly, the Indian patent filing in chemical sector dropped during 2006-08. This is quite in contrast to the trend registered by Indian patents in other disciplines. The possible reason may be the adverse impact of reduced research funding in overseas chemical sector due to economic recession.

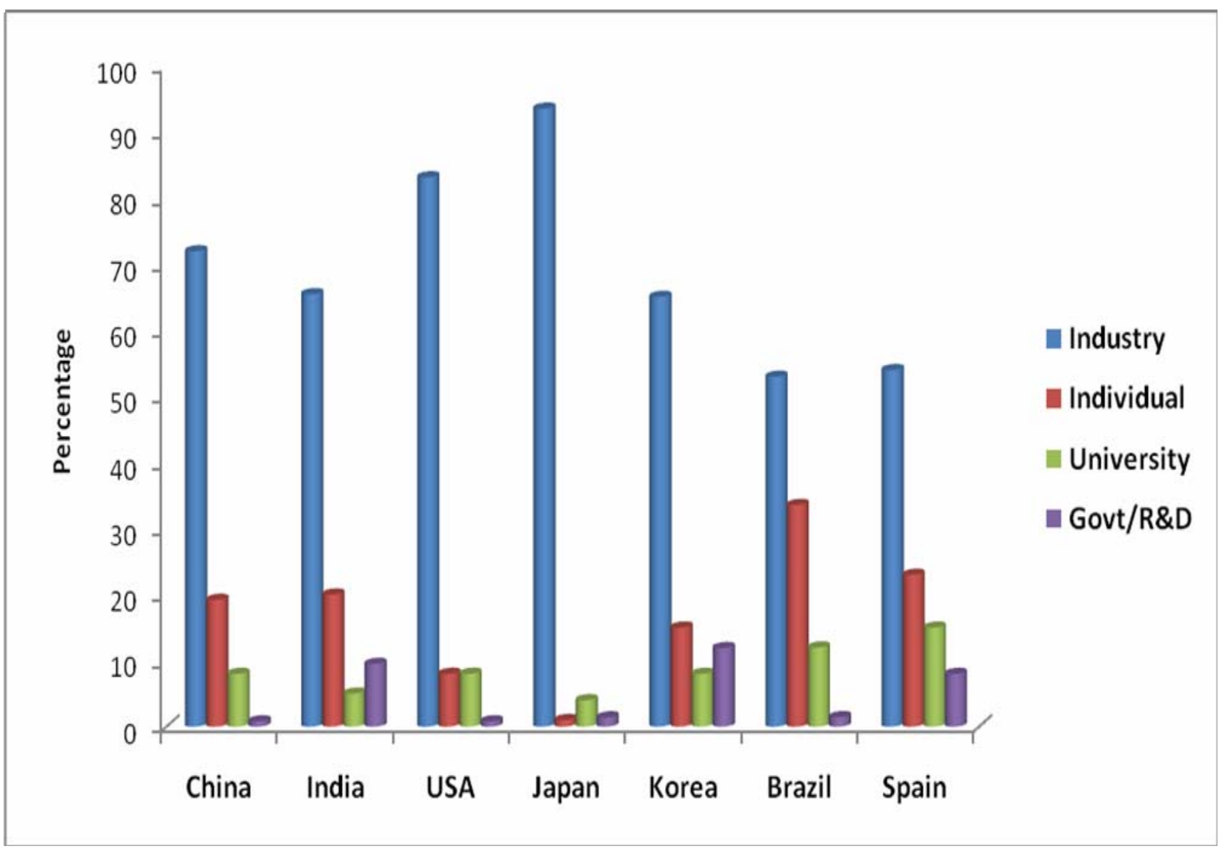


Fig. 5.2.6 : Distribution of PCT applications by ownership in all S&T disciplines

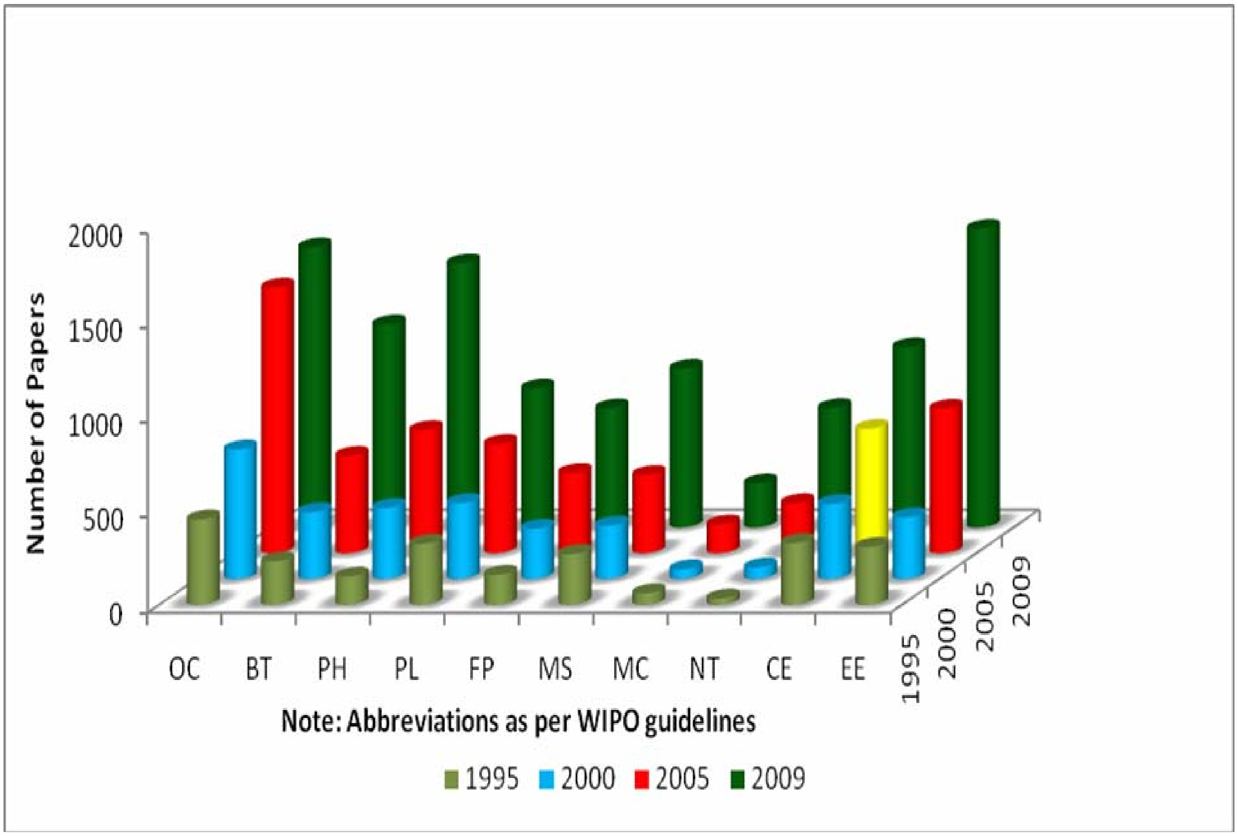


Fig. 5.2.8 : Growth of Research Papers in chemical subject areas 1995-09

5.2.3. IP Growth Trends in Indian Chemical Sector (1997-08)

The Growth Indices as presented in **Fig.5.2.7(b)** show that Indian patents in all S&T disciplines have registered impressive growth rate with chemical sector patents maintaining much higher growth rate till 2006. The growth index of chemical sector research papers is lower than that of chemical patents.

5.2.3.1 Growth Trends of Research Papers in Chemical Subdisciplines

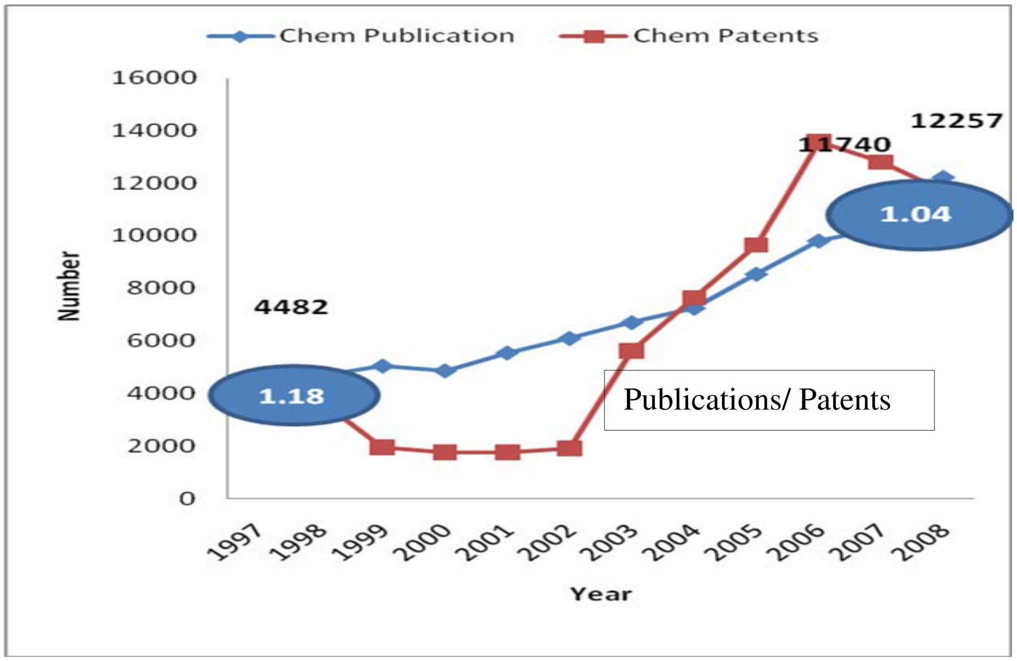
A total number of 1.17 lakh chemical oriented papers were published in SCI journals by the Indian researchers during 1992-09 covering 11 chemical subdisciplines as per WIPO classification. They attracted 5.92 lakh citations with an average of 7.5 citations per paper.

The growth breakup of Indian research publications in chemical sub-disciplines during 1992 - 09 is shown in **Fig.5.2.8**. An average annual growth of 7.8% was maintained throughout this period. The environmental engineering, organic chemistry and pharmaceutical disciplines attracted highest number of Indian research publications. The disciplines like coatings, nanotechnology, material science and food processing have registered less than 10% share of chemical area publications. However, nanotechnology publications growth is highest amongst all chemical sub-disciplines whereas the polymer publications have registered lowest growth rate.

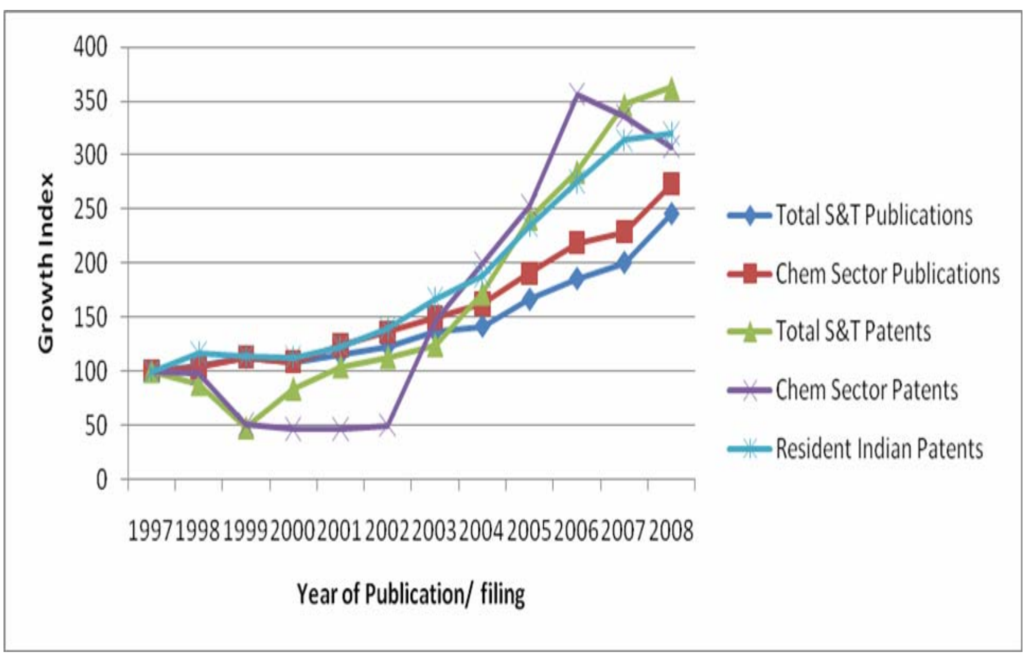
Fig.5.2.9 indicates the relative share of research papers relevant to the three sub-sectors. Understandably, the knowledge intensive chemical sector registered highest growth whereas the basic chemical sector has largest share (>50%) of chemical research papers. The speciality chemical sector has the lowest share with modest growth rate. This is somewhat disappointing since this is one of the fast growing IP generating sectors in the world.

Share of chemistry sub-disciplines in Research Paper

The chemistry sub-disciplines viz., organic, inorganic, physical, analytical, medical and electrochemistry are major areas for academic research publications in India. **Table 5.2.3** shows their percentage shares. It is interesting that organic and physical chemistry patents have more than 60% share in Indian chemical research publications. Inorganic and analytical chemistry have next higher share.



(a) Growth of Research Papers and Patents in all S&T disciplines



(b) Growth Indices of research papers and patents

Fig. 5.2.7 : Growth of Indian Chemical Research Papers and Patents (1997-08)

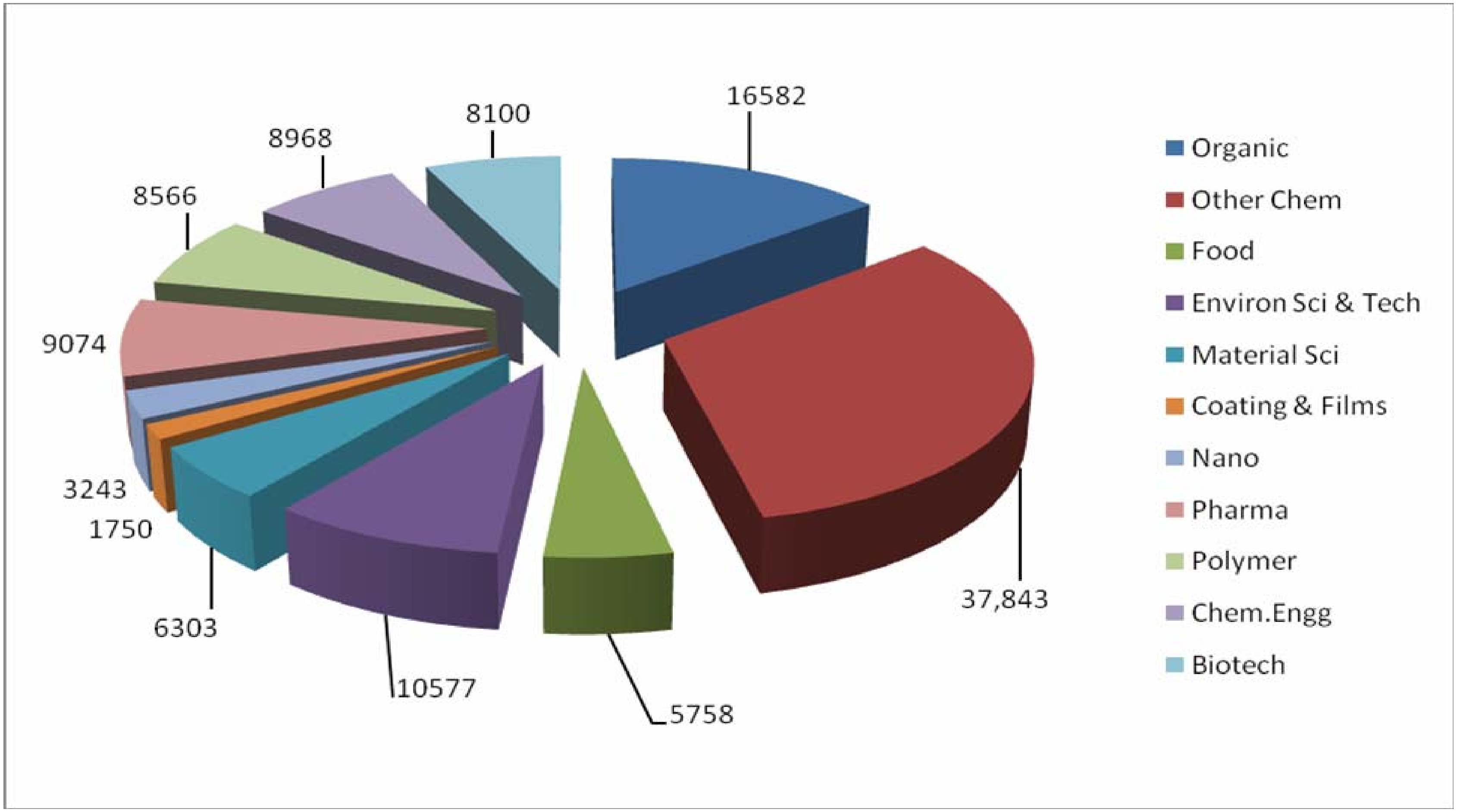


Fig. 5.2.8 : Chemical Sector Publications during 1992-2009 India

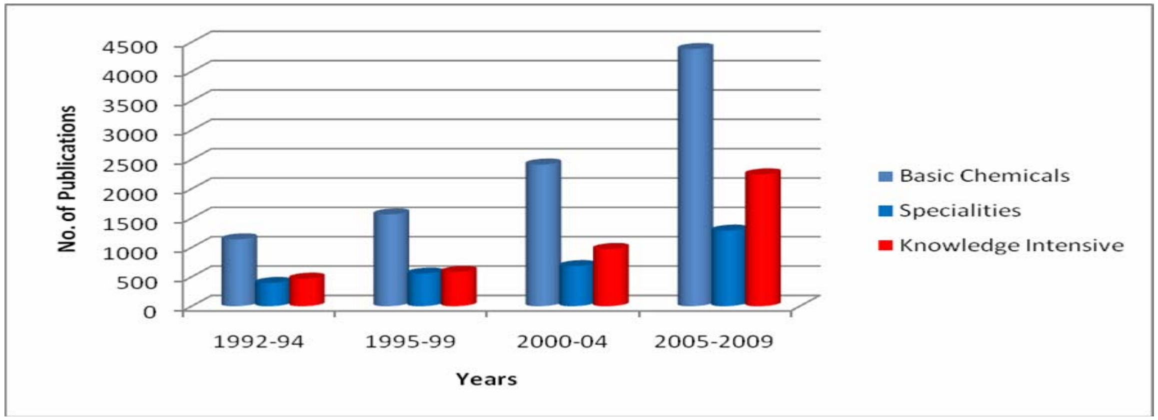
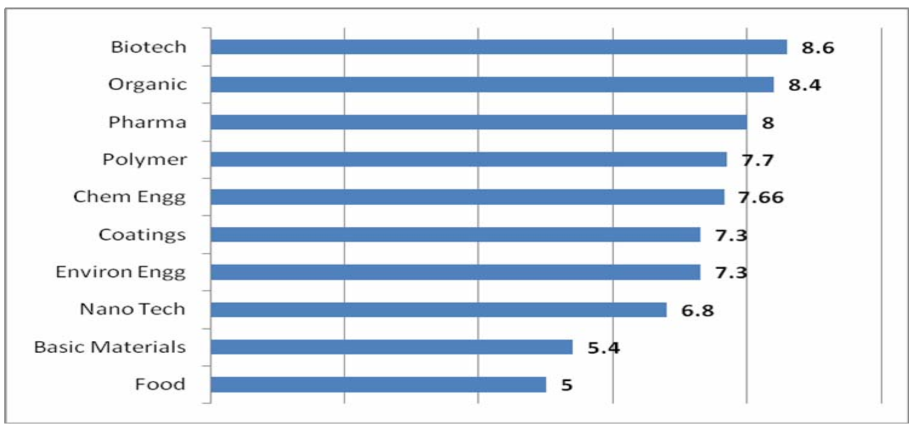
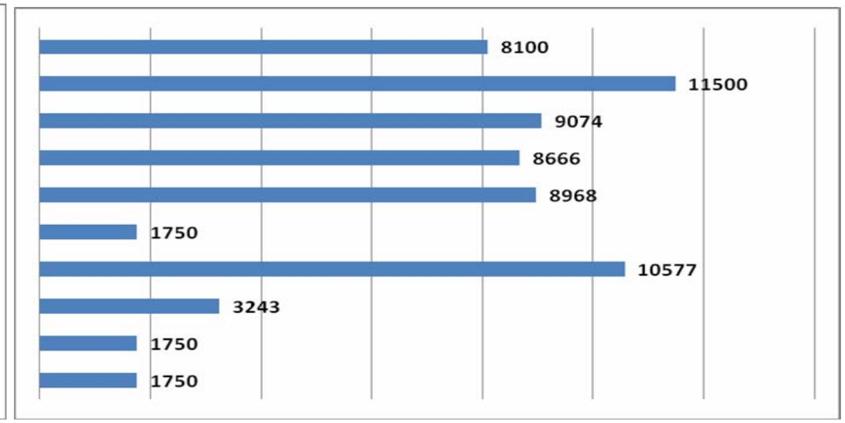


Fig. 5.2.9 : Share of Chemical sub-sector Research Papers (1992-09)



(a) Citation per Paper



(b) No. of Papers

Fig. 5.2.10 : Citations / Research Paper in Chemical Sub-disciplines (1992-09)

The total Indian chemistry research papers in national and international journals during 1992-09 is estimated as 54,424. Interestingly, medicinal chemistry publications grew by more than 6 times during this period followed by more than 3.5 times by organic and physical chemistry disciplines. The inorganic chemistry publications recorded relatively low growth (1.7 times).

Table 5.2.3 : Growth of Chemistry Research Papers (1992-09)

Sub-disciplines	**1992-94**		**1995-99**		**2000-04**		**2005-09**	
	No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Organic	383	24.6	645	31.8	995	34.0	1447	29.4
Analytical	223	14.3	242	11.9	282	9.6	501	10.2
Inorganic	363	23.3	318	15.7	396	13.5	618	12.6
Physical	458	29.5	607	30.0	834	28.5	1624	33.0
Medicinal	81	5.3	133	6.5	285	9.7	486	9.9
Electro	47	3.0	85	4.1	137	4.7	239	4.9
	1555		**2030**		**2929**		**4915**	

5.2.4 Quality of Indian Research Papers in Chemistry

The Institute for Scientific Information (ISI) in Philadelphia, USA created Science Citation Index (SCI) which shows how many times the various references have been cited during the previous years (**10**). While publication numbers are useful in measuring the quantum of research output in specific scientific fields, its citation count indicates its influence on new knowledge generation and its application. In scientific circles, citation counts are accepted as a robust measure of scholarly achievement as reflected in the referencing pattern of peer researchers (**11-17**).

Fig.5.2.10 provides the citation data for Indian research papers in various chemical subdisciplines. The Biotechnology, organic chemistry and pharmaceutical science publications attracted relatively higher number of citations per publication as compared to others. Research papers on surface coatings, basic materials and nanotechnology have attracted quite a good number of citations inspite of their number being small. An attempt has been made in this section to compare the citations per research paper attracted by USA and India during 1992-09 in chemistry (**Fig.5.2.11**). India had attracted a maximum citations per publication of 12.4 in 2000 as compared to 31.3 attracted by USA in 1993.

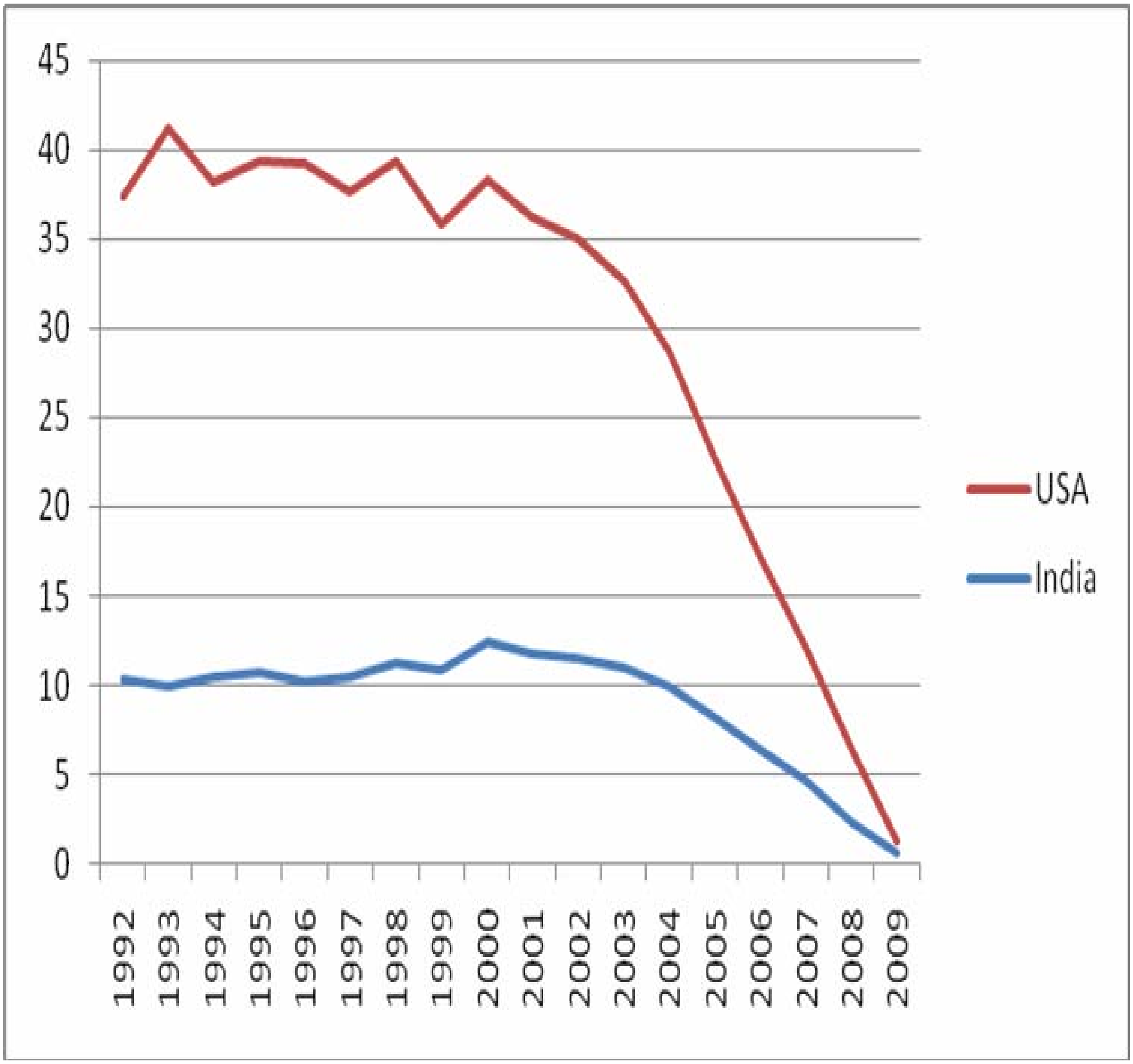


Fig.5.2.11 : Average Citations per Chemical Publications from India and USA

Impact Factors of Research Publications

S.Gunasekharan (2006) (**6**) made a bibliometric study of Indian Chemical research publications. He covered research publications from all the chemical disciplines in 2002 to assess % share of research papers at 6 impact factor levels. The INAE team made a similar analysis for Indian chemical research papers published in 2009 to assess their quality improvement or otherwise during 2002-09. The details are provided in **Table 5.2.4**. The data clearly establishes a significant improvement in quality and number of chemical research papers during 2002-09. The journal access has nearly doubled and % share of research papers with impact factor greater than 2 have registered an impressive growth. The research papers with impact factors less than one have been reduced by more than 50% during this period.

Table 5.2.4: **Quality Improvement in Indian Chemistry Research Papers 2002-09**

% Share in total publications

Impact Factors	*2002*	*INAE Study (2009)*
<1	48.2	20.9
>1<2	25.3	29.4
>2<3	19.4	27.1
>3<4	3.6	12.7
>4<5	1.8	7.3
>5	1.5	2.6
No. of Papers	6186	13480
AV. IF	1.39	2.13
Journals	569	957

5.2.3.2 Growth Trends of Indian Chemistry Patents

Foreign Oriented Patent Families (FOPFs)

WIPO defined them as a set of interrelated patent applications filed in one or more foreign countries to protect the same invention. India does not have any significant share in FOPFs at global level in any of the S&T sectors. The discipline wise breakup of FOPFs of Indian origin is given in **Fig.5.2.12.** The chemistry oriented FOPFs has a major share (69%) followed by instrumentation (17%). The FOPFs filed in various chemistry sub-disciplines by India, USA, Japan and China during 2002-06 are given in **Figs. 5.2.13.** It shows that

- India is far behind China in intellectual property protection in almost all chemical sub-disciplines. Its contribution is less than 10% of that achieved by China.

- India's best patenting performance in organics and pharmaceuticals achieved during 2002-06 is insignificant when compared to the number of FOPFs filed by the inventors from USA and Japan.

Fig.5.2.14 and **Table 5.2.5** show the share of Indian Chemical industry subsectors in filing FOPFs and those from USA, Japan and China. They show that:

- India is far behind China, USA and Japan in filing FOPFs.
- Japan dominates the world in filing highest number of FOPFs in speciality chemical sector
- USA dominate the world in filing highest number of FOPFs in basic chemical and specialities subsectors
- Indian FOPFs are predominantly in basic chemicals and knowledge Intensive sectors.

Table 5.2.5 Share of Chemical sub-sectors in FOPFs (2002-2007)

Area	India		USA		Japan		China	
	No	% share	No	% share	No	% share	No	% share
Basic Chemicals								
Organics	4623		1,15,792		60,706		15,537	
Enviro tech	183		25,047		60,261		9,617	
Polymers	241		48,048		80,038		9,686	
Chem. Engg	448		62,937		73,566		12,881	
	5495	**44**	**2,51,824**	**35.3**	**74,571**	**46.1**	**47,716**	**28.4**
Specialities								
Food	488		26,780		27,257		17,450	
Coatings	128		56,161		94,474		8,312	
Materials	1110		97,904		1,55,825		40,369	
	1726	**13.8**	**1,80,845**	**25.4**	**2,77,556**	**46.6**	**66,131**	**39.3**
Knowledge Intensives								
Pharma	4172		1,65,330		43,451		39,318	
Biotech	1089		1,10,378		37,252		14,107	
Nano tech	9		4,296		5,758		885	
	5270	**42.2**	**2,80,004**	**39.3**	**43,053**	**7.3**	**54,310**	**32.3**
	12,491	**100%**	**7,12,673**	**100%**	**5,95,180**	**100%**	**68,157**	**100%**

India Leads in Relative Specialization Indices (RSI) of Organic Chemistry and Pharmaceuticals

The Relative Specialization Index (RSI) is defined by WIPO as the ratio of a country's share of FOPFs in a specific technological field over its share in all FOPFs. It corrects for the effects of country size and focuses on the concentration of patent filings in specific fields. A positive RSI implies that the concerned country has a relatively high share of patent families in the selected technological field. The RSI is a strong indicator of a country's R&D focus accorded in a particular technological field.

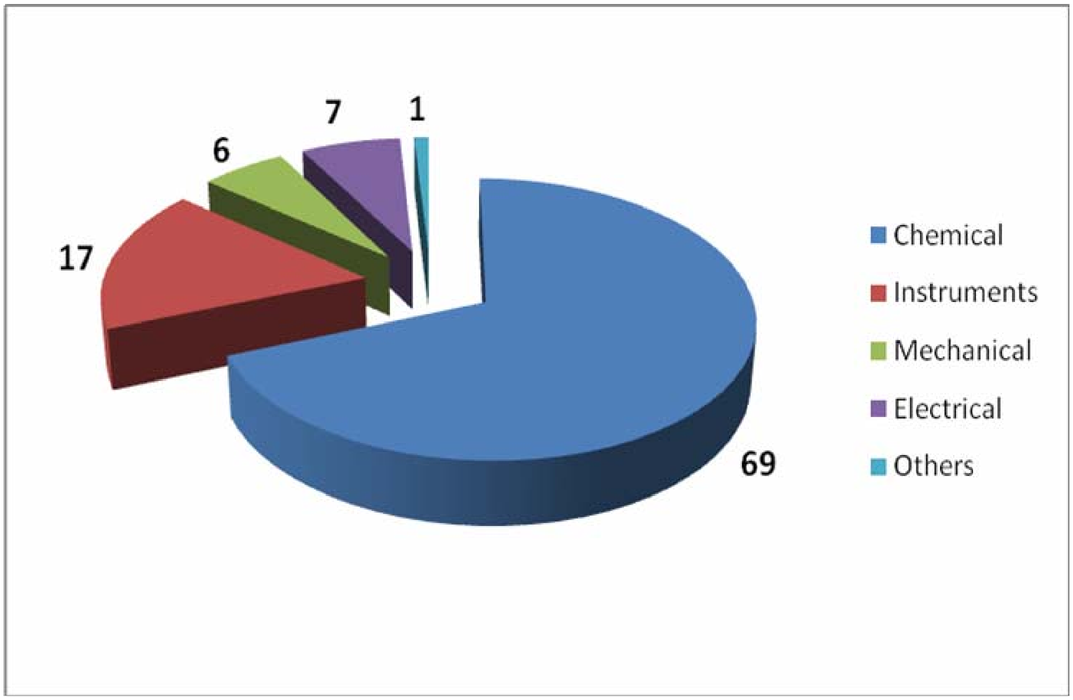


Fig.5.2.12: Disciplinewise Breakup of FOPFs Indian Origin (2002-06)

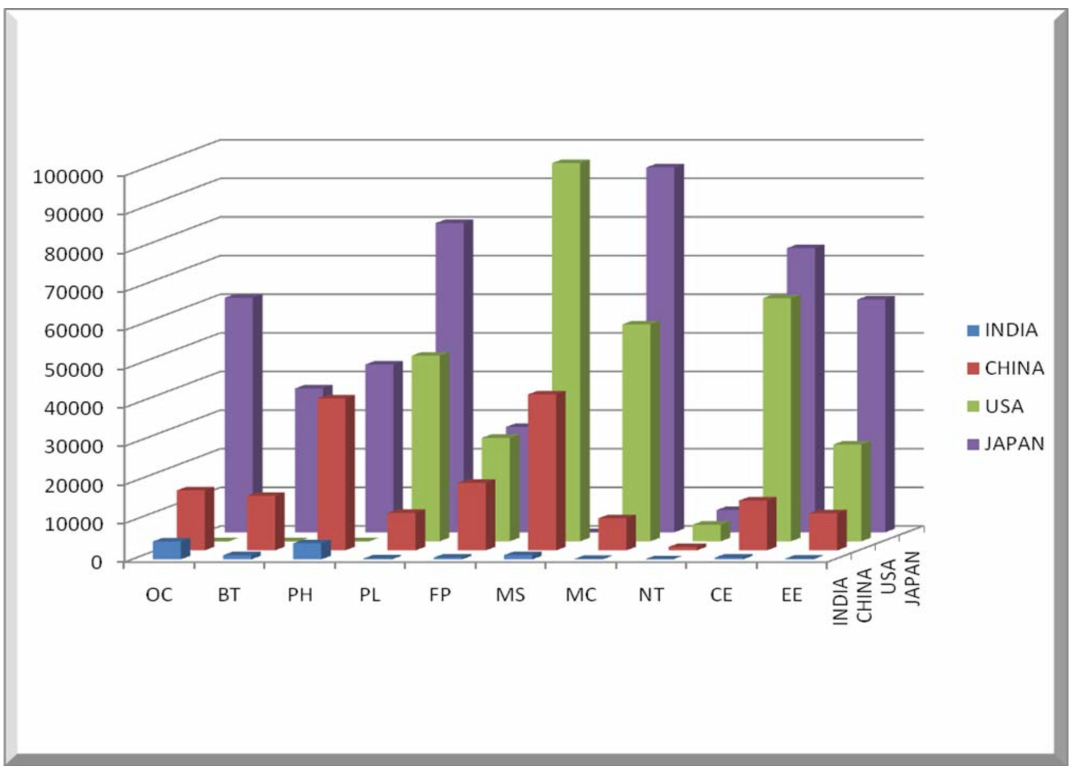


Fig. 5.2.13: Chemistry Oriented FOPF Applications (discipline wise) filed by

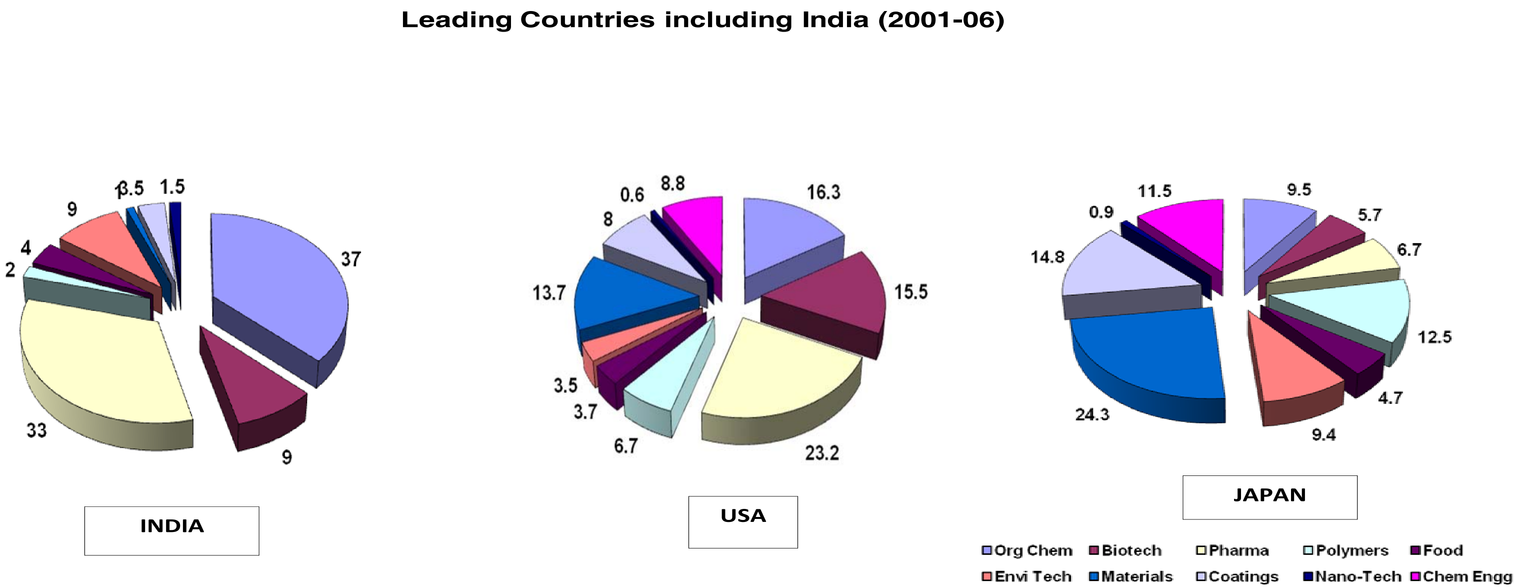


Fig.5.2.14: Subdiscipline breakup of Chemistry Oriented FOPFs filed by India, USA and Japan (2002-06)

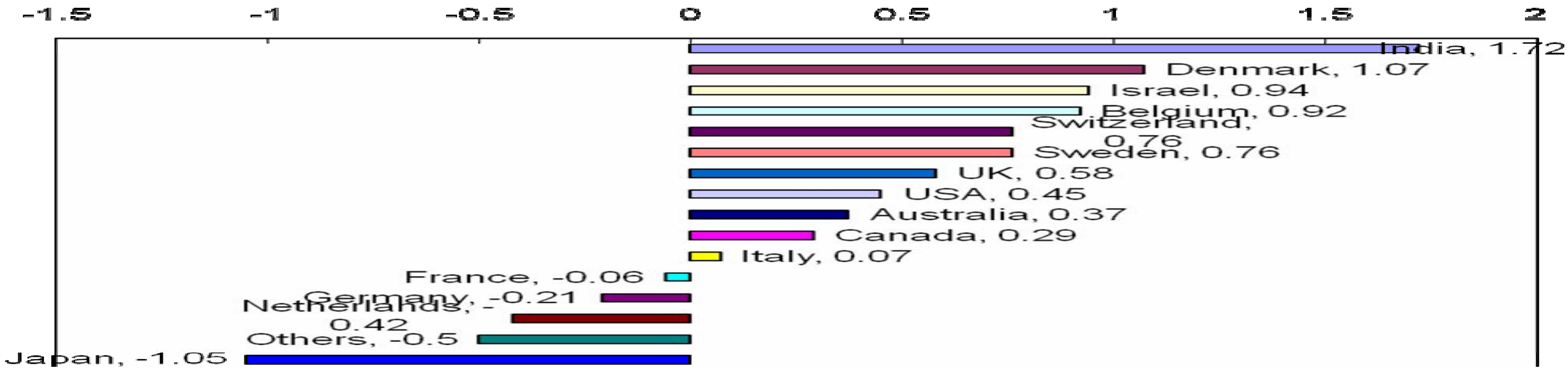
The WIPO published, RSI values for FOPFs in several technological fields for 22 countries including India in 2009. India holds an above the world average concentration of FOPFs in organic chemistry (RSI=1.93) and pharmaceutical sciences (RSI=1.7). There are several developed countries which have relatively low to very low RSI values. **Fig.5.2.15** provides the details. This is indicative of the dominance of organic chemistry and pharmaceutical science disciplines in Indian patenting efforts among all the S&T sectors.

Major Indian Patent Contributors in Pharma Sector

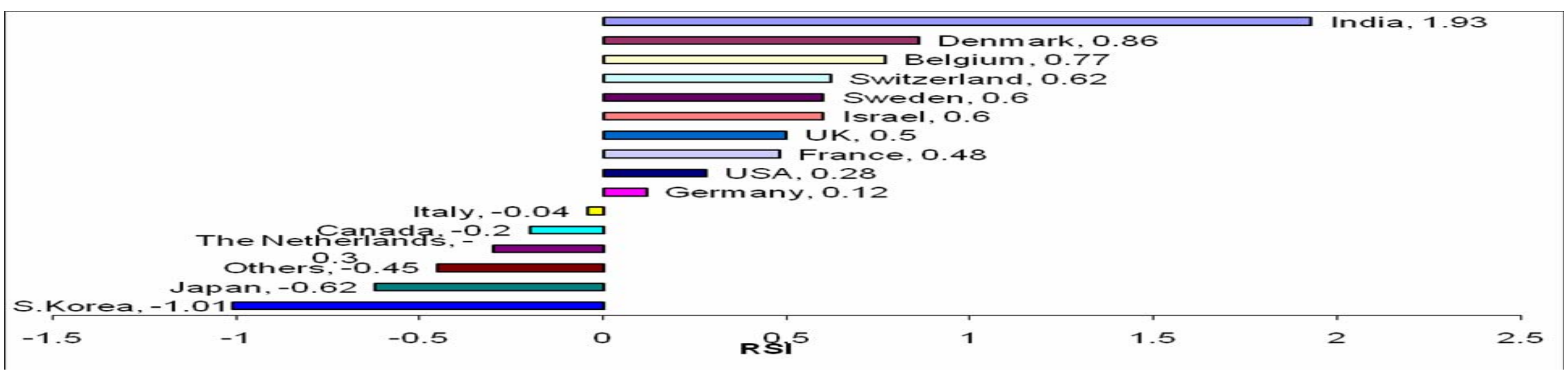
Evalueserve 2009 (**18**) reported the 10 major Indian contributors to pharmaceutical patents filed at IPO, USPTO and EPO during 2005-08. **Table 5.2.6** shows their IPO rankings which range from 31 to 183, significant level of patent activity at USPTO and EPO and relatively higher patenting intensity (PI) at IPO as compared to USPTO and EPO. The PI is defined as the ratio of company revenues in USD million to the number of patents filed by tem. While the matrix lab has the highest PI and IPO, Aurobindo Pharma has the highest overseas PI. The overall patent earnings of the above 10 Indian pharma companies are around USD 16.7 billion with M/s.Ranbaxy topping the list. The above statistics demonstrate the growing protected IP strength of Indian pharma sector and their ability to attract sizeable foreign exchange earnings.

Table 5.2.6: Major Contributors to Indian and Overseas Pharma Patents 2005-08

IPO Rank	**Company**	**Patent Filing (2005-08)**				**Patenting Intensity**		**Revenues (2005-08), *USDB***
		IPO	**USPTO**	**EPO**	**PCT**	**IPO**	**Overseas**	
31	Ranbaxy	455	117	240	531	8.9	2.8	3.70
45	Dr Reddy's Labs	369	40	62	165	8.9	5.2	3.29
66	Cadila HC	219	20	45	132	5.8	3.1	1.28
73	Orchid Chem	190	25	20	91	4.1	2.4	0.77
83	Cipla	165	30	44	100	11.5	5.4	1.85
93	Sun Pharma	133	22	17	89	13.7	7.0	1.82
111	Aurabindo Pharma	113	3	8	82	13.4	7.4	1.52
141	Panacea Biotech	97	8	73	21	6.4	3.1	0.62
178	Torrent Pharma	71	6	13	36	11.0	6.2	0.78
183	Matrix Labs	69	6	19	75	15.3	6.2	1.054
	Total	**1881**	**277**	**541**	**1322**	**9.9**	**4.8**	**16.684**



(a) RSI for Organic Chemistry FOPFs



(b) RSI for Pharmaceutical Science FOPFs

Fig. 5.2.15 : Relative Specialization Index (RSI) of FOPF Applications from India (2009)

Citation Value of Indian Chemical Patents

When a patent applicant cites "prior art" in the text of his/her patent, such citations are called applicant citations. It normally takes 5^+ years before a patent begins to be cited to any great extent. In general, 70% of all patents are either never cited or only once or twice. Citations to prior art is an indicator of the importance of the prior art to subsequent inventions. A highly cited patent is most likely to contain an important technological advance which many later patents are built upon.

MMS Karki (**19**) listed the important applications of patent citation data. M.Trajtenberg (**20**) put forward patents counts weighted by the citations as indicators of their innovation value. J Michel etal (**21**) focussed on the basic input data required for patent citation analysis. M.Meyer (**22**) suggested similar approach to applicant citations as in the cse of academic citations. Thomson Reuters published (**23**) a guide for evaluating research performance with citation data.

Globally, the citation value of patents is slowly being used in financial markets (**24**), since the citation weighted patent stocks are better correlatable with market value than ordinary patent stocks. Professional agencies employ multiple factors like forward and backward citation values, enforcement and partnering licensing potential, crowdedness, patent group competitive position etc,. A backward citation means the earlier citation which appears on the newer patent documents and the newer document is called the forward citation. The European Patent Office (EPO) is the main source identified globally for patent citation search bases. Since May 2007, EPO has been employing DOCDB bibliographic database for patent citation analysis. For the present analysis, the citation value of patents has been considered as a measure of technological quality of Indian patents in chemical sector and their broad innovation value.

The number of chemical patents filed through PCT route at IPO has been increasing steadily since 1998. **Table 5.2.6** shows the growth of Indian chemical patent families applied through direct, national and PCT filing routes at IPO. During 2005-08, around 87% of patent families have entered IPO through PCT route. It is interesting that patents filed through PCT route attracted much more citations as compared to those filed through national route.

Block Year	**Chemical Patent Families**			**Citations**		
	Number	% Nat	% PCT	Number	% Nat	% PCT
1995-99	2357	98.7	1.3	17,251	84.1	15.9
2000-04	9627	35.2	64.8	53,551	16.0	84.0
2005-08	5388	12.8	87.2	23,044	2.8	97.2

The data presented in **Table 5.2.7** shows that nearly 69% of chemical patents attracted atleast one citation each whereas more than 73% pharma and organic chemistry patents attracted one citation each. **Fig.5.2.16** shows the citations attracted per patent family of overall chemical, organic chemistry and pharma disciplines. The citation analysis of chemical engineering patents is given in **Annexure 5.2.1.**

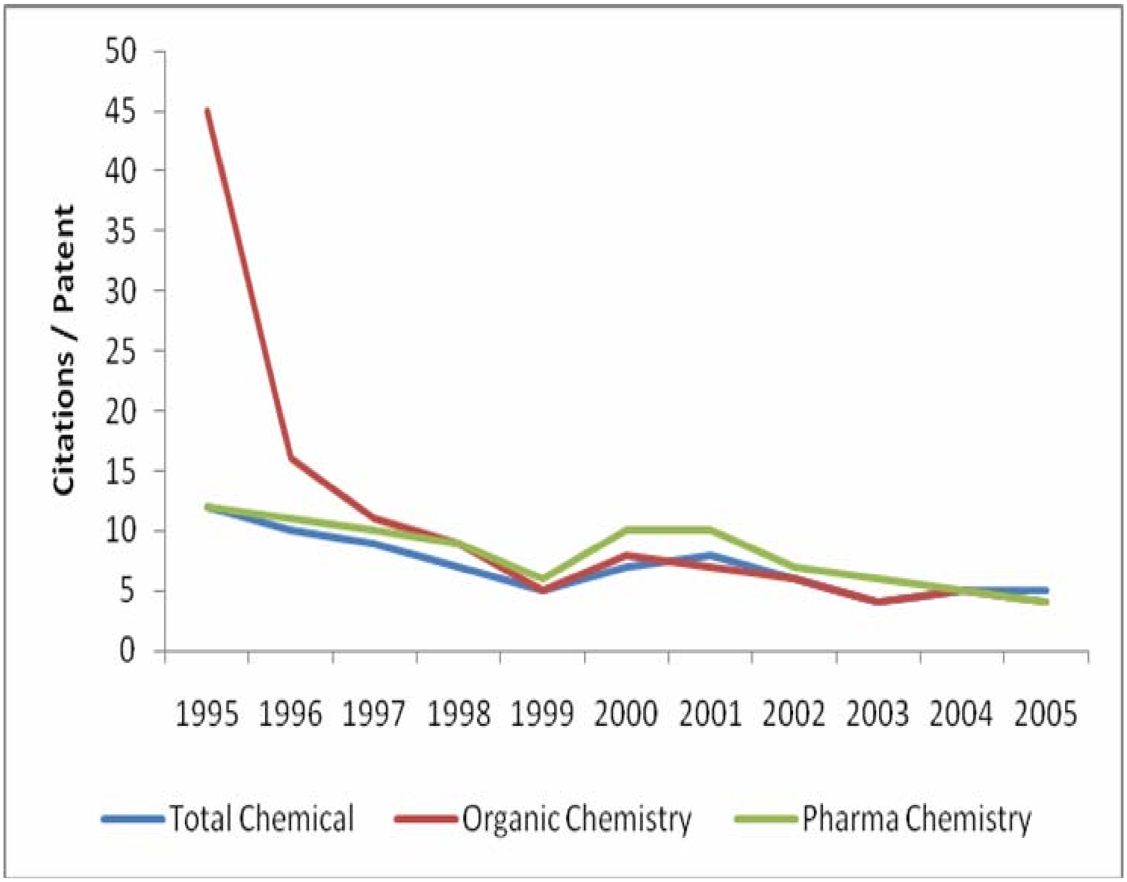


Fig.: 5.2.16: Citations/Patent for overall chemical, organic chemistry and pharma disciplines

Table 5.2.7: Percentage of chemical patents with atleast one citation

	Chemical		Organics		Pharma	
	Total No	%	Total No	%	Total No	%
1995	64	58	5	100	37	67.6
2000	1107	67.8	217	70.5	300	77.7
2005	3408	71.9	530	72.1	1382	76.8
Average (1995-05)		**69.0**		**74.1**		**73.4**

Frequency of Earlier Citations

Weighted mean years have been calculated considering weighted and simple patent counts (WPC and SPC) as weightages for overall chemical, organic chemistry and pharmaceutical science disciplines. The details are presented in **Table 5.2.8.** They indicate that the mean difference in months in the field of organic chemistry is much higher (>20 months) as compared to overall chemical and pharma disciplines.

It means that the earlier patents were cited more frequently in the case of organic chemistry as compared to other two disciplines

Table. 5.2.8 : Growth trends in weighted and simple patent counts (WPC and SPC) during 1994-06.

Field of technology	Weighted Means		Mean Difference in Months
	WPC	SPC	
Chemistry (all disciplines)	2001.73	2002.16	5.09
Organic Chemistry	2000.193	2001.898	20.45
Pharmaceutical	2002.021	2002.646	7.507

5.2.4 Institutional Performance in IP Generation in Chemical Sector

S.Gunasekharan (**6**) reported that 6186 research papers in chemical and allied sciences were published in 2002 by nearly 260 Indian institutions with more than 46% of the research papers published by leading institutions which represents less than 4% of the total institutions.

In a globalized knowledge regime, the R&D and academic institutions have to create, advance and transmit knowledge to the industry based on mutual growth interest. The Government of India, state governments and private sector are providing significant funding to the leading Indian institutions in support of their conduct of basic and applied research. With such levels of combined public and private investment, the pressure on these institutions are slowly increasing to generate new product and process knowledge of relevance to the industry. These pressures are inevitably resulting in a sort of competition amongst them to deliver quality research. They include national institutes like IITs, IICT, IISc, BARC, IACS and others and universities of Hyderabad, Mumbai, Madras, Anna, Rajasthan, Mysore and others. The Maharashtra, Karnataka, Andhra Pradesh and few other states are leading in their support to these institutions.

The INAE team has assessed the relative performance of leading institutions in Indian chemical sector in terms of their ability to generate quality research papers in organic chemistry, pharmaceutical, bio and nano technology and chemical engineering disciplines. A mini survey is undertaken to assess the ranking of the leading institutions in five selected chemical disciplines based on the data collected from the web of science (**25**). The results are presented in **Table 5.2.9** and **Fig.5.2.17.** Amongst the selected disciplines, the top 10 institutions in organic chemistry published the maximum number of research papers with relatively high impact factor. Their growth rate during 2002-09 is also the highest. It is also interesting to know that 6 institutions consistently maintained their ranking within top 10 positions. Biotechnology disciplines has the least number of R&D / academic institutions with consistent top ranking. In the case of pharmaceutical discipline, the top 10 positions were held during 2002-09 intermittently by 23 institutions. The performance data sheets of top 10 institutions in the selected disciplines are provided in **Annexures 5.2.2.**

The top institutions covered in this study have definitely shown their basic research strengths in various chemical subdisciplines. However, their creative and innovative abilities in applied research of relevance to chemical industry have not yet come to the fore with few exceptions. This is evident from the data presented in next section on Indian patenting ability. It is likely that the legal framework similar to the

Bayh Dole Act of USA which allows such institutions to own and transfer intellectual property and associated technologies emanating from projects funded by the government would enhance their patenting activity. An objective performance ranking system for assessing the quality of their IP may help them in capacity building in this area.

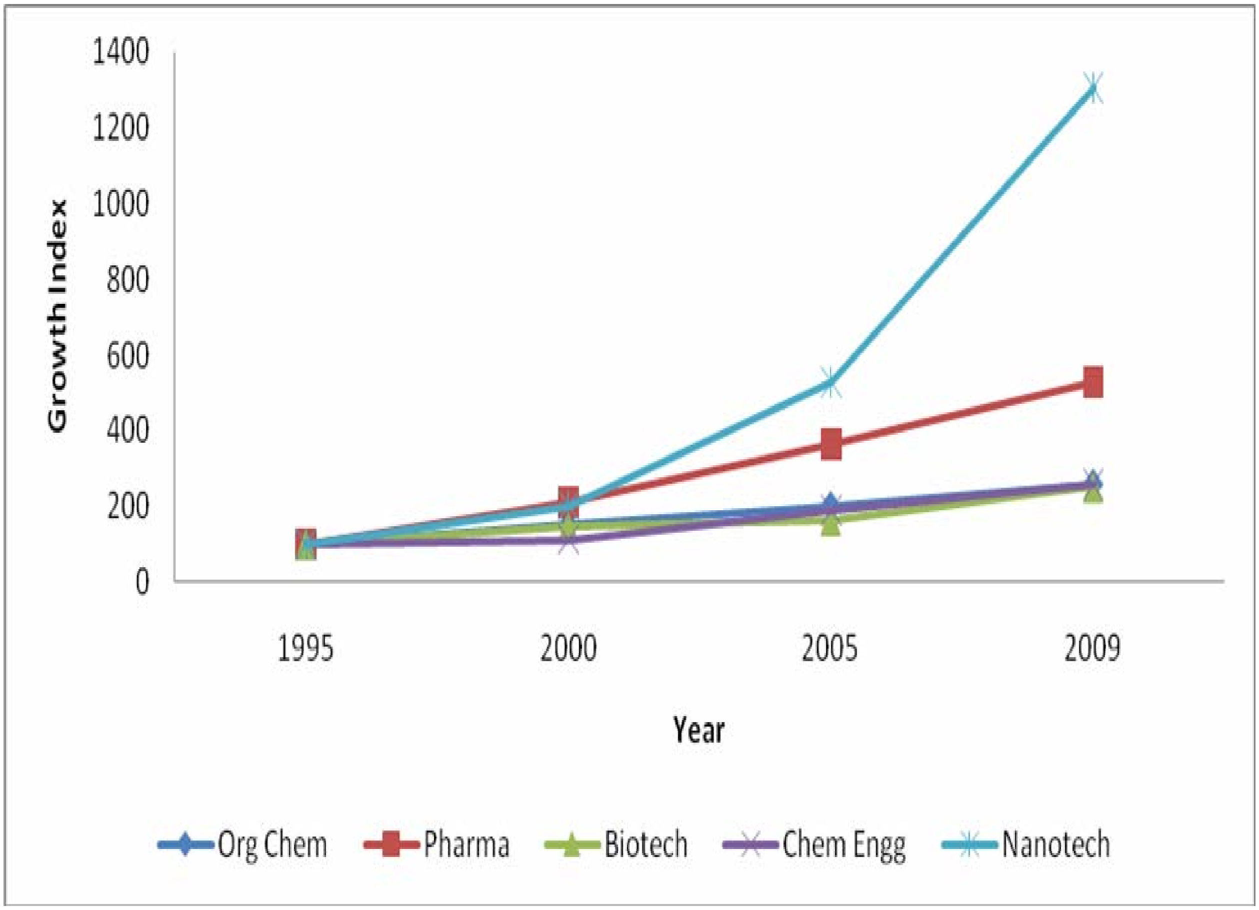


Fig. 5.2.17 : Growth of Chemical Research Publications from Top 10 Research / Acdemic Institutions

5.2.5 Transforming Chemical Research into Commercializable Products / Processes

The patents to publications ratio (P/PR) broadly indicates the ability to convert scientific research into commercializable processes and products. From WIPO report (**7**) and available scientific literature, the P/PR is evaluated for all S&T and chemical science disciplines for India, China, Japan, USA and Germany for 2003-07. The data presented in **Table.5.2.10** shows somewhat contrasting results. While USA and India have registered relatively higher P/PR in case of chemical sciences, the reverse is the case with Japan. The ratios are almost similar in China and Germany. From this data, it gives the impression that a lower priority has been assigned by the Indian agencies in protecting their intellectual property.

Table 5.2.9: Analysis of TOP Indian Institutional Performance in chemical and allied sciences (1995-09)

	Consistence Performance	**1995**		**2000**		**2005**		**2009**		**Institutions which intermittently held top positions**
		No.Pub	AIF	No. Pub	AIF	No.Pub	AIF	No.Pub	AIF	
Organic Chemistry (Annexure 5.2.1)	IIT, NCL, IICT, CDRI, UD	262	2.04	397	2.44	656	2.63	677	2.75	IACS, UM, UH, BARC, CSIR, RRL, UR, UK, CLRI
Pharmacology & Pharmacy	CDRI,JU, UP	63	1.74	134	2.07	230	2.10	334	1.75	BHU, Dr HSGVV, PGIME, IRC, KU,KMC, NIHM, UM, AIIMS, UK, IICB, AU, ANU, MSU, NIPER, HU, BV, UD, IIT,J H
Biotechnology Applied Microbiology	IIT, CFTRI	111	1.56	164	1.75	183	2.50	280	2.42	NCL, UB, IMTECH, BARC, CSIR, BHU, AU, MKU, OU, UD, TERI, PU, IARI, IICT, AMU, ANU
Chemical Engineering	IIT, NCL, IICT, ANU	188	1.53	212	1.35	357	2.0	490	1.72	UB, RRL, IIP, SVU, BHU, ISSc, CSIR, ANU, UM, CFTRI, AMU, BARC, CSMCRI, NIT, ICT, UK
Nano Science & Nanotech	IISc, IIT, BHU	28	1.3	57	2.19	148	2.3	366	2.63	MU, PTRSU, CEERI, DMRL, IST, IBSc, JNTU, BARC, IGCAR, NCL, IICT, IP, CSIR, JNAR, JU, NPL, IACS

AIF: Average Impact Factor

Please refer to Annexure.5.2.2 for Abbreviations of the Institutes.

Table 5.2.10 : Patents to Publications Ratio in India and selected countries

Country	P/PR for all S&T areas	P/PR for Chem Sciences	Remarks
India	0.14	0.24	Low
China	2.12	2.16	Medium
Germany	2.57	2.61	Medium
Japan	9.24	4.82	High
USA	9.78	12.83	Very High

The P/PRs for various chemistry sub-disciplines (as per WIPO classification) are given in **Table.5.2.11** for India and USA. It clearly shows that even in strong patentable areas like organics, biotechnology, polymers, pharmaceuticals and chemical engineering, Indian patenting position is extremely weak. As a matter of fact, India published more research papers in organic chemistry, polymers, food processing, chemical engineering and enviro technology during 2003-07 than USA. Unfortunately, Indian scientific community is yet to capitalize on this strength as far as patenting is concerned.

Table 5.2.11 : P/PR for various sub-disciplines of chemistry – India vs USA

No	Sectors	India			USA		
		Patents	Papers	P/PR	Patents	Papers	P/PR
1	Organics	3653	6745	0.54	66,066	2369	23
2	Biotechnology	970	2742	0.35	61,478	3437	18
3	Pharmaceuticals	3855	5602	0.69	1,02,133	7156	14.3
4	Polymers	253	3127	0.08	2,88,38	1471	19.6
5	Food Processing	366	2073	0.18	18,655	1396	13.4
6	Materials	426	502	0.85	41,444		
7	Metallurgy	294	1587	0.19	17,908	4,224	9.8
8	Surf Coatings	102	665	0.19	32,061		
9	Nanotech	10	1313	0.01	2,006	1,687	1.2
10	Chem. Engg	291	3213	0.09	36,172	1,466	24.7
11	Env.Tech	144	3909	0.04	16,165	5,056	3.2

5.2.6 Product Patenting Trends in Indian Chemical Sector

India had set up the Mailbox system on 1st January 1995, in compliance with the Trade Related Intellectual Property Rights (TRIPS) system. It allowed India to defer the granting of product patents for agrochemicals and pharmaceuticals until the amendments to the Patent Act of 1970 came into force in 2005.

An attempt has been made in this section, to trace the trends of product patent applications and grants since 2005 in the Indian chemical sector. Derwent Index system has been employed for the search exercise employing appropriate Derwent Codes and application number formats. **Fig. 5.2.18** shows the product patents granted by IPO in chemical and allied sciences during 2005-10 and associated product patent applications from 1995 to 2008. The grant of product patents achieved a peak in 2008 and exhibited downward trend during 2009, may be due to mailbox system effect. **Fig.5.2.19** shows the sectoral coverage of product patents with pharma (42%), organics (35%) and biotechnology (21%) constituting the major share. **Table 5.2.12** provides the list of Top 10 Indian Inventors of product patents filed at IPO. The overseas industry contributed more than 90% of product patents with resident institutions contributing less than 10%. This is indicative of yet to develop product patent culture amongst the Indian institutions and the industry in the chemical sector. Stronger foundation has to be laid for product oriented research in Indian Chemical R&D and academic institutions.

Table 5.2.12: Top 10 Indian Inventors of Product Patents (2002-10)

• **CSIR (42)**	• **Sun Pharma (10)**
• **Dr Reddy's (18)**	• **Cadila Health Care (10)**
• **Dabur Research (16)**	• **IPCA Labs (9)**
• **NATCO (16)**	• **Panacea Biotech (7)**
• **Orchid Research (11)**	• **Lupin Labs (6)**

5.3 Forecasting Emerging Technologies and their pathways in Indian chemical sector

It is extremely important for knowledge intensive segments of Indian chemical sector to forecast emerging technologies in their respective fields, for enhancing the global competitiveness of their research. Patent growth generally follows a s-shaped growth as in the case of their governing technologies. Though very few patents actually develop into technologies of commercial value, they are technically significant because they lead to follow on developments in technology.

In recent times, bibliometrics has been used to organise and analyse large amount of patent data to identify hidden technological patterns that may emerge. A.L.Porter et al., (**26**) employed bibliometrics for forecasting and management of technology.

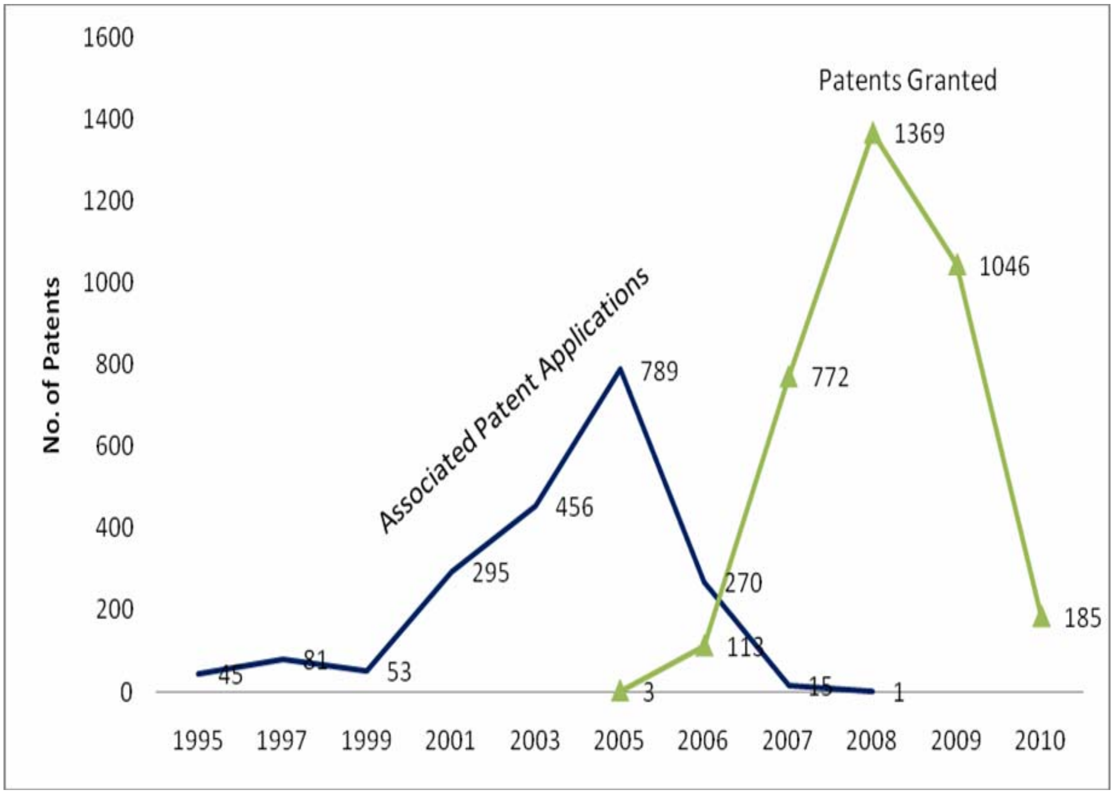
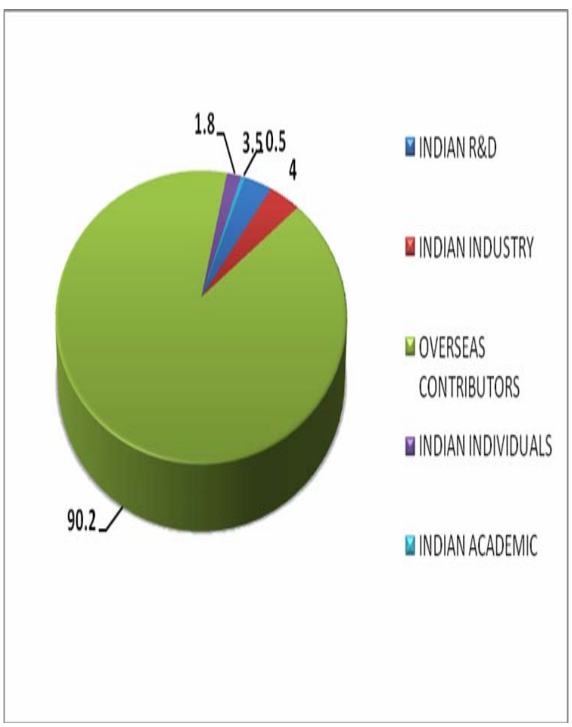


Fig. 5.2.18: Grant of Product patents by IPO (2005-10) and associated patent applications (1995-08)



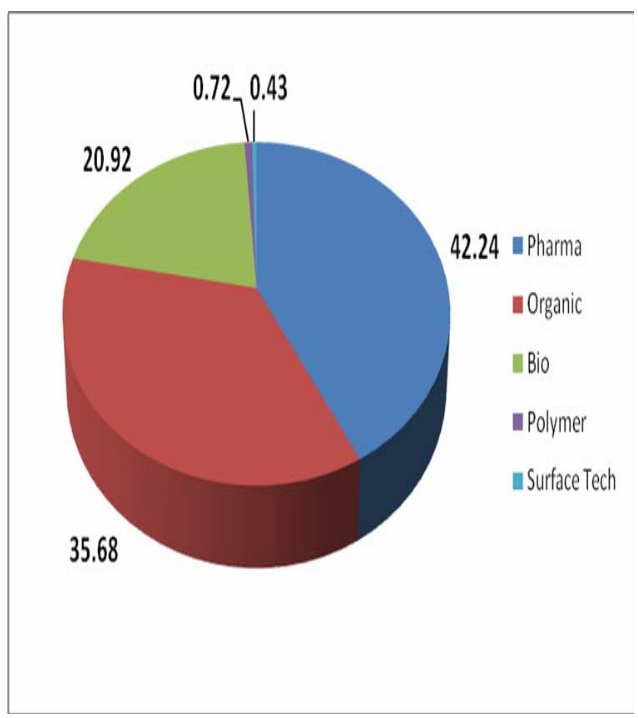


Fig. 5.2.19: Sources and Sectoral contributions to India chemical product patents

B.P.Abraham (**27**) used patent analysis for innovation assessment. T.U.Daim etal., (**28**) demonstrated the use of bibliometrics and patent analysis for forecasting emerging technologies. B.Andersen employed (**29**) patent study to hunt for s-shaped growth paths in technological innovation in case of 6 technological groups including chemicals. Lalitha Kumari (**30**) made a cross country comparison on research activities in the synthetic organic chemistry during 1998-03. The analysis showed the shifting interests of industrially advanced countries to pursue R&D in new emerging subdisciplines whereas Asian and other smaller nations continue to pursue research and IP protection in traditional scientific areas. These interesting developments motivated the INAE study team to make a brief study on Indian technological trends in organic chemistry discipline during the post globalization period viz., 1995-09 in comparison with China and USA.

5.3.1 Priority Subject Areas for Organic Chemistry Patent Analysis

Employing the appropriate class codes (E 11to 19) of Derwent Index, the patent statistics relevant to nine subdisciplines of organic chemistry viz. p/si based organics, organometallics, heterocycles, aromatics, alicyclics, aliphatics and others have been collected for India, USA and Japan. The data presented in **Fig.5.2.20** shows that aliphatics have the highest share in patents filed in USA, India, Japan and China. The next important subdiscipline for Indian patents is aromatics whereas in USA, Japan and China, the patents on heterocycles have the second highest share. The third highest patent share in these countries is for aromatics whereas in India, heterocycles has the third highest share.

The aliphatics compounds which are employed in several industrial applications are sub-divided into paraffins, olefins and alkynes. There are a variety of straight or branched chain and cyclic derivatives of high industrial importance. The major application areas for patents in aliphatics area in USA, Japan, China and India are in fluoro/chlorocarbons, fine chemicals, food products and propellants. They are of prime importance for the other industrially advanced countries including India.

Application Areas for patents on Heterocycles in India and USA

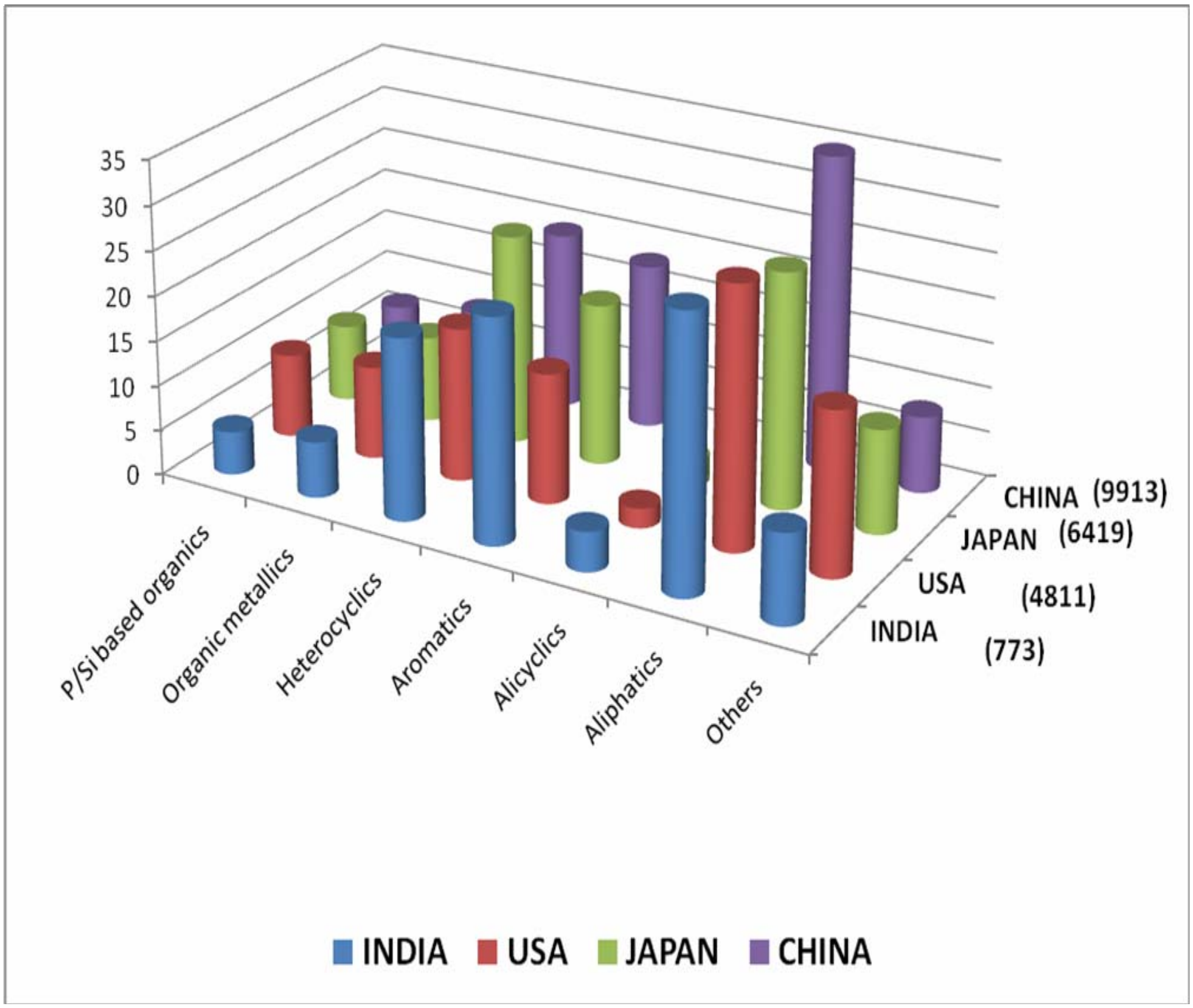
Heterocycles are cyclic compounds in which substituents are members of the ring itself. Pyridine and furan are typical examples of heterocycles. The commercially important heterocycles are used in dyes, pharmaceuticals, biochemicals, fine chemicals , high value optical compounds and a variety additives required for polymer, food, agrochemical and cosmetics. An analysis of Indian and US patents in Aromatics and heterocycle fields has provided some interesting results as shown in **Table 5.2.13**.

Table 5.2.13: Percent share of Application Areas forIndian and US Patents

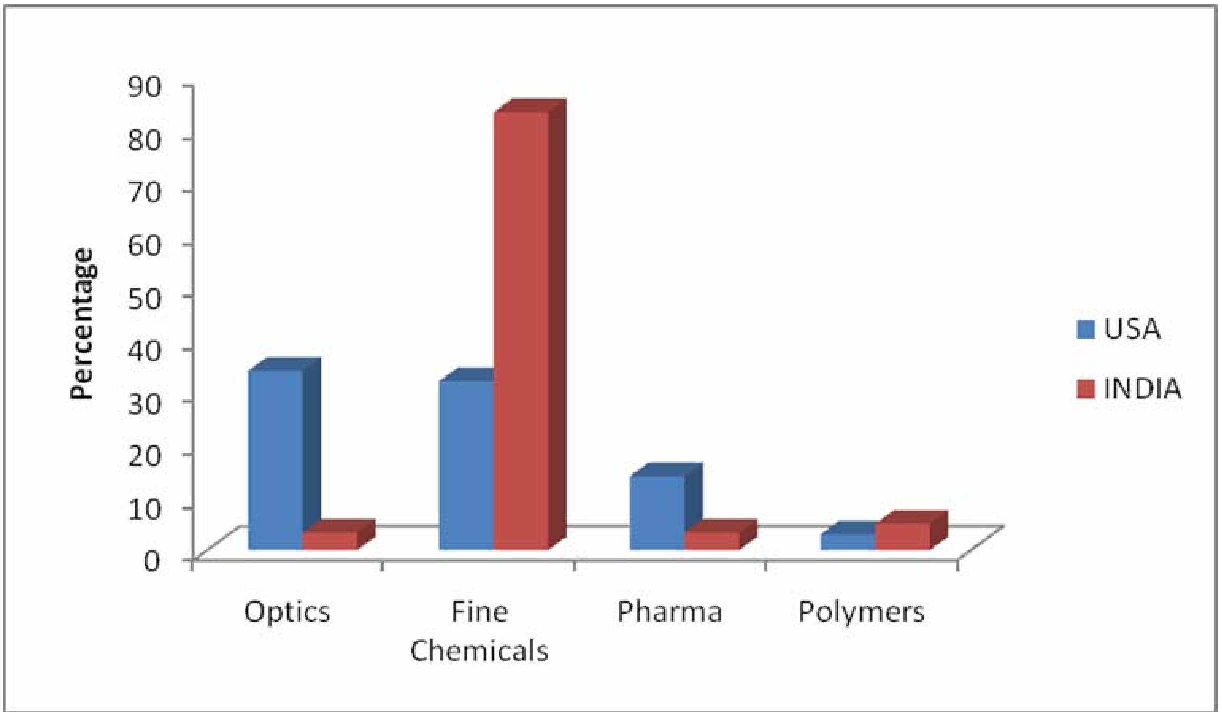
		Aromatics		Heterocycles	
		INDIA	**USA**	**INDIA**	**USA**
1	Number of Patents (2009)	212 (79)	793	181 (54)	991
2	Percent share in major application areas				
	• Fine chemicals	83	32	69.6	40
	• Photosensitives	3.3	34	6.6	30
	• Polymers	3.3	14	6.6	13
	• Pharmaceuticals	5.2	3	9.4	5.5
	• Others	5.2	17	7.8	11.5

Note : Numbers in parenthesis refer % Indian inventor's share

Substantial number of US patents in aromatics and heterocycles are in the photosensitive application field covering luminiscents, UV absorbers, opticals, LCDs / LEDs, solar cells, semiconducters, photographic and Xerox specialities etc,. The synthesis and characterization of relevant aromatic and heterocycle molecules accordingly formed the main theme of US patents. India, on the other hand, has minimal share in these applications. The Indian aromatic and heterocycle compounds patents predominantly lie in fine chemicals area with high application potential in pharmaceuticals, polymeric compositions, materials and biocides. This is reflective of lower priority assigned by the Indian inventors to electronic and optical hardware development for which number of speciality chemicals are required. It is also interesting to note the Indian resident inventor's contribution to aromatics and heterocycles patents is 79% and 54% respectively. This is much higher than their contribution in other S&T fields.



(a) Organic subject areas for Indian, Chinese, US and Japanese Patents



(b) Intended Application Areas for Patents on Aromatics in India and USA

Fig. 5.2.20 : Subject and Intended Application Areas of Organic Chemistry Patents

The preliminary patent analysis presented in this section demonstrates its importance in predicting technology pathways and national research priorities. A comprehensive patent analysis is strongly recommended for developing globally relevant technology vision for the Indian chemical sector.

5.4. Internationalization of IP Employed in Indian chemical sector

The growing cross border ownership or sharing of IP basically reflects two motivating factors (**36**) viz., the need to adopt products and processes to overseas markets and at the same time acquire new knowledge assets for domestic market. Crossborder ownership is predominantly the result of S&T activities by the well established MNCs. The multiple from countries like Australia, Canada, China, India, Israel and Mexico own more patents with inventors from USA than with European inventors (**37**). An attempt is made in this section to assess the extent of internationalization of chemical IP employed in India.

5.4.1 International Collaborations in Chemical Research Papers

It is not a new phenomenon in Indian chemical sector. Even before liberalization, 5-7% of Indian chemical research publication were based on international scientific collaborations. However, in postliberalization period, international collaborations have increased till 2005 and registered a minor fall thereafter. It attained a peak value of 15.95% in2004. This is much less than the peak value attained in 2006 of 23.6% in Indian publications covering all S&T disciplines. **Fig.5.4.1** shows that Indian chemical research papers attract high level of collaborations with EU countries, followed by USA, Canada and Asia-Pacific countries. **Fig.5.4.2** provides the growth status of S&T collaborations in all S&T and chemical research publications. Compared to all other S&T disciplines, the overseas collaborations in chemical research has grown much slower during 2000-08.

5.4.2 Internationalization of Chemical Patents Filed at IPO

The extent of internatinalization of Indian chemical patents is relatively low compared to other S&T disciplines because of higher domestic contributions from pharmaceutical and biotechnology sectors. During 2005-08, around 1.1 lakh patents were filed at IPO. As per ranking system adopted by IPO in 2008, only 20 Indian organisations are amongst the top 200 patent filers. Among these organisations, 10 are pharmaceutical companies. **Table 5.2.6** provides the necessary details. It shows that the top Indian pharma companies have successfully internationalized their commercializable R&D.

Indian biotech companies also have succeeded in internationalization of their R&D. They were placed 11^{th} in the world just below USA in 2003-05 with their share of Indian patents relative to total patents standing at slightly above 1.

The data presented in this section shows the Indian IP strengths in pharma and biotech sectors are two way. There is need for other chemical subsectors to develop similar capabilities.

5.5. Major Findings on IP Management in Indian Chemical sector

The studies undertaken in this chapter provide various facets of IP Management in Indian chemical sector. The notable amongst them are highlighted below.

5.5.1 Internationalization of IP Employed in India

Recent trends in overseas collaborations leading to joint research papers, Indian inventors filing patents abroad and overseas inventors filing patents at IPO have clearly established the internationalization of IP in all S&T sectors in India though the intensity is somewhat less in chemical sector. India is one of the major economics of the world with highest percentage of IP employed in the industry has been internationalized. It is important to consider positive and negative aspects of this phenomenon.

5.5.2 Post WTO Growth Trends of Chemical IP

Post WTO growth trend of chemical IP is characterized by an overall complementary growth profiles of research papers and patents. The growth index of research publications is slightly lower than that of patents. At national level, the chemical IP has a significant share in overall Indian S&T publications and patents. However, at International level, Indian share of chemical IP is rather insignificant. India has, so far, failed to achieve the impressive levels of Chinese contribution to chemical IP. The PCT has become the most preferred route for the overseas inventors to file patents at IPO. During 2005-08, 97.2% of citations to Indian patents have come through PCT route.

5.5.3 Institutional performance in Chemical IP Generation

Eventhough 260^{+} Indian institutions are involved in publication of research papers, hardly less than 4% of them have attained top 10 ranks and most of them are not consistent in retaining top positions for long periods. A significant increase has been noted both in quality and quantity of research papers from the top 10 ranked institutions during 2002-09. The performance of Indian universities in chemical IP generation is very disappointing and particularly so in patent filings.

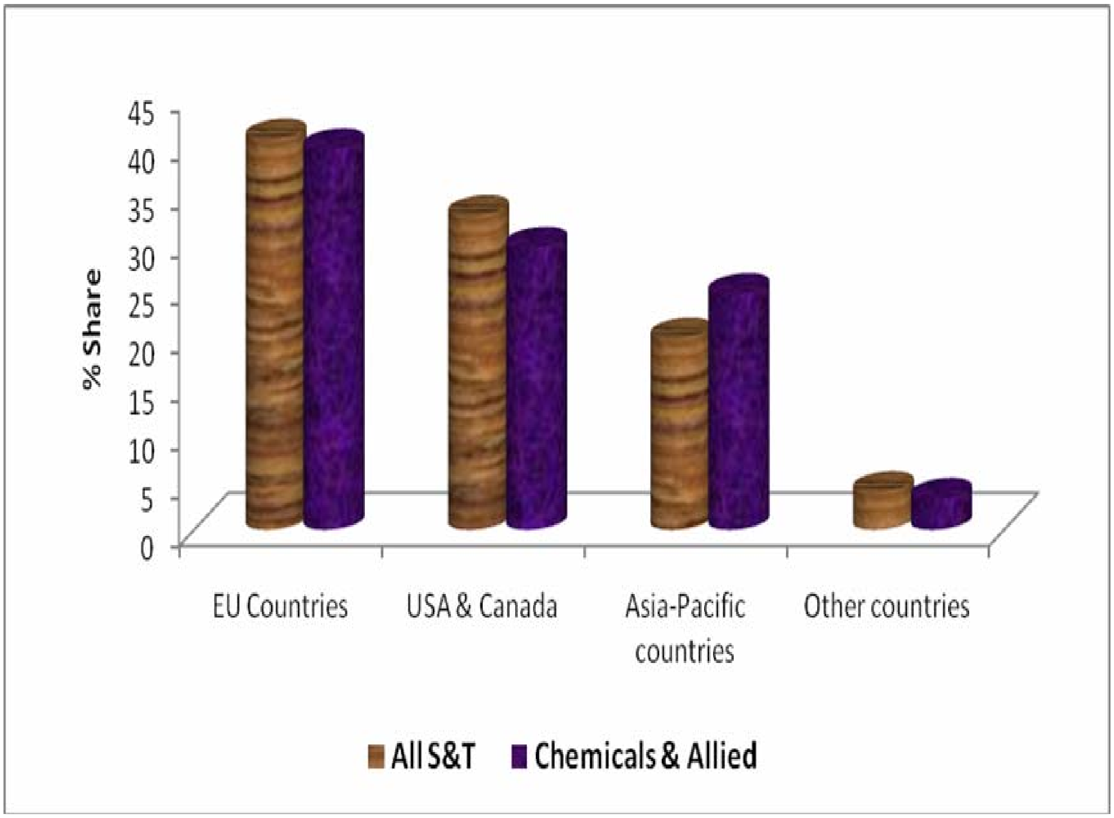


Fig. 5.4.1 : % Share of various collaboratories in Indian Research Papers (2005-08)

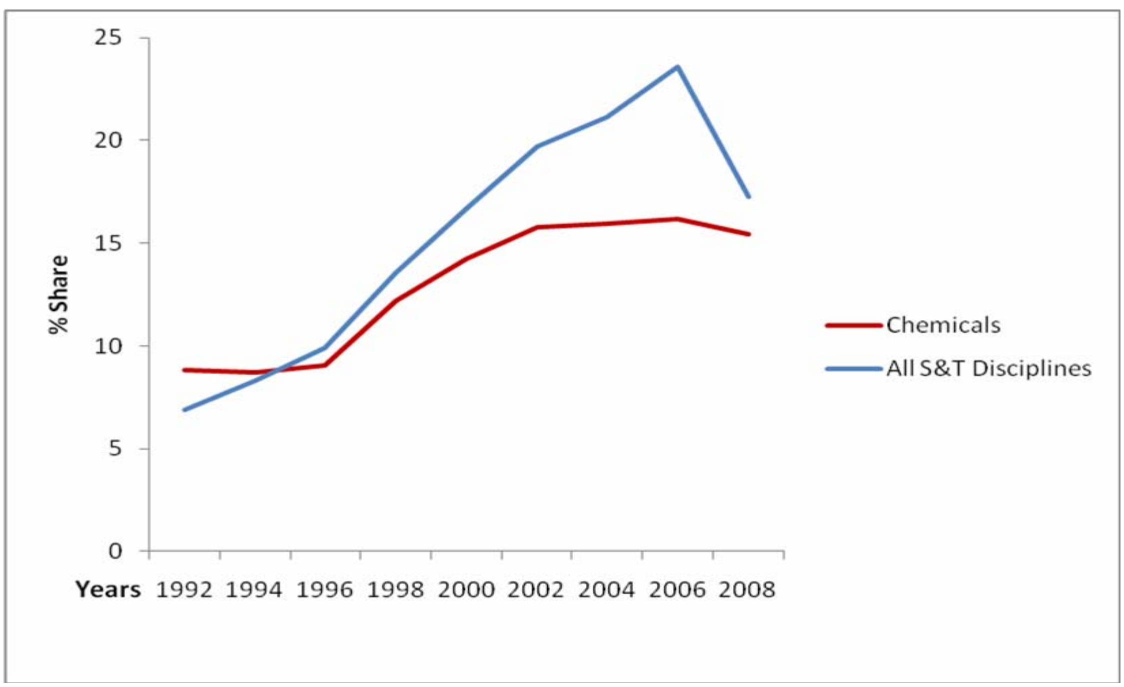


Fig.5.4.2: Overseas Collaborations in Chemical Vs Other S&T Research Papers

5.5.4 Indian ability to generate protected chemical IP

The Patents to Publications Ratio (P/PR) of India is one of the lowest among the major economics of the world eventhough its performance is much better in chemical sciences as compared to other S&T disciplines. Among the chemical disciplines, materials, organics and pharma chemistry have the highest P/PRs and the poorest record is for nano technology.

5.5.5 Product Patent Record of Indian chemical sector

Indian chemical sector has one of the best records of attracting product patenting in India since its formal introduction in 2005. The overseas inventor's contribution has been more than 90%. This is indicative of weak product oriented research in Indian institutions in chemical sector.

5.5.6 Emerging Technology Trends in Organic chemistry

The sample patent analysis conducted by the INAE team has shown that aliphatics, aromatics and heterocycles as the frontline research areas for Indian inventors as in the case of USA, Japan and China. However, in terms of potential application aeas, Indian patents deal with conventional areas of fine chemical applications whereas US patents deal with the frontier areas of photosensitive, luminescent, optically active and photographic chemicals.

In summary it can be said that Indian chemical IP largely remains in open domain with suboptimal efforts to generate protected intellectual property of industrial relevance.

5.6 Implementable Actions

The most vital measures needed for enhancing the inventorship of chemical IP protected in India and abroad have been covered under the major recommendations in Chapter 10. The other implementable actions under chemical IP are highlighted below:

5.6.1 Strengthening Patenting in Indian Speciality chemical sector

The data presented in Table 5.2.5 shows the Indian weakness in patenting speciality chemical inventions. This is a matter of concern since speciality chemical sector attracts very high level of patenting in Japan, China and other Asia-Pacific countries. Concerted efforts have to be made by the professional bodies to sensitize the Indian scientific community as well as the leadership of the speciality chemical industry on this issue. The patenting success achieved by the Indian pharma and biotech sectors need to be emulated. Government incentives to promote patenting in speciality chemicals will go a long way in meeting the stated objective.

5.6.2. Enhancing Indian University Contribution to chemical IP Generation and Protection

The contribution of Indian universities to research publications and patents in various chemical disciplines continues to be weak. The responsible factors are weak industry-academic linkage, poor research infrastructure at the universities, low level of sponsored research (public and private), not many incentives for faculty to undertake industrial research and to file patents and predominantly teaching centred academic programmes of state and deemed universities. These problems need to be addressed by the DST, UGC, AICTE, DBT, DMSME and other departments of Government of India to come out with a comprehensive plan on incentivizing IP generation by the Indian Universities. Launching of a Technology Mission to pilot test viable industry-academic linkage options is one of the major recommendations highlighted in Chapter 10.

5.6.3 Establishing a National level Bench marking System for Institutional IP Performance Assessment

There is a strong need to establish a scientific and transparent benchmarking system for assessing the institutional performance in IP generation and protection (research papers and patents) in chemical and allied sciences. Their ability to generate protected IP through national / international patents has to be one of the performance indicators. Currently, ranking techniques like SCIMAGO, MEEACT, WEBOMETRICS and GOOGLE FACTOR are being used in advanced countries for IP quality evaluation. They are amenable to online processing. The benchmarking responsibility has to be entrusted to a competant independent bibliometric group under the overall supervision of the DSIR of the Government of India.

5.6.4 Hastening the Modernization Process of Indian Patent Offices

Though Indian Patent Offices (IPOs) in various cities are undergoing modernization and major structural changes in recent years, several drawbacks exist in analyzing Indian patents. Though the existing data bases at IPOs are amenable to online access of title, abstracts and some bibliographic information, access to their legal status, full text and claims does not exist.

The Indian patent offices experience more than 20% annual growth in filing and granting of patents. More than 80% patent applications received by them belong to foreign residents. There is need for them to acquire modern text mining and visualization tools for patent analysis with output in the form of tables, maps, graphs and matrices to help patent researchers to understand the current landscape of Indian IP in various industrial sectors.

There is need to intensify the modernization process of Indian IPOs and achieve significant improvement in Indian databases. Competent scientific staff to be appointed by the IPOs for undertaking systematic patent analysis in various industrial sectors. Necessary action to be taken by the Chief Executive of IPOs. This will enable Indian researchers to make objective patent analysis in various industrial sectors.

5.6.5 IP Related Studies Recommended for Indian Chemical Sector

There is need to carryout special studies in the following areas to understand the underlying mechanisms and best practices elsewhere on IP in chemical sector:

5.6.6.1 Benchmarking Indian product and process patent activity in chemical sector with that from developed nations

The basic objective is to evolve medium and long term strategies for enhancing the utility of Indian Patents

5.6.6.2 Determinants for licensing of Indian pharma and biotech patents in Europe, America and Asia Pacific countries

The focus is on enhancing IP trade in Indian chemical sector.

5.6.6.3 Technological Assertiveness of Knowledge Intensive chemical sector

The scope of the proposed studies will be to compare Indian performance with China, USA and Japan. Recently, limited studies have been reported on IP performance on China and India.

5.6.6.4 Tracing long Term Technological changes in Indian Speciality chemical sector through Bibliometric Analysis

The basic objective is to evolve new growth strategy for this sector.

5.6.6.5 Extent of New Knowledge Diffusion into Indian Basic Chemical sector

The focus to be on the problems and challenges in making this sector more knowledge intensive

The above studies need to be sponsored at the competent Indian academic, R&D and management institutions. The DSIR of Government of India may like to take necessary initiative in this area.

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Chapter 6 Government Initiatives for Promotion of Innovation in Industry

This chapter deals with the critical role being played by the government in promoting R&D endeavours of Indian chemical sector. The first part of the presentation briefly covers post liberalization R&D scenario in India, an analysis of national R&D expenditure and the status of extramural research funding from various government departments.

The second part of the chapter focuses on the nature of government funded R&D programmes relevant to Indian chemical sector and their strengths and weaknesses.

The final part of the presentation highlights the major findings on the government funded R&D and recommendations for enhancing their relevance to Indianc hemcial industry.

6.0 Government Initiatives for Promotion of Innovation in Industry

6.1 Introduction and Literature Survey

Recognizing the importance of innovation in the changing paradigm both at industry as well as R&D institution level, Government of India has initiated several measures that would encourage development of innovation and translation of the innovation into product or process or service and at the same time to bring coherent synergy among the players. Such a synergy is also expected to address the increasing complexity of technologies that are becoming multidisciplinary. Many of the R&D initiatives of the government aim at bringing the much needed synergy through public-private partnership (PPP). This chapter, INAE team examines the various schemes that have been initiated by the government, their adequacy, their utilization by Indian Industry, R&D synergy and measures that are required to enhance its reach and utilization.

6.2 Indian R&D in Post Liberalization Period

Since early nineties, the Indian economy has undergone major structural changes. In the last decade, the shares of agriculture, manufacturing and services in the gross domestic product (GDP) had changed from 28.52%, 24.37% and 47.11% in 1997-98 to 20.83%, 26.78% and 52.39% respectively in 2007-08. The share of merchandise trade in GDP increased from 20.28% to 38.61% over the same period. India's share in world exports too registered good growth increasing from 0.5% in 1990 to 1.1% in 2006. The shift is definitely in favour of manufacturing and service sectors. Obviously, technology aided by qualified manpower resources and the government's resolve have played an important role in bringing about this transformation. An increase in Indian share in world exports indicates that India is becoming globally more competitive. To sustain this trend, the government is consciously bringing in research, innovation and technology (RIT) to the centre stage.

Fortunately, India is endowed with good R&D infrastructure with 400 national laboratories, 1300 recognized industrial R&D units, over 400 scientific and industrial research organizations (SIROs), besides several government departments and private foundations engaged in either scientific research or its promotion. In addition, several universities and academic institutions are engaged in basic research activities.

Prior to 1991, government funded R&D programmes predominantly aimed at advancing the scientific knowledge. They were executed in the publicly funded R&D and academic institutions supported by grant-in-aid known as extramural research funding. Whilst these efforts have laid a strong R&D base in the country, they did not translate the research outcomes into innovative technologies. As a result, the country was largely dependent on the technology imports. This led to a situation wherein the R&D investments by the private industry remained very low. Since the liberalization of economy and signing of the WTO, the direction of R&D pursuits in the country has significantly changed. Innovation driven R&D has become the order of the day. Since involvement of the industry has become very important in translating the innovations into commercializable technologies, there is a shift in the mandates of government R&D programmes. Industry involvement has become an essential factor in several programmes that have been launched in post liberalization period. They are either based on collaborative or PPP approach.

6.2.1 Analysis of *National* R&D Expediture

The Indian national R&D expenditure as a percentage of GNP has showed a marginal increase from 0.78% in 1998-99 to 0.89% in 2007-08. However in absolute terms, a significant improvement from Rs.5000 crores to approximately Rs. 40,000 crore has taken place. Simultaneously, the R&D expenditure of industry has increased from about 19% in 2002-03 to approximately 26% in 2005-06. For the same years, the public sector R&D expenditure has decreased from 61% to about 58%. **Figure 6.2.1** shows the national R&D expenditure and **Fig. 6.2.2** shows its sector wise distribution. However, when compared with rest of the world, India still lags behind not only the developed nations but also other BRIC nations. **Table 6.2.1** gives a comparative assessment of the current level of per capita national R&D expenditure of BRIC nations. It is clear from the presented data that India is spending far less than others. Even the R&D expenditure as a percentage of GNP is yet to pick up the momentum.

Table 6. 2.1: National R&D Expenditure in BRIC Countries

S.N.	Country	Per capita R&D expenditure ,USD
1.	Brazil	22.55
2.	Russia	24.91
3.	India	3.53
4.	China	12.15

(Source: UNESCO 2005)

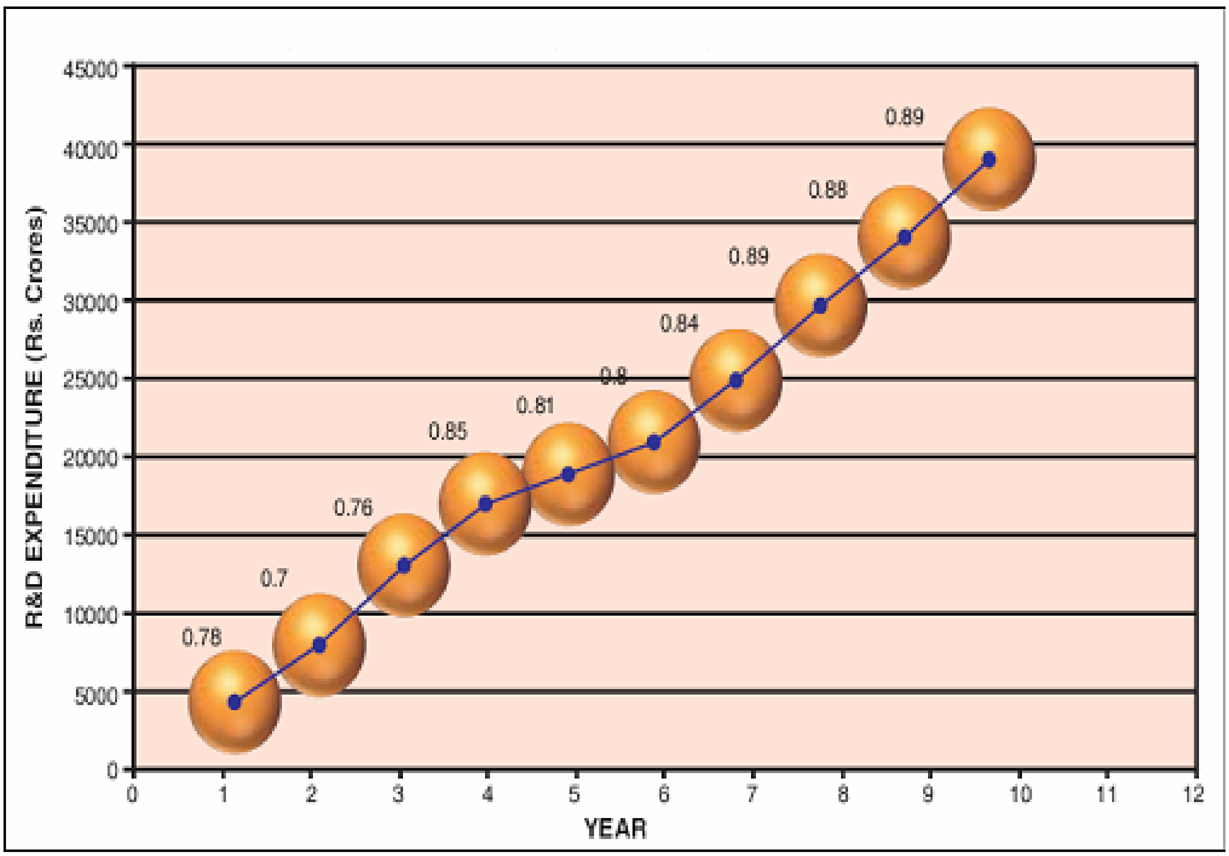


Fig 6.2.1. National R&D Expenditure and its percentage to GNP

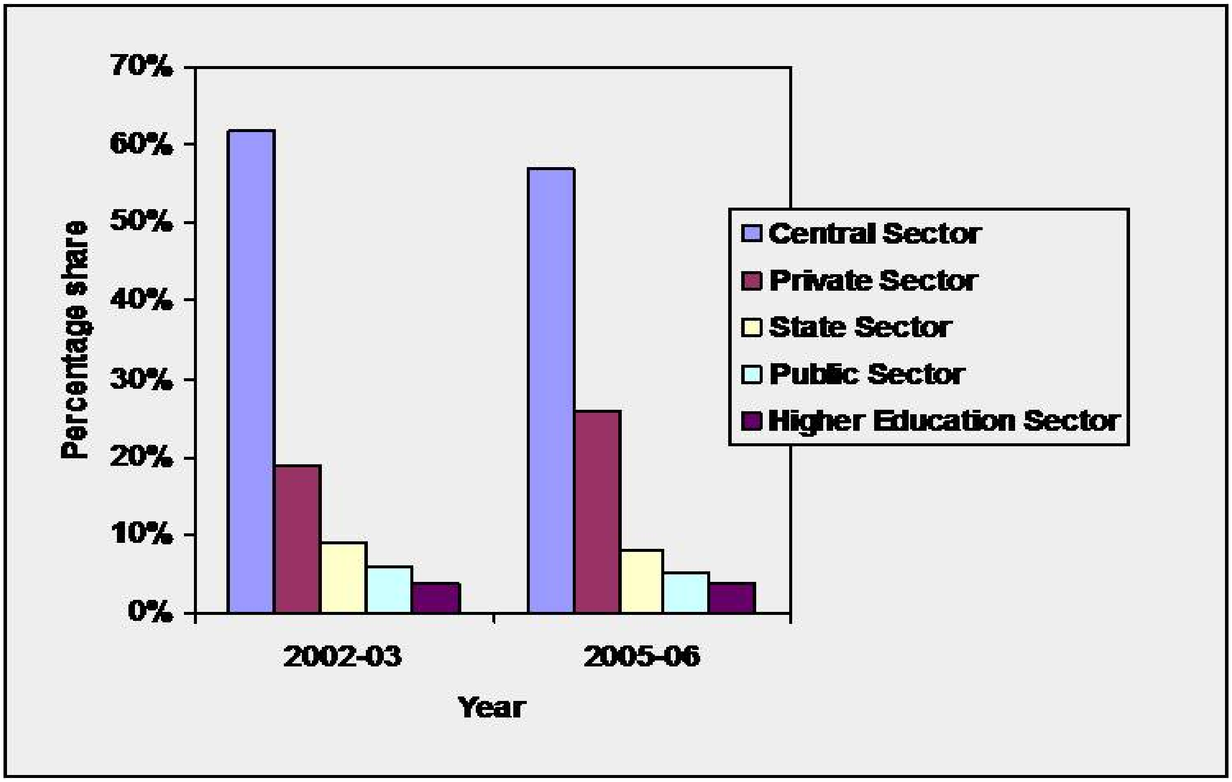


Fig 6.2.2: Share of National R&D Expenditure by sector

The **Fig 6.2.3** shows the R&D expenditure growth trends in private and public sectors in absolute terms during 1995-08. It shows that the R&D expenditure in public sector undertakings remained more or less stagnant whereas the private industry has significantly increased its R&D expenditure during the post liberalization period. It is a positive trend and good for the nation aspiring to become a knowledge storehouse. **Fig 6.2.4** shows the area wise national R&D expenditure. It shows that defense (21%) followed by health services, agriculture and forestry have taken the major pie of the budget. Knowledge advancement based R&D has a share of approximately 14%. **Fig 6.2.5** shows how public and private sectors in different industrial segments have accounted for the R&D expenditure.

It can be seen from the **Fig.6.2.5** that private sector R&D expenditure is almost 100% among the chemical subsectors such as soaps, cosmetics and toiletries, biotechnology, drugs / pharmaceuticals. Even in chemicals other than fertilizers, the private industry R&D expenditure is significant. This indicates the public sector investment in the chemical sector is almost non-existent.

The R&D expenditure by the important central government agencies is shown in **Fig 6.2.6** for the years 1995-96, 2000-01 and 2005-06. Their percentage share in XI Five Year Plan is shown in the **Fig 6.2.7**. It can be seen from these figures that the strategic sectors account for the bulk of the government expenditure in the R&D leaving a very small percentage for the civilian sectors.

Realizing the importance of translating innovation into products or processes of commercial utility for enhancing the technological competitiveness of industry, the Government of India through DST, DSIR and DBT have started supporting R&D projects that involve industry either through collaborative research or through PPP mode. Chief among these for Indian chemical and allied sectors are Pharmaceutical R&D Programme (PRDP), Home Grown Technology Programmes (HGT), Technology Development Borad (TDB) and Sectoral Mission Programmes of TIFAC, New Millennium Indian Technology Leadership Initiative (NMITLI) of CSIR, Small Business Innovation Research Initiative (SBIRI) and Biotechnology Industry Partnership Programme (BIPP) of DBT, Technopreneur Promotion

Programme (TePP) and Technology Development and Demonstration Programme (TDDP) of DSIR. These programmes endeavour to bring the expertise of different players such as the academic institutions, R&D institutions and industry synergistically towards the set objectives. Collectively, they have an outlay of less than Rs. 500 crore for all areas of science.

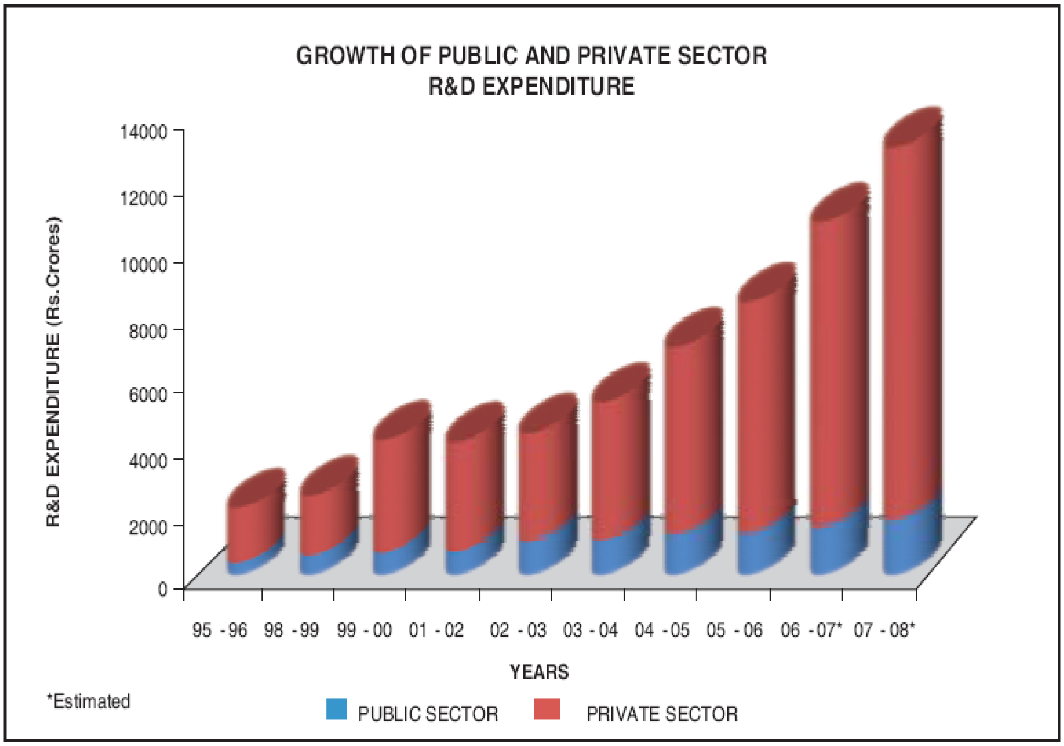


Fig 6.2.3: Growth of public and private sector R&D expenditure

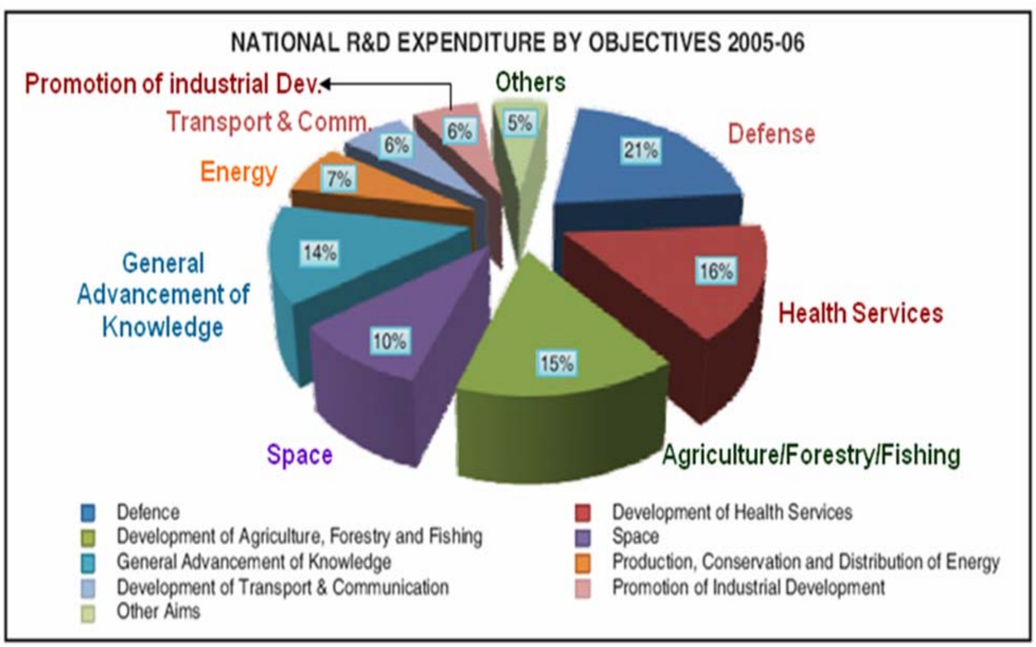


Fig 6.2.4: R&D expenditure areawise (2005-06)

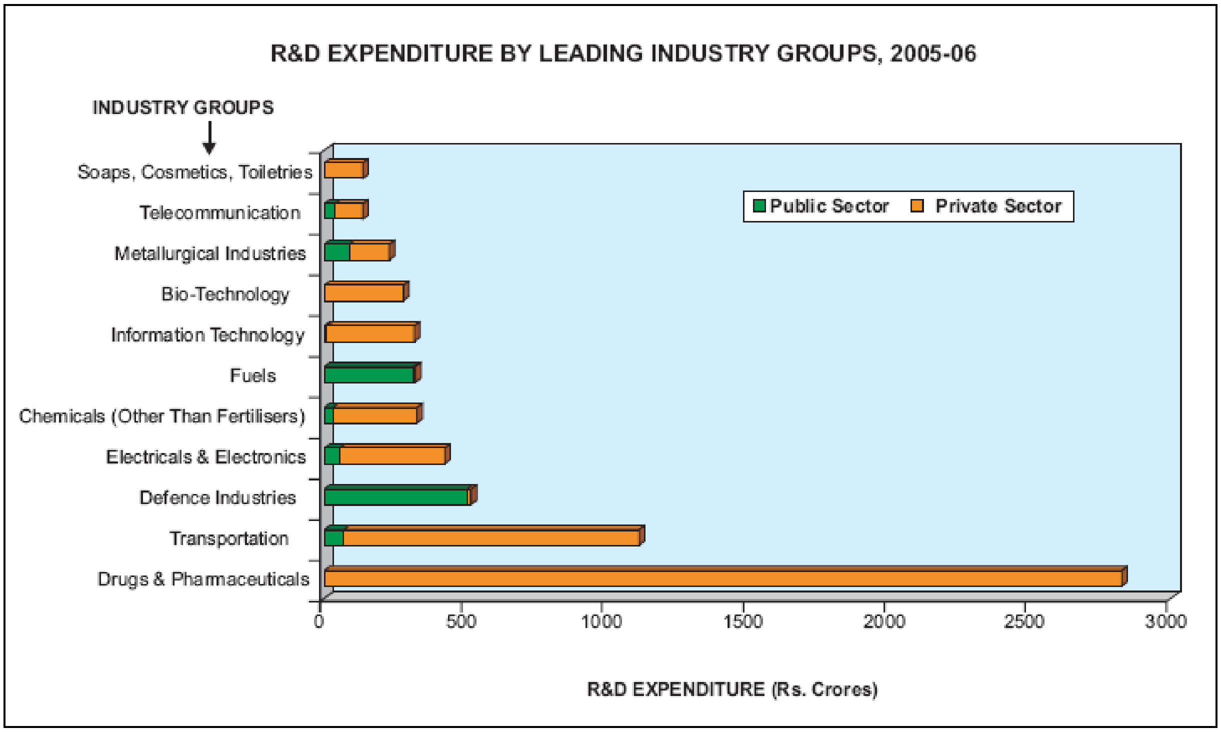


Fig 6.2.5: R&D Expenditure by Leading Industry Groups (2005-06)

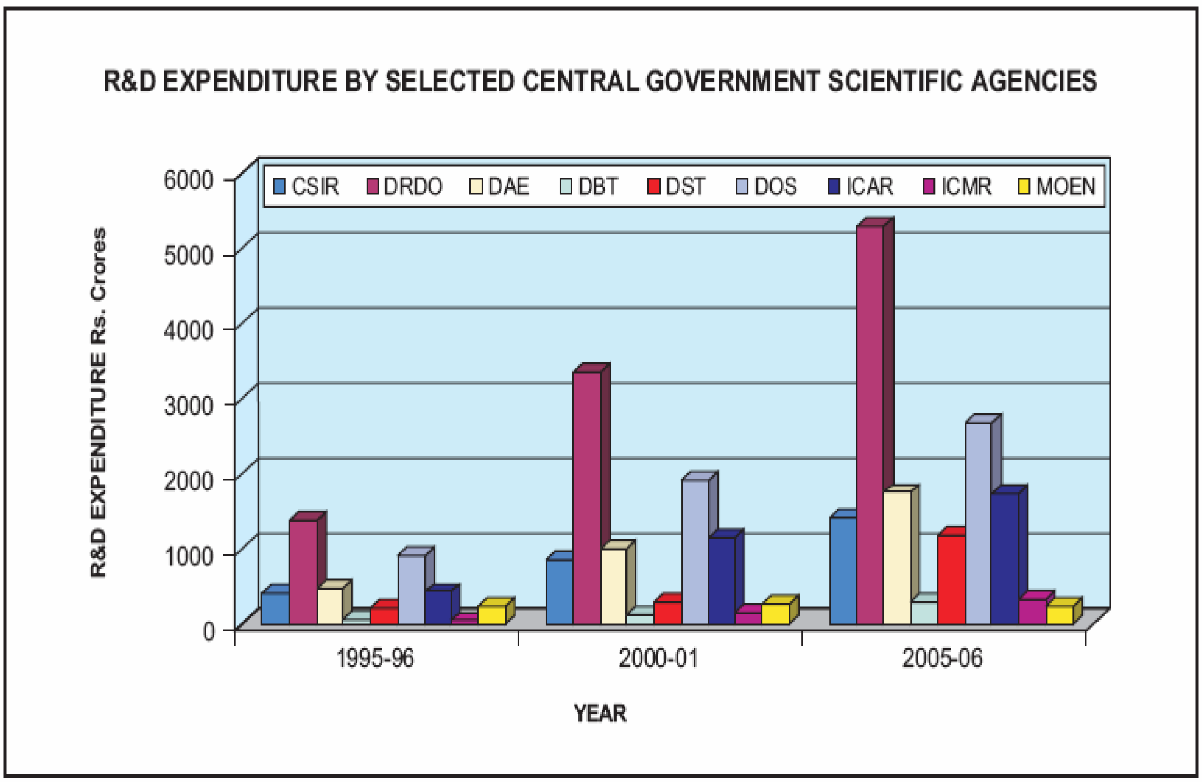


Fig 6.2.6: R&D Expenditure by Central Government Scientific Agencies

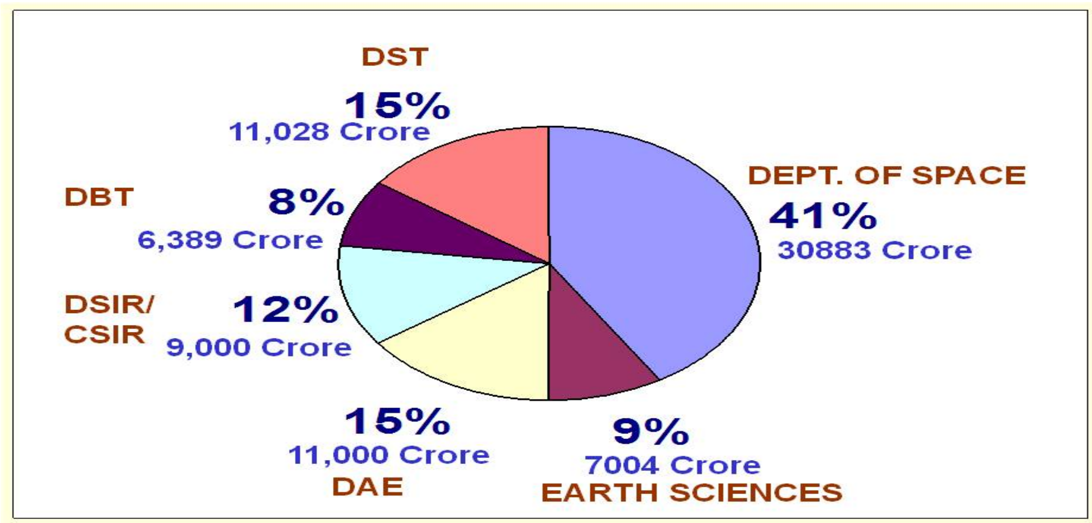


Fig 6.2.7: Percentage share of select scientific agencies in XI Five Year Plan

The Chemical sector is one of the major beneficiaries of government funded R&D programme primarily due to the heightened R&D activity in the drugs and pharma as well as biotechnology sectors. Small and medium sector companies are unable to draw the benefits of such schemes due to their small size, low R&D intensity and research capabilities. However the overall allocation of less than Rs 500 crores is too meager for an industry that contributes significantly to the national economy. Since technological innovations are the key determinant for global competitiveness of Indian industry, the INAE team feels that the government has to enhance the allocation to the scientific agencies in the civilian sector without which it would be very difficult for Indian industry to compete at global level. Also the team feels that the bulk of these funds must be provided for applied research in association with the industry preferably in a PPP mode.

6.2.2 Extramural Research Funding

Extramural project funding is the second most important allocation mechanism for public research funding alongside intramural institutional funds allocated to research organizations and universities. The research activities under extramural and intramural also bring in innovations. A brief analysis of extramural funding in terms of the funding instruments, the categories of beneficiaries and the disciplines benefiting are highlighted in this section.

An important aspect of the extramural funding is the issue of relative shares of funds received by the different scientific disciplines. **Table 6.2.2** shows the relative shares in respect of different disciplines. The data shows that engineering and technology disciplines received maximum support during 1990-06 followed by medical sciences. Among the basic sciences, the biological and chemical sciences received almost equal share of over 10% during 2000-06.

Another very important dimension is the changing perspective of EMR fund distribution to various categories of R&D and academic institutions in the country (**Table 6.2.3**). The university colleges (state and central) continue to receive more than 30% funds followed by national laboratories with their share of 27% during 2001-06. The Institutes of National importance have a share of 12% in 2001-06. The CAGR for 1990-06 for the four categories of institutions is between 10.6 to 12.2%.

Table 6.2.2: Discipline wise Distribution of EMR funds (1990-06)

Subject	1990-91 to 1994-95		1995-96 to 1999-00		2001-02 to 2005-06	
	No. of Projects	Total Approved Cost (Rs. In crores)	No. of Projects	Total Approved Cost (Rs. In crores)	No. of Projects	Total Approved Cost (Rs. In crores)
Agricultural Sciences	799 (11.8%)	64.06 (11.7%)	882 (9.6%)	125.63 (9.4%)	1273 (9.0%)	263.76 (8.6%)
Engineering & Technology	1433 (21.1%)	156.44 (28.6%)	2779 (30.5%)	504.04 (37.5%)	2985 (21.2%)	918.39 (29.9%)
Medical Sciences	865 (12.8%)	40.64 (7.4%)	881 (9.6%)	90.20 (6.7%)	2037 (14.5%)	708.79 (23.0%)
Natural Sciences						
Biological Sciences	1660 (24.4%)	155.67 (28.4%)	1820 (20.0%)	206.70 (15.4%)	2625 (18.6%)	332.47 (10.8%)
Chemical Sciences	789 (11.6%)	34.52 (6.3%)	1141 (12.5%)	138.52 (10.3%)	2173 (15.4%)	343.37 (11.1%)
Earth Sciences	532 (7.8%)	45.70 (8.3%)	688 (7.5%)	180.68 (13.5%)	1322 (9.4%)	254.97 (8.3%)
Mathematics	97 (1.4%)	3.80 (0.7%)	149 (1.6%)	5.33 (0.4%)	365 (2.6%)	17.92 (0.6%)
Physical Sciences	616 (9.1%)	46.81 (8.6%)	794 (8.7%)	90.69 (6.8%)	1303 (9.3%)	235.89 (7.7%)
Total	**6791 (100%)**	**547.64 (100%)**	**9134 (100%)**	**1341.97 (100%)**	**14083 (100%)**	**3075.56 (100%)**

***Source** : Compiled from the reports obtaining for the relevant period an extramural R&D funded projects,NSTMIS, DST, GOI*

Table 6.2.3: Institutional share of Extramural R&D Projects and Funds (1990-06)

	1990-95		**1995-2000**		**2001-2006**		**1990-06**
Types of Institutes	**Number of Institutes**	**Total Approved Cost (Rs. Crores)**	**Number of Institutes**	**Total Approved Cost (Rs. Crores)**	**Number of Institutes**	**Total Approved Cost (Rs. Crores)**	**CAGR %**
Universities/Colleges	576 (52.6%)	195.09 (35.6%)	836 (56.1%)	426.07 (31.7%)	2046 (53.4%)	1012.73 (32.9%)	11.6
Deemed Universities	16 (1.5%)	45.92 (8.4%)	24 (1.6%)	84.39 (6.3%)	127 (3.3%)	225.92 (7.3%)	11.2
Institute of National Importance	9 (0.8%)	66.69 (12.2%)	11 (0.7%)	131.26 (9.8%)	56 (1.5%)	371.26 (12.1%)	12.1
National Laboratories	233 (21.3%)	184.94 (33.8%)	274 (18.4%)	569.71 (42.5%)	680 (17.7%)	842.02 (27.4%)	10.6
Others	261 (23.8%)	55.00 (10.0%)	346 (23.2%)	130.35 (9.7%)	923 (24.1%)	623.64 (20.03%)	17.6
Total	1095 (100%)	547.64 (100%)	1491 (100%)	1341.79 (100%)	3832 (100%)	3075.57 (100%)	12.2

It may be mentioned that besides S&T ministries of Government of India, several other ministries provide grants to research projects. **Fig.6.2.8** provides the breakup of their share of funding. During 2000-05, around Rs 12,500 crores were spent by them. The ministry of Science and Technology has a major share of 59% followed by the ministry of HRD with 28% share.

6.2.3 Government Funded R&D Programmes Relevant to Chemical sector

The schemes operated by different ministries / departments of the government, financial Institutions and others are intended for all categories of units viz., large, medium and small and even individuals in various subsectors. It is for a process unit to choose which one of the programmes suits it best. Schemes which are important for Indian chemical sector are highlighted below.

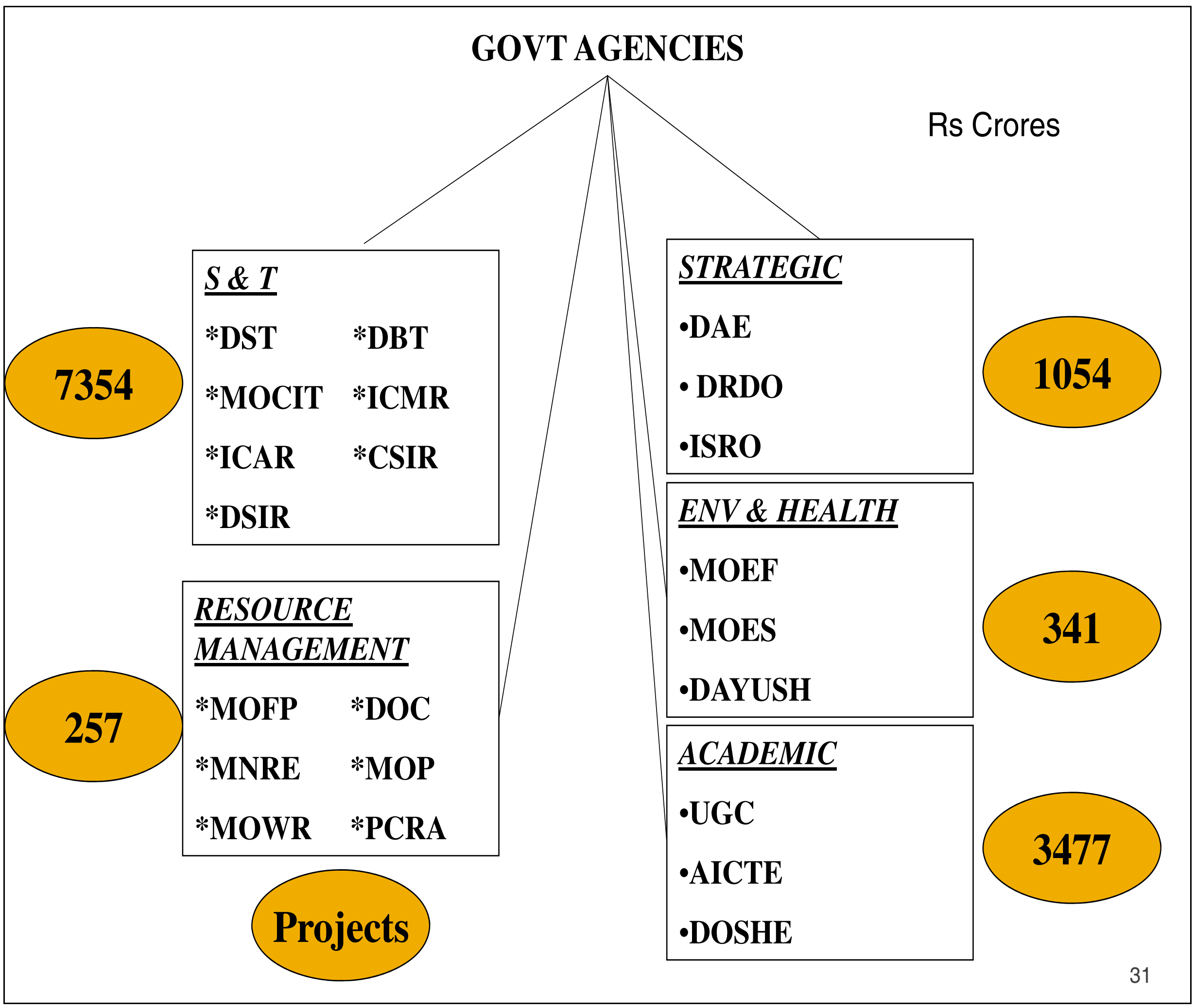


Fig.6.2.8: EMR Funding by various Departments of Govt. of India (2000-05)

6.2.3.1 Drugs & Pharmaceuticals Research programme (DPRP) - DST

The DPRP programme initiated in 1994 specifically addresses the R&D needs for the growth of the Indian drugs/pharma industry. The specific objectives of the programme are:

- Synergizing the strengths of publicly funded R&D institutions and Indian pharmaceutical industry to generate the collaborative R&D projects; creating an enabling infrastructure, mechanisms and linkages to facilitate new drug development;

- Stimulating skill development of human resource engaged in R&D and

- Enhancing the nation's self-reliance in drugs and pharmaceuticals, especially in areas critical to national health requirements.

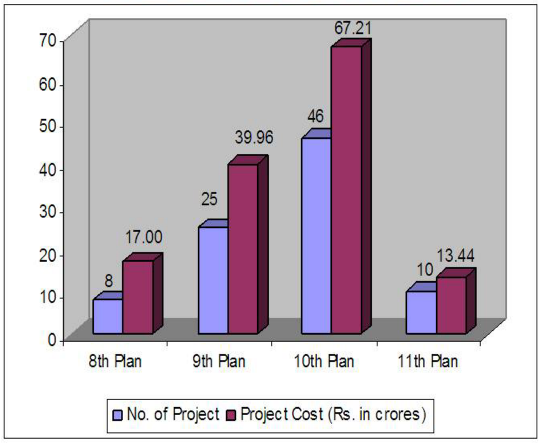
The programme supports variety of projects both in human and veterinary drugs through (i) industry-institution collaborative R&D projects (ii) creation of national facilities that are critical to the new drug development, (iii) pharma industry R&D projects and (iv) clinical trials on neglected diseases. In case of type (iii) projects, the assistance will in the form of soft loan with 3% interest with the principal payable over a period of 10 years. The programme supports both modern and traditional medicine oriented projects. The programme has so far supported 89 projects with an overall outlay of Rs. 137.61 crores under collaborative project component. **Fig 6.2.9** shows the approved projects during 8^{th} to 11^{th} five year plan period and their subject coverage.

In addition the DPRP programme has supported 39 national facility projects and 47 pharma industry projects. **Fig 6.2.10** shows the approved cost of facility creation projects as well as pharma industry projects.

6.2.3.2 Technology Development Board (TDB) - DST

The Technology Development Board (TDB) was established in 1996. The main objectives of the TDB are (i) to promote development and commercialization of indigenous technology and (ii) adaptation of imported technology for wider application. The TDB is the first organization of its kind within the government framework with the sole objective of commercializing the fruits of indigenous research. It provides finances in the form of soft loans and other financial assistance to innovative research and development projects. The TDB supports the following type of activities

PLAN-WISE APPROVED COST OF COLLABORATIVE PROJECTS



Total Project = 89;

Total approved Cost = 137.61 Crores

Average per project cost of Rs.1.55 crores

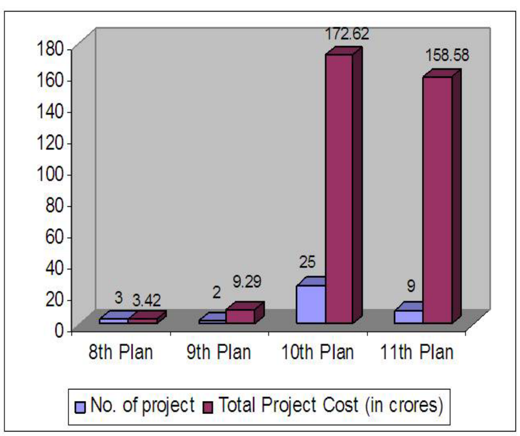
ratio of DST : INDUSTRY = 1 : 1.48

COVERAGE OF COLLABORATIVE PROJECTS

MODERN/NEW	:	58 PROJECTS
AYURVEDA	:	24 PROJECTS
SIDDHA	:	5 PROJECTS
UNANI	:	1 PROJECT
VETERINARY	:	1 PROJECT

Fig. 6.2.9 : Approved Projects under DPRP Scheme of DST (8 to 11 Five Year Plan)

PLAN-WISE APPROVED COST OF FACILITY PROJECTS



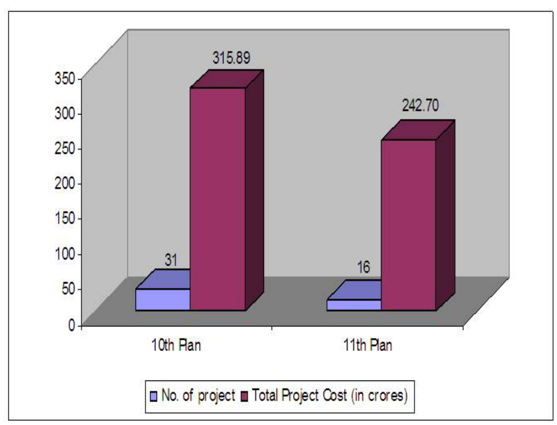
Total Project = 39;

Total approved cost = 343.91 Crores

Average per project cost of Rs.8.81 crores

ratio of DST : INSTITUTE = 1 : 0.40

PLAN-WISE APPROVED COST OF LOAN PROJECTS (SINCE 2004-05)



Total Project = 47;

Total approved cost = 558.59 Crores

Average per project cost of Rs.11.88 crores

ratio of DST : INDUSTRY = 1 : 1.04

Fig.6.2.10: Approved Facility Projects under DPRP Scheme (8 to 11 Five Year Plan)

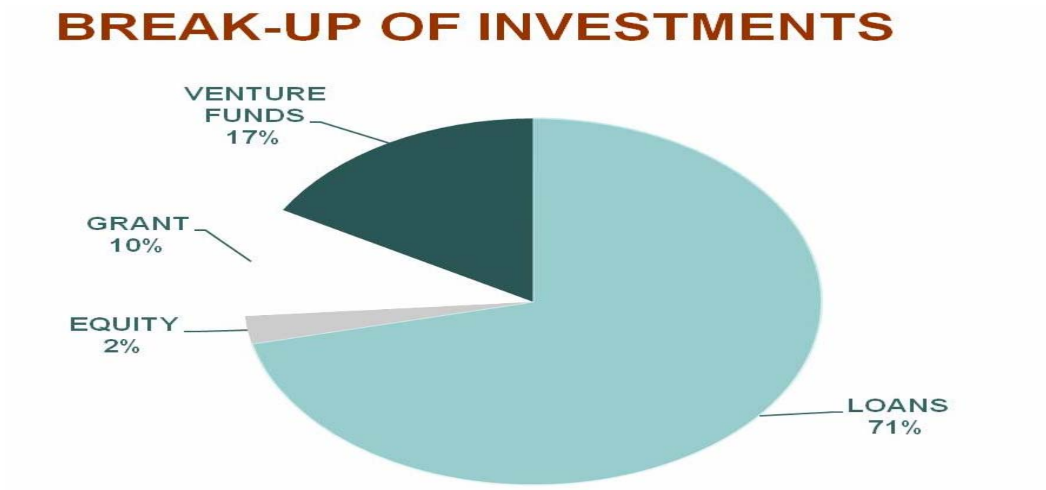
- Project funding for commercialisation of developments
- Venture capital support
- Seed capital support for new enterprises in the incubation centres and technology parks
- Implementation of Global Innovation Technology Alliance (GITA)

TDB provides financial support to industry for commercialization of indigenous technologies in the form of loan, equity and grant and a combination of these. Usually, the loan assistance does not exceed 50% of the total project cost against soft collaterals. It carries an interest of 5% and repayment is in nine half yearly instalments after one year gestation period from the date of commercialization. Usually the support does not cover purchase of land and construction of buildings. The assistance is available to industries in different sectors. The break up of the TDB support and sectorwise project coverage are shown in **Fig 6.2.11**. It can be seen from the figures that substantial part of the funds have been disbursed as loans and chemical, health and medical sectors account for over 30% of the total sanctioned funds. There is a strong need to enhance the project funding by the TDB.

6.2.3.3 New Millennium Indian Technology Leadership Initiative (NMITLI) - CSIR

The New Millennium Indian Technology Leadership Initiative (NMITLI) is a unique public-private partnership endeavour within the R&D domain. The Council of Scientific and Industrial Research (CSIR) is the implementing agency. The programme is based on the premise of consciously and deliberately identifying, selecting and supporting potential winners. The focus of the programme is to identify niche areas where India can gain leadership in about 10 – 15 years and to develop projects involving best brains of the country through a rigorous process. It builds knowledge network of partners from public funded institutions, academic institutions, Universities and private industries. Over the years, NMITLI has become the largest PPP programme in the country in the innovation space and enjoys an excellent reputation.

The main objective of the NMITLI is to catalyze innovation centered scientific and technological developments as a vehicle to attain for Indian industry a global leadership position, in a true 'Team India' spirit. The programme supports projects in all sectors of industry and provides funding to all partners. Whilst the funding is in the form of grant-in-aid to the publicly funded institutions, it is in the soft loan form to the industry repayable over a period of 10 years. NMITLI has so far evolved 60 largely networked projects in diverse areas. These projects involve 85 industry partners and 280 R&D groups from different institutions. Approximately 1750 researchers are engaged in these projects. These 60 projects cumulatively have had an outlay of approximately Rs.550 crores. The distribution of the projects in diverse areas is shown in the **Fig 6.2.12**.



SECTOR-WISE COVERAGE (1996-2010

(Rs. in crore)

Sector	1996 – 2010			2005 – 2010		
	Number of Agreements	Sanctioned Amount	%	Number of Agreements	Sanctioned Amount	%
Health & Medical	62	269.03	25.6	25	119.00	28.5
Engineering	49	156.45	14.9	19	87.21	20.9
Chemical	19	50.98	4.8	3	9.85	2.4
Agriculture	19	40.52	3.9	4	21.25	5.1
Energy & Waste utilization	8	55.98	5.3	3	15.25	3.6
Tele-communication	10	29.35	2.8	5	17.49	4.2
Defence and Civil Aviation	1	2.2	0.2	1	2.20	0.5
Road Transport	10	81.2	7.7	-	-	-
Air Transport	2	67.8	6.4	-	-	-
Information Technology	31	108.01	10.3	17	69.94	16.8
Others	22	190.5	18.1	19	75	18
Total	**233**	**1052.02**	**100**	**96**	**417.19**	**100**

Fig.6.2.11: TDB Support and Project Breakup (1996-10)

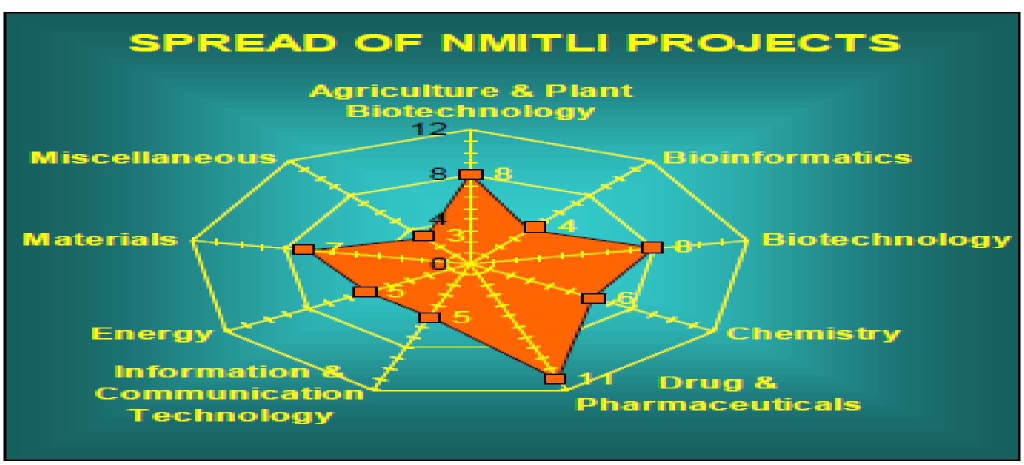


Fig.6.2.12 : Spread of NMITLI Projects

The NMITLI programme has catalysed development of several process / products in chemical and other sectors. **Fig 6.2.13** shows some of the important programmes.

NMITLI developments led to over 100 patents and generated over 150 peer reviewed publications. NMITLI supports different categories of projects viz., (i) Nationally Evolved Projects (NEP), (ii) Industry Originated Projects (IOP), (iii) 50:50 funding along with industry, (iv) co-financing with venture funds, (v) inter-departmental and inter-ministerial projects, and (vi) NMITLI Innovation centres in PPP mode. It also encourages acquisition of early stage relevant knowledge / IP in the projects it supports. NMITLI is successful in launching India's largest PPP and brought a change in thinking from imitation to innovation driven projecs among the researchers. It has become a trend setter for many subsequent programmes. Several chemical oriented projects have been funded by NMITLI.

6.2.3.4 Technopreneur Promotion Programme" (TePP) – DSIR & TIFAC

The "Technopreneur Promotion Programme" (TePP) was launched in 1998-99 by the Ministry of Science and Technology. TePP is operated by the DSIR and TIFAC to tap the vast innovative potential of Indian citizens. The programme enables and promotes indivudual innovators to become technology-based entrepreneurs (Technopreneurs). The main objectives of the programme are:

- To promote and support untapped creativity of individual innovators
- To assist the individual innovators to become technology based entrepreneurs
- To assist the technopreneur in networking and forge linkages with other constituents of the innovation chain for commercialization of their developments.

Fig.6.2.13 : Important NMITLI Projects

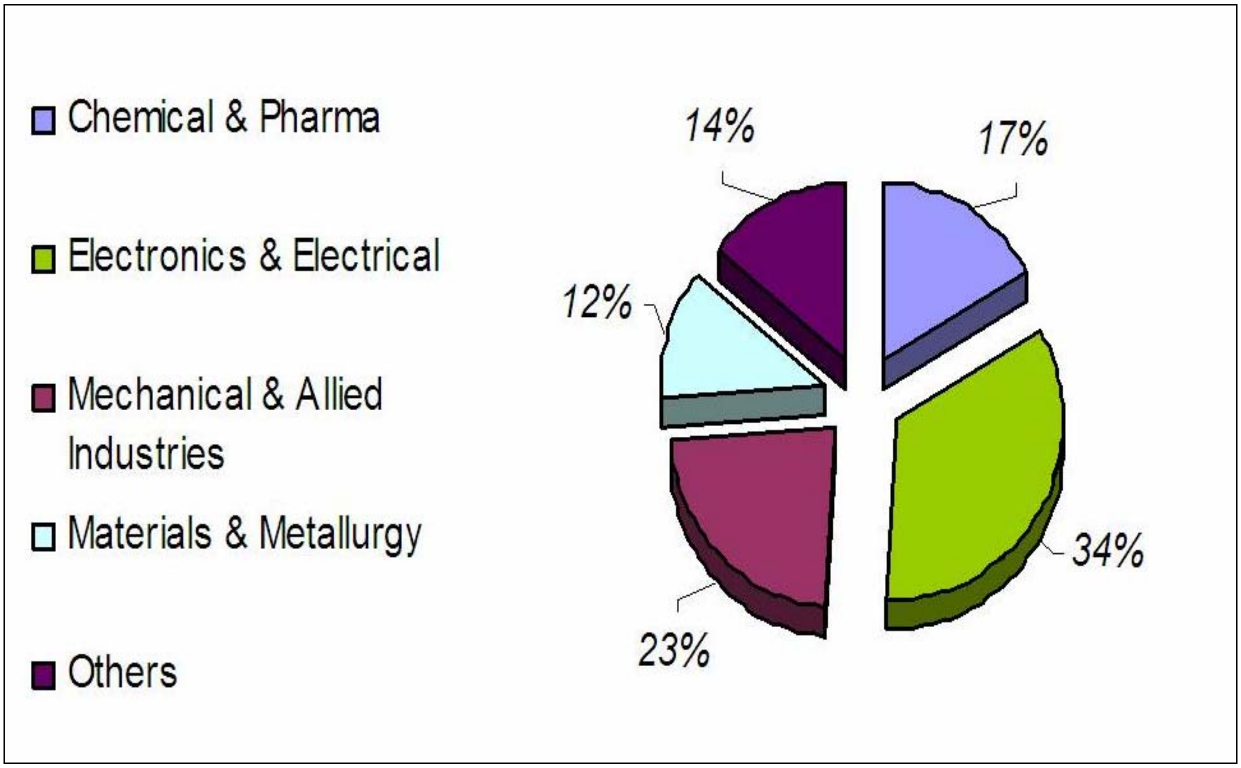


Fig.6.2.14 : Sectoral Distribution of TDDP Projects

Maximum support envisaged under this programme for each project is Rs 15 Lakhs subject to 90% of approved project cost. In all, about 200 projects have been supported under the TePP programme till March 2008. TePP has been playing a catalytic role in promoting individual innovators, particularly the ''Grassroot innovators'' and by encouraging them to become technology based entrepreneurs (technopreneurs).

6.2.3.5 Technology Development and Demonstration Programme (TDDP) - DSIR

This Scheme provides catalytic support for development and demonstration of innovative product and process technologies, traversing the journey from proof of concept or laboratory stage to pilot stage, rendering them fit for commercialization. Any sector leading to industrially useful applications is eligible for support under the scheme. The projects should aim at raising the technological level of the product or process, energy and material savings / recovery, export sales etc. The main objectives of TDDP scheme are:

- Development and demonstration of innovative need-based technologies for making industry competitive
- Strengthening the interface between industry, R&D establishments and academic institutions

The scheme supported over 200 projects till March 2010 with an overall financial assistance of about Rs. 100 crore. The scheme has been successful in enabling industry to strengthen the linkages with more than 25 national research laboratories and developing over 25 patents.

150 projects have been completed including 26 shortclosed and over 50 technologies developed under the scheme have been commercialized or under commercialization. The **Fig 6.2.14** shows the current focus of the programme and distribution of projects in different sectors. It can be seen from the figure, chemical & pharma projects accounted for about 17%.

6.2.3.6 TIFAC's mission-mode programmes and vision 2020 projects - DST

Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi was set up in 1988 with the objectives of (i) identifying priorities and strategies for research, technology development and technology import and (ii) carrying out promotional activities including programmes for research and technology. The council develops foresight and techno-market survey reports. Among other activities of the council, (i) Home Grown Technology programme (ii) sectoral mission projects and vision 2020 projects are important. Under sectoral mission projects, TIFAC has developed 3 major mission projects viz.

- Sugar Technology Mission (STM)
- Advance Composites Mission and
- Fly Ash Mission

The Sugar Technology Mission (STM) is a joint project of TIFAC and Department of Sugar and Edible oils (Ministry of Food) Government of India. The main focus of the sugar mission is on reducing sugar losses, energy conservation, achieving superior product quality, minimization of pollution and value addition to byproducts. In the mission, 27 sugar factories were identified for focused technology upgradation by studying the technology gaps and identifying the appropriate technologies for horizontal transfer. The Government of India, for this purpose has identified a special scheme of concessional finance through the sugar development fund. The scheme provides soft loans upto 60% of the project cost, at a simple interest rate of 6% per annum payable over 5 years with interest. .

The Advanced Composite Mission (ACM) attempts to bring together the R&D institutions and the industry towards the development and commercialization of novel composite product technologies. The ACM mission provides financial assistance in the form of soft loans to the industry on repayable basis. The mission has successfully supported about 30 projects with substantial financial participation by the industry. More than 180 composite products for building and construction uses have been developed. The technology for FRP doors has been transferred to 12 industries.

Fly Ash Mission is a joint activity of the TIFAC, Ministry of Power and the Ministry of Environment and Forests. It has so far financially supported 55 projects towards confidence building in fly ash disposal and utilization technologies, spread over 21 geographical sites in the country.

Arising out of the national exercise on vision 2020 carried out by the TIFAC in late 90s, the council had identified some select areas for focussed intervention. They include agriculture and agrofood processing, road construction and transportation equipment, textile machinery upgradation, health care services and targeted programmes on hydrogen energy, municipal solid waste and synergizing S&T with judicial processes.

6.2.3.7 Small Business Innovation Research Initiative (SBIRI) - DBT

The Small Business Innovation Research Initiative (SBIRI) is a new scheme launched by the DBT to boost public-private-partnership effort in biotechnology area in the country. The main feature of SBIRI is that it supports the high-risk preproof of concept research and late stage development in small and medium companies. SBIRI has rigorous process for generating ideas by bringing users and producers of technology together. As a part of the process, national consultations are held after every three to six months to generate ideas in different sectors of biotechnology. The aims of the programme are:

- strengthen existing private industrial units whose product development is based on in-house innovative R&D,
- encourage other smaller businesses to increase their R&D capabilities and capacity,
- create opportunities for starting new technology-based or knowledge-based businesses by science entrepreneurs,
- stimulate technological innovation,
- use private industries as a source of innovation and thereby fulfil government objectives in fostering R&D, and
- increase private sector commercialisation derived from Government funded R&D.

The SBIRI scheme will operate in two phases, viz. (i) for establishment of preproof of concept of innovations and (ii) for product and process development. In both phases, projects will be implemented at the industry site. Depending the nature of the project and its overall cost, part of the assistance upto a maximum of Rs. 50 lakh is provided as grant. The programme has so far supported 70 projects in diverse areas of biotechnology out of 600 ideas received. The outlay for these projects is approximately Rs. 70 crores. The projects have already started generating new IP.

6.2.3.8 Biotechnology Industry Partnership Programme (BIPP) - DBT

The programme was recently initiated by DBT to encourage industry to take up high risk transformational technology development in partnership. No incremental development will be supported under the progrmme. It encourages (i) path-breaking areas having major impact with potential to generate new IP and (ii) development of technologies relevant to national priorities in partnership with industry in PPP mode. The programme develops four categories of projects. These are:

***Category-I**:* Projects that fulfill major unmet national technology needs in health, agriculture, energy and environment friendly/ green manufacturing area.

Category-II: Projects that increase global competitiveness of Indian Industry in new and futuristic technology

Category-III: Projects that are of high national priority and ready for evaluation and validation

Category-IV: Projects involving creation of **s**hared major facilities around technology platforms

The programme provides different modes of financial assistance depending upon the nature of the project and its importance. This scheme provides for grant-in-aid to biotech industries ranging from 30-50% subject to maximum of Rs 50 lakhs for Category I and II projects and up to 100% for the product evaluation and validation. The intellectual property, technology transfer and licensing arrangements can vary with the model to be adopted partnership and cost-sharing.

6.2.3.9 Technology System Development (TSD) - DST

TSD Programme supports activities aimed at developing and integrating technologies to evolve technology systems both in the advanced/emerging areas and in traditional sectors/areas. Under the programme, feasibility of fresh ideas/ concepts is assessed for their potential conversion into useful technology/product. Application of R&D for socio-economic benefits is consciously promoted under this programme. The primary objective of the Programme is to facilitate and support development of products or techniques/technology aimed at specific end use. It clearly identifies the need for development of the technology so that the developmental effort could be useful to the targeted beneficiary. It envisages active user involvement and association in the development effort.

6.2.3.10 Programme Aimed at attaining Technological Self–Reliance (PATSER):

The PATSER scheme, established in 1988, has so far supported more than 100 projects for semi-commercialization purposes. With the following objectives, the PATSER supported the industry, preferably as a joint project with a national R&D lab for:

- Technology absorption, development and demonstration,
- Building indigenous capabilities and commercialization of contemporary products and process of high impact value

The PATSER projects strengthened the linkages with more than 25 R&D labs. Out of 110 projects, 20 patents were filed/granted, 45 projects were successfully developed, leading to the significant commercial production of new technology-based products

6.2.3.11 Home Grown Technology (HGT) Scheme:

The TIFAC managed the HGT scheme during 1993-2006 with a view to support the Indian industry for achieving competitive strength through technological innovation. It offered financial-cum-techno-managerial assistance for scaling up of lab/bench scale technology to the pilot plant, prototype, and semi-commercial level. About 100 projects were supported by TIFAC, under its HGT scheme: the important ones are in the field of CFC substitutes, detonation spray gun coating, safe disposal of hospital waste by plasma, aeration technology, coir pith blocks, ceramic crucibles and catalytic converters, titanium scrap recycling, bio-fertilizers, etc.

6.3 Major Findings and Implementable Actions

6.3.1 Major Findings

The country has passed through two decades of economic liberalization and 16 years of WTO regime. During this period, both the government and industry have realized the importance of R&D in sustaining the economic growth and it was accordingly brought to the centre stage. This is evident from the declaration of the current decade by Government as the “Decade of Innovation”. In this period manufacturing and services have become the leading contributors to the national GDP. The R&D expenditure in realistic terms has increased substantially but as a percentage of the GDP remained more or less stagnant. The R&D investment in the country as percentage of the GDP is far less than the other BRIC nations. As stated earlier, this does not augur well for the nation aspiring to be a crucible of innovation. The declining R&D expenditure in public sector units is a worrying factor. Although the private sector expenditure is increasing, it is not evenly distributed in all the sectors. Significant part of this enhancement is coming from very few subsectors such as drugs and pharmaceuticals, biotechnology and automobiles. This is a matter of concern since very few segments of Indian industry are able to respond positively to innovative technology based ventures.

A brief review on the Government of India initiated schemes / programmes aimed at development of innovation and enhancing the industrial competitiveness has been made in this Chapter. These programmes by and large encourage industry participation in the projects right from its conception stage and in some cases the schemes provide soft loan to industry to take up its part of research. Some of these schemes / programmes are almost two decades old and some others are of recent origin. Few of these programmes address a specific sector / sub-sector like DPRP programme of DST or SBIRI of DBT, the others address broadly all sectors such as NMITLI of CSIR and TDDP of DSIR. Collectively all these programs approximately have an outlay of Rs. 500 crores per annum. This works out to be approximately 3% of the outlay of the National S&T agencies in the XI FYP. It may be pointed that out of this outlay of Rs. 500 crore per year only about 40% reaches to the industry as financial support in the form of loan and the rest goes to R&D institutions and Academic institutions / Universities, who partner the industry in the project as grant-in-aid.

6.3.2. Implementable Actions

Looking at the size of the Indian economy and healthy growth rate, the allocations that support industrial competitiveness through innovations are too meager to cater to all sectors of industry. As a result the outcome from these schemes is not to the desired level. Recognizing the fact that R&D is risky and innovative R&D is far more risky, the schemes / programmes provide assistance in the form of loan. Since rate of failures are expected to be significant, it is leading to a situation where the recovery of loans is becoming a problem. The loan model for innovative research is not a workable proposition and as a nation we need to evolve some newer models of support to industry, with the cardinal principle that the risk takers from both public and private sectors need to be supported with grant-in-aid. Under the WTO regime, the only legitimate support governments can provide to the industry is through R&D programmes funding. Hence several developed nations and developing nations have substantially increased their allocations for innovation development and translational research to help their industry to maintain a competitive edge in the global markets. India too need to enhance its R&D contribution.

With a view to providing a thrust to the government supported R&D programmes that encourages innovation and innovative technology development, the INAE team discussed the issue of how to enhance the reach and effectiveness of these programmes. Some of the recommendations emerged from these discussions are given the chapter 10.

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CHAPTER – 7 R&D THROUGH INDUSTRY – UNIVERSITY LINKAGES

This chapter deals with an extremely important issue of industry – university (I-U) linkage in Indian chemical sector. The first part focusses its attention on global trends in I-U linkages, ownership of externally funded inventions and drivers for I-U link formation.

The second part of the chapter deals with the Indian situation with regard to I-U networking, few successful examples, recent government initiatives and creation of institutional framework for its promotion in IITs and central, state and deemed universities.

The last part of the chapter highlights the technology incubation system in India contributing to I-U linkages and the success achieved so far in Indian chemical sector. The establishment of technology driven start-up companies in Indian chemical sector and their strengths and weaknesses are briefly examined.

7. R&D THROUGH INDUSTRY – UNIVERSITY LINKAGES

This chapter covers an extremely important issue which is vital for the sustainable growth of R&D in all segments of the Indian chemical industry. Since the Indian achievement, so far, on establishing strong industry – university (I-U) linkages has been rather unimpressive, an attempt is made to highlight the global developments in this area, few successful case studies in India, resent government efforts and technology incubation ventures in India. This is mainly to draw inspiration from them to improve the Indian situation.

7.0 Preamble

Universities world over have a fairly long history of contributing to industrial growth in a variety of ways depending upon local demands. In recent years, under the influence of growing competition of globalized economies, the importance of academic research to industrial innovation has been receiving greater attention. Traditionally, quantitative measure of academic research output seldom went beyond counts of research papers, participation in national and international conferences and academic awards and honours. In recent times, filing of patents, consultancy services to the industry, royalty / consultancy earnings and industrial research awards are slowly being accepted by the academic community as additional R&D performance indicators.

The chemical industry has always taken a lead role in USA and Europe in making effective use of academic institutions for fundamental research as well as using them as test beds for R&D commercialization. The National Academy of Engineering (NAE) in USA had made an interesting study on the impact of academic research on Industrial performance in 1998 with support from the Alfred P Sloan Foundation. The major recommendations called for actions that could enhance the contributions of university research to industrial growth and performance. As a matter of fact, the INAE drew inspiration from this endeavour to launch the present project focussing on Indian chemical industry.

7.1 Global Trends

The strengths of I-U Linkage in various parts of the world vary with Europe and USA providing a number of driving forces to promote them whereas in several developing countries, they are practically non-existent. In between lies India, China and other Asia Pacific countries. An attempt is made in this section to briefly analyse the global scenario with the help of research studies reported on this subject.

7.1.1 USA Scenerio

Rosenberg and Nelson (**1**) studied the role of American universities in the technological advancement of US industry. George (**2**) dwelt with the patenting and licensing trends at the Wisconsin University. Miner et al., (**3**) analysed the commercialization aspects of university inventions. Zucker and Darby (**4**) highlighted the importance of academics in bioscience inventions. Lockeh et al., (**5**) stressed the importance of academics in commercialization process in new knowledge intensive fields. For most academics in universities, taking the leap into the world of commercialization represents a non trivial challenge involving the modifications of their role identify. They have to address the conflicting pressures associated with the cultures of academic and business worlds. S.Jain et al., (**6**) offered fresh insights into the social and psychological processes underlying the university-industry linkage.

NAE Studies

As stated in previous section, the NAE of USA made an interesting study (**8**) in 1998 on the contributions of the academic research to the performance of nonchemical industry sectors viz., network systems, medical devices, aerospace, transportation / distribution and logistics services. The following needs which were established from these studies are relevant to the Indian chemical industry.

- Maintenance of balanced portfolio of academic research (basic / applied) for government funding.
- I-U joint initiatives to explore novel pathways for taking academic research to industry.
- Competent or designated bodies to periodically monitor and assess the effectiveness of incentives for transferring academic research to industry.
- I-U-Govt initiatives to explore new mechanisms for bringing S&T advances to industrial technologies.
- Boost government funding for multidisciplinary research of relevance to industry.

Bayh-Dole Act on Ownership of Externally Funded Inventions

The US Government adopted Bayh-Dole Act in 1980 through a Parliamentary legislation (**19**) to deal with IP arising from government funded research. Among other things, it provided universities, small business and non profit agencies control over their IP and innovations developed by them. It reversed the presumption of title and enabled them to pursue ownership of their inventions in preference to the government and ensure their commercialization upon licensing. The royalties and other financial benefits arising out of such ventures can be shared by the inventors and the institutions providing support to such efforts.

The enactment of Bayh – Dole Act had become necessary in USA since the federal government had hardly succeeded in commercializing 5% of 30,000 patents held by them. This is due to lack of resources on the part of US Government to develop and market such large number of inventions. Prior to enactment of Bayh Dole Act, less than 250 patents were filed by all US universities per year. By 2000, more than 300 US universities and other institutions were actively engaged in technology transfer. This also gave impetus to I-U linkages in USA to move new discoveries from the laboratory to the market place faster and more efficiently than ever before. In terms of gross licensing revenues of US universities, they rose from USD 200 million in 1991 to USD 1.26 billion in 2000. A remarkable transformation indeed.

As per the provisions of Bayh Dole Act, the recipient can retain the title of the invention in exchange for

- Reporting each disclosed invention to the funding agency
- Retaining the title of invention within a statutorily prescribed timeframe
- Granting the US Government a non exclusive, irrevocable and paidup licence to practice on its behalf throughout the world

- Actively promoting commercialization of the invention
- Sharing royalty with the inventor(s)
- Using any remaining income for education and research
- Giving preference to US industry and small business houses

Government of India has already initiated the process of enacting a legislation with similar provisions as in the case of Bayh-Dole Act of USA. This bill is before Indian Parliament.

Other Developments

- The US federal government has made technology transfer to industry an obligation for the receipt of government grants by the universities.
- The faculty of US Universities have become more entrepreneurial to translate their research for public good. Some of them have involved in entrepreneurial ventures.
- Strong I-U linkages promoted employment opportunities for students, additional sponsored work for universities and industry support to establish novel R&D or analytical facilities at the academic institutions.
- Establishment of research universities to strengthen R&D commercialization prospects in Industry clusters or high industry growth regions.
- Establishing research consortia / centres within the university system to bring together academic and industry researchers to solve specific R&D problems including precompetitive research in industry relevant areas.
- Establishing high level research alliances at universities based on research projects jointly selected by the industry and academia.

7.1.2 Drivers for formation of I-U Linkages

University research has a value perse, whether or not it is connected directly with industry because it generates fundamental knowledge worth transmitting to succeeding generations. There is a strong feeling amongst a section of academic community that universities whose links with industry are too intensive, their research is likely to be of short term in nature which is more of problem solving type possibly undermining the researchers's intellectual freedom. Apart from this, some critics say the R&D commercialization may contribute to conflicts of interest which compromises on the objectivity of university research and its outcomes. There are also critics who would like universities to improve social outcomes by retaining their right on product development to benefit underdeveloped regions or countries. There is a definite need to balance the academic and industrial R&D interests in a rational manner to avoid drift in either way.

E.Giuliani (**7**) identified factors responsible for fortifying I-U Linkages. The level of industry's knowledge base vis-à-vis quality of university research output is an important issue. J.M.Azagra (**14**) investigated the reasons for the delocalisation of I-U collaboration. S.Jani etal., (**15**) studied the social and psychological processes underlying a faculty's involvement in commercialization activity and new insights into the academic entrepreneurship. J A. Seversen (**16**) identified several pathways for the transfer of knowledge and technology from universities to industry. They include training of students, publication of research results in scientific journals, consulting arrangement by the faculty, industrial sponsored research in university laboratory, licensing of university inventions to industry for commercialization, creation of companies specifically for the development of university inventions and exchange of S&T personnel and materials.

7.2 I-U Linkages in India

As stated earlier, I-U linkages in India have not yet gained adequate strength to become a strong technology transfer tool for Indian Universities.

7.2.1 Effectiveness of I-U Linkages in India and Other Countries

A study was sponsored in 1999 by the Government of Japan and the World Bank (**9**) to identify most promising paths to enable universities to promote economic and industrial growth in East Asia including China, India, Singapore and Thailand. The studies related to India highlighted some of the interesting experiments undertaken by the academic and R&D institutions and the lessons learnt from them.

The role of the diaspora in forging I-U linkage in the globalized knowledge economy was examined by M.H.N.S. Shahin etal., (10) in Africa, Americas, Asia, Europe and Oceana continents. India is not covered in this study. Their conclusions on diaspora entrepreneurs and university-Industry collaborations as a viable knowledge platform for their development are relevant to India.

R.Nezu (**11**) examined the technology transfer, intellectual property rights and effective I-U partnerships in China, India, Japan, Phillippines, S. Korea, Singapore and Thailand. **Table 7.1.1** shows the CAGR of patent filing by universities in India, Thailand, S. Korea, China and Japan. India has to substantially increase patents filing by its universities both in numbers and in growth terms. Based on the above report, the status of I-U collaborations are compared in India, China, S. Korea and Japan and presented in **Table.7.1.2**.

Table 7.1.1: CAGR of Patent Applications filed by Universities (1996 – 02)

Country	1996	1998	2000	2002	CAGR, %
1. India	29	50	78	79	18.2
2. Thailand	1	16	16	29	75.3
3. S.Korea	141	327	627	957	37.6
4. China	705	879	2,010	4,677	37.1
5. Japan	76	235	618	1335	61.1

Contribution of I-U Linkages to Technology Transfer and IP Generation

P Ganguli (**12)** made a detailed study on Indian I-U Linkages for Technology Transfer and IP generation. He examined S&T policy framework, opportunities for higher technical education, S&T administration, I–U interactions and IPR status to suggest:

- Formulation of a comprehensive IPR policy for Indian academic institutions and the establishment of patent facilitation cells in universities.
- Training in IPR management and creation of a consortium of IPR professionals
- Creation of an Association of Technology Transfer Executives (ATTE) in universities
- Creation of a consortia of funding agencies for technologies developed in academic institutions.
- Holding IPR awareness workshops in various universities

7.2.2 New Enterprise Creation through I– U Linkage

New Enterprise Creation through I-U linkage is still at a nascent stage in India. Technology incubators are being set up by IITs, IIMs, IISc and some of the national laboratories. R.Basant et al., (**13**) discussed the strategic and policy issues related to the I-U links and enterprise creation in India. Their main observations are:

- IP protection does not seem to be critical for spinoffs and new enterprise creation through Indian educational institutions
- Tremendous motivation is required by the academic community to deal with the trade off between publications and industry related activities
- Current Indian academic culture does not create opportunities for university faculty to become entrepreneurs
- Incubators in academic institutions in India have achieved moderate success so far in new enterprise creation
- The lack of industry orientation among academic institutions and the limited R&D orientation of the industry have constrained I–U linkages
- The near absence of angel and venture funding for the startups.
- Need to design appropriate work environments and compensation packages that will attract talented young people to take up industry research oriented careers in universities.

Table 7.1.2: Policy and Management framework for I-U Collaboration

	Highlights of I-U Linkages	National Policy Framework	National Management Framework	Administrative Entities
China	• 40% R&D funded by Universities. • 50% Commercial technology earnings retained by faculty. • University supported ventures for R&D commercialization	• The PRC (1994) enables universities to make investments and establish corporations with their own capital. • Supplementary laws facilitate technology commercialization.	• Law for promotion of S&T Transformation (1996). • Universities announced IP rates. • Established IP Management Centres at Universities.	• Technology Transfer Centres at Universities.
Japan	• Establishment of University promoted ventures • Universities are slow and less experienced in managing IPR's.	• National Policy is very similar to that of Korea.	• Universities own IPRs . • University established internal patent policies. • Faculty shares royalty from patents.	• Technology Transfer Centres at Universities. • Government Subsidies
S.Korea	• I – U Cooperation Foundation (IUCF) established for IPR management.	• Technology Transfer Promotional law to enable Universities to work with industries for R&D commercialization.	• Insufficient IPR Management mechanism	• IUCF provides technology transfer services.
India	• Indian Universities yet to realize IPR importance. • Few industries supporting university research.	• General directions given in science Policy (2003) of GOI. • No precise policy framework for I-U collaborations	• Few Universities established Industry coordinated cells. • Universities deal IPR on case to case basis.	• UGC • AICTE

7.2.3 Successful Examples of I - U Linkages in Indian Chemical Sector

Institute of Chemical Technology, Mumbai (ICT)

A two member INAE team consisting of Prof A N Maitra, Project Consultant and Sri A Narasimha Rao, Research Scholar visited ICT, Mumbai on 9th November 2010 to study the I-U linkage system as practiced at ICT. They met Prof G D Yadav, Director of ICT and senior colleagues for detailed interactions on the above subject. The following points emerged during the study visit:

- Consultancy or sponsored project mode is adopted for solving industry problems. The industry-ICT linkage normally extends beyond the sponsored activity for better hand holding. The industry is keen to offer study fellowships to students and visiting fellowships to faculty. The ICT also offers Adjunct Professorship to industry scientists.

- The nature of assignments under industry-ICT linkage include process or product development, troubleshooting and consultancy on technology related matters. The process development assignments of ICT covered sucralose, artemisinin, vitaminB12, biodiesel, wire enamel coatings, food product dehydration, enzyme extraction from vegetables, hydrogen for fuel cells etc.,

- The intellectual property is protected jointly for industry sponsored research. The industry bears the entire patenting expenditure. The nature of industry support to ICT include creation of distinguished chairs, financial support to acquire specific equipments and instruments and fellowships to students.

- ICT management, faculty and students play specific roles with regard to R&D support to industry. The management encourages faculty involvement in industrial research and their periodic visits to the industry. In some cases, the management provides bursaries to the faculty. Most of the faculty undertake industrial research in addition to their academic research activities. The postgraduate, doctoral and postdoctoral students are involved in industry oriented research activities. Some of them receive fellowship from the industry. In 2008-09, the research students at ICT published 225 research papers and filed 8 patents.

- The alumni of ICT have established chemical plants on commercial scale and provide continuous support to ICT for its all round development. They include distinguished industrialists like Mukesh Ambani, Narotam Sekhsaria, KH Gharda, and Dr Anji Reddy.

- The ICT has sustained research activities based on green chemistry viz., solar cookers, organic solvent replacement, heavy metal removal from industrial waste water, dissolved organics removal, water disinfection and ecofriendly lubricants.

Practice School Concept of BITS, Pilani

As part of its efforts to promote work integrated learning while simultaneously developing career benefits to undergraduate students in science and engineering, the Birla Institute of Technological Sciences (BITS) at Pilani and its sister institutions in Goa and Hyderabad have introduced the Practice School Concept for undergraduate students. The programme has grown from a level of 30 students in 1979 to over 19,000 students in 2008. The programme places emphasis on work integrated learning of their students in industry and R&D institutions. The BITS has entered into long term contract with leading chemical companies viz., Tata Chemicals, Dr Reddy's Labs, Matrix Labs, Dabur Pharma and Hindustan Zinc and institutions like CSIR Laboratories and Consultancy Development Centre (CDC) of DST, Govt. of India. The students are paid stipends by the host institutions during their 6 to 7 months stay in their premises.

Recent Government Initiatives to promote I - U Linkages

DST: The DST is actively engaged in evolving technology development models based on public funding in which solution providers from private sector will be enrolled as partners. The DST aim is to develop convergent solutions of socially relevant problems associated with water, energy, fertilizers and allied products where technologies could provide sustainable solutions by connecting the people involved in mind to market space. One of the identified problems pertains to establishing test bed for continuous potash based fertilizer plants based on CSMCRI, Bhavnagar Knowhow with Tata Chemical collaboration. This is expected to solve the long standing need for Indian technology to minimize its large scale import by the Indian fertilizer sector.

***ISRO*:** The I-U interface is being strengthened by creating a wider research base and expertise of its relevance in academic institutions. They include fellowships for microgravity based R&D programmes, establishment of research chairs, continuing education programmes, support to PhD programmes etc. The ISRO is supporting 200 projects in 80 universities with an annual budget of Rs 15 Crores.

DRDO: It is based on DRDO – academic partnership model covering technology development, system integration and product development. There is provision for academia, industry and DRDO to form strong knowledge consortia for a long term R&D in high end S&T areas. The focus of these collaboration programmes is on conversion of scientific concepts into technological process / product options. The DRDO has entered into MoUs with IITs, IISc, BHU and JNCASR in IT, communications, nanomaterials, thin films, semiconductors, biomedicine, water purification etc. It has also established centres of excellence in high energy materials with Hyderabad University and composite materials with NAL, IISc and IIT-K and Kgp.

DBT: It has been making sustained efforts to enhance I-U collaborations through its Small Business Innovation Research Initiative (SBIRI) and other programmes based on global partnerships in vaccine development.

7.2.4 INAE Web based survey on I-U Linkages in Indian chemical sector

Very little information is available on the status of I-U linkages in chemical sector covering Indian academic institutions including IITs, NITs and State, Central and deemed universities. The INAE project team has, therefore, undertaken a mini survey by getting access to the websites of more than 500 Institutions. Information on their institutional framework for promoting I-U linkages, sponsored projects, extent of their funding from public and private sources, percent share of chemical projects and broad areas of their coverage has been collected. The following have been launched by the Indian academic institutions with varying degrees of success:

- Industry – Institute Interaction cells
- Joint Workshops / Symposia
- Exchange of personnel (short term)
- Consultancy projects offered by faculty
- Hiring of process equipments by industry
- HRD programmes to industry
- Professional chairs by the industry
- Industry sponsored student fellowships
- Practice schools for students in Industry premises

Centres for Industry – Institute Partnership

These centres are established at the Indian academic institutions to bring industry closer to the academia, to make academic curricula more relevant to the user, to generate resources in the form of industry supported projects and consultancy programmes and to organise placement programmes for the students. The AICTE provided seed money of around Rs 5 lakh to some of the engineering institutions. The **Table**

7.2.1 shows the limited number of such centres established in central, state and deemed universities in the country after 2000.

Table 7.2.1 : I – U Centres in India

	Number of Institutes Surveyed	Number of I-U Centres	%
IITs	12	5	42
NITs	22	10	45
Central Universities	22	5	23
State Universities	230	30	13
Deemed Universities	127	22	17
	413	**72**	

Many of the I-U centres are not very active in terms of technology transfer to the industry inspite of having following objectives:

- Establishing close links with industry
- Evolving and executing R&D partnership programmes
- Training Students under industrial environment
- Converting scientific concepts into marketable products
- Organising guest lectures and workshops
- Encouraging student – industry interactions
- Incubation of viable projects
- Promoting entrepreneurship among engineering / science students
- Identifying high tech areas with entrepreneurship opportunities

Entrepreneurship Development Cells

Some of the academic institutions in public and private sectors have established entrepreneurship development cells under the National Science and Technology Entrepreneurship Development Board (NSTEDB) of DST, Government of India. Apart from creating entrepreneurial culture in academic institutions, they help them to develop partnership between industry – institutes, design and develop activities to improve performance of the industry, to facilitate mobility of academic and industrial personnel and to train industry shopfloor personnel under Continuing Education Programmes (CEP).

Table 7.1.4 : Broad Contours of Govt/Industry Funded Research Projects in Indian Academic Institutions

Type	No. of Institutions		Projects		
	Total	Project Implementing	Total	Chemical Oriented	
				Number	Rs.lakhs
IIT's@	07	5(71)	650	99(15)	NA
NITs	22	10(46)	741	91(12)	736(16)
Central Universities	22	5(23)	617	100(16)	1300(11)
Deemed Universities	127	40(31)	2541	434(17)	4380(40)
State Universities	243	30(12.34)	1082	279(26)	4636.47(28)
Total	**421**	**72(17)**	**5837**	**873(15)**	**11273(25)**

Note: Numbers in parentheses indicate % share

Table 7.2.3 : Chemical Projects of IITs

No	IIT-BM (IRCC)	IIT-KH (SRIC)	IIT-DL (FITT)	IIT-MD (IC&SR)	IIT-GT	Total
Total Projects	43	88	474	10	13	628
Chemical Projects	24	42	16	8	4	94
% Share	56	47	3	80	25	15

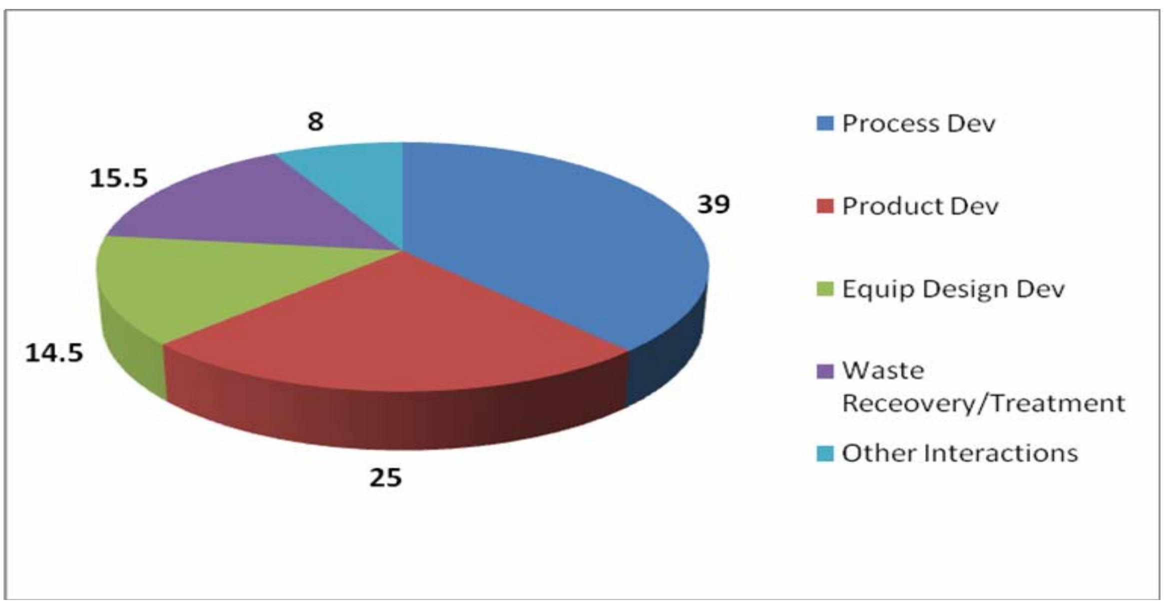

Fig. 7.2.1: Subjectwise breakup of IIT Projects relevant to Chemical Sector

Campus Recruitment Cells

They are established by IITs, NITs and several of the universities to help final year students to be placed in Industrial and R&D positions in public and private sector organisations. They also arrange student projects (1 or 2 semester duration) at the industries under joint supervision. Some of them are also involved in industry – institute joint research programmes.

Nature of Research Projects in Academic Institutions

An analysis of the research projects (**Table 7.2.2**) executed by the Indian academic institutions during 2008-09, has indicated following trends:

- The chemical oriented consultancy projects handled by IITs (**Table 7.2.3**) are relatively more application oriented with more than 20 industry beneficiaries. The subjectwise breakup of these project activities is given in **Fig.7.2.1**. The process and product development oriented projects constitute around 64% of the total projects. The IIT, Kharagpur has maximum number of chemical oriented projects as compared to other IITs. However, the share of chemical projects at IIT, Bombay and Madras is quite high through their number is less.

- Around 15% of the projects being handled by the central, state and deemed universities belong to chemical sector.

- The research projects being executed by the central, state and deemed universities are not relevant to industry eventhough their numbers are very high. The content of chemical oriented projects is around 15 to 25%.

7.2.5 Reported Pilot Study on I-U Linkages

S. Bhattacharya and P.Arora (**18**) examined I-U linkages through a pilot survey conducted in seven Indian universities located in different regions with student enrolment on All India basis. They identified 5 major factors responsible for strengthening I-U linkage viz., improved personal contacts (29%), acquisition of specialized S&T skills (19%), government sponsorship (37%), creation of specialized facilities (8%) and others (7%). They also identified 6 major constraints in developing I-U linkage in Indian institutions viz., lack of mututal trust, poor infrastructure, absence of different norms for evaluation of industry oriented projects, different ethos, lack of financial incentives to faculty and IPR ownership problems. They concluded that the I-U linkages in India are somewhat sporadic in nature with occasional success inspite of fiscal and nonfiscal incentives offered by the government to strengthen the linkage.

7.2.6 Extramural Research (EMR) Support to Indian Academic Institutions

The purpose of EMR support to academic institutions is to build the general research capabilities of their faculty and students and to provide incentives to the postgraduate students to pursue research careers. The National Science and Technology Management Information System (NSTMIS) of the DST is maintaining a comprehensive data base on all exramural R&D projects funded by the various central government agencies since 1985.

N Gupta and R Chetal (**17**) reported that the EMR funding by the central government increased from Rs 127 Crores in 1993-94 to Rs 449 Crores in 2002-03 at a CAGR of 15%. The number of research projects funded in 2002-03 was around 2720. The chemical science oriented projects accounted for 13% and chemical engineering and biotechnology projects accounted for 38% share of engineering oriented projects. The DST accounted for nearly 39% of Govt support, 9.2% by the DBT, 8% by the ICMR and 5.4% by the DSIR in 2002-03. During this period, the state and central universities and their affiliated colleges received around 31% extramural support for executing 1305 projects whereas Deemed universities received around 13% support for executing 190 projects and the rest of the support was received by the National Laboratories and Institutes of National Importance for executing 1223 projects. The expenditure on extramural support to state, central and Deemed universities had grown from Rs 120 crores in 2000-01 to Rs 198 crores in 2002-03. However, it is not clear as to the extent of benefits derived by the industry.

7.3 Technology Incubation through I–U Linkage

7.3.1 Global Scenerio

The importance of I-U linkage stems from the fact that scientific inventions without industry support will not create wealth or improve the life quality of people nor the industry will derive the full benefits of public funded research. Globally, universities function as generators as well as transmitters of new scientific knowledge to progressive industries through the technology transfer and absorption processes. The potential growth in new technologies has been phenomenal in recent times in industrially developed countries due to the proactive role played by the universities and R&D institutions in effectively transferring their scientific knowledge and technological capabilities. It is this role of R&D and academic institutions, which has prompted the governments in several developing countries to establish science parks, innovation centres, technology business incubators and allied initiatives.

The technology incubation process is primarily concerned with nurturing startup and early stage ventures. The starting force is the entrepreneur, operating in a national industrial and academic environment, trying to overcome technological, financial and administrative obstacles to create new ventures. R.Lalkaka (**20**) prepared a technology business incubator manual under the auspices of UNESCO in 2000. Incubator enterprise support system as proposed by Lalkaka is reproduced in **Fig.7.3.1**. It shows the overriding importance of knowledge base creation through I-U linkages. It clearly indicates the numerous barriers to be crossed by the new entrepreneurs in commercializing newly developed technologies. It also shows the complex mechanisms involved in transforming an innovation into a commercial proposition.

The number of technology business incubators in the world had crossed 2000 mark at the beginning of the 21st century. The subsequent growth has been faster in countries with emerging economies like China, Uzbekistan, South Africa, Malysia, Egypt, Indonesia, S Korea, Turkey and Brazil. They have established more than 300 technology business incubators recently. There are around 1000 technology business incubators in Europe and 550 in USA. Roughly half of them are linked to universities and 33% to technology parks. They are responsible for establishing more than 20,000 companies by creating nearly 3 lakhs jobs.

7.3.2 Indian Scenario

The National Science and Technology Entrepreneurship Board (NSTEDB) initiated the Science and Technology Entrepreneurs Park (STEP) programme in 1984 with three major objectives viz., to forge close I-U linkages, to promote entrepreneurship among S&T personnel and to provide R&D support to MSMEs.

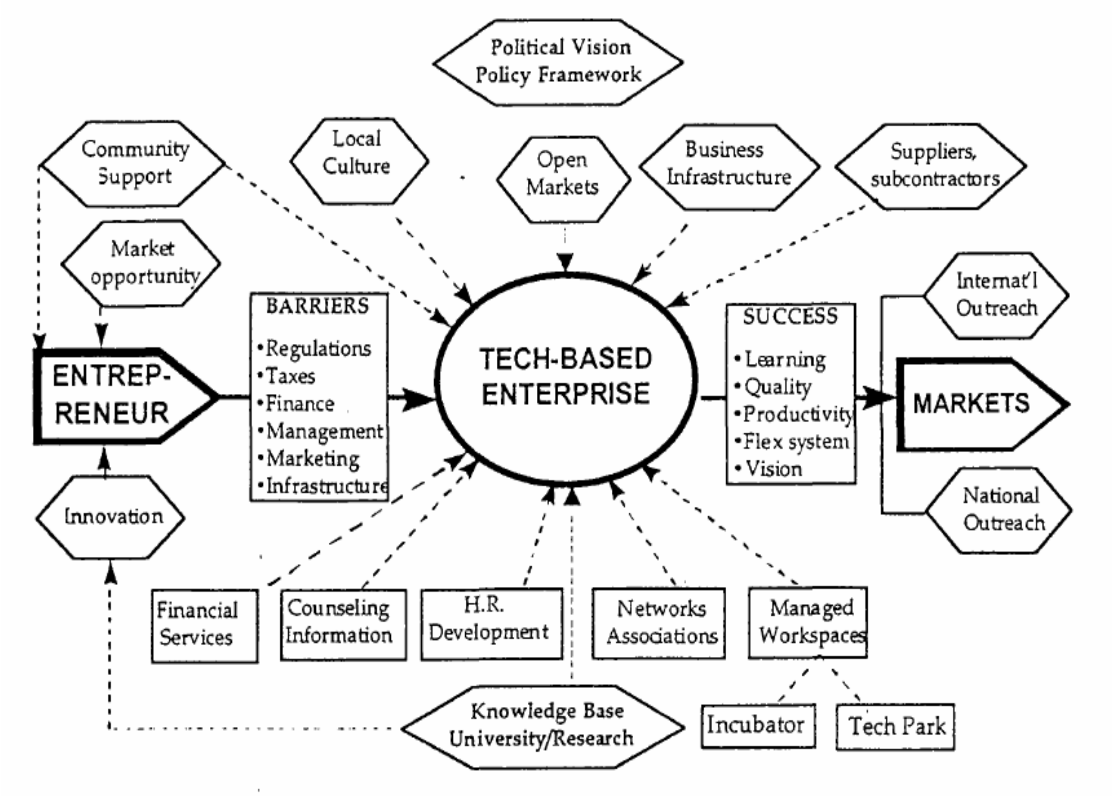

Fig:7.3.1 Enterprise Support System to Develop Technology based Enterprises

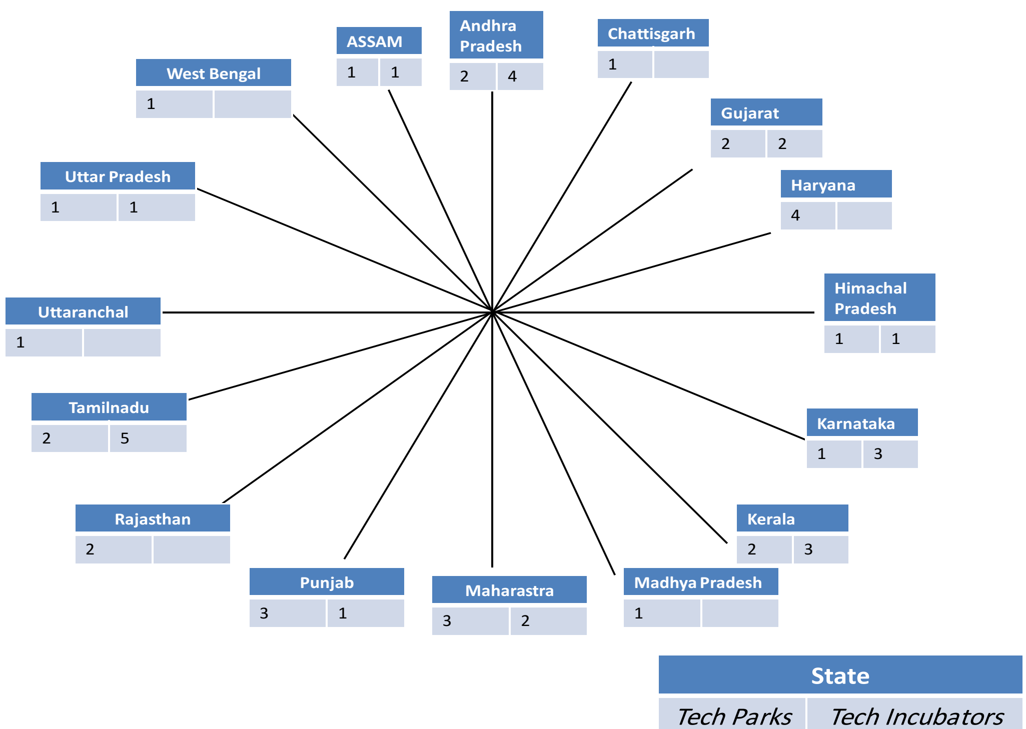

Fig.7.3.2.: Biotechnology Parks and Incubators in various Indian States

The STEP programme has been designed to create appropriate climate for innovation, opportunities for sharing of ideas, experience and facilities, opening up avenues for trans-disciplinary culture amongst students, faculty, researchers and industry managers. This is expected to create mutual dependency and understanding amongst them for setting up new start ups.

The STEPS sanctioned by the DST, Government of India as on 31 December 2009 are 15 out of which 12 STEPS were established prior to 1999. Three of them are established in Karnataka, two each in Punjab and Tamilnadu and one each in Delhi, Gujarat, Jharkand, Maharashtra, Madhra Pradesh, Uttar Pradesh, Uttarakand and West Bengal. Till 1999, they helped establishment of over 600 startup units, developed 340 technologies and generated employment opportunities for nearly 5000 persons. They cover S&T thrust areas viz., energy, mechanical engineering, electronics, IT, food processing, textile, building technology, agri and food products, paints, chemicals, environment and materials. Three of the 15 STEPS focus on chemical and allied areas and account for 20% of the technologies developed and 10% of the employment opportunities.

Science and Technology Parks and Incubators in India

Science and Technology Parks in India are integrated facilities created to promote micro, small and medium scale entrepreneurs to facilitate them to setup startup companies and to provide fillip to public-private partnership. They also facilitate technocrats from academic and R&D institutes to commercialize their own technologies and proven S&T concepts. Towards meeting these objectives, the central and state governments have been instrumental in promoting science parks and technology incubators in designated areas. The lead was taken first by the software sector in India (**1**) and an autonomous organisation viz., Software Technology Parks of India (STPI) was setup in 1991 by the Ministry of Communications and Information Technology, Government of India. The STPI achieved tremendous success after 1996 and it spreed its wings to 21 cities in India within 2 years. It provided ready to use incubating infrastructure for startup companies, integrated data centres, business support services and administration / legal support to SMEs.

Encouraged by the above developments, the central and several state governments took the initiative to establish science parks and technology incubators in other industrial sectors. The Government of India is promoting 170 Technology Business Incubators and 50 Technology Innovation centres during 11th Five year plan (**3**) to create a congenial climate for entrepreneurship. Rs 1100 crores budget has been earmarked by the DST of Government of India.

Technology Incubators in Indian Chemical sector

The concept of technology incubation has not caught up with several chemical subsectors in India. The probable reasons may be scarcity of innovative processes and products, poor I-U linkage and concerns on protecting the secrecy of technologies during incubation process. The biotechnology sector has attracted maximum number of technology incubators in India. There is one reported case of technology incubation in speciality chemical sector.

More than 25 Biotechnology Parks are under various stages of implementation in 16 states in India with an overall outlay of Rs.1000^{+} crores and more than 5000^{+} acres of land earmarked for their establishment. They offer basic facilities needed to start any biotech business. **Fig.7.3.2**. provides their distribution in various Indian states. Nearly 25 biotech incubation centres are under various stage of implementation in the biotech parks. India's first fully equipped biotechnology incubation centre was commissioned in 2010 at SP Biotech Park in Genome Valley near Hyderabad city. It was established at a cost of Rs 27 crores through the joint initiative of Govt. of AP, DBT (GOI) and CSIR. It is currently managed and operated through a public-private partnership arrangement. It may be too early to evaluate the impact of biotech parks and incubators on establishing new start-ups and technology upgradation of existing process plants.

A Unique Incubator for Speciality Chemicals

The Shriram Institute of Industrial Research, Delhi has recently setup a technology business incubator with the support from the Department of MSME, Government of India. The thrust areas are polymers / plastics, composites, nanotechnology, speciality chemicals and materials and green processing. The materials areas covers medical products, biomaterials, aerospace materials and electronic polymers.

The incubator is open for use by scientific researchers, product developers, new entrepreneurs, students with bright ideas, professionals and NRIs with startup ideas. Laboratory or microprocesses, incompletely developed products or knowledge intensive services are eligible for further development.

STEP at Thapar University, Patiala

It is a technology business incubation centre in biotechnology field established in 2005 as a joint venture between NSTEDB of DST, Government of India and Thapar University at Patiala. It focuses on agrio biotechnology, biofertilizers, plant tissue culture and food process technology. It has successfully incubated 8 companies till 2010 out of which 4 have graduated to generate 29 jobs and Rs 1 crore revenue. It has gained good level of visibility in the region for technology incubation.

7.4 Establishment of Technology Driven Startup Companies in India

Globally technology based startups are growing much faster than their low technology counterparts because of their vital role in the emergence of knowledge economy. The rate of new knowledge generation has become fast and also the technology obsolescence rate. For example in USA, the survival rate of high tech start up companies is less than 40%. In India, technology based start-ups have come up in chemical, mechanical, instrumentation, electronics, IT, telecom, metals and transportation sectors.

S.Mani (**20**) analysed the growth of knowledge intensive entrepreneurship in the post liberalization period (1991-07). The growing dynamism of Indian private sector in the globally competitive markets is evident with 8 to 25% improvement in its export intensity, significant increase in overseas company acquisitions and emergence of sizeable number of knowledge intensive firms in IT, BT and PT sectors.

Startups in Indian Chemical Sector

The Indian chemical sector has led all other industrial sectors during 1991-08 in implementing technology oriented new industrial ventures whose total value is USD 54 billion. Its share is 34% as compared to 15% by the mechanical industries. **Fig.7.4.1** provides the details.

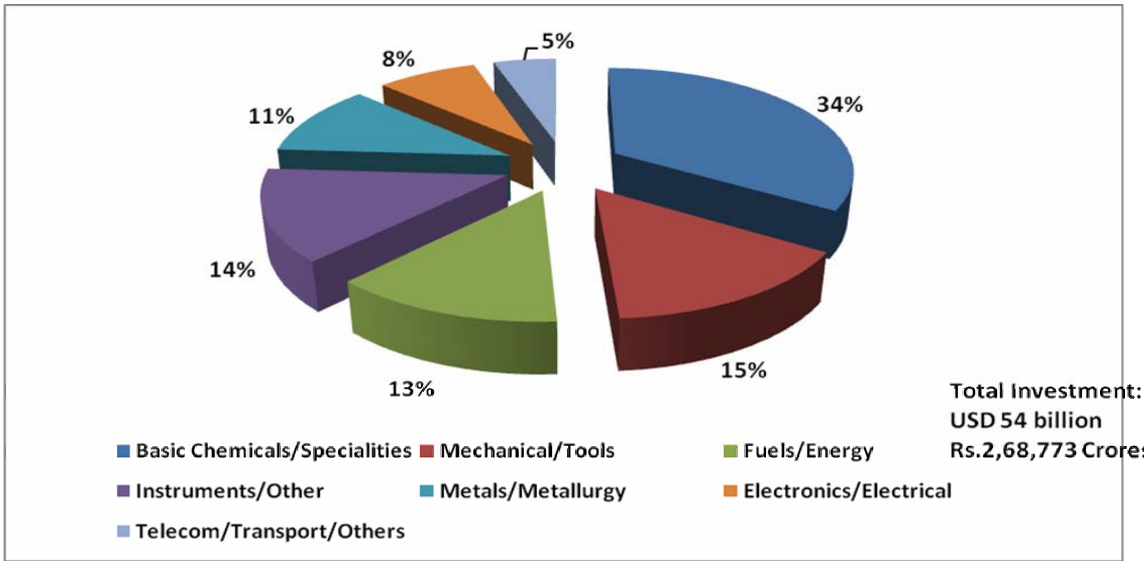

Fig.7.4.1 : Share of Indian Industrial Sectors in creating new startups

A pilot study cum opinion survey was conducted (21,22) by the Centre for International Trade and Technology (CITT) of the Indian Institute of Foreign Trade (IIFT) in 2007 covering 400 Indian startup companies in all S&T sectors including those from chemical sector (dyes, chemicals and pharma). Following points emerged from the above exercise:

- Most of the start-ups do not have adequate access to information on new venture financing and emerging technologies and markets for planning their future expansions.
- Very few start-ups could establish strong collaborative links with R&D / academic institutions in India. They sourced their technologies through their partners or overseas tie-ups.
- The R&D intensity of start-ups based on traditional technologies is around 1-2% whereas those based on high technology reorded 8-10%. The average turnover of the former is in the range of Rs 25-100 lakhs whereas that of the latter is around Rs 1-20 Crores.
- The major constraints faced by the new start-ups in order of priority are:
  - Deficiencies in government policies, procedures, duties and labor laws
  - Poor access to financial resources
  - Non availability of appropriately skilled manpower
  - Poor access to modern technologies
  - High raw material and infrastructure costs
  - Dearth of competent consultants on technoeconomics

The above study has also established the need for forming integrated networks of startup companies with similar technoeconomic background. It has definitely established the weak linkage between Indian R&D / Academic institutions and the new start-ups.

Venture Capital Problems in Indian Startups

The Indian venture capital funding agencies are concerned with following factors confronting the new startup companies in India.

- Low risk taking tendencies of their management
- Unsustainable remunerations offered to managerial and operation staff
- Less comfortable to sell unproven concepts / products to new customers.

The INAE team is of the opinion that the Indian entrepreneurial ecosystem in chemical sector has to improve significantly in the coming years by making effective use of their accrued experience, new information sources and government support systems. Under the present situation, it is vital for new start-ups in India to have a strong leadership with multiple capabilities to run the startup ventures.

7.5 Overall Findings and Implementable Actions on I-U Linkages

7.5.1 Overall Findings

Substantial literature information has been collected by the INAE Project Team on this subject. An analysis of the available data indicate the following:

- The Indian Universities irrespective of their status (central, state or deemed) have more or less same academic culture and working philosophy viz., predominance of basic research which is less relevant to Industrial application and more directed towards publications most of which fall under moderate quality. Unfortunately their available talent has seldom been utilized either to resolve social or industrial problems.

- There is hardly any incentive mechanism by which the university faculty is involved in industrially oriented research.

- A few Indian academic institutions have made significant contribution towards the industrial research and they can very well act as role models for other institutions.

- The Indian academic institutions have not made substantial contribution to make their students develop inquisitive eyes to surround themselves with latest innovations in science and technology from the industrial viewpoint.

- University faculty and research scholars are mostly dependent on government funding with very little efforts made to attract industry sponsorship for their research projects.

- The selection of research areas for EMR projects of the central government is totally based on academic research criteria and data collection and very little attention is given industrial research.

7.5.2 Implementable Actions

Launching of a Technology Mission to formulate and pilot test India specific I-U models has been one of the major recommendations of Chapter 10 of this report. The following implementable actions are suggested to strengthen I-U linkages:

- The AICTE may evolve appropriate guidelines to enable industry sponsorship and participation in the execution of undergraduate and postgraduate engineering project works in Indian engineering colleges.

- Amendments to be brought in the university act to facilitate engineering faculty participation in industrial research, sharing of consultancy / royalty charges paid by the industry and exchange of personnel between industry and universities under sabbatical leave programmes. The UGC and AICTE to take necessary facilitating action.

- Industry associations to take more initiatives to associate academic and R&D institutions to set up technology incubators in specialty chemicals and basic chemical downstream products with public-private funding.

- The Ministry of HRD, Government of India is in the process of setting up research universities in specific subjects. Speciality and knowledge intensive chemical sectors to be given adequate priority.

- Special studies are needed in following areas:

  - Knowledge transfer pathways from academic institutions to various segments of Indian chemical industry

  - Policy framework needed to enable Indian universities to be proactive in establishing I-U linkages and associated joint initiatives.

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CHAPTER 8 HUMAN RESOURCE QUALITY AND MANAGEMENT ISSUES

This chapter broadly deals with Human resource position in Indian chemical sector. The first part of the presentation quickly reviews the higher S&T education and manpower position in India and the incentives available for bright students to pursue science and engineering education.

The main part of the presentation in this chapter examines the present manpower position in the Indian chemical industry, the HR skill pyramid, HR deployment as from the INAE sponsored survey and allied issues.

The last part of the presentation briefly examines the HR mobility in global chemical sector and future directions for the HR growth in Indian chemical sector

8. HUMAN RESOURCE QUALITY AND MANAGEMENT ISSUES

The growth of Indian chemical sector is closely interlinked with its ability to attract and retain bright R&D talent from various subdisciplines. This chapter looks at the human resource position in Indian chemical sector with wide skill variations in quality of R&D manpower required for basic, speciality and knowledge intensive chemical segments. In order to provide proper perspective to the human resource issues in the chemical sector, an attempt is made to broadly analyse the higher education and research facilities in India, human resource (HR) development in Indian chemical sector, its mobility issues and HR management in chemical research. Prior to this, a brief mention has been made on the HR situation in Global chemical sector.

8.0 HR Situation in Global Chemical Sector

The international Labour Office (ILO) in Geneva brought out (**1**) in 2003, a report on the impact of the best practices on the HR quality in chemical industries. As per the presented data, around 9 million personnel were employed by the industrial chemical units in 1994. It started falling thereafter with countries in transition and developing economies contributing a major share to this fall. Only three chemical segments viz., soaps / personal care products, inorganic chemicals and pharmaceuticals have registered increased employment. The industrial chemical workforce has decreased in Europe and North America during 1999-01 but increased in East Asia by 2 million.

International Recruitment is not practiced for production jobs in Europe but is limited to R&D, sales, marketing and management. Recruits in highest demand are postgraduates with specific scientific expertise. Within a particular company, transfer of existing staff is a far more common practice than recruitment from other countries because of the value given to the accumulated experience in production practices. However, the situation is different in chemical R&D units in Europe.

The Global chemical industry employs innovative techniques like performance based pay, multiskilling, skill mobility, continuing education, outsourcing and knowledge management for attracting and retaining the best quality manpower. Indian chemical industry has to learn a lot from these experiences.

8.1 Higher S&T Education and its Promotional Pursuits in India

8.1.1 Enrolment and Growth

India has formally recognized the importance of higher education in several S&T areas soon after its independence to develop high quality manpower. While institutions like IISc and IITs offer world class education and training in engineering, there are number of educational institutions offering substandard programmes with less relevance to employment needs. Research and post graduate education in engineering and technology are confined to few institutions and universities. Annually less than 400 research scholars quality for their PhD in engineering. The situation is much better in chemistry and biology disciplines. Improvement in the quality of S&T education in India at the very large number of central, state and deemed universities is a major challenge. There is a strong need to improve S&T infrastructure in these institutions since quality of S&T education is infrastructure and faculty dependent.

The UNESCO Science Report 2010 by S.Mani (**9**) indicates that the gross enrolment ratio in higher education in Indian institutions is around 11% in 2007 and is expected to go upto 21% by 2017. This means that the universities and colleges in India need to grow by 8.9% per annum. Nearly 25% of Indian students are now enrolled in S&T fields. The Government of India is establishing 16 central universities, doubling the number of IITs, adding 10 NITs, 20 IIMs and 3 IISERs. They are in various stages of implementation. The Government is in the process of adopting a policy permitting foreign universities to enter the higher education system in India by establishing their own campuses or JVs with existing Indian Institutions. All these developments augur well for increasing both quality and quantity of S&T education in the country. It is interesting to note that higher education sector constitutes only a fraction of R&D

performed in India despite the fact that this sector encompasses the best institutions in the country. In other words, higher education sector in India is not a major source of technology for its industry since much of R&D in academic institutions is of basic research type.

8.1.2 Schemes to Promote Science Pursuits

One of the concerns of Government of India is the large scale deviation of students from science stream to other disciplines at higher education level. In order to attract Indian students towards science disciplines, following three important schemes have been introduced by the government:

- **National Talent Search Examination (NTSE)** was introduced in 1963 by the National Council of Education Research and Training (NCERT) for students from Class VIII to X. Attractive scholarships for pursuing education upto doctoral level are offered to those students who successfully come out of Mental Ability (MAT) and Scholastic Aptitude (SAT) Tests.

- **Kishore Vaigyanik Protsahan Yojana (KVPY)** was introduced by DST in 1999 to encourage students of basic sciences, engineering and medicine to pursue their education upto PhD levels. The selection is made through national level competitive examination.

- A novel scheme titled **Innovation in Science Pursuit for Inspired Research (INSPIRE)** was introduced by DST in 2008 to provide science innovation scholarships of Rs 5000 for one million young learners in 10-17 years age group in a period of 5 years. The scheme also provides for mentorship through global icons including Noble Laureates and offer of scholarships for doctoral research with assured research career opportunity for 10,000 young person's for a period of 5 years. It is too early to assess the impact of this schemes on the Indian youth.

8.1.3 Gender and S&T Education in India

This is an important issue for Indian chemical sector with its large scale demand for women employees with S&T proficiency in subsectors like food processing, personal care products, pharmaceuticals, biotechnology and others. Considering the prevailing sociocultural system in India, the Institute of Applied Manpower Research (IAMR), New Delhi studied (**5**) the women enrolment in Indian universities in different faculties of higher education. The details are reproduced in **Table 8.1.1**. They indicate that education, medicine and humanities disciplines are most preferred by Indian women. Their growth in science and engineering is quite attractive to augur well for disciplines like chemistry, pharma, food and biotechnology which are important for Indian chemical sector.

Table 8.1.1 : Enrolment of Indian Women as percent of Total University Enrolment

Year	Education	Medicine	Humanities	Science	Eng/Tech
1960-61	32.5	20.4	18.6	NA*	0.8
1980-81	46.7	23.8	37.5	27.9	4.6
1990-91	44.2	34.3	39.8	36.8	10.9
2993-04	52.1	46.3	45.5	39.8	23.1
CAGR% (1960-04)	**1.1**	**1.9**	**2.1**	**2.34****	**8.13**

*1970-71 : 18.5% **for 1970-04 period

8.2 Indian S&T Manpower

8.2.1 Qualified Manpower for Industry

Though India has a very large pool of S&T manpower in various disciplines, the actual density of personnel in R&D and innovation is around 137 per million population. The Indian manufacturing industry has been complaining of severe shortage of suitably qualified and technically trained personnel. The IT and other service sector industries are absorbing a sizeable number of S&T personnel from various disciplines. A FICCI study (**2**) conducted in 2009 in 25 Indian industrial sectors had shown that rapid industrial expansion in a globally integrated Indian economy has stimulated a huge demand for skilled personnel. It had placed the stock of Indian scientists and engineers engaged in R&D around 0.39 million in 2005 as compared to 1.36 million in China. The two contributing factors for the shortage are migration of highly skilled personnel from India to west and the offer of attractive salaries by the MNCs and their R&D centres in India. S.Mani (**3**) reported that the Indian brain drain has been increasing from 2.6% in 1990s to 4.2% in the early 2000s.

The NISTADS, New Delhi (**5**) made an assessment of the stock of Indian S&T manpower in the agriculture, engineering, science, medicine, veterinary and education fields. It shows the growth rate of highly specialized manpower in India is much less than that of S&T graduate generated annually. **Fig.8.2.1,** reproduces its findings on global upskilling and employment growth patterns in various industrial sectors. The chemical sector is placed in the second quadrant characterized by moderate to high skill requirement with less than 2% of annual employment growth.

8.2.2 R&D Manpower in India and Other Countries

According to UNDP Human Development report (**6**) of 1998, the per capita availability of S&T personnel in India is significantly low as compared to many developed and industrially developing countries. However, percentage of S&T personnel engaged in R&D is relatively high in India as compared to other important countries in chemical sector. The details are presented in **Table 8.2.2**.

8.3 Human Resources Situation in Indian Chemical sector

8.3.1 Functional Distribution and Quality

The National Skill Development Corporation (NSDC), New Delhi with the help of ICRA Management Consultancy Services Ltd., India has recently made an assessment of HR and

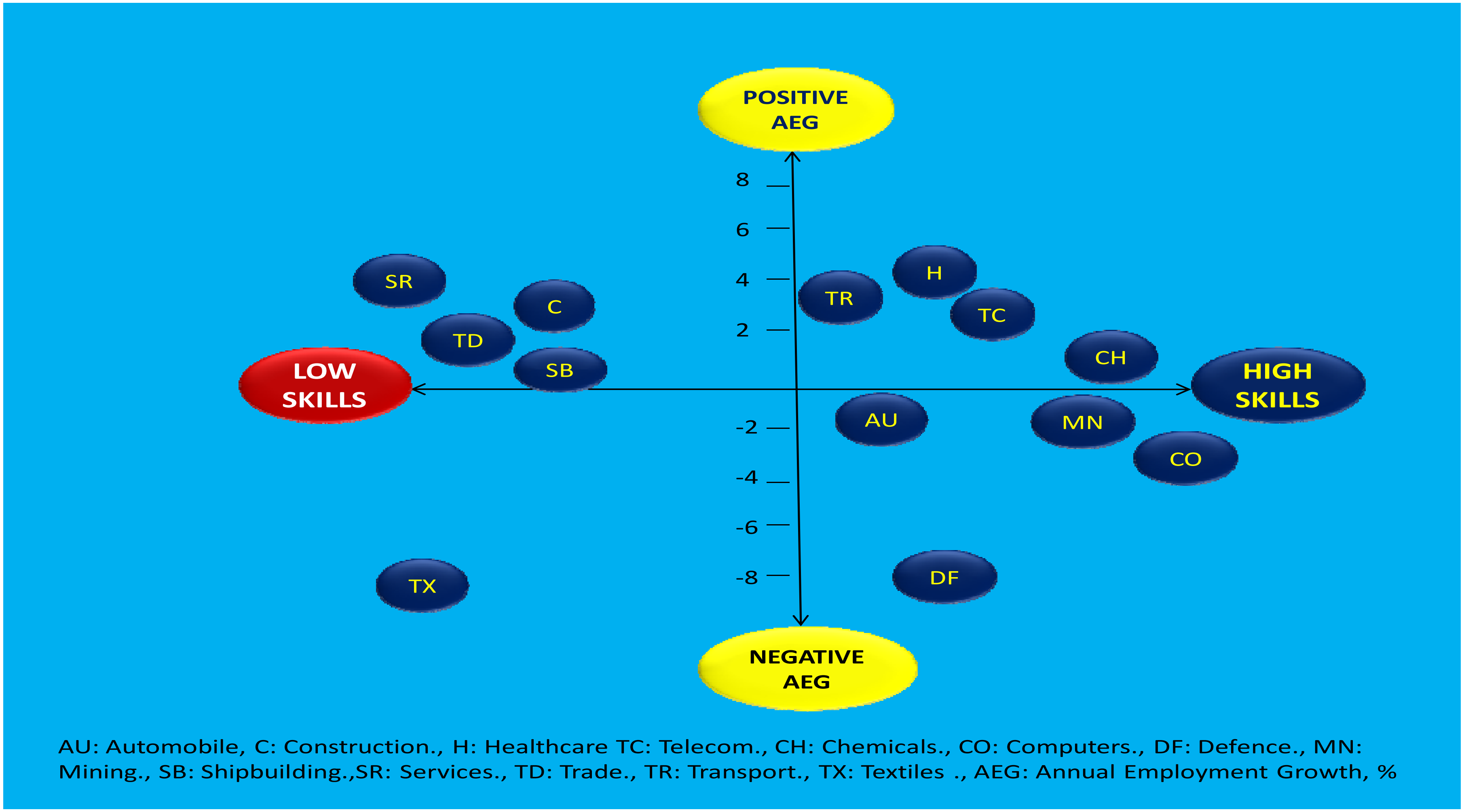

Fig. 8.2.1 : Global Upskilling and Employment Growth patterns in various Industrial sectors

skill requirements of the Indian chemical and pharmaceutical sectors (**4**). The study shows the functional distribution of human resources in these sectors. The details are provided in **Fig.8.3.1**. It clearly shows the relative manpower priorities of pharma and chemicals (other than pharma) sectors. The R&D has the second highest priority after production and quality control operations in pharma sector. The estimated personnel requirement in Indian chemical sector is about 1.88 million by 2022 with more than 80% of them required by the Indian pharma sector. The details are given below:

Function	**HR requirement in 2022 (in 000s)**
Production	973 (85.5)
Purchase / Stores	172 (96.5)
R&D	337 (99)
Sales / Marketing	209 (79.4)
Support Staff	188 (88.3)
Total	1879

Note : Numbers in parantheses represent % share of pharmaceutical sector

Fig.8.3.2 shows the overall education levels of personnel employed in Indian chemical sector. Nearly 45% of them have undergraduate qualifications in science and engineering disciplines and almost equal percentage of personnel have diploma, ITI and 12th Class qualifications.

8.3.2.The Skill Pyramid of Chemical sector Personnel

The NSDC study has brought out the human resource profile of Indian chemical sector including pharmaceuticals but excluding food processing segment. It shows that the relative proportion of skills in chemical sector is much different from textiles, food and gems / jewellery sectors. Higher skills are required in this sector on account of higher R&D content, management of automated processes, more extensive regulatory purview with reference to environment and safety and more sophisticated sales operations in speciality and knowledge intensive sectors.

The distribution of S&T personnel of various qualification and skill levels is given in **Fig. 8.3.3** in the form of HR Pyramid. The shortages are more felt on the positions in the pyramid top i.e. the situation is acute in the case of research and design personnel.

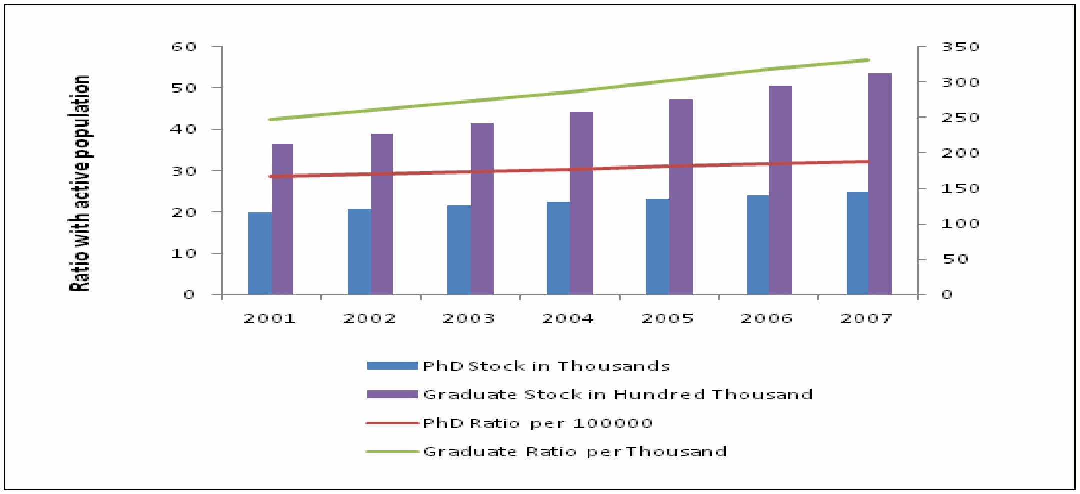

Fig. 8.2.2 : Indian S&T Manpower Stock and Ratio

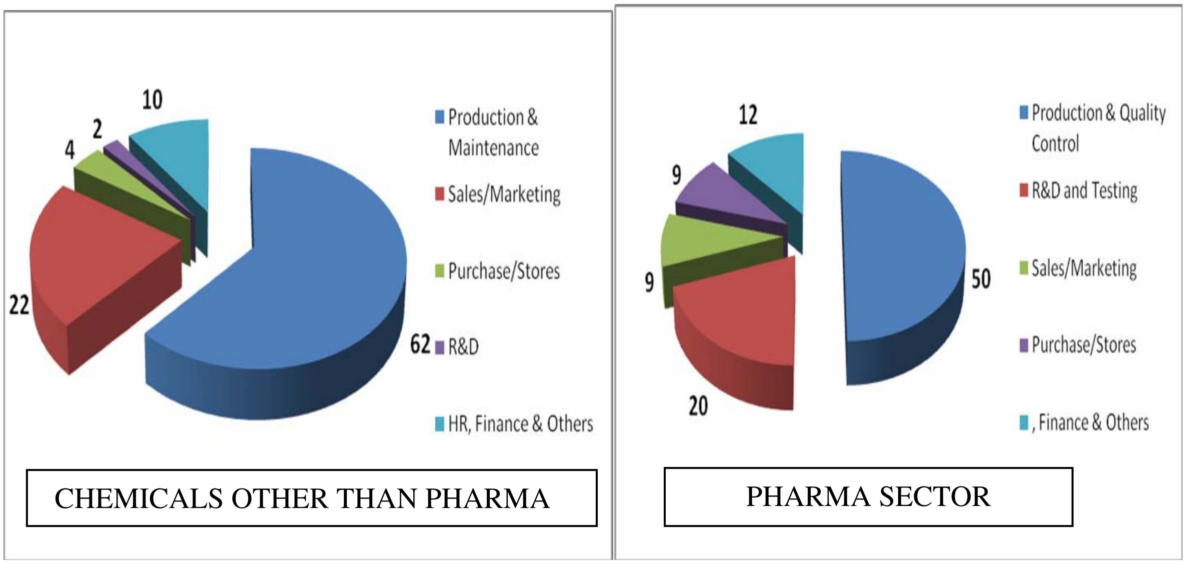

Fig. 8.3.1 : S&T Personnel engaged by Indian Chemical and Pharmaceutical Sectors

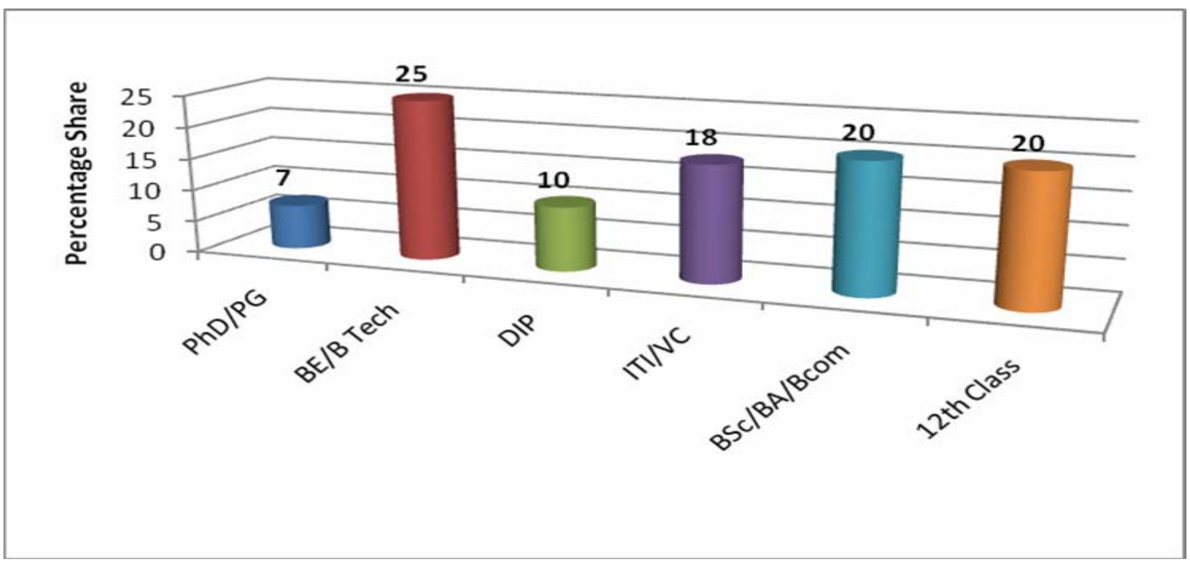

Fig. 8.3.2 : Educational levels of Personnel Employed in Indian Chemical sector

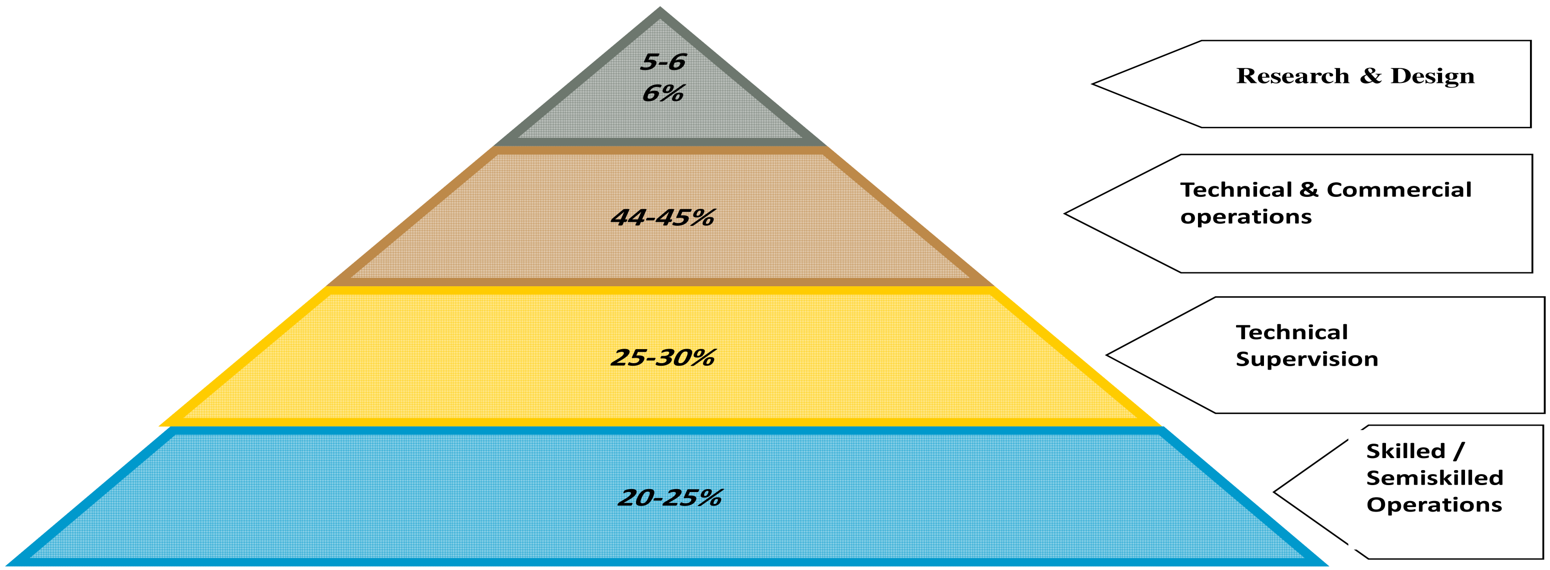

Fig.8.3.3. HR Pyramid of Indian Chemical Sector

Table 8.2.1 compares the scientific manpower engaged in R&D in India with that in developed and developing countries during 1990-96. It shows the very low per capita figures for India, Brazil and China as compared to developed nations. Interestingly, India has relatively higher percentage of S&T personnel amongst R&D staff employed by the industry.

Table. 8.2.1: Scientific Manpower in R&D in India and other countries (1990-96)

		per 1000 Population
Country	**Total S&T Personnel**	**R&D Personnel**
India	3.5	0.3 (8.6)
Brazil	29.5	0.2 (0.7)
China	8.1	0.6 (7.4)
S Korea	45.9	2.9 (6.3)
USA	55	4.0 (7.3)
Germany	86	4.0 (4.7)
Japan	110	7.1 (6.5)

Note: Numbers in parentheses refer to% of S&T personnel

8.3.4 Less Known HR Aspects of Indian Chemical Sector

INAE Sponsored Survey on HR Deployment

Since no statistics are available on the deployment of scientific, technical and administrative staff in the Indian chemical companies in various turnover zones, the INAE sponsored study was undertaken by the experts from Administrative Staff College of India (ASCI), Hyderabad. Though the response from the industry has not been very good, it nevertheless provides some valuable insights into the S&T manpower deployment in production and R&D activities in Indian chemical companies in various turnover zones.

Fig. 8.3.4. shows the deployment of supervisory manpower belonging to scientific, technical and administrative cadres. Though the general trend is to increase the manpower as turnover increases, it is not clear as to why the manpower has dropped in case of companies in Rs 250-500 turnover range. It is also interesting that companies in lower turnover zones have higher percentage of scientific staff as compared to companies with great than Rs 500 crores turnover. This is probably due to larger number of administrative cadre personnel engaged by them.

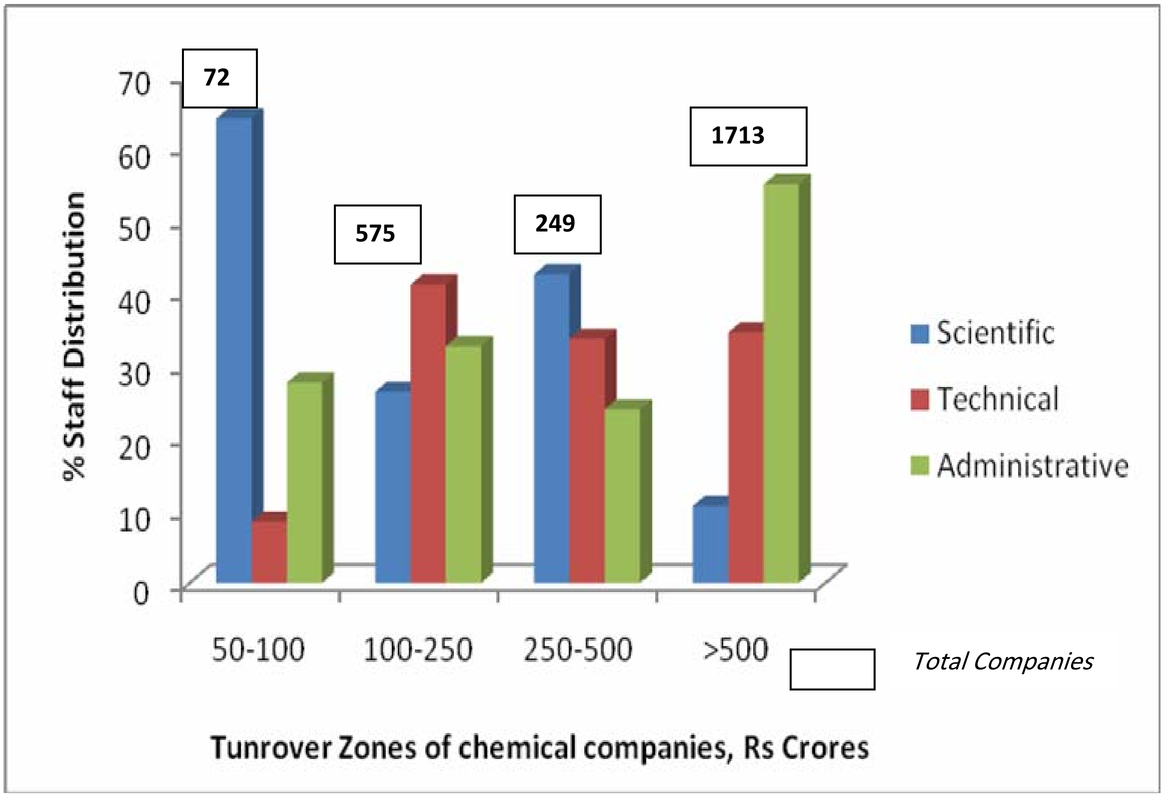

Fig. 8.3.4 : Supervisory Manpower Deployment in chemical companies in various turnover zones.

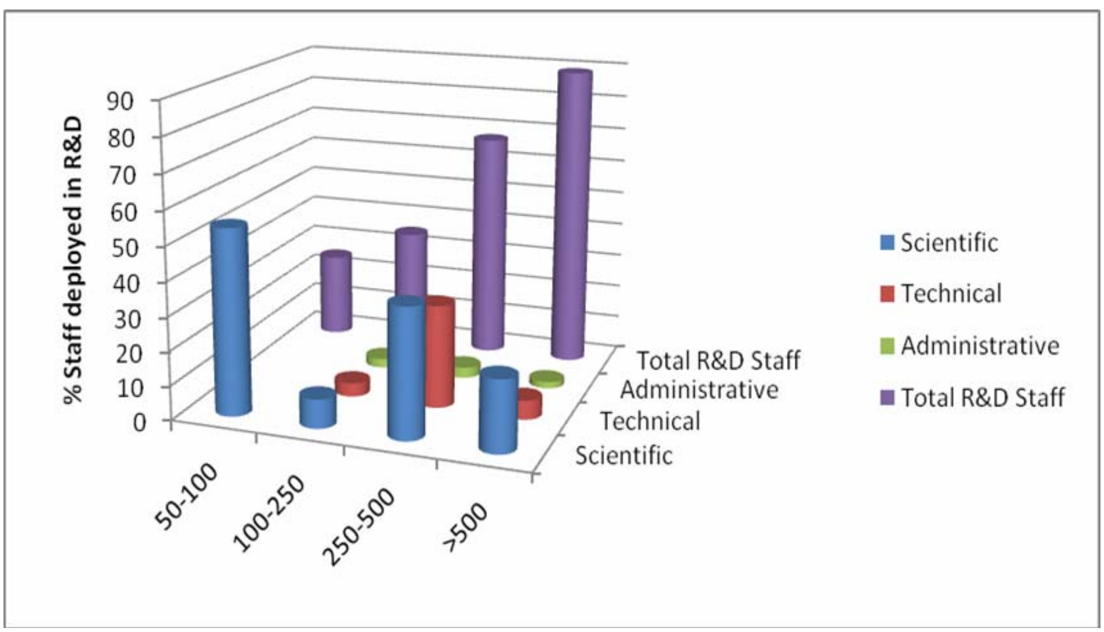

Fig. 8.3.5 : % Staff deployed in chemical R&D Units in various turnover zones

Fig. 8.3.5. shows the percentage staff deployed in R&D activities in scientific, technical and administrative categories in chemical units. It shows the minimum percentage of staff are deployed for R&D in companies falling under Rs 100-250 crores turnover zone. It also shows that the highest

percentage of scientific personnel are deployed in R&D activities in companies with Rs 50-100 crores turnover.

The ASCI Survey results also indicate that middle and senior level R&D personnel are trained in subjects like R&D science, innovation and technology management and research administration by 70^{+}% of the large chemical companies. On an average 2-3 programmes are held by them every year.

8.3.5 The Mobility of Human Resource in Chemical Sector

Generally employees with medium and high education qualifications constitute about 80% in industrially advanced nations in speciality and knowledge intensive chemical sectors. The percentage employees with lower and medium education qualifications has been decreasing since last decade. The continued success of these sectors in developed countries is attributed to the well trained pool of employees. The chemical companies in the above countries encounter (a) intrafirm mobility of qualified staff (b) intersectoral mobility due to better career prospects and (c) mobility of researchers between universities and industry under their joint R&D initiatives.

The intrafirm mobility can be either vertical or horizontal depending upon the company skill requirements at various levels. A regular promotion earned on the ladder of the same profession after a prolonged tenure is termed as the smokestack model and is generally adopted in basic chemical sector. Earning of promotion after one or several horizontal moves in different functional fields with higher pay packets in most cases is popularly referred to as special staircase model and is more popular in speciality and knowledge intensive chemical sectors.

Fewer opportunities to reach senior positions in several companies have led to intersectoral mobility for better career prospects. The information on the human resource mobility in the Indian chemical sector is rather scanty to make any realistic trend analysis. There is a strong need to undertake an exclusive study of this aspect of HR management.

8.4 Broad Directions for HR Management in Chemical Research

From the prospective of improving the R&D manpower situation in Indian chemical sector and for creating a more vibrant research environment, the INAE team has broadly analysed the specific features of R&D manpower deployment in the three major segments of Indian chemical industry to provide broad directions for HR management in the coming years.

Basic Chemical Sector

The R&D in organics, inorganic and petrochemical segments is predominantly process oriented. However, certain amount of product oriented R&D is required for downstream applications in polymers, plastics, synthetic fibres and allied products. They are functionality specified as compared to the products pertaining to speciality and knowledge intensive chemical sectors. A R&D technologist's opportunities are somewhat limited since they have to meet the company's specific needs. R&D staff recruitment in this sector is generally done on traditional lines with very little opportunistic hiring. The Indian basic chemical companies have established remuneration guidelines or scales of pay for employing new R&D staff. Their performance is managed within the team environment. Campus interviews are held at academic institutions to attract well qualified engineers by the Indian petrochemical companies. The mobility of research personnel from public to private funded R&D centres and vice versa is more common in basic chemical sector. In many basic chemical R&D centres, the research infrastructure is relatively outdated as compared to those in knowledge intensive sector.

The future R&D manpower for the basic chemical sector has to be well equipped in research areas like green processing, alternative feedstocks selection, energy minimization and networking, process intensification, biotransformations and biocatalysis and nanotechnology applications for enhancing process efficiency. The mobility of researchers between academic institutions and industry should be basically to acquire new expertise in these areas. The Indian basic chemical companies have been employing hierarchical and centralized human resource management (HRM) practices. Several Indian companies are encountering increased competition from nontraditional sectors from chemical as well as other industries. There is need to change the HRM practices to attract and retain bright young talent. Options like performance linked pay system, share ownership scheme for employees and rewarding individual achievement through financial incentives to be examined.

Speciality Chemical Sector

Based on the product demand and process economics from time to time, the manpower deployment practices in this sector has been sufficiently flexible. The core researchers of the R&D groups play a major part in achieving progress in their research programmes. Most of the personnel involved in speciality chemical companies in India are chemists or technologists with adequate product development background. These jobs provide opportunity for some of the researchers to design suitable products for the national or global markets. This sector requires analytical chemists and testing personnel for a wide range of state of art support services.

Most of the Indian speciality chemical companies are small in size. A post graduate degree holder normally manages a product development assignment with the help of 2 or 3 technicians. He/she undergoes relevant training within or outside the company to acquire the ability to lead a multidisciplinary team. An understanding of business and market demands and ability to use chemistry to achieve these ends are the required qualities. In most of the Indian speciality companies, the R&D positions are considered as launching pads for entering bigger companies. Finding and retaining qualified people are therefore, major challenges for Indian speciality companies. Another issue of importance is the staff poaching by competitors in several SMEs. There is need to look at core, functional and job competency levels much more objectively in this sector to introduce new HRD policies that are likely to provide further impetus to creative thinking.

8.4.3 Knowledge Intensive Chemical Sector

Since the knowledge is rapidly changing and innovation becoming critical to business success and sustainability, the R&D manpower management is more closely embedded in this sector in organizational strategy to facilitate innovation. Compared to traditional manufacturing companies in the Indian chemical sector, the financial capital is central to the growth of knowledge intensive companies. J.Swart et al., (**7**) reported on the human resource management in KI sector companies and suggested that the effective management of highly qualified workforce to be governed by market value creation through the exploitation of tacit knowledge, F Jorgensen et al., (**8**) identified the commonalities and differences between traditional manufacturing and KI companies and the role of HRM in supporting innovation.

The human resource management in Indian KI companies is a big challenge since they are experiencing the transformation of an industrial economy to a knowledge economy. The Indian pharma and biotech companies are facing the challenges of enhancing the R&D motivation of their employees. The senior R&D Managers in Indian KI chemical sector companies receive incentive based compensation and internal career opportunities depending on their contribution to innovation. There is no formal orientation, training or career development programmes which are in place in most of the Indian companies. They however outsource customized courses on team working, problem solving, creativity and communication skills. Formal performance appraisal are conducted annually by the management for their R&D staff development purposes. In recent years, Indian KI companies have begun offering stock options and private health insurance to their employees.

In case of KI sector, high tech R&D recruitments may have to cover national and international job markets since Indian companies experience shortage of middle and senior level personnel. The options like multiskilling and skill mobility through serial and near transfers to be explored on a much larger scale. The entire HR management in Indian KI sector has to revolve around new knowledge management which can draw expertise beyond the scope of its own knowledge base. Another guiding policy has to be to ensure the quality and adequacy of its human resource from time to time to match the increasingly higher levels of competitiveness necessitated by the globalized markets.

8.5 Core competence building for open innovation in chemical R&D

The increasing complexity of innovation in knowledge intensive industrial sectors is leading to the concept of open innovation. Traditional Indian R&D in speciality and knowledge intensive chemical sectors is largely carried out within the confines of respective R&D centres that are equipped with the required infrastructural facilities and R&D manpower. In pharma and biotech sectors, much of the R&D inputs may reside outside the R&D premises of a particular company. In order to shorten the span of research, R&D need to be carried out in a network mode involving competent external institutions within and outside the country. In other words, Indian companies in KI chemical sector have to no longer rely on their internal resources to innovative. The networked R&D require a new management model based on heterarchy type of leadership with parallel leadership centres.

Indian speciality and knowledge intensive chemical companies need to build core competencies based on complementary expertise along the particular value chain of a networked research. The researchers in different disciplines and expertises may have to follow synthesis approach to bring out hidden features of innovations not previously explored by Indian researchers. The complexities of modern product discovery and development dictate that the research methodologies and management practices in Indian chemical companies have to undergo more rapid changes in the future. **Fig.8.5.1** suggests the professional competency evaluation system for Indian KI chemical sector.

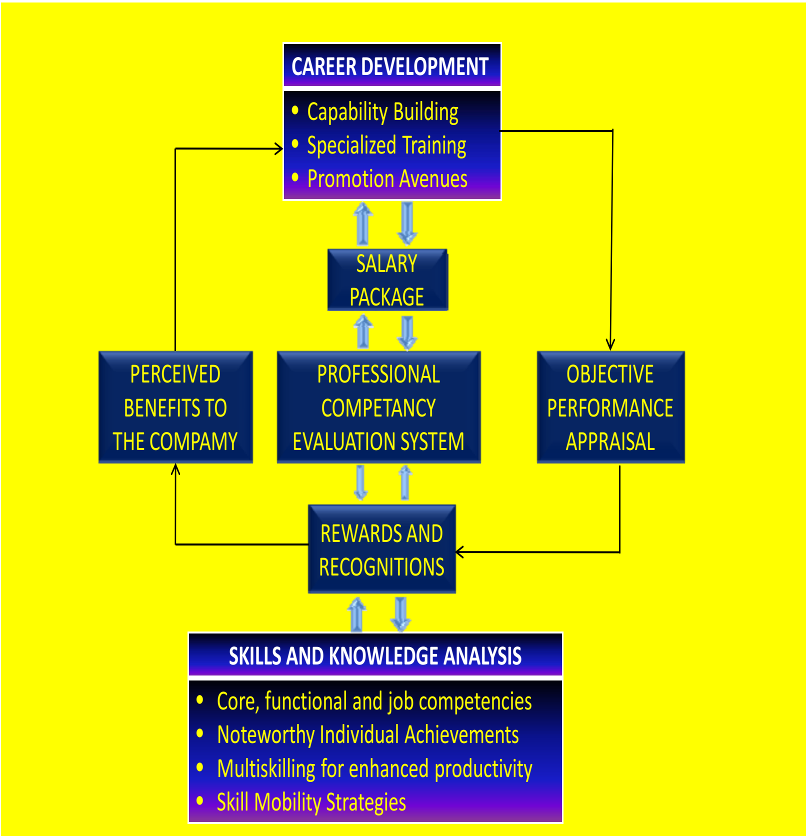

Fig. 8.5.1 : Professional Competency Evaluation System for Indian KI Chemical Sector

8.6 Overall Findings on HRM in Indian Chemical sector

The lack of data has been the major constraint in making an indepth analysis of human resource management situation in Indian chemical sector. Detailed studies are required on this subject which is too important to be ignored for drawing a blueprint for its future growth. Insufficient R&D job attractions offered by the various subsectors of Indian chemical industry has dampened the prospects for rapid expansion of its own R&D. The major exceptions are drugs / pharma and biotechnology.

The reported studies on human resource profile of Indian chemical sector shows its skill pyramid to be much different from other process industries. The results of INAE-ASCI survey show that the highest percentage of scientific personnel are deployed in R&D activities in chemical companies with Rs 50-100 crore turnover.

The present study also shows the HR management policies for R&D pursued by Indian basic, speciality and knowledge intensive chemical sectors vary because of their differing innovation levels and global competitiveness.

8.7 Implementable Actions to Improve Chemical HRM

While long term measures to improve HR position in Indian chemical sector is one of the major recommendations made in Chapter 10 of this report, the INAE team suggests following actions for implementation:

8.7.1 Reforms to enhance the industry relevance of S&T Courses

The INAE team has identified following as essential to enhance the chemical industry's active participation in science and engineering courses offered by the private and government colleges of Indian universities:

Curriculum Design

The curriculum design in Indian Universities and Institutes of Science and Technology should be based on the latest knowledge in different disciplines with high industrial relevance. They include reliability engineering, process safety and productivity, quality management, clean technologies, zero waste concepts and environment impact assessment. The faculty to be well trained in curriculum design, lesson planning, setting creative exercises and incorporating modern evaluation techniques. Since chemical industry has to face much higher global challenges, the S&T course curricula should cover global perspectives of high technologies and product / process development.

Finishing Courses Based on industrial practices

With wide variations in quality of undergraduate and post graduate science and engineering courses in the Indian universities and their industrial relevance, there is need to introduce one year post graduate finishing course in selected universities / institutes located near industrial areas. They have to be jointly designed and managed by the academics and industrial experts. They should also cover softskills covering good communication and cross cultural understanding.

Industry-Academic Networks for Student Project Evaluation

The student projects at undergraduate and post graduate levels can be made more meaningful to the industry by designing the problems, guidance during execution, monitoring the progress and evaluation of the project jointly by the faculty and industry experts. At present, the valuable inputs of students through these projects are mostly unutilized by the chemical industry.

8.7.2 Mobility of S&T Personnel

There is a strong need to enhance te mobility of researchers from chemical industry to relevant university departments and vice versa. Some of the options available for its facilitation are:

- Part time professorships in universities for industry researchers
- Sabbatical leave for university faculty to work in the industry R&D departments
- Creation of Institutional framework for strengthening industry-academic partnerships
- Generous government funding for SME-academic R&D networks

Apart from the I-U mobility, there is need for chemical industry to create conditions for internal mobility (vertical and horizontal) to be achieved through

- job rotation within one or more functional units of the same company
- maintaining a good balance between developing competancies internally and attracting new competancies from outside

8.7.3 R&D Driving Forces to be created by the Industry

Chemical companies need right mix of high talented and experienced R&D scientists who have acquired experience in different research domains. Creating new challenges and learning opportunities are the best way of guaranteeing employability of young researchers for a sufficiently long time. Higher emphasis to be placed on innovative product design and development in to new R&D entrants. The culture of outsourcing specific HR functions in R&D to academic institutions to be cultivated to tap external domain expertise in a cost effective manner.

8.7.4 Special Studies Recommended

Special studies are required in following areas for better understanding of the HR situation in India chemical sector:

- Mobility of R&D manpower in BC, SC and KI subsectors both within and outside the industrial domain
- Nature of career incentives to be provided to R&D personnel for enhancing their employability in Indian chemical sector.
- Type of finishing courses required for enhancing the industrial relevance of academic courses.
- Flexible recruitment policies to be adopted by various segments of Indian chemical industry for attracting qualified personnel into contract, semi permanent and permanent jobs.

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Chapter – 9 Environmental Impact on Future Growth of Indian Chemical Sector

This Chapter deals with a subject of long term importance to Indian chemical sector. The first part of the chapter deals with chemical and process safety, strengths and weaknesses of Indian regulatory framework,, post Bhopal chemical industry scenerio and implications of REACH on Indian chemical sector. The second part of the chapter discusses the environmental implications on the future growth of Indian chemical sector and measures to meet the emerging challenges.

9. Environmental Impact on Future Growth of Indian Chemical Sector

The balancing of economic and social benefits of chemicals with their health and environmental risks is a highly complex issue. It encompasses global warming, ozone depletion, loss of biodiversity and degradation of air, water and soil. The disproportionately high level of risks faced by developing economies like India due to unscientific management of chemical and process hazards can undermine the sustainability of their chemical industries. An attempt is therefore, been made in this chapter to examine this issue in an objective fashion.

9.1 Indian Legal Instruments on Chemical and Process Safety

The Indian chemical sector is one of the most regulated of all industries. In addition to the regulation of its speciality products, it is subjected to number of environmental and safety requirements aimed at minimizing chemical releases both regularly and accidentally during manufacture. The chemical industry in USA and Europe has made very good progress in reducing emissions and energy consumption and enhancing safety of operating personnel and public. A series of Reports were published (1-10) by OECD. UNEP, USEPA and Royal Society (UK) during 1996-00 on environmental aspects of chemical industry. They clearly establish that there are still many unanswered questions and knowledge gaps in the understanding of chemical impact on living systems and environment. As the chemical industry becomes more globalized in nature, there will be additional challenges of managing transboundary environmental issues.

During the life cycle of a chemical product, there are number of chances for it to negativity impact the environment, renewable resources and living systems. Its downstream disposal by combustion may lead to emissions of CO_2, VOCs and NO_X. Their processing may result in the release of hazardous pollutants into the environment. Limited Indian information is available on the volume of such chemical pollutants released to the environment, the targets of their exposure and their toxic properties. The future growth of Indian chemical industry greatly depends on its ability to minimize ecofootprints of its products and processes. This chapter deals with the current Indian environment regulatory scenario, the effectiveness of legal instruments and future challenges before Indian chemical industry from environment protection and safety points of view.

Indian Legislative Framework

Indian legislative framework for import / export, production, storage, transportation, recycling and disposal of chemicals is quite comprehensive. The Ministry of Environment and Forests (MOEF), Government of India in association with the Central Pollution Control Board (CPCB) and the United Nations Institute for Training and Research (UNITAR), Geneva as part of Canada – India Environmental Institutional Strengthening (CIEIS) project brought out a special report (**11**) on chemical management in India. **Fig.9.1.1** provides an overview of Indian legal instruments for managing chemicals. With regard to environment protection, the Air (Prevention and Control of Pollution) Act-1981 (amended in 1987), the Water (Prevention and Control of Pollution) Act-1974 (amended in 1988) and Environment (Protection) Act-1986 (amended in 1991) and Hazardous Wastes Management and Handling Rules-1989 (amended in 2000 and 2003) are very relevant to Indian chemical sector.

The India chemical industry is governed by (a) the Insecticide Act (1968) and Rules (1971) formulated by the Ministry of Agriculture and managed by the Central Insecticide Board (CIB) and Registration Committee (RC) for management of agrochemicals (b) the Drugs and Cosmetics Act (1940) formulated and operated by the Ministry of Health and Family Welfare to regulate import, manufacture, distribution and sale of drugs / pharmaceuticals (c) the Prevention of Food Adulteration Act (1954) operated by the

Ministry of Health and Family Welfare to prevent adulteration of all food grade chemicals, colourants and preservatives and (d) the Notification (1993 and 1997) of MOEF on banning carcinogenic and harmful dyes / intermediates.

Non Regulatory Initiatives

The Indian chemical industry is also associated with non-regulatory voluntary programmes and self induced incentive systems in reducing chemical risks. The non-regulatory mechanisms include Responsible Care, Corporate Responsibility in Environmental Planning (CREP) formulated by the CPCB to adopt clean technologies and better environment practices, ISO 14001, OHSAS 18001, ISRS and ISI and ECO marking systems. The Government of India has been offering economic incentives through the reimbursement of expenses for acquiring Quality Management System (QMS) by the SMEs. It is administered by the Development Commissioner (SSI), Government of India. The effectiveness of Indian legal instruments varies from sector to sector with higher level of success achieved in the case of larger companies and minimal or moderate success in the case of SMEs.

International Impact on Indian Regulations

The growing international environmental concerns on chemicals and their usage for public good are likely to impact with increased intensity on Indian environmental regulations in the coming years. They include:

1. The ozone depleting substances (Regulations and Control) Rules 2000 are based on the Montreal Protocol which came into existence in 1989 to protect the stratospheric ozone layer from CFCs, HCFCs, halons, chlorinated solvents and allied chemicals. The protocol stipulates that the production and use of above type of chemicals to be phased out and replaced with better alternatives. India has made significant progress in implementation of the these rules.

2. The Hazardous waste (Management and Handling) Rules-1989 which were amended in 2000 and 2003 are based on Basel convention on the transboundary movement of hazardous wastes and their disposal. India has evolved a number of environmentally sound management guidelines under these rules.

3. The Chemical Weapons Convention (CWC)-1997 on the prohibition of development, production, stockpiling and use of chemical weapons and their destruction is very relevant to Indian chemical industry since it imposes restrictions on certain dual purpose chemicals categorized as Groups I to III. The verification provisions of CWC may affect the Indian chemical industry. India has established a National Authority under the Ministry of External Affairs to monitor its implementation. Two Indian laboratories have received OPCW recognition for testing of chemicals coming under the purview of CWC convention.

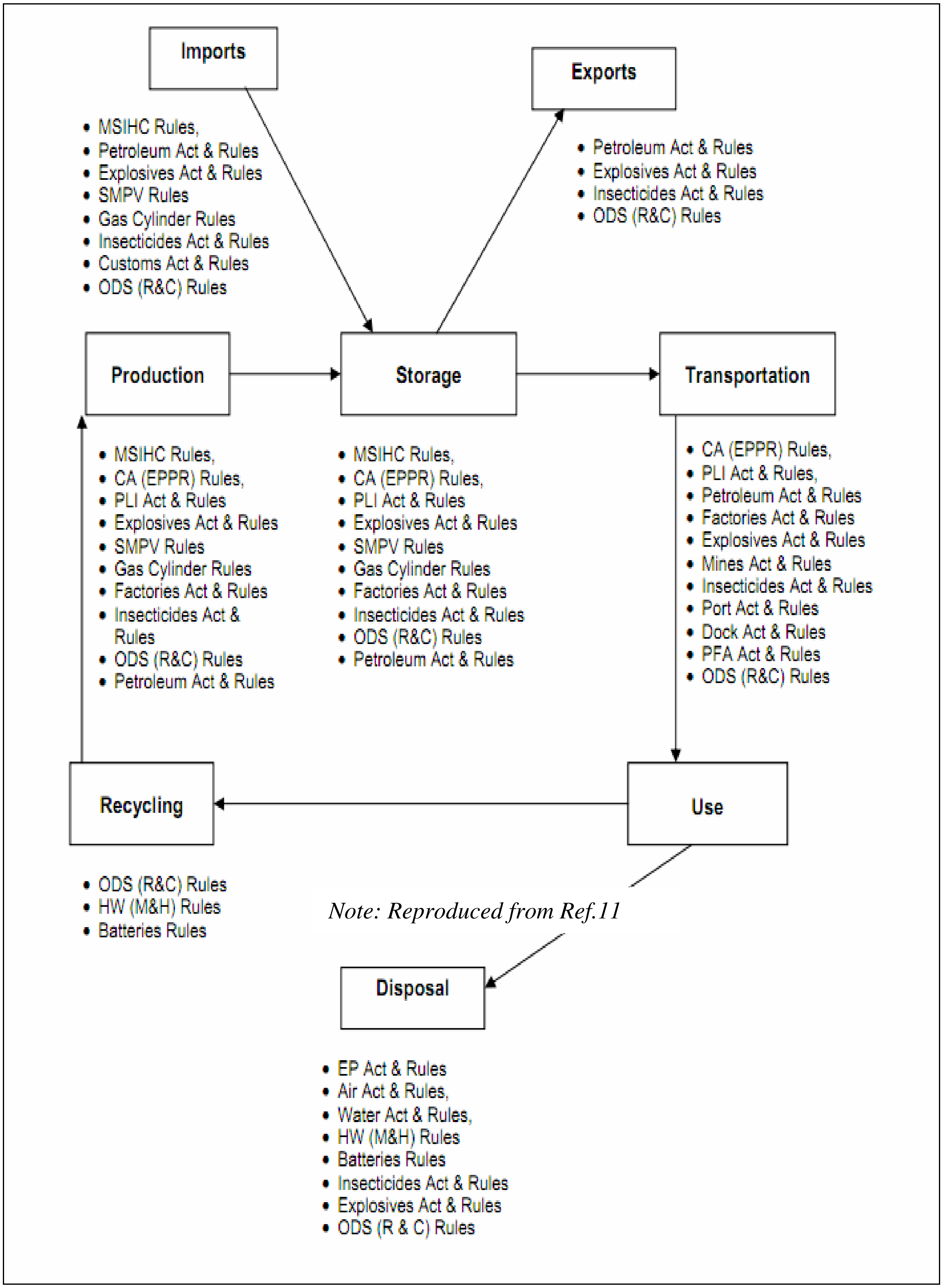

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Fig. 9.1.1. : Indian legal instruments addressing chemicals management

4. The Stockholm Convention on Persistent Organic Pollutants (POPs)-2004 provides for reduction or eliminate release of 12 important POPs of greatest concern to the environment safety. India is committed to implement the provisions of this treaty.

5. The Registration, Evaluation and Authorization of Chemicals (REACH) policy was adopted by European Union countries in 2007. It requires manufacturers and importers to register their chemical substances in EU markets when their quantities are above 1 metric ton per year per manufacturer / importer. Indian chemical industry is currently grappling with the compliance to the REACH protocol involving preregistration and registration processes which requires enormous data on chemical hazards. REACH basically places greater responsibility on industry to manage the risk of chemicals and provide appropriate safety information to the users. It allows for appropriate regulatory action by the public authorities. It is likely that more and more chemical substances will be included under REACH policy to help downstream users of chemicals to get relevant information on the safe use of the concerned chemical substances.

9.2 Chemical and Process Safety – The Post Bhopal Scenario

Prior to Bhopal Gas disaster in 1984, the Indian chemical industries practiced safety as per the guidelines provided by the Indian Factories Act of 1948 which is more oriented towards mechanical industries. After the Bhopal Disaster, major changes were brought into force to strengthen chemical and process safety in India. The factory act was amended to fix the responsibility on the occupier of a process installation, environment protection act was promulgated in 1986 for making environment clearance mandatory for industrial plants. Rules pertaining to the manufacture, storage and import of hazardous chemical Rules were introduced in1989 to make safety audits mandatory, chemical accidents emergency planning, preparedness and response rules were revised in1996 and onsite and offsite plans were made mandatory for establishing and expanding the capacities of chemical isntallations.

The R&D activities covering MIC effects on living systems, kinetics and thermodynamic studies on MIC-H_2O reaction, modelling of dense vapour-gas dispersions, clinical studies on MIC effects and scientific techniques of hazard and risk analysis received major attention of Indian academic and R&D institutions in post Bhopal period. More than 700 research papers were published in scientific journals during 1984-03. Special cells were established by the Indian Institute of Chemical Technology (IICT), Hyderabad and the Central Leather Research Institute (CLRI) at Chennai with advanced computer software packages and microcalorimetric experimental facilities for quantitative chemical hazard and risk analysis.

For the first time, an attempt was made at the global level to assess the implications of Bhopal gas disaster on the growth prospects of chemical industry. Both optimistic and pessimistic scenarios were developed. It is interesting to note the positive growth trends registered by the chemical industry during 1984-05 and the continued positive growth in chemical industry stock prices during 1984-04. **Fig.9.2.1**. provides the details.

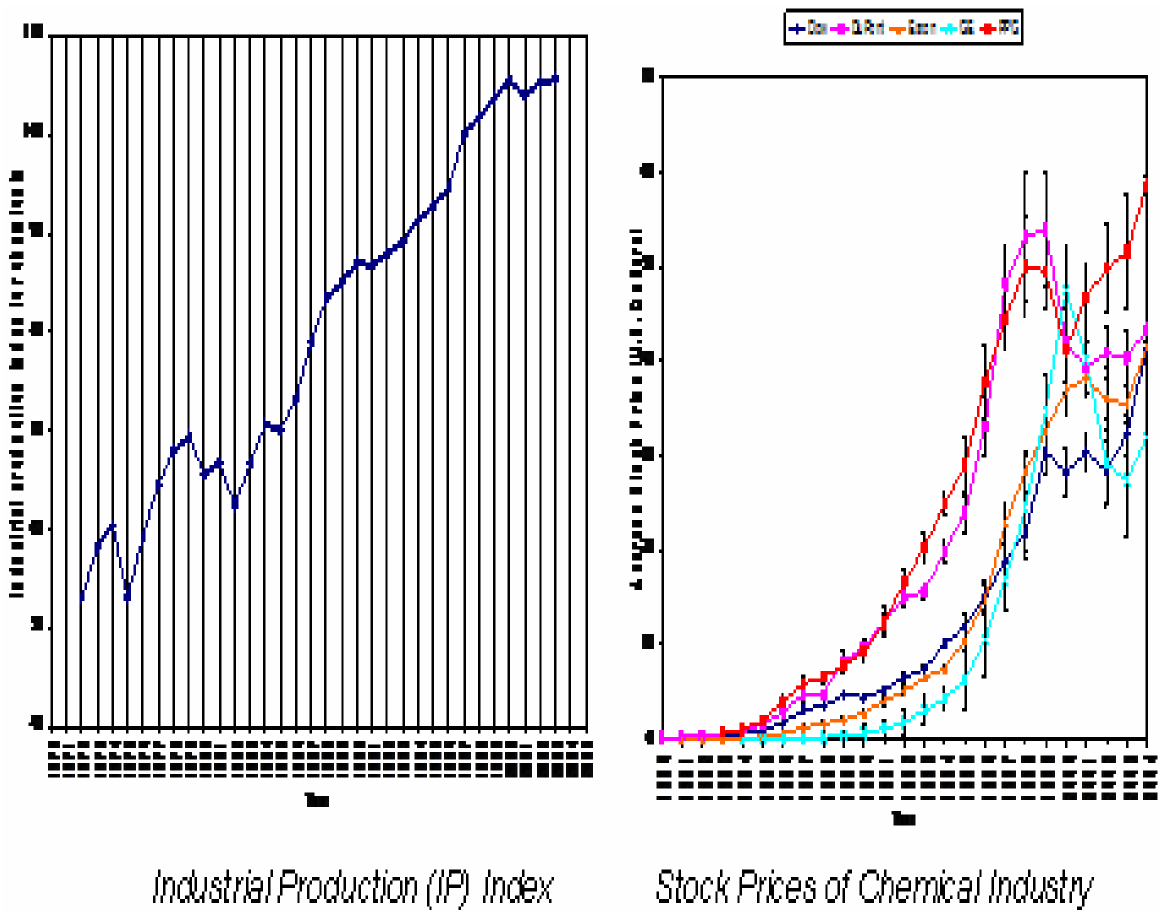

Fig. 9.2.1. Post Bhopal Global Chemical Production and Stocks (1980-2004)

The safety studies made by Prof Saraf, IIT, Kharagpur forecasted **(Fig.9.2.2.)** a significant drop in incidents with 1-10 fatalities, whereas 100^+ fatality events to remain at comparable level. The main causative factors for process related accidents are identified as human errors, siting deficiencies, population proximity, poor plant design and suboptimal inspections. On the research front, significant advances have been made in evolving scientific assessment techniques for developing accidental chemical release scenarios, effect and consequence modelling of fires, explosions and toxic gas dispersions (dense and passive), thermal runaway and parametric sensitivity, confined and unconfined gas-vapor explosions, microcalorimetry based thermal analysis of chemical reactions and allied areas. Couple of Indian research groups have acquired the latest knowledge in above areas.

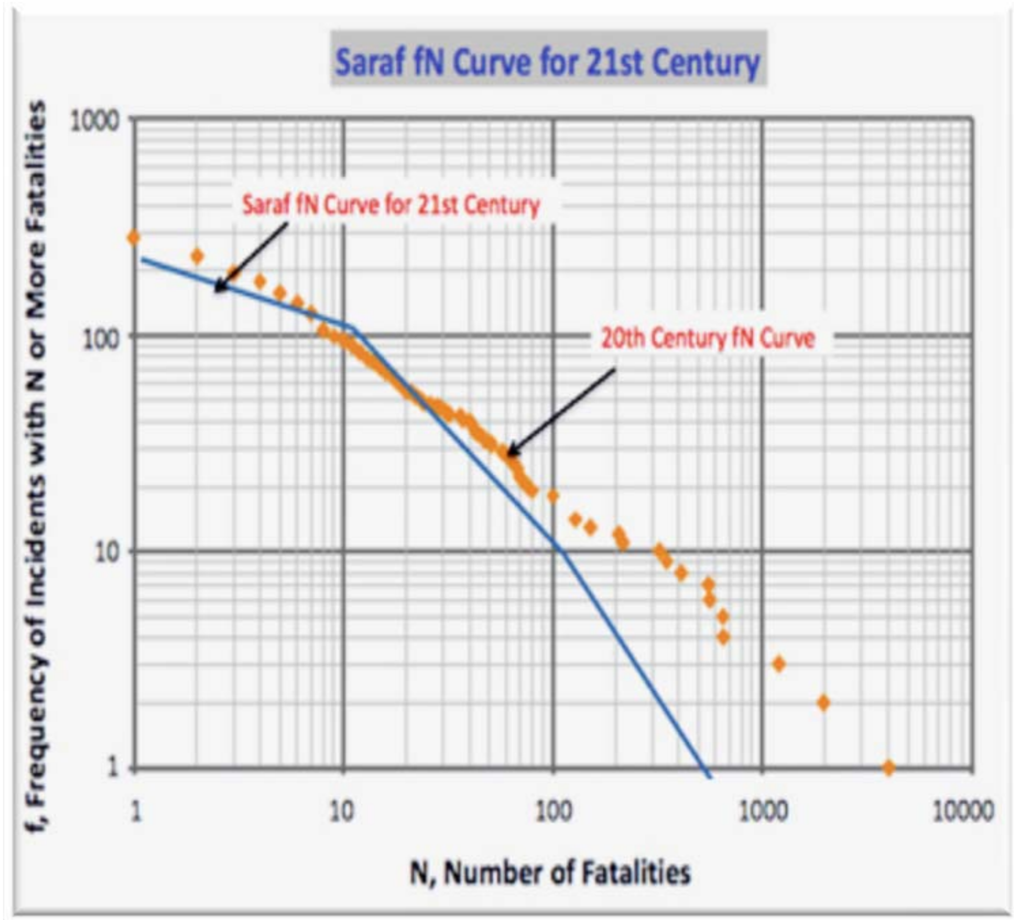

Fig. 9.1.3. Safety Forecast for 21 Century

9.3 Effectiveness of Environmental Protection Measures in Chemical sector

It is generally believed that environmental degradation gets worse in the early stages of an industrial development, eventually reaches a peak and starts improving as income exceeds a certain level. This relationship has been defined (**14**) as the Environmental Kuznet's Curve (EKC) named after Simon Kuznets who observed a similar changing relationship between income and inequality.

It is perceived by many that manufacturing industry is more polluting as compared to agriculture or services. The impact of chemical based industrialization on environment quality, based on Indian past record on air and water quality management, has been found to possess negative externality of industrial development. This is due to the fact that out of total pollution contributed by the Indian industry, nearly 40% of the pollutants can be traced to the processing of industrial chemicals and around equivalent percentage to the food processing industry (**15**).

Table 9.1.4. shows the relative share of water pollution (BOD) by chemical, food processing, pulp and paper and textile industries in India during 1980-96. It shows the pollution from food and textile sectors showing a moderate decline. Increased pollution level of the chemical sector during 1980-96 has been attributed to the change in product profile of Indian chemical industry and its environmental pollution potential. In 1992, the Central Pollution Control Board (CPCB) identified 1551 medium and large scale units in the country as highly polluting (77% water and 15% air and remaining water and air polluting).

By September 2000, 1326 of them installed requisite pollution control facilities and 168 have closed down. The remaining 57 units did not install the necessary facilities leading to their closures. It shows the positive responsiveness of the Indian chemical sector to the environment pollution control measures. M N Murti etal., (**16**) broadly estimated the annual capital and operating costs required for water pollution abatement in major water polluting industries to be around Rs 1410 Crores which is about 1.17% of the annual turnover of all water polluting industries.

Table: 9.1.4: Share of Water Pollution by 4 Industrial Sectors

Percent share

S.No	**Industry**	**1980**	**1990**	**1996**
1	Chemical	5.98	7.29	8.23
2	Food	53.85	50.92	51.14
3	Pulp / Paper	7.57	7.96	7.92
4	Textile	14.08	13.18	12.54

9.4 Public Concern on Less Effectiveness of Indian Environmental Instruments:

Though the provisions of Indian legal instruments are quite comprehensive in nature, the degrees of their effectiveness during ground level implementation varies from place to place. It has accordingly become a matter of public concern. The subject of their effectiveness was dealt to some extent in CIEIs report (**11**). While the implementation of air and water pollution acts, hazardous waste management rules, Ozone depleting substances rules, the petroleum rules, the acts related to explosives, factories, dock workers and prevention of food adulteration are found to be reasonably effective whereas the acts related to environment protection, manufacture, storage and import of hazardous chemicals, motor vehicles, merchant shipping and drugs and cosmetics act have been reported as less effective.

The public concern on chemical effects on agricultural and dairy products persists and there are atleast four areas (details below) of their concern which need to be addressed adequately in future to improve the public confidence level in Indian chemical sector:

Air Pollution Concerns

1. Particulate matter, SO_x, NO_x and volatile organics

2. Greenhouse gases and their effect on climate

3. Occupational health problems due to toxic dusts

Water Pollution Concerns

1. Effectiveness of hazardous chemical waste treatment and safe disposal

2. Pollution of fresh water bodies viz., rivers, lakes and canals

3. Growing ground water pollution in industrial areas

Food / Soil Pollution Concerns

1. Toxic chemical residues in fruits, vegetables, cereals etc.,
2. Chemical polluted soils
3. Polluted Marine Products

Chemical Accident Concerns

1. Fires and Explosions and their domino effects in large flammable product storage.
2. Toxic gas releases from highly hazardous chemical installations

   It is encouraging that Government of Indian and state Governments have taken following environment linked fiscal and industry siting policies:

- For hazard chemicals manufacture, 100% FDI is not allowed under automatic mode. The Government / FIPB approvals and industrial licences are required.
- Plans are underway in some states to set up sea port based chemical parks in SEZs to facilitate industry clustering and close monitoring of environmental effects.

9.5 Perceived Environmental Implications on Indian Chemical Industry

More Extensive Process/Products Safety Regulations

By 2030, the Indian chemical industry will undergo structural as well as competence related transformations to meet growing demands of global markets. Its outputs will contain more middle and higher end chemical, biological or their combination speciality products. A significant growth is anticipated in medium scale process units which may be better equipped to deal with environmental challenges related to greener products and enhanced public concerns. The future products from speciality and knowledge intensive chemical sectors are likely to face more rigorous environmental regulations as demanded by more extensive notifications and data submission requirements from national and international regulatory bodies.

Shift from end to middle of the pipe strategy

The present regulatory emphasis on end of the pipe treatment and disposal concepts is likely to make way for an environmental action programme aimed at inplant pollution reduction, recycling and treatment / disposal of minimized wastes based on more comprehensive zero air, liquid and solid discharge concept. The chemical industry will strive to more actively participate in voluntary environmental regulation programmes to project its clean image to its knowledgeable customers.

Environmental Cleanup Programmes on a larger scale

Eventhough there has been noticeable improvement in managing chemical and process safety in Indian chemical plants in post Bhopal period, the pressures from public on industrial establishments to clean up industrial area atmosphere, fresh water bodies and contaminated soils will significantly increase. Public concerns on unwanted residues in fresh and processed foods will grow to make government and scientific bodies to rethink on fertilizer and agrochemical application strategies.

Future R&D to be more environment driven

The R&D in Indian chemical sector will be based on sustainable chemistry, biology and process / product engineering. More research efforts will be directed towards the generation of scientific models and data on diffuse emissions such as those from road traffic, industrial establishments, households and land use activities and their interactions. Indian researchers will be urged to assist the chemical industry in generating scientific data on atmospheric emissions which can distinguish between safer and riskier chemical products of commercial importance.

The chemical process oriented research will be focussing on designing new reaction media and contact systems that ensure process intensification to achieve minimum pollution and energy demands and environmentally cleaner products. The safety analysts for Indian chemical industry will be more research oriented to develop an array of hazard and risk management techniques in case of cascade and domino type of unwanted events catastrophic damage potential.

Energy Sources to come under scrutinity

The share of energy use by the Indian chemical industry has been steadily growing but no data on its efficient use is currently available in public domain. Several Indian chemical installations rely on coal based electric power. In the long run, they could be cause of public concern if clean coal and IGCC type of technologies are not employed by the power generators. The above matters may receive more attention by the Indian chemical users. The concept of cogeneration for captive power will receive attention of all agro based chemical industry segments.

9.6 Overall Findings and Implementable Environmental Actions

9.6.1 Overall Findings

The Indian chemical industry being one of the highly regulated industrial sectors, environment will continue to influence its growth dynamics in the coming years. Eventhough, Indian legal and regulatory framework is quite comprehensive in its contents, the major weakness lies in its in effective implementation. The post Bhopal chemical and process safety scenario appears to have some bright patches in terms of Indian safety assessment and consequence prediction capabilities and dark patches in terms of poor process related accident containment.

The public concern on air, water, food and soil pollution continues in several chemical sectors and the time has come to address their concerns much more effectively than earlier.

The perceived environmental implications on Indian chemical sector may bring in more extensive process / product safety regulations, shift from end to middle of the pipe treatment strategy, larger scale water / soil remediation and more environment driven chemical R&D.

9.6.2 Implementable Actions

One of the major recommendations made by the INAE team in Chapter 10 of this report pertains to the serious efforts needed to improve the environmental brand image of Indian chemical sector to ensure its sustainable future growth. The following actions are suggested by the INAE team :

Adoption of Zero Emission Concept

The Zero Emission Concept (ZEL) is a holistic approach for environmental pollution control in India chemical sector in which the emissions that pass the deferred system boundary will neither interfere with ecological nor social system. The defined system boundary may enclose a single process entity or a cluster of process units. The ZEC is not a stand alone technology but rather combines the strengths of several clean concepts for minimizing the gaseous, liquid and solid emissions / discharges.

Depending upon the relative importance and available technologies, chemical process units have to prioritize zero liquid, zero gaseous and zero solid discharge concepts for implementation. There is a strong need for environmental regulatory authorities to create necessary incentives for implementing clean process concepts in preference to end of the pipe treatment option(s). The INAE has noted that the Central Pollution Control Board (CPCB) has launched a clean technology scheme for environmentally polluting chemical and allied process plants in SME sector. This programme can become a launching pad for ZEC technologies in the coming years.

Solid / Water Remediation

There is a strong need to map the most polluting industrial sites and water bodies in the country which need urgent remediation. Remediation programmes have to be launched on a large scale in 12th Five Year plan by the Ministry of Environment and Forests, Government of India in partnership with concerned state governments. The financial and technical participation by the chemical industry is vital for the success of these projects. It will also enhance its environmental brand image.

The technologies for soil and ground water remediation are yet to be perfected in India. International technical collaboration is very essential in this area. Several pilot projects can be taken up in the initial stages for technology proving. The AP Pollution Control Board has recently taken up a major initiative with World Bank funding to remediate a major water body and solid waste dump site. This may be a first of its kind projects. More such projects are needed in Indian chemical sector.

Special Studies Suggested

Special studies are suggested in following areas:

- Effectiveness of Indian Regulatory framework in speciality and knowledge intensive chemical sectors
- Technoeconomics of zero liquid and solid discharge concepts in selected chemical industry subsectors with high environmental pollution potential
- Technoeconomics of novel and non-invasive pesticide application technologies

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CHAPTER 10 MAJOR FINDINGS AND RECOMMENDATIONS FOR ENHANCING R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

This Chapter has prioritized the major findings of INAE study for recommending appropriate measures to enhance the R&D impact on the Indian chemical sector. For convenience of presentation, they have been classified into 5 categories with reference to intended goals.

For each recommendation, the set goal(s), intended actions and the implementing agencies have been clearly identified. This is mainly to provide necessary clarity while implementing it. The INAE team is confident that implementation of suggested measures will make a noticeable difference in R&D impact on Indian chemical sector.

10.0 The Overall R&D and Environment Footprints of Indian Chemical Industry

The data and analysis presented in Chapters 2 to 9 of this report, provides a semiquantitative understanding of the R&D impact on the growth of various subsectors of the Indian chemical industry. Knowledge intensive companies are trying to use R&D to capture knowledge and market opportunities internationally. R&D led innovations of one company may have positive effects on other companies to reap the benefits of similar successes. A strong education system in chemical field has become one of the key factors in determining the innovative capacity of a particular subsector. In contrast, the impact of government financed R&D commercialization programmes on chemical industry has been somewhat muted for various reasons. The human capital in R&D has significantly impacted the growth of knowledge intensive chemical sector. To conclude, the R&D has not uniformly impacted the growth of Indian chemical sector.

Table 10.0.1 provides an overview of R&D and adverse environment impacts on all subsectors of Indian Chemical Industry in a semiquantitative way. There is a strong need to make serious R&D efforts in chemical industry subsectors in which R&D impact has been rated as poor and very poor. The moderately impacted subsectors need to look into ways and means of further strengthening their R&D infrastructure and human resource potential with focus on achieving higher level of national competitiveness. The high and moderately high impacted subsectors have to reorganise their R&D machinery to be amongst the top performers at global level.

The chemical subsectors with high and very high adverse environment impact need to make special efforts to improve their environmental brand image within and outside the country with focus on clean products and processes leading to near zero emissions. The moderately impacted subsectors need to place emphasis on inprocess environmental pollution control measures leading to cleaner processes and products.

From R&D intensity point of view, the basic chemical sector needs to assign high priority in enhancing the effectiveness of process oriented R&D for productivity enhancement and more rational material and energy utilization. The speciality chemical sector has to make serious efforts to come out of moderate R&D intensity growth band through higher quality product oriented research.

Table 10.0.1: Overview on R&D and Environment Impact on Indian Chemical Industry

S.No	SECTOR	R&DI (1998-08) %	R&D IMPACT	R&D DRIVER (S)	ADVERSE ENVIRONMENT IMPACT
1	BASIC CHEMICALS	0.25 - 0.5			
1.1	CHLOR KALI/INORGANICS		LOW	PROCESS	V HIGH
1.2	FERTILIZERS		V.LOW	-DO –	MODERATE
1.3	ORGANICS		MODERATE	- DO –	HIGH
1.4	PETROCHEMICALS/ INTERMEDIATES		LOW	- DO -	HIGH
2	SPECIALITY CHEMICAL S	1.0 – 1.4			
2.1	DYES/INTERMEDIATES		LOW	PROCESS	V HIGH
2.2	FOOD PROCESSING		LOW	PRODUCT/PROC	LOW
2.3	LIPIDS/HOUSEHOLD/ PERSONAL CARE PRODUCTS		MODERATE	PRODUCT	-DO-
2.4	PAINTS / COATINGS		-DO-	PROD / PROCE	MODERATE
2.5	CHEMICAL AUXILIARIES		-DO-	-DO –	-DO-
2.6	ADHESIVES AND SEALANTS		-DO-	PRODUCT	LOW
2.7	ADDITIVES		LOW	- DO -	MODERATE
3	KNOWLEDGE INTENSIVES CHEM	3.1 - 4.5			
3.1	DRUGS/PHARMA		HIGH	PROCESS / PROD	HIGH
3.2	AGROCHEMICALS		MODERATE	PROCESS	HIGH
3.3	BIOTECH/PRODUCTS		V HIGH	PRODUCT /PROC	MODERATE
	OVERALL		**LOW TO MODERATE**	**MORE PROCESS AND LESS PRODUCT**	**MODERATE TO HIGH**

R&DI: R&D Intensity of Top Turnover Generators

Amongst the knowledge intensive chemical subsectors, the agrochemical sector has to catch up with pharma and biotech sectors in innovative product development for global markets.

10.1 Major Findings and Recommended Measures to Enhance R&D Impact

As stated in previous section, the R&D impact on Indian chemical industry is not uniform in view of the heterogeneity of its subsectors, varied scales of operations, uneven responses to globalization challenges, product portfolios of varying complexities, contrasting HR capabilities and allied factors. In order to improve the R&D impact on Indian chemical sector with its built-in heterogeneities, the recommended measures have been classified into following five categories with reference to intended goals:

- Developing vision and Foresight for balanced future growth
- Multipronged Approach for R&DI Enhancement
- Promoting Innovation and Knowledge Intensity
- Nurturing Environmental Brand Image
- HR Competency Building

An attempt is made to highlight the set goal(s), intended action(s) and implementing bodies for 10 major recommendations discussed in the following paragraphs.

I. DEVELOPING FOREISGHT AND VISION FOR BALANCED FUTURE GROWTH

The severe limitation of public domain information on future R&D and technology trends in several chemical industry sectors has been echoed by the eminent scientists and industry leaders who attended the Conclave of Chief Executives of Indian Chemical sector held on 8th November 2010 at Mumbai. The information sources include Annual Reports brought out by the Departments of Chemicals, Fertilizers, Pharmaceuticals, Biotechnology and others of the Government of India, special issues brought out by the chemical industry journals and a number of priced publications from the private sector.

10.2 National Level Initiatives on Foresight and Vision Development

The Indian Chemical Industry has to face significantly heightened technological and business challenges as well as opportunities in the 21st Century. A number of global and national level factors will shape its future. The chemical industry being the cornerstone of Indian manufacturing sector, there is a strong need to foresee the implications of various technoeconomic factors before developing a long term perspective for its sustainable growth.

Chemical Industry Foresight Development

It represents a deep understanding of the emerging trends, drivers, inhibitors, potential dislocations and emerging opportunities in globalized markets. Worldwide, industrial sectors that are endowed with foresight are better positioned to establish a strategy that carries them to a prominent position in the global markets. Gaining and applying industry foresight is a continuous activity that requires a strong organisational support. Indian chemical industry in general and its speciality and knowledge intensive sectors in particular have to understand the interplay of various growth trends that may potentially impact their national and global businesses.

The administrative ministries of Government of India pertaining to Indian chemical industry have to play a major role in developing chemical industry foresight in critical areas. The INAE team strongly recommends this responsibility to be undertaken on a mission mode basis in association with thought leaders from academia, research and industry. There is need to orchestrate their interactions in a public forum. The Annual Reports of the administrative departments should reflect the orchestrated views for the benefit of whole industry.

Long Term Vision Development

The INAE team has noted that the technology forecasting exercise was not undertaken in the recent past for the Indian chemical sector except for the forecasting exercise undertaken by the TIFAC of DST (GOI) for some specific subsectors of Indian chemical industry in the mid 1990s. **The INAE team, therefore, recommends that such an exercise to be undertaken to draw the vision map for the Indian chemical industry till 2025 or 2030**. Such a study may also cover the adequacy of the current environment regulatory policies and practices for the next 20 years from now. The study should also foresee the impact of international programmes like REACH on the future Indian chemical business. A national level Taskforce is recommended to be formed representing all sectors of the Indian Chemical industry and experts from academic, R&D and policy makers for the development of a National level perspective plan for chemical sector. The TIFAC of DST is eminently suited to take the leadership role in this matter.

II. MULTIPRONGED APPROACH FOR R&DI ENHANCEMENT

The INAE team recommends a four pronged approach consisting of improving the effectiveness of government funded R&D commercialization programmes, evolving an integrated framework for R&DI capacity building in chemical MSMEs, turnover centred R&DI promotional programmes and broadbanding PCPIR policy for R&DI enhancement in petrochemical sector. This approach has been chosen because of INAE team's strong conviction that "**across the board**" type of solutions for enhancing R&DI may have little impact on the heterogeneous segments of Indian chemical industry.

10.3. Enhancing the Reach and Effectiveness of Government Funded R&D Programmes

Realizing that technological innovation is the key determinant for global competitiveness of Indian industry, the Government of India has established several R&D support programmes at national level along with wide ranging policy measures. The details are given in Chapter 6. Chief among them for Indian chemical and allied sectors are Pharmaceutical R&D Programme (PRDP), Home Grown Technology Programmes (HGT), Technology Development Board (TDB) and Sectoral Mission Programmes of TIFAC of DST, New Millennium Technology Leadership Initiative (NMITLI) of CSIR, Small Business Innovation Research Initiative (SBIRI) and Biotechnology Industry Partnership Programme (BIPP) of DBT, Technopreneur Promotion Programme (TePP) and Technology Development and Demonstration Programme (TDDP) of DSIR and others.

The general perception of the industry about the effectiveness of these programmes is that they have not achieved the success to the desired extent due to inadequate fund allocation (less than Rs 300-500 crores / annum for all programmes put together), long processing time, lack of remedial action on earlier programme failures, ineffective implementation, relatively lower priority assigned to R&D commercialization by the R&D institutions and suboptimal participation of private sector companies. Against this backdrop, the INAE team examined various options available for enhancing the reach of above programmes to a larger number of chemical companies in general and small and medium scale companies in particular. The team has come to following conclusions:

i. The current practice of government department wise allocation of funds for R&D support to the industry may be transformed fully or partly into a unified revolving fund of larger size for utilization under single window dispensation.

ii. The various funding departments of Government of India can formulate appropriate umbrella programmes and have access to the unified revolving fund.

iii. The possibility of outsourcing the management aspect of the unified fund to the private sector to be explored.

iv. An Apex Monitoring Committee (AMC), with wider industry representation may be required to oversee the programme implementation.

It is, therefore, recommended that a Unified Revolving Technology Innovation Fund (URTIF) with an initial contribution of Rs 10,000 crores may be created in the XII Five Year Plan period for the Indian chemical and allied sectors. There will be no specific allocation to any Department of Government of India for R&D support programmes under similar budget head(s). The Departments have to compete to utilize URTIF funds. There may not be any upper or lower limit for the fund utilization as long as the funds are claimed within a particular bandwidth. The main focus of the above programme is to encourage innovative technology development preferably through a public-private partnership (PPP) mode.

It is further recommended that URTIF be administered by the Department of Science and Technology under the overall guidance of an Apex committee comprising Principal Scientific Advisor to Government of India as the Chairman, Secretary, DST as the Convenor, two secretaries of scientific departments and two secretaries of economic ministries as members. The committee among others provide (i) overall guidance to the management of fund and its effective utilization (ii) provide broad framework of guidelines for implementing the individual programmes / schemes (iii) set the performance criteria and critically review once in 5 years, the performance of the schemes / programmes that draw funds from URTIF, (iv) atleast 30% of the programmes / schemes should be closed once in five years for shortfall in their performance and (v) decide on the cases where writing off the recoveries / loan etc., becomes necessary.

The URTIF could support three types of projects and these are:

Proof of concept projects – Industrially relevant projects under this category, can be submitted by the industry, research institutions, educational institutions (both public and private), universities, SIROs, and other organisations engaged in R&D activities either individually or jointly. Support to the projects will be provided as grant upto a maximum of Rs.50 lakhs.

***Intermediate stage projects including prototype / semi-pilot scale process and product development*:** These projects are beyond the proof of concept stage and will have compulsory industry involvement. Projects can be submitted by industry either on its own or jointly with institution(s) engaged in R&D activity. The cost of project under this category will be shared equally between industry and government. The benefits of IP generated in the project will also be shared equally with first right of refusal for commercial exploitation resting with the industry partner. Industry shall pay royalty to the government for exploiting the IP. The project costs will be limited to a maximum of Rs 5 crores. In case of failure of a project, both parties shall write off their respective costs on receiving approval from the Apex Committee.

***Technology development projects including pilot plant and market seeding*:** These projects will only come from industry with or without external R&D institutional participation. The industry under this category can get funds as loan at simple interest rate of 2%, payable over a period not exceeding 7 years from the date of completion of the project. The project costs will be limited to a maximum of Rs.20 crores. The cluster based R&D programmes will also be eligible for above type of support.

The scientific departments and/or economic-ministries either individually or jointly can develop two or three specific umbrella schemes / programmes that encourage innovation or technology development in specific industrial sectors or segments based on the broad guidelines provided by URTIF. These programmes will draw funds from it as revolving advance for implementing the schemes / programmes. DST may have to create a separate wing may be created to manage the fund. The recoveries of the funds from various partners, if any shall be managed by this wing.

Technology Development Board (TDB), a body established through an act of Parliament, can also draw funds for its activities particularly commercialization of innovative technologies. These measures are expected to bring in uniformity and flexibility in R&D funding policy and thrust to innovation development and commercialization of the resultant technologies.

10.4 Integrated Approach for R&D Capacity Building in Chemical MSMEs

The INAE study team broadly reviewed the current R&D and technological status of 80+ chemical MSME clusters in India. The team briefly studied the current systems and strategies being employed in Asia Pacific countries in general and Taiwan, S Korea, China and Japan in particular for R&D capacity building in their industrial clusters. It has also interacted with the senior management of Vapi Industries Association in November 2010 with reference to the Centre of Excellence recently established by them with assistance from DIPP, Ministry of Commerce, Government of India. **These findings have enabled the INAE team to recommend an integrated approach for R&D capacity building in the 80+ chemical MSME clusters in various parts of India** and also for adopting a similar approach in new chemical clusters and SEZs proposed. If implemented, the action programme as suggested in this section, is expected to make a noticeable improvement in R&D capacity building in chemical MSMEs in India. **Fig.10.3.1** provides the contours of the proposed model. **It is recommended that Department of MSME to spearhead such a major activity in association with DIPP and other S&T Departments of Government of India and industry associations**. The salient features of the INAE recommendations are:

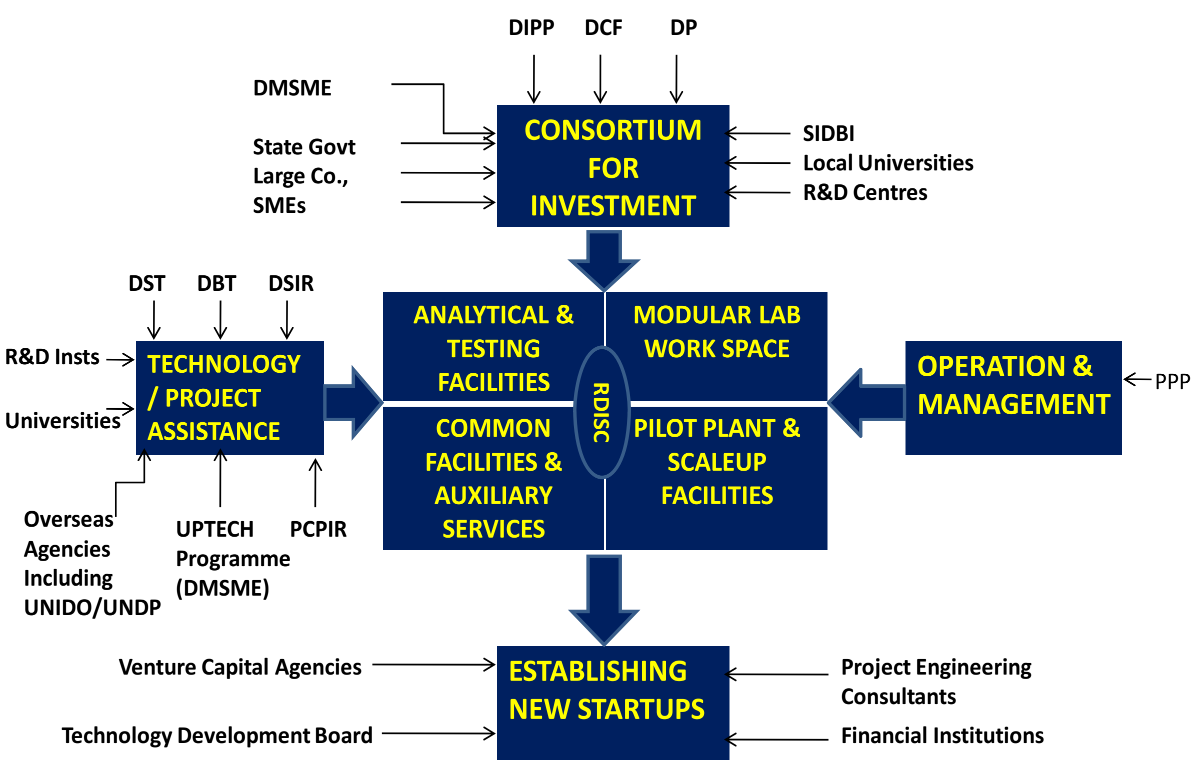

Fig. 10.3.1 : Proposed Cluster Based R&D Capacity Building Model

Redefining the Cluster Boundaries for R&D Facilitation

To enable unhindered R&D facilitation to the constituent units of a chemical cluster, its boundaries have to be virtually expanded to bring within its jurisdiction local universities / science and engineering colleges, leading public / private research institutions in proximity, technology transfer centres, MSME guidance organisations, selected business and IT enterprises and banking / financial institutions. The major objective is to make them the stakeholders for R&D capacity building of MSMEs in the cluster.

Empowering the Chief Executive of the Cluster

There is a strong need to empower the Chief Executive of the cluster to establish formal linkage through umbrella agreements with all institutions and agencies relevant for R&D capacity building of constituent units in the cluster. The responsibility of monitoring the progress may also be entrusted to the same authority by the Department of MSME, Government of India.

Institutional Networking Arrangements

A wide range of networks may have to be established within the virtual boundaries of the cluster to achieve the overall goals of the programme. They may include:

- Cluster – University – R&D Institution(s)
- Cluster – Technology Transfer Centres – Business Agencies
- Cluster – HRD Institutions for training
- Cluster – S&T Departments of Government for R&D project funding

The Industry Coordination Cells at Universities and R&D Institutions can act as the contact points for entering into umbrella agreement with the cluster management.

Formation of R&D Investment Support Consortia

Establishing a standing investment support mechanism may go a long way in providing assistance not only to establish and expand common facilities for R&D at the cluster but also to help the SMEs to establish new or expanded manufacturing facilities based on R&D outcomes at the cluster from time to time. Organisations like SIDBI, Clean Technology Promotion Council, Technology Development Board and administrative ministries of the Government of India, State Industries Departments, large industrial houses and UGC/AICTE and other bodies of MHRD of Government of India have to be the members of such consortia. Funds from URTIF and other schemes can be utilized.

Establishing R&D and Innovation Support Centres (RDISC) at MSME Clusters

The proposed centres hold the key to the success of R&D capacity building in MSME clusters since they provide access to state of art R&D and support facilities to a large number of SMEs. The following facilities are proposed at these centres:

- Modular research laboratory workspaces which can be leased to SMEs for a specified period for concept proving in process / product oriented research
- Centralized analytical and testing Facilities for characterization and performance evaluation of relevant chemicals / products.
- Multipurpose pilot plant facilities for process and product development and scaleup
- Supporting utilities and service facilities
- Inhouse training Centre(s)

Public-Private (75:25) Investments are recommended for establishing these facilities. The RDISC to be managed and operated either on Special Purpose Vehicle or Technology Business Incubator concept through an appropriate public – private partnership model. The RDISC will provide R&D infrastructure to SMEs at an affordable cost on shared resource ownership concept. For their effective functioning, R&D expertise has to be delivered to either group or individual SMEs through institutional networks as suggested in **Section 10.2.3**.

For implementation of this recommendation, technoeconomic feasibility studies and detailed project report preparation for RDISCs have to be undertaken by competent agencies to make the proposals financially attractive to fund by the Investment Consortia. **The R&D capacity building of SMEs being an extremely important programme, a national level monitoring system has to be established by DMSME of the Government of India**.

10.5. Turnover Centred Approach for R&D Intensity Enhancement

The INAE Team has noted the stagnancy in R&DI growth profile of specialty chemical sector, very poor R&DI level of basic chemical sector and the insignificant influence of turnover enhancement on R&DI of all chemical subsectors except organic chemicals and drugs / pharma segments. Comprehensive policy, organizational reforms and fiscal incentive driven measures by the government are required to tackle the core issue of raising the R&DI of Indian chemical industry.

The INAE Team has identified three turnover zones viz., <Rs 100 crores, Rs 100-500 crores and >Rs 500 crores. They broadly represent small, medium and large company categories.

Cluster Centred R&D Access

Most of the chemical companies with **annual turnover less than Rs 100 crores** exist within or in proximity to Industrial estates or complexes / clusters or SEZs. These companies due to their size and low profitability are not in a position to undertake R&D activities at a globally competitive level. Nonetheless, these companies form an important segment of national economy as they provide large employment and contribute significantly to GDP. Therefore it would be the responsibility of State to support these companies to enhance their R&DI to position competitively in the global market place. The team feels that a cluster based R&D access system is well suited to them. It accordingly recommends that a major Government of India initiative is to be undertaken by the Department of MSME. This is basically to establish RDISCs equipped with most modern facilities at select locations to cater to group of SMEs. **These centres will carryout only application oriented R&D activities in specified S&T areas for which funds from various schemes under URTIFs** (the details are given in **Section 10.2**) can be utilized. The projects undertaken by RDISC may be shared on a 50-50 ratio, where the 50% of the cost will come from the URTIF or associated schemes and the rest to come collectively from the beneficiary industries**.** As an incentive, the staff working in RDISC may be permitted to retain a percentage of the external funding as salary plus. It is estimated that the cost for setting up 8 centres would be approximately Rs 1000 crores in the XII FYP. These funds may be made available from URTIF and other sources.

Matching R&D Grant as Incentive

The R&DI chemical companies with **annual turnover in Rs 100-500 crore range** has not kept pace with their level of annual earnings. This is particularly so with speciality and basic chemical sector companies. This trend is probably indicative of the perception that R&DI has a negligible influence on industrial growth under the Indian context. The importance being attached to R&DI by the knowledge intensive chemical sector companies in recent years should remove the above misconception and show the way forward for enhancing R&DI in other chemical companies in the above turnover zone. However to stimulate this growth there is a need for providing large scale support at individual unit level. **It is recommended that for every rupee invested by the industry from this zone on R&DI, atleast Rs 0.3 to be made available from URTIF as a special incentive.**

In addition to the above measures, the INAE team recommends:

- Softloans / partial grants for developing ecofriendly processes or products
- Encouraging and supporting industry R&D joint ventures in areas of common concern including energy minimization, byproduct recovery and value addition, zero liquid / solid discharge concept implementation and developing alternatives to banned chemicals.
- Promoting Contract R&D and manufacture through partial subsidies
- Providing incentives to setup R&D companies by subsidizing overseas product patent costs, income tax benefits to outsource clinical trials and liberal grants for GLP/GMP facilities

Shared R&D Vision and Responsibility in Frontier Areas

The third zone comprises chemical companies with **turnover exceeding Rs 500 crores**. Although these companies are ramping up the R&DI efforts, further fillip is needed from Government so that these could quickly attain global standards. **It is recommended that the support from URTIF may be prioritized for these companies towards R&D related to innovative product development and eco-driven process intensification. Additionally, for every rupee invested in R&D activities, these companies may be permitted to draw a minimum of Rs. 0.3 from the URTIF to support directed research at public or private funded R&D and academic institutions as well as universities.** Besides enhancing the industry – academia interaction, this measure will promote industry oriented applied research in Indian R&D and academic institutions. It will also promote patenting of IP jointly developed by them with industry.

Broadbanding PCPIR Policy for R&DI Enhancement

In case of petrochemical, organic and allied chemical units in basic chemical sector, **the PCPIR policy of Government of India need to be broadbanded to include enhancement of R&DI of basic chemical sector as one of the core objectives with onus on industry to implement them**. Provision has to be made for financial support to industry proposals for following activities:

- Development of process knowhow and basic design engineering packages for commercialization of Indian knowhow through Industry – R&D – Project Engineering company joint initiatives.
- Process Intensification of existing technologies adopted by the Indian industry for maximizing material, energy and environmental gains through industry – R&D joint initiatives
- Development of novel downstream products for domestic and overseas markets through industry – R&D/academic initiatives.

The broad banded PCPIR policy is recommended to be applicable to the concerned basic chemical sector units in all turnover zones.

Large R&D based chemical companies understand the national and global implications of innovation better. Their decision processes are much stronger. The INAE team has noted the growing tendency in developed nations of establishing Joint R&D ventures (JRVs) even amongst the competitors in chemical industry. Specially so, in areas like process intensification for minimizing energy and environmental implications on chemical products / processes, byproduct recovery and value addition, zero liquid / solid discharge options, alternatives to internationally banned chemicals, and disruptive technologies for established basic chemicals etc. Hence, these large companies can undertake projects of increased technological complexity and risk potential under the broad banded PCPIR policy.

It is therefore recommended that Government may mount R&D Joint ventures in collaboration with consortia of large chemical companies for development of new or more efficient processes with large public good potential specifically in bulk commodity chemicals sectors such as fertilizers, polymers, petrochemicals, inorganic chemicals etc.

In addition to the above measures, the INAE team recommends following incentives to be provided to the industry:

a) Subsidy for overseas product patenting costs (100-200%);

b) Income tax benefits to outsourcing overseas services for development of innovative products for Indian and global markets;

c) Income tax exemption on clinical trials conducted in overseas institutions;

d) More liberal government grants for project activities involving GMP, GLP and other international compliances; and

e) Speedy clearance of novel products and formulations developed by the Indian R&D companies by the regulatory authorities including DCGI.

III. MEASURES TO PROMOTE INNOVATION

The Indian chemical industry suffers from chronic shortage of innovative scientists for undertaking high end R&D. The small and medium scale industry continues to depend on public funded R&D centres for technologies with little success because of their size and financial limitations. The potential of university research more or less remain untapped. The role of academia is important for transfer of innovative products and processes to industrial users.

The INAE team has identified four important issues for which viable solutions are required. They include industry-university linkage, enhancing Indian inventorship of IP protected in India, Technology Innovation Centres for R&D commercialization and FDI as a vehicle for innovations. The recommendations 10.5 to 10.8 revolve around these four vital issues.

10.6 Forging and Nurturing Industry –Academic Linkages

The current level of industry – University / academia / R&D instituions linkages in Indian chemical sector is very disappointing. The INAE team has recognized its overriding importance in generating industrially relevant knowledge at affordable cost and has simultaneously noted several grey areas and institutional bottlenecks in forging such relationships. These obstacles need to be overcome in the larger interest of the nation and competitiveness of the Indian industry in the global arena. Whilst the URTIF initiatives will enhance such interactions in future, the INAE team **strongly recommends launching of a Mission mode programme in the XII FYP by Ministry of Science and Technology for evolving various India specific industry – academic linkage models and pilot test their applicability to different chemical subsectors and company** sizes to (a), evolve appropriate IPR sharing and technology transfer mechanisms, (b) the nature of policy changes required at university level (c) organizational transformations needed and (d) faculty incentives to be introduced in popularizing industry oriented

R&D**.** The active association of UGC and AICTE of the Ministry of HRD with the proposed programme will be most desirable.

10.7. Technology Innovation Centres for R&D Commercialization in Frontier Areas

The basic objective of this recommendation is to provide necessary driving forces for development of highly innovative technologies in frontier areas which can provide global leadership to India. The proposed Technology Innovation Centres (TIC) have to be equipped with state of the art facilities with the highly qualified faculty usually sourced nationally or internationally at competitive salaries. **They are different from the full fledged research institutions, in the sense that they concentrate on a specific subject and pools together all the resources that are needed to develop commercially viable technologies in the frontiers of science suitable for knowledge intensive sectors** of Indian chemical industry. Many developed countries have adopted this kind of model to build new knowledge so that it could be advantageously leveraged to the benefit of the nation. For example, UK has identified high value manufacturing, energy and resource efficiency, transport systems among others for setting up such TICs. **The INAE team recommends setting up such centres initially in 5 subject areas in the XII Five Year Plan**. The core group of Secretaries to the Government of India could identify the suitable S&T areas through extensive consultations with experts in the concerned fields. These centres could be established in the premises of the existing R&D or academic institutions or universities. They should have freedom to acquire IP from various sources including abroad in the chosen areas and leverage it for cross licensing in the interest of the nation. The funding required for establishing such centres should be met from the URTIF. For making centres to be efficient and effective, a good governance system need to be evolved by a competent group of experts. As a rule, these centres should be provided government support in the formative years to take care of the salaries, maintenance of facilities and replacement of equipments on a continuous basis and the centre should be asked to earn in course of time for its research activities. As an incentive to the staff, they may be permitted to retain a percentage of the external funding as salary plus. This measure is expected to position Indian industry and India as a whole advantageously in developing technologies in emerging scientific areas.

10.8. Enhancing Indian Inventorship of IP Protected in India and Abroad

After putting in place the Intellectual Property regime compatible to that followed by developed nations, the IP protection by international companies have significantly grown in India. The intellectual contribution of Indians and Indian organisations to patents fled in India is fast declining. When this is viewed in association with India's large S&T manpower but low on innovative capability index, it does not augur well for a country aspiring to be a knowledge driven nation. With a view to over come this, **India would need to adopt a two pronged approach. On one hand the Indian industry may access and utilize world class knowledge and cutting edge technologies wherever available to ensure their global competitiveness, specially in knowledge intensive industry segments. On the other hand, it has to ensure that Indian innovative capability is systematically strengthened to enhance its creative contribution to generation of new knowledge being used in the country**. Such measures alone are expected to provide the necessary impetus to build capability for India to maintain its technological competitiveness and help India move up the IP development ladder to catch up with several countries which are able to maintain a high share of their domestic inventorship inspite of severe competition from overseas R&D. This measure is particularly important for countries like China and India, whose huge domestic markets are extremely attractive for rapid entry of transnational R&D.

After a careful assessment, the INAE team makes the following recommendations:

- Study the strategies adopted by countries like USA, Japan, Europe, China and S Korea that have managed a reasonably high level of domestic inventorship of patents filed at their patent offices. The

DST may consider to initiate such studies. Appropriate measures may be evolved to implement the recommendations emerging from the studies;

- Evolve programmes for providing incentives to companies for filing international patents and / or their commercialization. Indian speciality chemical sector should receive focus since the opportunities for product patenting are many. SMEs in Indian chemical sector may be encouraged to patent their inventions even if they are incremental in nature;

- A formal mechanism of knowledge for equity has already been created by the Government of India and there is a strong need to propagate this concept more vigorously amongst the public funded R&D institutions and universities as well as among industries for its wider use. DSIR may take special measures to popularize the scheme and

- The medium and long term evolution paths of major technologies and their adaption in the speciality and knowledge intensive segments of chemical sector may be studied by the TIFAC of DST in association with Indian Science and Engineering Academies.

- There is need to evolve a transparent and unbiased benchmarking system for ensuring the Indian institutional performance with reference to both open and patented IP and the degree of balance maintained between them.

- High priority has to be assigned for funding R&D programmes contributing to environmental and occupational safety through process intensification, product upgradation and inprocess pollution minimization.

10.9 Devising Appropriate Policies to make Transnational R&D and FDI as Vehicles for Indian Innovation

Transnational research and FDI flows into emerging economies like India are driven by the strategic global and regional industrial environments as experienced by the multinational investment agencies. The need for development of appropriate policy framework by the Government of India for retaining the competitive advantage of Indian S&T by maximizing the benefits of transnational research as well as FDI inflows into the Indian chemical sector has been the main theme of this recommendation.

Deriving Transnational R&D Benefits

The Indian chemical sector is still in the early phase of R&D internatioanalization process with its main focus on attracting transnational research in high tech areas. However, knowledge intensive segments of Indian chemical sector with their robust infrastructure, highly trained workforce, WTO driven IP protection system and highly appealing domestic market are well placed to absorb the technology spillovers and spinoffs of transnational research in India. **There is enough justification for India to maximize the benefits of transnational research on its soil to promote new knowledge diffusion into its R&D system**. In this connection following measures are recommended:

- Identification of potential spinoff and spillover outcomes of transnational research and Indian institutions by experts identifications by the Governments of India.

- Sensitization of potential chemical companies which have the necessary R&D capabilities to absorb them for commercialization

- Vigorously explore the possibilities of establishing R&D Joint Ventures (JV) between MNC-R&D centres and Indian institutions in product upgradation, innovative process options and process intensification for ecofootprints minimization in relevant areas.

The countries like Brazil and China have been making efforts to formulate Government policies to maximize the positive impact of their overseas R&D centres. Since this is a new type of endeavour for India, a study on international practices may be necessary. The DST, DSIR and DBT have the necessary competence to setup expert committees to explore ways and means of incentivizing the utilization of spinoff outcomes of transnational research for higher value addition by the speciality and knowledge intensive segments of Indian chemical industry.

Foreign Direct Investment as a Vehicle for Innovation

India, as a nation, has limited experience in introducing globally competitive technologies / products. Indian chemical industry can gain significantly if national S&T Innovation policies are more strongly linked to FDI policies being pursued by the Government of India. It will eventually enhance the chances of knowledge alliances between Indian industry and global R&D / academic / industrial institutions in emerging S&T areas for development of new products and technologies.

Given the fact that Science, Technology and Innovation (STI) are at the centre stage of socio-economic development world over, it would be imperative for Indian government to factor innovation policies into FDI policy. Technology intensive, pharma and biotechnology components of Indian chemical industry have undergone much higher level of R&D globalization as compared to others in India. Therefore, a STI driven FDI policy is most desirable to deliver financial benefits to Indian chemical sector in terms of state of art equipments, transfer of new application knowledge, novel research methodologies, new R&D subcontracting opportunities and host of other high-tech benefits. The transnational R&D spin off effects can result in transfer of technologies from MNCs to local firms, new opportunities to setup ventures by the former MNC employees and opportunities to acquire new skills and knowledge from global technology supplier agencies. The spillover effects may contribute to the emergence of a new class of world class entrepreneurs in the host country. **The INAE team, therefore, recommends the formulation of a STI driven FDI policy by the commerce Ministry in consultation with the Ministry of Science and Technology under the new context of global FDI regime**.

IV. IMPROVING ENVIRONMENTAL SUSTAINABILITY

Until middle of 80s, the chemical industry used to enjoy a positive image worldwide because of its utility to the society and for its ability to improve the quality of life of people. Major accidents like Bhopal and Flixborough and growing chemical based water and air pollution and environmental damage in several other forms causing public health risks have contributed to unfavourable public image of chemical industry. There is need to transform this image through proactive environmental protection measures to be put in place by the Indian chemical industry.

10.10. Nurturing Environmental Brand Image to Sustain Future Growth

Transforming public perception is a highly challenging task and Indian chemical industry needs to take concerted actions in the future to regain its positive image by achieving a higher level of eco-sustainability. It has to demonstrate its total commitment to environment in several ways, the notable amongst them being:

- Building “Green” concepts into Indian chemical industry by implementing green labeling and life cycle analysis of chemical consumer products, achieving reduced carbon footprints through active participation in carbon trading and aiming for near zero liquid and solid waste discharges.

- The major drawback in Indian environment regulatory system is its inability to achieve the desired level of effectiveness at the ground level due to lack of rigorous monitoring and implementation. A stronger link between industry, government research institutions and NGOs, who can act as watchdogs for their implementation, has to be established. Simultaneously, Indian regulations on environmental protection and safety of chemicals need to be revisited. Some of them need to be harmonized and updated to set achievable targets within specific timeframe.

- The compliance of SME sector to environmental regulations is very poor since their resource base is very limited. The government has to support the environmental improvement efforts of this sector much more proactively. The RDISCs suggested earlier should take up environmental issues for this sector on priority basis and needed technologies may be developed.

- The programmes like REACH will impact the chemical business in much stronger way in the future. Indian chemical sector has to respond much more proactivity to such regulations with higher focus on speedy implementation.

V. HR COMPETENCE BUILDING

The current HR situation in Indian chemical R&D is not very comfortable considering the mounting challenges of globalized economy. This recommendation is specifically tailored to meet the future HR challenges to be met effectively by the Indian chemical sector.

10.11 *Measures for Augmenting HR Resources and Building Core Competencies*

Appropriately skilled, innovative and efficient S&T personnel remain the most important R&D growth engine of all three segments of Indian chemical industry. Industry itself has to play a major role in creating conducive environment for attracting and retaining bright talent.

Evolving Effective HR Policies and Practices by the Industry

The major factors contributing to R&D capability building in Indian chemical sector are appropriate basic education, training in modern research methodologies, attractive salary structure, imaginatively designed inhouse career development programmes, conducive working environment for the performers and proactive R&D management policies. While most of these conditions have to be created by the individual chemical companies, there is scope for evolving workable guidelines for HR competence building in basic, speciality and knowledge intensive chemical subsectors considering their distinct R&D requirements. The main stakeholders viz., company leadership of these segments with global outlook, eminent scientists in HRD area and concerned professional bodies of the industry have to establish a forum to interact on following aspects:

- Identification of most appropriate educational courses relevant to present and future chemical R&D (process and product oriented) and the current status of their syllabus
- Nature of prejob training on modern research methodologies (process and product oriented) and identification of suitable Indian and overseas institutions to impart such a training
- Formulation of generalized recruitment policies and personnel selection guidelines for adoption by the individual companies with appropriate modifications
- Formulation of generalized guidelines for inhouse career development programmes including internal R&D staff mobility schemes to provide wider R&D job exposure to young and middle level scientists.
- Evolving broad contours of R&D personnel management policies specific to basic, speciality and knowledge intensive chemical sectors for adoption by the individual companies.
- Evolving appropriate strategies for improving the stock of present R&D personnel through advanced training and qualification improvement programmes.
- Evolving special schemes for attracting well qualified and experienced non resident Indians.

The industry representative bodies like ICC, FICCI and CII should take lead in creating appropriate forums for interactions of the stakeholders. Though government has a minimum role to play in above areas, it can facilitate the thought process by providing national and international experts, by providing fiscal incentives for R&D HR modernization programmes particularly for SMEs and sponsoring advanced training programmes in well established management institutions.

Building HR Core Competency for meeting open innovation challenges

Future R&D in knowledge intensive sector has to be carried out in a network mode involving competent agencies within and outside the country. The networked R&D requires a new HRD model based on heterarchy type of leadership. The basic components of such a model are enhanced mobility of researchers between industry and academic institutions, creation of enhanced job attractions and learning opportunities in new technology frontiers, job rotation between various functional departments within and outside the parent institute, career building for long term employability of research staff and management of outsourced R&D personnel in external locations. **Fig.10.10.1** highlights the complexities of an open innovation system. There is a strong need for involving eminent HR experts from India and abroad for evolving an appropriate management framework.

CONCLUDING REMARKS

The INAE Study Team, after carefully examining the current performance and future challenges ahead of Indian chemical sector, is optimistic that Indian chemical sector has the potential to become much more knowledge intensive to facilitate faster growth and improved global footprint. The full potential of public-private partnership and visionary thought process has to be realized by the Indian chemical companies through their global outlook.

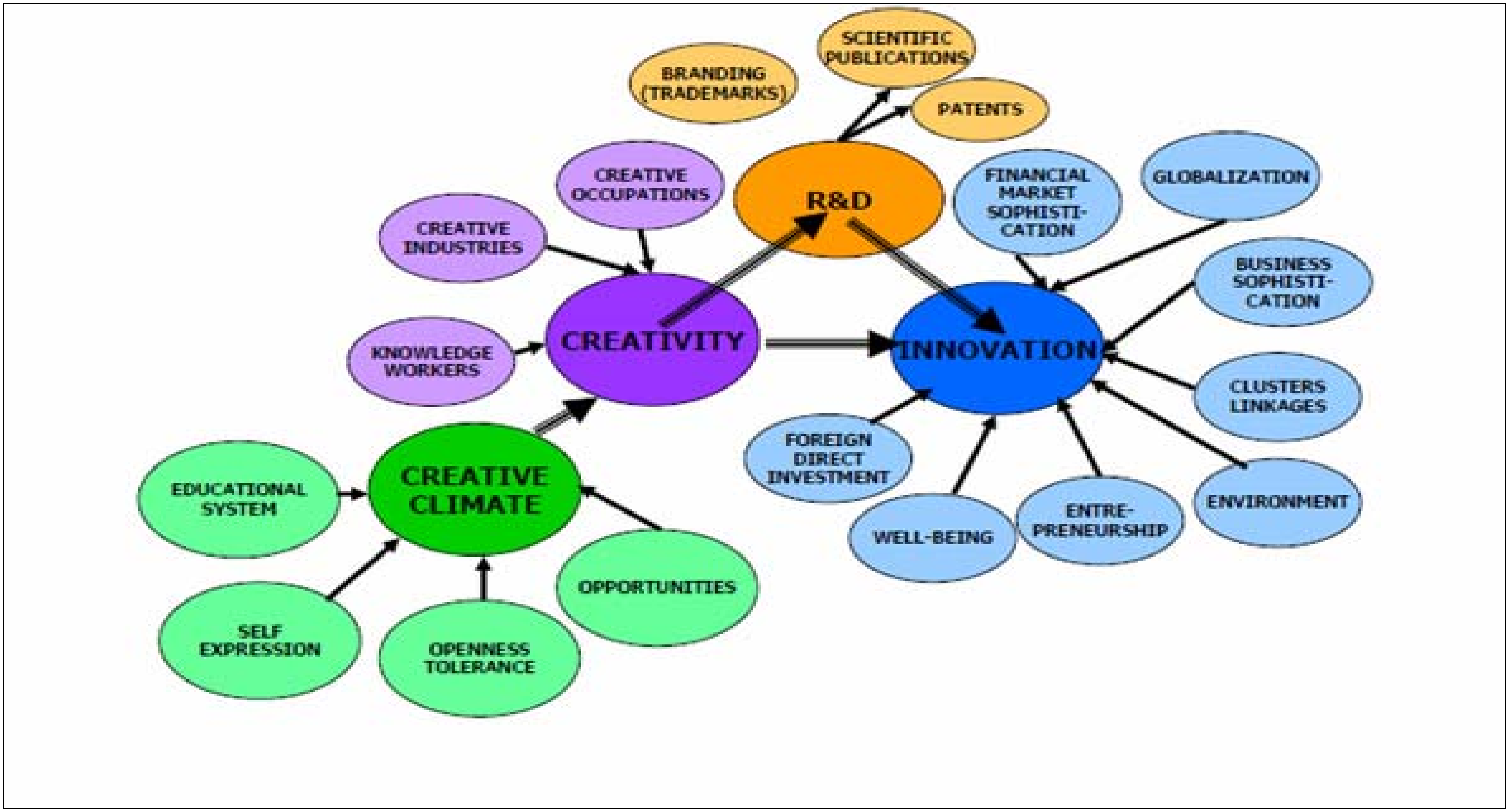

Fig. 10.10.1 : The Intricate Relationship of various factors in an open innovation R&D system

ABBREVIATIONS

A

ACM	:	*Advanced Composite Mission*
AICTE	:	*All India Council for Technical Education*
AIIMS	:	*All India Institute of Medical Science*
AMU	:	*Aligarh Muslim University*
AMC	:	*Apex Monitoring Committee*
ANDA	:	*Abbreviated New Drug Applications*
ANU	:	*Acharya Nagarjuna University*
API	:	*Active Pharmaceutical Ingredients*
APITCO	:	*Andhra Pradesh Industrial Technical Consultancy Organization*
ASCI	:	*Administrative Staff College of India*
ATTE	:	*Association of Technology Transfer Executives*
AU	:	*Andhra University*
AU	:	*Automobile (chapt-8)*
AYUSH	:	*Ayurveda, Yoga, Unani, Siddha and Homeopathy*

B

BARC	:	*Bhabha Atomic Research Centre*
BC	:	*Basic Chemicals*
BHU	:	*Banaras Hindu University*
BIPP	:	*Biotechnology Industry Partnership Programme*
BITS	:	*Birla Institute of Technological Sciences*
BM	:	*Bombay*
BOD	:	*Biological Oxygen Demand*
BRAI	:	*Biotechnology Regulatory Authority of India*
BT	:	*Biotechnology*
BV	:	*Bharatia Vidyapeeth*

C

C	:	*Construction*
CA	:	*Chartered Accountants*
CAGR	:	*Compound Annual Growth Rate*
CDC	:	*Consultancy Development Centre*
CDRI	:	*Central Drug Research Institute*
CE	:	*Chemical Engineering*
C&EN	:	*Chemical and Engineering News*
CEP	:	*Continuing Education Programme*
CEERI	:	*Central Electronics Engineering Research Institute*
CEO	:	*Chief Executive Officer*
CER	:	*Carbon Emission Reduction*
CFCs	:	*Chlorofluorocarbons*
CFTRI	:	*Central Food Technological Research Institute*
CH	:	*Chemicals*
CHT	:	*Centre for High Technology*
CIB	:	*Central Insecticide Board*
CIEIS	:	*Canada-India Environmental Institutional Strenthening*
CITT	:	*Centre for International Trade and Technology*
CLRI	:	*Central Leather Research Institute*
CMIE	:	*Centre for Monitoring Indian Economy*
CO	:	*Computers*
COE	:	*Centre of Excellence*

CPCB	:	*Central Pollution Control Board*
CRAMS	:	*Contract Research Manufacture and Allied Services*
CREP	:	*Corporate Responsibility in Environmental Planning*
CSIR	:	*Council of Scientific and Industrial Research*
CSMCRI	:	*Central Salt and Marine Chemicals Research Institute*
CWC	:	*Chemical Weapons Convention*

D

DBT	:	*Department of Biotechnology*
DCF	:	*Department of Chemicals and Fertilizer*
DCGI	:	*Drugs Controller General of India*
DDPE	:	*Drug Development Promotion Foundation*
DEPBS	:	*Duty Entitlement Pass Book Scheme*
DES	:	*Duty Exemption Scheme*
DF	:	*Defence*
DILs	:	*Direct Industrial Licenses*
DIPP	:	*Department of Industrial Policy and Promotion*
DL	:	*Delhi*
Dr HDGVV	:	*Dr Hari Singh Gour Vishwavidyalaya*
DMRL	:	*Defence Metallurgical Research Laboratory*
DMSME	:	*Department of Materials Science and Mineral Engineering*
DOSHE	:	*Department of Secondary and Higher Education*
DP	:	*Department of Pharmaceuticals*
PRDP	:	*Pharmaceutical R & D Programme*
DRDO	:	*Defence Research and Development Organization*
DSIR	:	*Department of Scientific and Industrial Research*
DST	:	*Department of Science and Technology*

E

EE	:	*Environmental Engineering*
EKC	:	*Environmental Kuznet's Curve*
EMR	:	*Extramural Research*
EOUS	:	*Export Oriented Units*
EPCG	:	*Export Promotion Capital Goods*
EPO	:	*European Patent Organization*
EPPR	:	*Emergency Planning, Preparedness and Response*
EU	:	*European Union*
EXIMB	:	*Export-Import Bank*

F

FDA	:	*Food and Drug Administration*
FDI	:	*Foreign Direct Investment*
FI	:	*Financial Institutions*
FICCI	:	*Federation of Indian Chamber of Commerce and Industry*
FIPB	:	*Foreign Investment Promotion Board*
FITT	:	*Foundation for Innovation and Technology Transfer*
FOPFs	:	*Foreign Oriented Patent Families*
FR&D/FRIEND	:	*Funding of R & D in Electronics Industry*
FT	:	*Food Chemistry*
FTA	:	*Free Trade Agreements*

G

GDP	:	*Gross Domestic Product*
GFCF	:	*Gross Fixed Capital Formation*

GIDC	:	*Gujarat Industrial Development Corporation*
GITA	:	*Global Innovation Technology Alliance*
GLP	:	*Good Laboratory Practice*
GM	:	*General Electric*
GMP	:	*Good Manufacturing Practice*
GNP	:	*Gross National Product*
GOI	:	*Government of India*
GT	:	*Gauhati*

H

H	:	*Healthcare*
HCFCs	:	*Hydro chlorofluorocarbons*
HFI	:	*Herfindah Index*
HGT	:	*Home Grown Technology*
HTE	:	*High Tech Exports*
HR	:	*Human Resource*
HRD	:	*Human Resource Development*
HRM	:	*Human Resource Management*
HS	:	*Harmonized System*

I

IACS	:	*Indian Association for the Cultivation of Science*
IAMR	:	*Institute of Applied Manpower Research*
IARI	:	*Indian Agricultural Research Institute*
ICAR	:	*Indian Council of Agricultural Research*
ICC	:	*Indian Chemical Council*
IC & SR	:	*Industrial Consultancy & Sponsored Research*
ICMR	:	*Indian Council of Medical Research*
ICT	:	*Institute of Chemical Technology*
IDP	:	*Instrumentation Development Programme*
IEM	:	*Industrial Entrepreneur Memoranda*
IFPEI	:	*Inward FDI Performance Index*
IFPOI	:	*Inward FDI Potential Index*
IGCAR	:	*Indira Gandhi Centre for Atomic Research*
IGCC	:	*Integrated Gasification Combined Cycle*
IICB	:	*Indian Institute of Chemical Biology*
IICT	:	*Indian Institute Chemical Technology*
IIDS	:	*Industrial infrastructure Development Scheme*
IIFT	:	*Indian Institute of Foreign Trade*
IIMs	:	*Indian Institutes of Management*
IISc	:	*Indian Institute of Science*
IISERs	:	*Indian Institutes of Science Education and Research*
IIP	:	*Indian Institute of Packaging*
IIT	:	*Indian Institutes of Technology*
IMTECH	:	*Institute of Microbial Technology*
INAE	:	*Indian National Academy of Engineering*
INPI	:	*Institut National de la Propriété Industrielle*
INSPIRE	:	*Innovation in Science Pursuit for Inspired Research*
IOC	:	*Indian Oil Corporation*
IOP	:	*Industry Originated Projects*
IP	:	*Intellectual Property*
IPCA	:	*Indian Pharmaceutical Congress Association*
IPM	:	*Integrated Pest Management*
IPO	:	*Indian Patent Office*
IPR	:	*Intellectual Property Right*

IRC : *India Research Center*
IRCC : *Industrial Research and Consultancy Centre*
IREDA : *Indian Renewable Energy Development Agency*
IS : *Information Systems*
ISI : *Institute for scientific Information*
ISRO : *Indian Space Research Organization*
ISSC : *Interdisciplinary School of Scientific Computing*
ITC : *International Trade Commission*
ITRC : *Industrial Toxicological Research Center*
I-U : *Industry-University*
IUCF : *Industry-University Cooperation Foundation*

J

JNCASR : *Jawaharlal Nehru Centre for Advanced Scientific Research*
JNTU : *Jawaharlal Nehru Technological University*
JRVs : *Joint R&D Ventures*
JU : *Jadavpur University*

K

KH : *Kharagpur*
KI : *Knowledge Intensive*
KPMG : *Klynveld Peat Marwick Goerdeler*
KU : *Kakatiya University*
KVPY : *Kishore Vaigyanik Protsahan Yojana*

L

LCD : *Liquid Crystal Display*
LED : *Light Emitting Diodes*
LOIs : *Letters of Intent*

M

MAT : *Minimum Alternate Tax (chapt-2)*
MAT : *Mental Ability Test (chapt-8)*
MC : *Surface Materials / Coatings*
MCE : *Management Centre Europe*
MD : *Madras*
MHRD : *Ministry of Human Resource Development*
MIC : *Methyl Isocyanate*
MKU : *Madurai Kamaraj University*
MMTPA : *Million Metric Tonnes per Annum*
MN : *Mining*
MNC : *Multi National Corporations*
MNRE : *Ministry of New and Renewable Energy*
MOCIT : *Ministry of Communications and Information Technology*
MOEF : *Ministry of Environment and Forests*
MOFPI : *Ministry of Food Processing Industry*
MOES : *Ministry of Earth Sciences*
MOP : *Ministry of Power*
MoU : *Memorandum of Understanding*
MS : *Materials chemistry and metallurgy*
MSIHC : *Manufacture, Storage, and Import of Hazardous Chemicals*
MSME : *Micro, Small and Medium Enterprises*
MSU : *The Maharaja Sayajirao University*
MU : *Mumbai University*

N

NAFTA	:	*North American Free Trade Agreement*
NAL	:	*National Aerospace Laboratories*
NATCO	:	*Natco Pharmaceutical Company*
NCERT	:	*National Council of Education Research and Training*
NCL	:	*National Chemical Laboratory*
NCPC	:	*National Cleaner Production Council*
NGO	:	*Nongovernmental Organization*
NEP	:	*Nationally Evolved Projects*
NIHM	:	*Northern Institute of Hotel Management*
NMITLI	:	*New Millennium India Technology Leadership Initiative*
NIPER	:	*National Institute of Pharmaceutical Education and Research*
NISTADS	:	*National Institute of Science, Technology and Development Studies*
NKC	:	*National Knowledge Commission*
NOx	:	*Nitrogen Oxides*
NPD	:	*New Product Development*
NPL	:	*National Physical Laboratory*
NSDC	:	*National Skill Development Corporation*
NSTEDB		*National Science and Technology Entrepreneurship Development Board*
NSTMIS	:	*National Science and Technology Management Information system*
NT	:	*Nanotechnology*
NTSE	:	*National Talent Search Examination*
NU	:	*Number of Units*

O

ODS	:	*Ozone Depleting Substances*
OECD	:	*Organization for Economic Co-operation and Development*
OC	:	*Organic Chemistry*
ONGC	:	*Oil and Natural Gas Corporation*
OPCW	:	*Organization for the Prohibition of Chemical Weapons*
OST	:	*Observatoire des Sciences and des Techniques*
OU	:	*Osmania University*

P

PATSER	:	*Programme Aimed at attaining Technological Self-Reliance*
PCPIR	:	*Petroleum, Chemicals and Petrochemical Investment Regions*
PCRA	:	*Petroleum Conservation Research Association*
PCT	:	*Patent Cooperation Treaty*
PEC	:	*Project Engineering Companies*
PFA	:	*Prevention of Food Adulteration*
PGIME	:	*Post Graduate Institute of Medical Education*
PH	:	*Pharmaceuticals*
PIS	:	*Project Import Scheme*
PL	:	*Polymers*
PLI	:	*Public Liability Insurance*
POPs	:	*Persistent Organic Pollutants*
PPP	:	*Public Private Partnership*
P/PR	:	*Patents to Publications Ratio*
PRC	:	*People's Republic of China*
PRDC	:	*Pharmaceutical Research and Development Committee*
PRDP	:	*Pharmaceutical R&D Programme*
PRMC	:	*Project Review Monitoring Committee*
PSI	:	*Principal Scientific Investigator*

PVC	:	*Polyvinylchloride*
PTRSU	:	*Pandit Ravishankar Shukla University*
PU	:	*Punjab University*

Q

QMS	:	*Quality Management System*

R

RC	:	*Registration Committee*
REACH	:	*Registration, Evaluation, Authorization and Restriction of Chemicals*
R & D	:	*Research and Development*
RDE	:	*R & D Expenditure*
RDI/R & DI	:	*Research and Development Intensity*
RDISC	:	*R & D and Innovation Support Centre*
RIS	:	*Research and Information System*
RIT	:	*Research Innovation and Technology*
RRL	:	*Regional Research Laboratory*
RSI	:	*Relative Specialization Index*

S

SAT	:	*Scholastic Aptitude Test*
SB	:	*Ship building*
SBIRI	:	*Small Business Innovation Research Initiative*
SC	:	*Speciality Chemicals*
SCI	:	*Science Citation Index*
SEZs	:	*Special Economic Zones*
SIRO	:	*Scientific and Industrial Research Organization*
SME	:	*Small and Medium Enterprises*
SMPV	:	*Static and Mobile Pressure Vessel*
SOx	:	*SulphurOxides*
SR	:	*Services*
SRIC	:	*Sponsored Research and Industrial Consultancy*
SSIs	:	*Small Scale Industries*
S & T	:	*Science and Technology*
STI	:	*Science, Technology and Innovation*
STPI	:	*Software Technology Parks of India*
STM	:	*Sugar Technology Mission*
SVU	:	*Sri Venkateswara University*

T

TC	:	*Telecom*
TD	:	*Trade*
TDB	:	*Technology Development Board*
TDDP	:	*Technology Development and Demonstration Program*
TePP	:	*Technopreneur Promotion Programme*
TERI	:	*The Energy and Resources Institute*
TICs	:	*Technology Innovation Centers*

TIFAC	:	*Technology Information Forecasting and Assessment Council*
TOR	:	*Turnover*
TPA	:	*Tons per Annum*
TR	:	*Transport*
TRIPS	:	*Trade Related Intellectual Property Rights*
TSD	:	*Technology System Development*
TUFS	:	*Technology Upgrade Fund Scheme*
TX	:	*Textiles*

U

UD	:	*University of Delhi*
UGC	:	*University Grants Commission*
UH	:	*University of Hyderabad*
UK	:	*University of Kalyani*
UKT	:	*University of Kolkata*
UM	:	*University of Madras*
UNDP	:	*United Nations Development Programme*
UNEP	:	*United Nations Environment Programme*
UNESCO	:	*United Nations Educational, Scientific and Cultural Organization*
UNIDO	:	*United Nations Industrial Development Organization*
UNITAR	:	*United Nations Institute for Training and Research*
UR	:	*University of Rajasthan*
URTIF	:	*Unified Revolving Technology Innovation Fund*
US	:	*United States of America*
USD	:	*United States Dollar*
USDB	:	*United States Dollar billion*
USEPA	:	*United States Environmental Protection Agency*
USPTO	:	*United States Patent and Trademark Office*
UV	:	*Ultra Violet*

V

VIA	:	*Vapi Industries Association*
VOCs	:	*Volatile Organic Compounds*
VWEMCL	:	*Vapi Water and Effluent Management Company Ltd*

W

WIPO	:	*World Intellectual Property Organization*
WTO	:	*World Trade Organization*

R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

"The Indian National Academy of Engineering (INAE), founded in 1987, comprises India's most distinguished engineers, engineer-scientists and technologists covering the entire spectrum of engineering disciplines. INAE functions as an apex body and promotes the practice of engineering & technology and the related sciences for their application to solving problems of national importance. The Academy provides a forum for futuristic planning for country's development requiring engineering and technological inputs and brings together specialists from such fields as may be necessary for comprehensive solutions to the needs of the country. INAE is an autonomous institution supported partly through grant-in-aid by Department of Science & Technology, Government of India. It is the only engineering Academy in India. INAE represents India at the International Council of Academies of Engineering and Technological Sciences (CAETS), USA and is one of the member Academies of CAETS.

Among other things, studies on important/topical national issues are undertaken by the Academy through specially constituted Study Groups/ Task forces. The objective is to bring out a comprehensive/exhaustive document covering review of existing international and national technological and commercial aspects, analysis of options, future trends and specific implementable policy/recommendations and methodology of execution. Separate Task Forces have been set up by the Academy to undertake Research Studies on Technologies related to the issues of National Importance. One of these study pertains to R&D Impact on Indian Chemical Industry.

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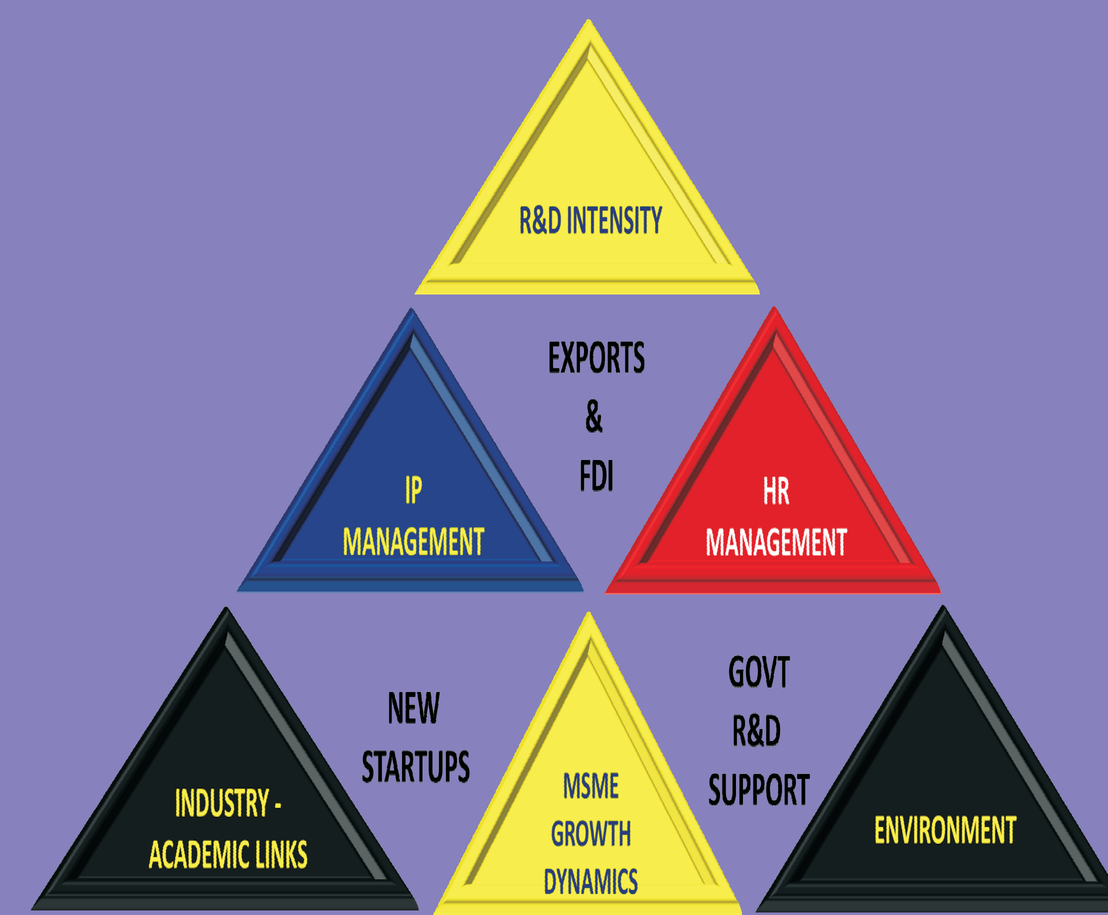


Prepared by
Indian National Academy of Engineering, (INAE)
New Delhi

MAY 2011

Submitted to
Principal Scientific Advisor (PSA)
Government of India
New Delhi

Indian National Academy of Engineering

ANNEXURES TO CHAPTER 1 TO 10

ANNEXURE 1.3.1

No. Prn.SA/INAE/2009
Government of India
Office of the Principal Scientific Adviser
to the Government of India
*****

211, Vigyan Bhawan Annexe,
Maulana Azad Road,
New Delhi -110011.
Dated 27th May, 2009.

To

The Pay and Accounts Officer,
Department of Science and Technology,
Technology Bhawan,
New Mehrauli Road,
New Delhi - 110016.

Subject: Financial assistance for the project "Impact of R&D on Indian Chemical Industry – Current Status and Future Strategies" - Regarding.

Sir,

I am directed to refer to this office order dated 15th May, 2009, conveying the sanction of the President to the Project entitled **"Impact of R&D on Indian Chemical Industry – Current Status and Future Strategies"** by the Indian National Academy of Engineering (INAE), New Delhi, at a total cost of **Rs. 36,25,000.00 (Rupees Thirty six lakhs twenty five thousand only)** within a duration of one year.

2. Pursuant to para 2 (a) of the sanction order dated 15th May, 2009, the Indian National Academy of Engineering, New Delhi, has submitted the Indemnity Bond, which has been found to be in order and accepted. I am, accordingly, directed to convey the sanction of the President to the release of the **first instalment** of funds, amounting to **Rs. 29,00,000.00** (Rupees Twenty Nine lakhs only) to **the Indian National Academy of Engineering, New Delhi.** The expenditure involved is debitable to the following Head of Account under **Demand No. 83 (Department of Science and Technology): -**

Major Head 3425	-	Other Scientific Research
60	-	Others
60.200	-	Assistance to Other Scientific Bodies
34	-	Synergy Projects
34.00.31	-	Grants-in-aid

for the year **2009-10 (Plan).**

3. The amount sanctioned, vide para 2 above, shall be drawn by the Drawing and Disbursing Officer, Department of Science and Technology and remitted to the **Indian National Academy of Engineering** through **Demand Draft/Cheque** payable at **New Delhi** and sent to the Executive Secretary, Indian National Academy of Engineering, 6th Floor, Vishwakarma Bhawan, IIT Campus, Shaheed Jeet Singh Marg, New Delhi – 110 016.

4. This being a new project to the Indian National Academy of Engineering, New Delhi, there is no question of getting utilisation certificate for earlier Grants-in-aid.

5. The other terms and conditions of the sanction remain the same as stipulated in the sanction order of even number dated 15th May, 2009.

………2/-

6. The amount of Grants-in-aid sanctioned/ released has been entered in the Grants-in-aid Register maintained in GFR-Form 39 read with Rule 212(4) of GFR at **S. No. 03, page No. 151** of the Expenditure Control Register.

7. This issues with the concurrence of IFD vide their Diary No 504, dated 14.5.2009.

(S.P. Singh)
Under Secretary to the Government of India
Tel. 23022010

Distribution :

1. The Drawing and Disbursing Officer, Department of Science and Technology, New Delhi (**3 copies**).
2. DS (IFD), Department of Science and Technology, New Delhi.
3. Dr. K.V. Raghavan, INAE Distinguished Professor, Reaction Engineering Lab., Indian Institute of Chemical Technology (IICT), Tarnaka, Uppal Road, Hyderabad – 500 007.
4. The Principal Director of Audit (Scientific Ministries/Departments), III Floor, AGCR Building, IP Estate, New Delhi –110 002.
5. Dr. P.S. Goel, President, Indian National Academy of Engineering, 6th Floor, Vishwakarma Bhawan, IIT Campus, Shaheed Jeet Singh Marg, New Delhi – 110 016.
6. Addl. PS to the Principal Scientific Adviser to the Government of India.
7. PA to the Scientific Secretary, Office of the Principal Scientific Adviser to the Government of India.
8. DDO, Office of the Principal Scientific Adviser to the Government of India.
9. Sanction Folder.
10. Guard File.

(S.P. Singh)
Under Secretary to the Government of India

ANNEXURE 1.6.1a

Minutes of the First PRMC meeting of the IRICI-INAE Project on "Impact of R&D on Indian Chemical Industry" on 3rd November 2009 at PSA's office, Vigyan Bhavan, New Delhi

Time: 10.30 AM

Venue: Conference Room

Present

Dr.Chidambaram, PSA
Sri Somenath Ghosh, CMD, NRDC and Chairman, PRMC
Dr.P.S.Goel, President, INAE
Dr.R.P.Gupta, Director, PSA's Office and Member Secretary, PRMC
Dr.K.V.Raghavan, Principal Scientific Investigator, IRICI-INAE Project
Brig SC Marwaha, Executive Secretary, INAE
Sri D.P.Misra, INAE Fellow and Project Consultant, IRICI-INAE Project
Prof.A.N.Maitra, INAE Fellow and Project Consultant, IRICI-INAE Project
Dr.Neeraj Atray, Scientist, IIP and Project Associate, IRICI-INAE Project

Sri Samir Somaiya and Dr J P Gupta, Members of PRMC could not attend the meeting due to their unforeseen engagements.

Dr.R.P.Gupta, Member Secretary welcomed the members of PRMC and special invitees to the meeting. He highlighted the importance of the present project from the point of view of evolving development strategies for future growth of Indian chemical industry. He invited Sri Somenath Ghosh, CMD, NRDC to chair the meeting and conduct the meeting.

Sri Ghosh expressed his happiness to chair the PRMC meeting to review the progress of IRICI-INAE project specially designed for assessing the R&D impact on the Indian chemical industry. He expressed his gratitude to Dr.Chidambaram, PSA and Dr.P.S.Goel, President, INAE for their participation in the meeting and invited them to offer their valuable advice. He cited several challenges including attracting and retaining highly innovative scientists and talented persons before the Indian chemical sector in the coming years.

Opening Remarks from Dr.Chidambaram, PSA

Dr.Chidambaram, in his opening remarks highlighted the need for development of technology foresight and roadmap for all important industrial sectors in India. Appropriate R&D backup is necessary to realise the goals set in the foresight analysis. He emphasized the need to look at the likely impact of climate change and environmental factors on future growth of industry. He could foresee several challenges in attracting highly qualified manpower for R&D in various industrial sectors. He finally stressed the importance of (a) evolving long term perspective of R&D impact on Indian chemical sector and (b) evolving appropriate strategies for encouraging directed basic research in Indian academic and R&D institutions. Dr.Chidambaram also offered the expertise of Dr.Prabhunath Ganguly of PSA's Secretariat in IP Analysis.

Remarks from Dr. P.S. Goel, President, INAE

He highlighted the unique features of present project as conceived by the project team and expressed his happiness that this project which is first of its kind to be handled by INAE has been selected for support from PSA's office. He stressed that in a competitive global environment, R&D has to be very strong to make the concerned industrial sector strong. Regarding the projected outcome of the present assignment, he stated that major emphasis in the proposed studies would be to correlate R&D impact with the current development of various sub-sectors of Indian chemical industry and it is likely that Phase-2 Studies may be required for making long term projections after making more detailed micro analysis.

The chairman then invited Dr.Raghavan the Principal Scientific Investigator to present the current status of IRICI-INAE project investigations and the studies proposed during the rest of the project period. Dr.Raghavan first highlighted the basic objectives, scope and likely outcomes of the present project and its unique features. He stated that the main focus of the project has been:

i. Confining the studies to eight factors whose impact has to be assessed at macro and micro levels on the Indian chemical industry which is categorized into three important sectors viz., basic chemicals, specialities and knowledge intensives.

ii. The impact will be assessed with respect to conditions in line with the post liberalization period viz., 1990-2009.

iii. Mini surveys and a National survey are planned to collect reliable information on factors for which information in open literature is not available.

iv. Attempts will be made to avail the services or part time inputs of experts who earlier made useful research contributions in analyzing the impact of R&D intensity on the Indian industry in general and Indian chemical industry in particular.

Dr.Raghavan then made a detailed presentation of project activities, scope of proposed studies and its likely deliverable outputs. The participants discussed various aspects of the project in sufficient detail and following points emerged from the discussions:

1. Need for making studies to highlight important developments in Indian chemical industry which have ramifications on its growth, competitiveness and R&D capabilities.

2. The important role played by the Government in supporting pre-competitive applied research to be analysed carefully.

3. Crowding of public and private sector agencies, if any, in funding R&D in certain disciplines or areas of applications to be examined.

4. The influence of chemical weapons convention, Montreal and Kyoto protocols and other international treaties on Indian R&D in chemical sector

5. Role of Academies in identifying and promoting R&D in new existing and frontier areas

6. R&D technology commercialization in industry clusters (homogeneous and heterogeneous) to be studied in sufficient detail.

7. To identify some important issues which were not covered in INAE project but which are important for the future growth of Indian chemical sector.

8. Need for incorporating case studies in specific areas which bring out the best and worst case scenarios

9. Protected Intellectual Property generated from R&D schemes based on public - private partnerships

10. The implications of introducing an act in India similar to Bayh Dole Act of USA for utilization of public funded intellectual property.

11. The role of R&D on human resource capability enhancement is one of the most vital subjects to be studied in the IRICI-INAE project. The studies done by USA on this subject need to carefully studied

12. R&D Impact on import performance of Indian chemical sector to be studied from the point of view of its minimization, quality enhancement, high technology product / knowledge content and extent of value addition achieved in the corresponding exports etc,.

The PRMC has taken note of the following actions reported by the Principal Scientific Investigator :

i. Launching mini surveys in 2nd Quarter on (a) the extent of utilization of government supported R&D to be coordinated by Dr M O Garg, Project Consultant and (b) extent of utilization of industry – university linkages for generating commercializable R&D to be coordinated by Prof A N Maitra, Project Consultant.

ii. Participation of INAE project team in the National Seminar to be conducted by the Indian Chemical Council, Mumbai on 4/5 December 2009 to be coordinated by Sri D P Misra, Project Consultant. This seminar is intended to provide chemical industry's initial response on R&D impact on its various subsectors.

iii. Proposal of Principal Scientific Investigator (PSI) to approach well known Indian research groups in analysing the impact of R&D intensity on chemical exports/imports, attracting FDI, and undertaking innovative R&D with medium and high risk levels etc., during the post liberalization period viz., 1990-2009.

iv. Engagement of an External Expert from Administrative Staff College of India, Hyderabad to plan, coordinate and organise the National Survey to be conducted during the 3rd Quarter.

The PRMC approved the proposed timeframe and activity schedules as presented by the PSI for execution of INAE project during June 2009 to May 2010. The project progress will be monitored with the suggested milestones. The PRMC also approved the budget allocation made under various heads for all the four quarters of project implementation. The PRMC has noted the budget utilization in the first quarter.

Sri Ghosh, the chairman of PRMC summed up the recommendations of the committee and complimented INAE for agreeing to work on such an important project to the Indian chemical industry. He then formally closed the proceedings. The meeting ended with the vote of thanks to the chair and the participants.

ANNEXURE 1.6.1b

MINUTES OF THE 2ND PRMC MEETING ON IRICI-INAE PROJECT ON "IMPACT OF R&D ON INDIAN CHEMICAL INDUSTRY"

Date 10th August 2010

Venue: Vigyan Bhavan Annexe, New Delhi

Time: 10.30 to 13.30 hrs

Participants

Dr Chidambaram, PSA, Govt. of India

Dr P S Goel, President, INAE

Sri Somenath Ghosh, Chairman, PRMC

Dr K V Raghavan, PSI, IRICI-INAE Project

Dr R P Gupta, Member Secretary, PRMC

Dr Samir Somaiya, Member, PRMC

Dr J P Gupta, Member, PRMC

Dr Surappa, Special Invitee

Sri D P Misra, IRICI-INAE Project Consultant

Prof A N Maitra, IRICI-INAE Project Consultant

Dr Nirmalya Bagchi, Principal Investigator, National Survey

Dr Neeraj Atrey, Scientist, IIP, Dehradun

Sri Rajendran, Advisor, PSA's Office

Dr R P Gupta, Member Secretary, PRMC welcomed the distinguished participants, Chairman and Members of PRMC and the special invitees to the meeting. In his opening remarks, Sri Somenath Ghosh, Chairman, PRMC highlighted the interesting insights on various issues covered under the IRICI-INAE Project study. He appreciated the efforts of the project team in bringing out the new dimensions of intellectual property management and in establishing technology intensive startups by the Indian Chemical sector. He informed the participants on the relevance of the studies undertaken by a NRDC Taskforce under the Chairmanship of Dr K V Raghavan on the transfer of innovation to SMEs in China, S Korea and Taiwan. He offered to share these experiences with IRICI-INAE project team.

Dr Chidambaram, PSA to Govt. of India expressed his appreciation to the efforts of IRICI-INAE project team in providing extensive coverage to several vital issues of importance to the Indian chemical sector. He stressed the need to study the impact made by (a) the green chemistry on this sector and (b) reinnovation concept on speciality chemical sector. To make the findings of the present study more purposeful, the knowledge / R&D gaps need to be identified and measures needed for closing these gaps to be highlighted.

Dr P S Goel, President, INAE in his opening remarks, expressed his happiness for undertaking the IRICI-INAE project study and the results of the study have shown how R&D can empower the knowledge intensive segment of Indian chemical industry. Intervening in the discussions, Dr Chidambaram highlighted the importance of technology foresight analysis in specific areas in Indian chemical sector.

The experiences of TIFAC on technology impact studies on SME clusters can be shared by the project team.

Presenting the Action Taken Report, Dr K V Raghavan, PSI highlighted the progress achieved in the implementation of very useful suggestions made by the 1st PRMC and INAE Annual Convention held in December 2009. They include impact of climate change and environmental factors, challenges in attracting and retaining highly qualified manpower, consideration of Chinese performance in chemical sector, FDI utilization, quality of Indian intellectual property, industry-academic linkage, management of chemical R&D, transition from process to product patenting, outsourced chemical R&D and leveraging international expertise. Further details are provided in Annexure-I.

Presentation of Project Activities ..

Dr K V Raghavan

The Chairman, PRMC invited Dr Raghavan, PSI to present the progress made in the various activities of IRICI-INAE project. Dr Raghavan highlighted the progress achieved in important project activities viz., R&D Intensity Analysis, IP Management, Promoting new startups, University – Industry linkages and R&D impact on SMEs in industrial clusters.

Sri D P Misra

Sri DP Misra made a brief presentation on the "Role of Consultancy Agencies in promoting R&D commercialization in Indian chemical sector".

Dr Nirmalya Bagchi

He apprised the PRMC on the progress achieved in the 4 module national survey launched by him and Prof M Chandrasekhar of ASCI. He mentioned about the sluggish response received so far from the industry and sought some suggestions from PRMC to speed up the survey process.

Dr Neeraj Atrey

He briefly presented the progress achieved in preparing a special report on "R&D Impact on Indian Petrochemical sector".

Discussion

The members of PRMC actively participated in the discussion on various issues covered in the above presentation. The salient points of these interactions are highlighted below:

i. TIFAC studies on FDI to be consulted for any useful information relevant to Indian chemical sector.

ii. International restrictions on toxic chemicals and their effect on their growth in Indian chemical sector to be examined.

iii. TIFAC's project on Technology impact on Indian SMEs has some relevance to the present studies.

iv. GDP growth rate is dependent on the innovation capacity of a company to sustain long term market leadership.

v. The role of consultancy agencies is to fill in the knowledge gap between R&D institutions and industry in technology commercialization through the development of basic design package. There is a strong need to create special support mechanism for R&D institutions and the consultancy agencies to work together to develop prefeasibility and project reports and basic engineering packages. They can also identify potential users.

vi. The technological problems faced by SMEs in industrial clusters require special attention by the R&D and academic institutes.

vii. The members of PRMC felt that a letter from Dr Chidambaram to PSI, IRICI-INAE Project may be in order. The challenges of the national survey and the need to provide full support to INAE team by respondents to the survey questionnaires to be stressed.

viii. The PRMC is of the opinion that the R&D needs of SMEs in industrial estates / clusters have to be approached on a different footing. Suitable guidelines / incentives have to be evolved to facilitate participation of R&D and academic institutes to solve common and individual unit problems.

ix. The members of PRMC stressed the need to disseminate the very valuable information and analysis presented in the final report to larger audience viz., R&D and academic institutions (public and private), policy making bodies of the government and all segments of chemical industry in India. The PSI is advised to take necessary measures in this regard.

x. There may be a need for undertaking Phase-II studies of the present project which have to be focussed on modelling studies to relate R&D Intensity with several growth factors of Indian chemical sector, to evolve an innovation index based on the quality and quantity of intellectual property generated and protected, to evolve development models for SMEs in speciality and knowledge intensive chemical subsectors with innovation as the core strategy, human resource development model for future growth of Indian chemical sector and allied issues to be identified during the next 3 months. The proposed studies may require inputs of research groups with appropriate competency at IITs, IIMs and reputed Business schools in the country. The PSI is advised to prepare a draft proposal for consideration of the PRMC in the next meeting.

Dr Samir Somaiya, Members PRMC stressed the need to promote deeper relationship between academic institutions and the industry to respond to the challenges of global competitiveness in speciality and knowledge intensive chemical sectors. The private academic institutions can play a much greater role in this area. The developing countries like India need to make special efforts to promote the culture of setting up startup companies in high tech areas of the Indian chemical sector. He also stressed the need to activate and encourage available talent in the industry and academic institutions to be more and more innovative to tackle industry problems.

PRMC's Recommendations on Project Activity Schedule

a) The PRMC is keen to complete the IRICI-INAE Project activities by 27 November 2010 as approved by PSA. The PSI has to take all necessary steps to meet this deadline.

b) The second workshop for obtaining feedback from the chemical industry on the final recommendations of IRICI-INAE project is preferably held during 15-30 October 2010, to provide adequate time to incorporate the inputs from the industry in the final report. A separate interactive session with the carefully selected CEOs of the industry will be very useful for formulating corporate level policies and senior managerial solutions to some of the vital issues confronting the Indian chemical sector.

c) The third and the last PRMC meeting of IRICI-INAE project is proposed during the middle of November 2010 to enable PRMC to offer its views on the final recommendations of the ongoing studies.

In his closing Remarks, Dr Chidambaram, PSA advised that while analysing various factors in the final report, following two sceneries to be given due consideration.

a) Implications if "Business as Usual" approach is followed

b) Implications if "Changed Business Attitude" approach is adopted through appropriate S&T interventions.

He also stressed the need to make specific recommendations which outlines the new policy initiatives to be taken by the competent authorities / agencies.

The meeting ended with the vote of thanks to the chair.

ANNEXURE 1.6.1c

Minutes of 3rd PRMC Meeting of INAE Project on "R&D Impact on Indian Chemical Industry"

Date: 10th January 2011

Time: 10.30hrs

Venue: Vigyan Bhavan Annexe

New Delhi

Present

1.	Dr. PS Goel Chairman, RAC, DRDO	Chairman, PRMC
2.	Sri Sameer Samaiya CMD, GBRL, Mumbai	Member, PRMC
3.	Prof J P Gupta Director, RGI PJ, Rae Bareili	Member, PRMC
4.	Dr. K.V. Raghavan INAE Distinguished Professor	Principal Investigator
5.	Prof S V Raghavan Scientific Secretary to PSA	PSA Official
6.	Sri B Rajendiran Advisor, PSA Office	- do -
7.	Prof N Bagchi ASCI, Hyderabad	PI (Surveys)
8.	Sri D P Mishra Director, TCE, Mumbai	Project Consultant
9.	Dr Yogeshwar Rao Scientist G, IICT	Project Expert
10.	Brig Marwaha Hon Secretary, INAE	CO-PI
11.	Sri Soumitra Biswas Advisor, TIFAC	Special Invitee
12.	Ms. Sangeetha Baksi Scientist, TIFAC	Special Invitee
13.	Sri N Atray Scientists, IIP, Dehradun	Special Invitee
14.	Dr. R P Gupta Scientist 'E' (Retd), PSA Office and Former Member-Secretary, PRMC	Special Invitee

1.0 Preamble

Sri Somenath Ghosh, Chairman, PRMC could not attend the meeting due to his unforeseen engagement on 10th January 2011. Dr P S Goel, chairman RAC, DRDO chaired the PRMC Meeting in his absence. Dr. RP Gupta, Former Member Secretary, of PRMC is specially invited to attend the PRMC meeting.

Sri. B. Rajendiran, Advisor, PSA's office extended warm welcome to chairman and Members of PRMC, Senior Consultants and members of INAE Project and Special invitees to the meeting. He stated that a two member TIFAC team has been specially invited to attend the PRMC meeting in view of the relevance of their study on the impact of technology on Indian chemical industry to the INAE project.

Dr P S Goel, Chairman, in his opening remarks, stated that the present project is considered by INAE as the role model for its future project activities and the studies undertaken by the INAE team is quite revealing in several aspects. This PRMC meeting has been specially convened to deliberate on the draft recommendations of the project and he requested the members and the special invitees to be critical and objective in analysing the recommendations proposed by the INAE team. He stressed the need for the recommendations to be precise and action oriented with clear indications provided regarding the agencies that have to take actions for their implementation. He invited the PRMC members and invitees to make preliminary observations, if any.

1.1 Remarks by PRMC Members

Sri D P Mishra, Senior Consultant, (INAE Project), expressed concern over the poor response received from the chemical industry to the surveys conducted by the INAE team on specific issues. Prof SV Raghavan stated that dominant impact can be made by the newly generated intellectual property on the technological growth of chemical industry. This is evident from the rapid advances made by China in IP generation as well as its utilization by its chemical industry.

The chairman, PRMC brought to the notice of the members about its previous recommendation to analyse the implication of "Business as Usual Approcah" in relevant cases. Dr Raghavan confirmed that this aspect has been considered particularly in recommendations related to R&D Intentsity in SME sector, internationalization of intellectual property, environmental implications on future growth of Indian Chemical sector and allied issues.

1.2 Presentation of INAE PROJECT

The Chairman, PRMC then invited Dr KV Raghavan PSI, INAE Project to make an overview presentation on the major findings of the INAE study and suggested recommendations for the benefit of PRMC. DR. Raghavan presented following with respect to the Indian Chemical Industry:

1) Current size and Reach
2) R&D Intensity, Investments, FDI and Exim performance
3) IP Management
4) R&D Access to SME's
5) Strengthening University – Industry Linkages
6) Effectiveness of Govt supported R&D Commercialization programmes
7) Enhancing HR quality in chemical R&D
8) Information Deficiency Areas.

A copy of his presentation is enclosed herewith as an Annexure.

1.3 PRMC's observations

The PRMC members and special invitees actively participated in the post presentation interactions. The salient points which emerged from these interactions are:

1) SEZ's and their role in enhancing R&D access to SME's to be examined
2) Effect of REACH and other International Environmental Regulations on future growth of Indian Chemical Industry needs to be analysed carefully and appropriate actions to be specified in the INAE Report.
3) The strengths and weaknesses of PCPIR policy of Government of India with reference to enhancing R&D intensity in petrochemical and downstream sectors to be discussed report.
4) Indian medium scale companies are more aggressive as compared to their large counterparts as well as MNC's in boosting Indian Chemical exports. The role of FDI in boosting exports may be of secondary importance to the former.
5) Indian record is impressive with regard to FDI/GDP Ratio as per recent Times of India report. The INAE report should cover this aspect with reference to Indian export/FDI performance.
6) Sustainability of R&D in SME Sector is vital for future growth of Indian Chemical Industry.
7) Under changing paradiagms of modern technology intensive industries, the passion for S&T driven growth alone provides the main driving force for innovation.
8) The issues pertaining to FDI utilization for R&D and modernization of Indian Chemical Sector and Internationalization of its IP have to be carefully analysed and appropriate recommendations to be made in such a way that their growth momentum is maintained.
9) It will be useful to identify the determinants for acquisitions of new technologies for the Indian Chemical Sector.
10) The success stories in university-industry linkage in Indian Chemical Sector have to be brought out in the INAE Report. The Committee is happy that ICT case study is being covered in the final report.
11) The main reasons for their suboptimal performance of several sectors in Indian Chemical industry with reference to patenting to be discussed in the report.
12) Process intensification efforts are vital for enhancing the environmental acceptability and for minimizing material and energy consumption in existing and future processes to be employed by the Indian Chemical Industry. This should be one of the main focus areas for R&D in chemical industry to address environmental concerns.

1.4 Presentation on Surveys by ASCI

Prof N Bagchi, Principal Investigator, ASCI (Hyderabad) presented the results of the surveys conducted by their group. He stated that the response from the industry has been very poor inspite of sending several remainders. The PRMC expressed its disappointment with the survey results. It has recommended that only important results which have acceptable level of responses and standard deviations to be included in the report. They include key determinants for technology acquisition, commercially important terms and glitches in technology transfer, patent utilization, level of confidence between manufacturing and R&D wings of chemical industry and allied factors.

1.5 Presentation on the Role of Consultancy Agencies on R&D Commercialization

Sri D P Mishra, Senior Consultant made the presentation. He highlighted the main functions and engineering capabilities of Indian Consultancy companies and few success stories. The chairman sought from Sri Mishra, specific recommendation on the precise mechanism to be adopted by the consultancy agencies (both knowledge and engineering consultancies) in R&D commercialization in SMEs in general and MEs in particular. The nature of support required from government and mode of its delivery to the industry also needs to be specified.

1.6 Presentation by the TIFAC Team

The presentation has been made by Sri S.Biswas and Mrs. Sangeeta Bakshi of TIFAC on the ongoing TIFAC studies on "Indian knowledge chemical Industry – technology Imperatives and Business Opportunities". The presentation covered the identification of technology gaps, academia-industry linkages, process intensification, technology absorption capabilities of Indian SME's etc.,

The Chairman appreciated the TIFAC efforts in the above areas and their relevance to INAE study. He expressed satisfaction that INAE and TIFAC teams will consult each other on issues of mutual interest. This will benefit both projects. Dr. Raghavan will be visiting TIFAC shortly to continue exchange of ideas on vital issues and information exchange between the above projects.

1.7 Actions to be taken by INAE Team for Project completion:

The PRMC discussed all aspects pertaining to project completion and made following recommendations.

1. The Draft Recommendations chapter of INAE Report will be circulated to Chairman and Members of PRMC for their comments by 31st January 2011. The Chairman requested PRMC members to offer their comments within a week i.e. by the end of first week of February 2011.
2. Dr. K V Raghavan, Sri D P Mishra, Sri Samir Somaiya and Dr. Yogeshwara Rao will meet at Mumbai during 20 – 25 January2011 to give a final shape to the recommendation pertaining to the enhancement of the effectiveness of government supported R&D commercialization programme for small, medium and large chemical companies.
3. The draft INAE report, complete in all respects to be sent to the chairman and Members of PRMC by the end of February 2011. Their response to be given to Dr Raghavan within 10 days. Efforts should be made to submit three copies of the Final report to Dr Chidambaram, PSA by 31st March 2011. Simultaneously action to be taken to print (under the aegis of INAE) adequate copies of the report for wide circulation to the government agencies, chemical industry, R&D / academic institutions and other stake holders.
4. The INAE Project Accounts to be formally closed on 31st March 2011 after fulfilling all financial commitments. The INAE to provide project fund utilization details to PSA's office by the middle of April 2011.

The meeting ended with vote of thanks to the chair.

ANNEXURE – 1.6.2a

MINUTES OF THE FIRST MEETING OF THE CONSULTANTS OF IRICI-INAE PROJECT HELD ON 17TH JULY 2009 AT REACTION ENGINEERING LABORTORY, IICT, HYDERABAD.

Following were present:

1.	Dr.K.V. Raghavan	Principal Scientific Investigator (PSI)
2.	Dr.M.O.Garg	Consultant
3.	Sri D.P.Misra	Consultant
4.	Prof.A.N.Maitra	Consultant
5.	Dr.D.Yogeswara Rao	Special Invitee
6.	Sri G.A.Reddy	Special Invitee

Dr.K.V.Raghavan, Principal Scientific Investigator (PSI) of the project welcomed the consultants and special invitees to the meeting and highlighted the genesis and importance of the project to the Indian Chemical Industry and its unique features viz., the first project of its kind handled by INAE and the first attempt to make a microanalysis of the R&D Impact on the Indian chemical sector. He also stated that the project activities have to be executed through a Task Force consisting of 4 consultants with one of them acting as the PSI.

Dr.Raghavan made a detailed presentation (Annexure 1)* of the proposed activities of the project, their relevance to the chemical industry and the scientific challenges associated with the analysis of various factors contributing to the R&D Impact on the Indian Chemical Sector. During the presentation and later during the detailed interaction, the following points emerged:

1. The total investment of the Indian Chemical Sector including petroleum and petrochemicals sectors is around 100 billion US$ and the market size is about 60 billion US$.

2. The R&D should include (a) Research efforts by Indian institutes, (b) adaptation of research imported from other countries and (c) R&D executed by the overseas R&D centres established in India.

3. A distinction has to be made between licensing of technology, knowledge, services and the results of R&D while analysing the impact of R&D.

4. It is noted that the chemical sector is classified into following 3 main categories for the purpose of the analysis namely Basic chemicals, Specialities and Knowledge chemicals and following sub categories:

** Already handed over to the Consultants on 17th July 2009.*

1. Basic Chemicals

1.1 Organic, Inorganics and Intermediates

1.2 Fertilizers

1.3 Petroleum and Petrochemicals

1.4 Gas based chemical

2. Specialities

- 2.1 Plastics and Polymers
- 2.2 Coatings and Colorants
- 2.3 Sealants and Adhesives
- 2.4 Construction Chemicals
- 2.5 Lipids and Cosmetics
- 2.6 Oilwell additives
- 2.7 Food Additives
- 2.8 Cosmetics, favours and fragrances
- 2.9 Leather chemicals

3. Knowledge Intensive Chemical

- 3.1 Drugs and Pharmaceuticals
- 3.2 Agrochemicals
- 3.3 High Spectrum Bioproducts and Biotech based chemical products.

5. While petroleum exploration sector is outside the scope of the studies on chemical sector, the petroleum refining involving physicochemical processing of crude oil to be considered as the part of the petrochemical sub-sector.

6. Flavours and Fragrances and Leather Chemicals to be added to the list of Specialities sub-sector.

7. The Biotechnology and Bioproducts of relevance to chemical sector should be included as part of the knowledge chemical sector.

8. About 70 associations exist in India to look after the professional, business and other interests of chemical sector. There is need to involve them and seek their inputs, whenever needed, on important issues related to IRICI-INAE Project.

9. Among the institutions to be approached by the management of the IRICI-INAE project for possible assistance, following have been identified at this stage:

- ❖ Indian Institute of Chemical Technology, Hyderabad
- ❖ National Chemical Laboratory, Pune
- ❖ Indian Institute of Petroleum, Dehradun
- ❖ Administrative Staff College of India, Hyderabad
- ❖ Indian Institutes of Technology
- ❖ Institute of Chemical Technology, Mumbai

- ❖ TCE Consulting Engineers, Mumbai
- ❖ Indian Chemical Council, Mumbai
- ❖ Sectorial Industry Associations including Bulk Drugs Manufacturers Association
- ❖ Patent Research Unit of Govt. of India
- ❖ CSIR, DST,DBT,DSIR,MOEF, DRDO, ISRO,AEC etc.,
- ❖ CPCB and Maharashtra, Gujarat and Tamilnadu Pollution Control Boards

More such institutions will be added to the list from time to time as per the advice of consultants. Their contributions to the project will be acknowledged.

10. There may be a need for consulting the Central Pollution Control Board (CPCB), and Pollution Control Boards of Maharashtra, Gujarat, Tamilnadu and other states on environmental issues relevant to the proposed study.

11. R&D intensity is an important factor to be analyzed by the project team and its impact can be much more broad based than anticipated at this stage.

12. Impact of short, medium and long term research in chemical sector need to be examined wherever it is appropriate.

13. Idea patenting is prevalent in developed countries and it will be interesting to see how far this concept has taken its roots in Indian Chemical sector.

14. On the subject of human capital and turnover, there is need to examine the leadership role or lack of it in the execution of R&D programmes, nurturing bright talent and enhance mobility of scientific personnel through chemical industry – academic linkages.

15. The utilization of new knowledge generated through Indian or overseas R&D by the Indian Chemical sector need to be analysed in terms of its scientific, business and social impact making capabilities.

16. The extent of success or failure of Entrepreneur Development Programmes (EDP) in Indian Chemical Sector need to be assessed.

17. The use of reinvented technologies in Indian Chemical Sector and the complementary role of engineering R&D to promote commercialization of chemical technologies need to be addressed.

The PSI has requested the consults to consider above issues relevant to their studies:

He invited the consultants to provide following information to him on or before 15th August 2009:

a) Revised list of issues to be examined under each subject allocated to them

b) Approximate financial support (within the suggested limit) required to execute their activities and the break up in terms of consumables, honoraria to supporting staff and experts, expenditure, if any, for mini survey(s) or group meetings to be held at local level and priced information collection through internet etc.

c) Questions suggested for National Survey at this stage of project execution

d) Mode of providing financial support viz., advance payment (Rs.30,000/-) followed by additional support (within the agreed limits) on submission of vouchers or reimbursement of costs through cheques.

Organisational Aspects of IRICI – INAE Project

The team of consultants discussed the organisational aspects of the IRICI-INAE project. They expressed the need to make the project implementation procedures as simple and flexible as possible for speedy execution of the plan and activities. Each consultant should have the facility to select local experts and seek support from local institutions for speedier execution of their respective tasks. The team of consultants have noted that Rs.14.00 Lakhs have been earmarked for activities to be executed by the consultants. They expressed the need to earmark a minimum of Rs.1.00 Lakh per consultant to facilitate hiring local consultants, payment of honoraria to experts / S&T personnel engaged for short duration, execution of specific tasks with the help of local institutions, organisation of mini opinion surveys on vital issues, and procurement of consumables required for their project activities. The Principal Scientific Investigator has agreed to discuss these issues with INAE management for facilitation. The team of consultants have also noted that adequate funds have been earmarked for conducting a national survey and a workshop which are very important tools to obtain industry's feedback on the recommendations of INAE project team. The consultants are in agreement with the budget allocation made with reference to other heads. The details are given below:

Total Budget Allocation : Rs.36.25 Lakhs

Break up

1. Consultancy	:	39%
2. Advisory / Supporting Services	:	16.5%
3. Survey/Workshop Organisation	:	16.5%
4. Travel	:	8%
5. Institutional Overheads	:	20%

Allocation of Project Responsibilities to Consultants

The consultants, after detailed discussions, agreed to the following subject allocation:

1. Dr.K.V.Ragahvan (Consultant 1)

- Fostering new entrepreneurs / start ups
- Generation of intellectual property and its utilization
- National workshop Organisation

2. Sri D.P.Misra (Consultant 2)

- R&D intensity & investment
- R&D Impact on export / import of basic & knowledge chemicals
- National Survey Organisation

3. **Dr.M.O.Garg** **(Consultant 3)**

- Utilization of Govt. funded R&D / benefits
- Utilization of new knowledge / services as a result of R&D

4. **Prof.A.N.Maitra** **(Consultant 4)**

- R&D linkage with universities / research institutes
- Human capital and its turnover

It can be seen the Consultants 1&2 have been entrusted with additional responsibilities of the national survey and workshop organisation. In addition, Dr.Raghavan will also undertake additional administrative, managerial and financial management responsibility of IRICI-INAE Project.

Project Personnel

There is no proposal to appoint any S&T personnel on full time basis except for two research scholars at the project secretariat.

1. The consultants have noted that two Project Officers / Advisors will be engaged on part time basis by the PSI to be stationed at the project secretariat at IICT, Hyderabad to provide support to all consultants in data acquisition, scientific analysis, and interpretation of results with reference to their subjects. They will be assisted by the two full time Research Scholars / Associates to be engaged by the PSI from the project funds. The basic objective is to help the consultants to make the project findings most scientific, innovative and highly analytical.

2. The rough basis for fixing the financial compensation to the personnel engaged by the consultants on part time basis is as follows. This is keeping in view, limited funds available with the project for such activities. The following figures are merely indicative:

   a) Honoraria to support part time services of personnel Rs.

   employed by an existing institution

   - Scientific 200 – 300/day
   - Technical 150 – 200/day
   - Administrative 100 – 150/day

   b) Honoraria for Resource Persons / Experts engaged

   for short duration (< 3 months) on part time basis 2000 – 3000/day

   c) Student Trainees (full time) engaged upto 6 months 1000 – 2000/month

   d) Full time Research Scholars / Associates 10,000 – 15,000 per month

Financial Transactions

The PSI has been authorised to open a bank account by the INAE for IRICI-INAE Project at SBH, IICT Branch, Hyderabad to receive project grants from INAE, New Delhi from time to time and to incur expenditure on various heads of the project. The PSI and one of the Project Officers will sign the cheques on behalf of IRICI-INAE Project. There is provision for paying an advance amount to consultants to incur their project expenditure or reimburse the same on submission of necessary documents to PSI.

Time Frame for Execution of the project

The consultants have noted the overall timeframe as indicated by the programme sponsors. Eventhough nearly 2 months have already elapsed before the commencement of project activities, the PSI indicated that INAE is keen to complete the project activities as per the deadline prescribed by the sponsor by hastening the process of execution of project activities during the first and second quarters. The consultants agreed to make all efforts to achieve this target. Accordingly, during the first and second quarters, the following activities will be hastened as indicated below:

1. Data acquisition and gap analysis .. Completion in 2 months instead of 3 months

2. Identification of issues for survey questionnaire … 2 months instead of 3 months

   This will enable the execution of survey and analysis of results to start from the beginning of the second quarter as planned. The revised time schedule is enclosed herewith (Annexure-II)

3. Sri D.P.Misra suggested that an initial interaction meeting with important representatives of various sub-sectors of chemical industry may be held during the last week of September 2009 at Mumbai under the auspices of Indian Chemical Council (ICC). The participants endorsed this suggestion and requested Sri D.P.Misra to take necessary measures to hold the proposed industry meet.

4. The next meeting of the consultants is proposed during the end of September 2009 possibly at Mumbai either during or after the proposed meeting with industry association.

ANNEXURE 1.6.2b

Agenda for the IRICI-INAE Project Consultants Meeting on

23rd June 2010

Venue: Committee Room

IICT,Hyderabad

Time: 10.30 hrs

10:30		WELCOME AND INTRODUCTIONS	
SESSION – 1:			
R&D INTENSITY AND IP MANAGEMENT IN INDIAN CHEMICAL SECTOR			
10:45hrs	1.1	R&D INTENSITY AND EXPORTS/IMPORTS	
		- Overview & Progress	DR. K.V.RAGHAVAN
		- Remarks on status and	
		- Role of Consultancy Agencies	Sri. D.P. MISHRA
		- Discussions on Future actions	
11:30hrs	1.2	IP MANAGEMENT	
		- Overview & Progress	DR. K.V. RAGHAVAN
		- Presentation on Status	DR(MRS)J.ANNAPURNA
		- Discussions on Future actions	
SESSION - 2:			
SURVEYS AND WORKSHOPS			
12:15hrs	2.1	NATIONAL SURVEYS ON R&D IMPACT ONCHEMICAL INDUSTRY	ASCI EXPERTS
12:45hrs	2.2	NATIONAL WORKSHOP IN SEPT 2010	DR.K.V. RAGHAVAN D.P. MISHRA
LUNCH			
SESSION – 3 :			
R&D UTILIZATION BY INDIAN CHEMICAL SECTOR.			
14:00hrs	3.1	GOVT FUNDED R&D PROGRAMMES	
		- Overview & Progress	Dr K V Raghavan
		- Remarks on Status	Dr. MO. Garg
		- Presentation on R&D Impact on Indian Petro-Chemical sector	Sri.N.Atray
14:45hrS	3.2	UNIVERSITY – CHEMICAL INDUSTRY LINKAGE	
		- Overview & Progress	Dr. K.V.Raghavan
		- Remarks on Status	Prof. A.N.Maitra Sri. A. Narasimha Rao
15:15hrS	3.3	R&D UTILIZATION BY SME SECTOR	
		- Overview & Progress	Dr K V Raghavan
		- Presentation on Status	Sri. G.A.Reddy
15:45hrs	3.4	OBSERVATIONS ON PROJECT APPROACH AND GOVT. FUNDED R&D PROGRAMMES	Dr. D Yogeshwara Rao
16:00hrs		FINAL REMARKS AND VOTE OF THANKS.	Dr K V Raghavan

ANNEXURE 1.6.3a

Two-day Workshop on

R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

on 4/5 December 2009

at TRIDENT HOTEL, C-56, G Block, Bandra Kurla Complex, Mumbai – 400 098.

P R O G R A M M E

DAY-ONE: Friday, 4 December 2009		
09.30 a.m. – 10.00 a.m.	REGISTRATION	
INAUGURAL SESSION		
10.00 a.m. – 10.45 a.m.	***Welcome Address:*** Mr. Jai Hiremath, President, Indian Chemical Council	
	Introductory Remark: Mr. D. P. Misra, Director, TCE Consulting Engineers Limited	
	Inaugural Address: Padmavibhushan Dr. M. M. Sharma, Former Director, Institute of Chemical Technology	
	Vote of Thanks: Mr. H. S. Karangle, Director General, Indian Chemical Council	
10.45 a.m. – 11.00 a.m.	TEA	
Technical Session – I : **R&D Impact on Indian Chemical Sector – Basic Issues**		
11.00 a.m. – 11.40 p.m.	R&D Impact on Indian Chemical Sector – Current Status and Future Prospects	**Dr. K. V. Raghavan** INAE Distinguished Professor IICT, Hyderabad

11.40 a.m. – 12.10 p.m.	R&D Commercialization in Chemical Sector – Major Issues	**Mr. Somenath Ghosh** Managing Director National Research Development Corporation Mumbai
12.10 p.m. – 12.40 p.m.	Government Supported Initiatives for Technology Commercialization Current Status and Future Directions	**Dr. D. Yogeswara Rao** Scientist "G", Indian Institute of Chemical Technology Hyderabad
12.40 p.m. – 01.10 p.m.	Technology Imperatives and Business Opportunities in Indian Chemical Industry Intense R&D for Self Reliance – Talcher Experience	**Dr. P. R. Mohanty** Associate Director Heavy Water Plant
01.10 p.m. 01.50 p.m.	LUNCH	
TECHNICAL SESSION – II: **R&D Impact on Basic Speciality & Knowledge Chemical Sectors – Industry view Point**		
01.50 p.m. – 02.30 p.m.	Commercialization of R&D Initiatives by ICT	**Prof. G. D. Yadav** Director Institute of Chemical Technology, Mumbai
02.30 p.m. – 03.00 .m.	R&D Impact on Basic Speciality & Knowledge Chemical Sectors – Industry View Point	**Dr. Surendra Kulkarni** Director – Global R&D Centre Dow Chemical International Pvt. Ltd.
03.00 p.m. – 03.15 p.m.	**Tea**	

03.15 p.m. – 03.50 p.m.	Indian Pharmaceutical Sector	*** Dr. J. M. Khanna** JUBILANT ORGANOSYS LTD
03.50 p.m. – 04.20 p.m.	Technology Parks and Business Incubators for Promoting Start Up Companies in Chemical Sector	**Dr. Jitendra Kumar** Vice President ICICI Knowledge Park, Hyderabad
DAY-TWO: Saturday, 5 December 2009		
TECHNICAL SESSION – III : **R&D Impact on Indian Chemical Sub-Sectors – Current Status**		
09.30 a.m. – 10.00 a.m.	Impact of R&D on Indian Petrochemical and Gas Based Chemical Sectors	**Dr. M. O. Garg** Director Indian Institute of Petroleum, Dehradun
10.00 a.m. – 10.30 a.m.	R&D Development needs for Indian Chemical Industry	**Dr. Hamid Bhambal** Sr. President Aditya Birla Group
10.30 a.m. – 11.00 a.m.	Impact of R&D on Indian Fertilizer Sector	**Mr. B. Nagraj** General Manager Rashtriya Chemicals & Fertilizers Ltd.
11.00 a.m.- 11.15 a.m	TEA	
11.15 a.m. – 11.45 a.m	Impact of R&D on Indian Speciality Chemical Sector	***Specialist Invited**

<table>
<tr><td>11.45 noon –
12.15 p.m.</td><td>Impact of R&D on Indian Inorganic and Chlor Alkali Sectors</td><td>Dr. Arup Basu
COO – Chemical India
TATA CHEMICALS LTD.</td></tr>
<tr><td>12.15 p.m. –
12.45 p.m.</td><td>Impact of R&D on Indian Agro Chemical Sector</td><td>Dr. Arun V. Dhuri
Vice President
Excel Industries Ltd</td></tr>
<tr><td>12.45 p.m. –
01.15 p.m.</td><td>Technology Imperatives and Business Opportunity in Indian Chemical Industry.</td><td>Ms. Sangeeta Bakshi
Scientist “D”
Technology Information, Forecasting & Assessment Council (TIFAC), New Delhi</td></tr>
<tr><td>01.15 p.m.-
02.00 p.m.</td><td colspan="2">LUNCH</td></tr>
<tr><td colspan="3">Panel Discussion: Identification of Issues and Methodologies for Objective Assessment of R&D Impact on Indian Chemical Sector
Chairman and Moderator: Dr. K. V. Raghavan, INAE Distinguished Professor</td></tr>
<tr><td>02.00 p.m.-</td><td colspan="2">Panelists:
Mr. D. P. Misra, Director, TCE Consulting Engineers Limited
Retd. Prof. A. N. Maitra, Delhi University
Dr. Hamid Bhambal, Sr. President, Aditya Birla Group
Dr. M. O. Garg, Director, IIP, Dehradun
Dr. Arup Basu, COO – Chemical India, Tata Chemicals Ltd.
3 Speakers from Technical Session 2 representing 3 major Chemical Sectors</td></tr>
<tr><td></td><td colspan="2">Closing Remarks</td></tr>
</table>

*Confirmation Awaited

ANNEXURE 1.6.3b

One-day Brainstorming Workshop on

R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

on 8 November 2010 at Terrace Hall, West End Hotel, Mumbai

PROGRAM

09.30 a.m.- 10.00 a.m.	**Registration**
Inaugural Session **Presided by Padmavibhushan Prof. M. M. Sharma,** Former Director, Institute of Chemical Technology, Mumbai	
10.00 a.m.- 10.30 a.m.	**Address by:** **Mr. R. Parthasarathy,** President, Indian Chemical Council (ICC) **and** **Dr. Prem Shanker Goel,** President, Indian National Academy of Engineering(INAE)
	Inaugural Address: **Dr. R. Chidambaram**, Principal Scientific Advisor, Government of India
	Theme of the Workshop: **Dr. K. V. Raghavan,** Principal Scientific Investigator of INAE Project
10.30 a.m. 11.00 a.m.	**TEA BREAK**
Technical Session I	

11.00 a.m. 12.15 p.m.	**Overall and Sectoral R&D Intensity Profiles of Indian Chemical Sector** Current Scenario (National & Global) R&D Intensity Trends and their implications on industry performance and accruel of techno economic benefits Measures to improve R&D Intensity in various subsectors	**Mr. D. P. Misra** Director Tata Consulting Engineers Ltd.
	A Case Study on R&D Impact on Indian Petrochemical Industry	**Dr. M. O. Garg,** Director Indian Institute of Petroleum
Technical Session II		
12.15 p.m. 01.30 p.m.	**Intellectual Property Generation, Protection and Utilization in Indian Chemical Sector** Current Scenario (National and Global) Impact of Internationalization of Knowledge Measures for Enhancing Protected Intellectual Property Generation Technological Growth Trends	**Dr. K. V. Raghavan** Principal Scientific Investigator of INAE Project
01.30 p.m.- 02.15 p.m.	**LUNCH BREAK**	
Technical Session III		
02.15 p.m.- 03.30 p.m.	**R&D Support Systems, University – Industry Linkages and New Startups** Current Scenario (national and international) Policy initiatives and Techno Economic Measures for facilitating Innovative Knowledge Sectoral Strategies for Promoting new startups Incentives driven approaches for R&D Commercialization by SME's	**Dr. K. V. Raghavan** Principal Scientific Investigator of INAE Project **and** **Prof. A. N. Maitra**

	Factors and driving forces to forge Strong University Industry Linkages	**Prof. G. D. Yadav,** Director Institute of Chemical Technology Mumbai
03.30 p.m.- 03.45 p.m.	**TEA BREAK**	
Technical Session : IV		
03.45 p.m.- 05.00 p.m.	**Government Support to R&D Commercialization** Current Programs (strengths and weakness analysis Future approaches for innovative product / process development and scale up New Policy frame works needed for enhanced outputs	**Dr. Yogeshwara Rao,** Sc. G. Indian Institute of Chemical Technology, Hyderabad
05.00 p.m.- 05.30 p.m.	**Valedictory Session**	

Office of the Principal Scientific Adviser to the GOI Prof. S.V. Raghavan, Scientific Secretary Email : svr@cs.iitm.ernet.in
Shri B. Rajendiran, Adviser Email : b.rajendiran@nic.in
PRMC Chairman & Members Shri Somenath Ghosh, Chairman Chairman & Managing Director, National Research Development Corporation, New Delhi. Email: sghosh@nrdc.in
Shri Samir Somaiya, Member Executive Director Bhawan 45/47, Mahatma Gandhi Road, Fort Mumbai - 400 001 E-mail : samir@somaiya.com
Dr. J. P Gupta, Member Professor, Department of Chemical Engineering, IIT, Kanpur E-mail : jpg@iitk.ac.in
Prof. M.K. Surappa, Co-opt Member Director Indian Institute of Technology Ropar Nangal Road, Rupnagar - 140001 Email : director@iitr.ac.in

PRMC Principal Investigator and Co-Investigator Dr. K.V. Raghavan, INAE Distinguished Professor, Reaction Engineering Lab. Indian Institute of Chemical Technology (IICT), Tarnaka, Uppal Road, Hyderabad Email : kondapuramiict@yahoo.com	Principal Investigator
Brig SC Marwaha, VSM (Retd.), Indian National Academy of Engineering, 6th Floor, Vishwakarma Bhawan, IIT Campus, Shaheed Jeet Singh Marg, New Delhi – 110 016. Email : inaehq@inae.org	Co- Investigator
Special Invitee Dr. P.S. Goel, Chairman Recruitment and Assessment Centre (RAC) Delhi, Email : dr.psgoel@gmail.com	Special Invitee
Dr. M.J. Zarabi, Vice President (Finance & Establishment) INAE, 6thFloor, Vishwakarma Bhawan, IIT Campus, Shaheed Jeet Singh Marg, New Delhi Email : mjzarabi@yahoo.co.in	Special Invitee
Shri Soumitra Biswas, Adviser, TIFAC Email : compotifac@gmail.com	Special Invitee
Dr. R.P. Gupta, Former Member Secretary, PRMC Email : guptarp@yahoo.com, rpgpsa@nic.in	Special Invitee

One-day Brainstorming Workshop on

R&D IMPACT ON INDIAN CHEMICAL INDUSTRY

on 8 November 2010 at Terrace Hall, West End Hotel, Mumbai

PARTICIPANT

	Mr. Rajen Mariwala Managing Director	HINDUSTAN POLYAMIDES & FIBRES LTD.
	Mr. Z. F. Lashkari	YEZPER CONSULTANTS
	Dr. Prakash Trivedi Sr. Corporate Adviser to Sustainable Chemistry	SOLVAY INDIA
	Prof. Dr. G. D. Yadav Director	INSTITUTE OF CHEMICAL TECHOLOGY
	Dr. Mrs. Sangeeta Srivastava General Manager – Corp. R&D	GODAVARI BIOREFINERIES LTD.
	Mr. S. R. Lohokare Chairman Technology & Energy Expert Committee	INDIAN CHEMICAL COUNCIL

INDIAN CHEMICAL COUNCIL

REGISTRATION FORM

Date : ____________
The Secretary General
INDIAN CHEMICAL COUNCIL

A-6/E, Munirka(DDA Flats)
New Delhi-110067 TelFax: 26192910
E-mail: iccnro@gmail.com
iccnri@iccmail.in

Sub : Seminar on the Global Harmonized System and Chemical Classification & Labeling **on Friday the 26th November 2010 At Magnolia Hall, India Habitat Centre, Lodhi Road, New Delhi**

Dear Sir,

With reference to your Circular dated 19th October 2010, we are deputing following representative/s from our organization to attend the Seminar:

Name of Participant	**Designation**	**Contact Details** (Tel / Fax / E-mail)

Registration Charges : Rs.3,000/- per delegate
For ICC,AMAI, FAI members registration fee will be Rs2500

We are enclosing herewith our Cheque / Demand Draft No. ____________ dated ____________ for Rs. ______________ being the Registration Fee.

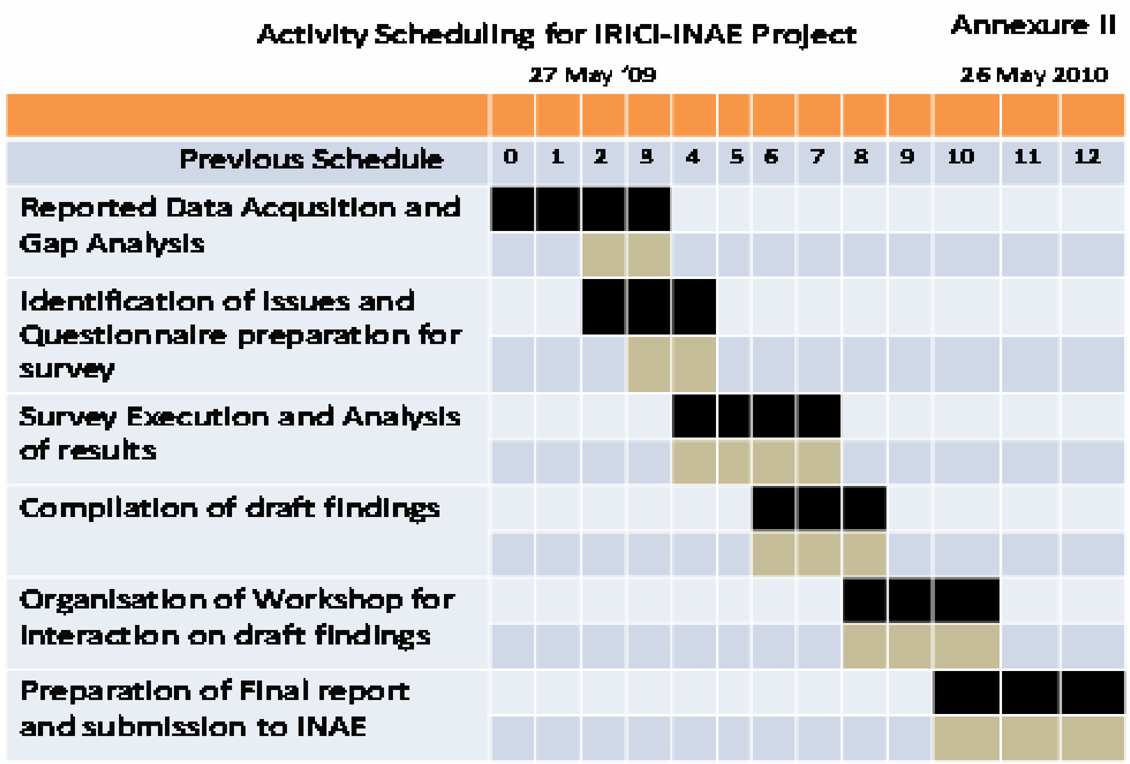
Thanking you,

Yours faithfully,

Name: ________________________________ *Signature:* ______________________

Name of the Organisation : ________________________________
Address : ________________________________
____
____
Tel. Nos. : ________________________________
Fax No. : ________________________________
E-mail : ________________________________

Kindly draw the Cheque/Demand Draft in favour of
INDIAN CHEMICAL COUNCIL


Activity Scheduling for IRICI-INAE Project
Annexure II
27 May '09
26 May 2010
Previous Schedule
0 1 2 3 4 5 6 7 8 9 10 11 12
Reported Data Acqusition and Gap Analysis
Identification of Issues and Questionnaire preparation for survey
Survey Execution and Analysis of results
Compilation of draft findings
Organisation of Workshop for interaction on draft findings
Preparation of Final report and submission to INAE

ANNEXURE 1.6.4
Prn.SA/SAC-C(20)/2010
Dated 4th October, 2010

Dear Sir/Madam,

A copy of the 'Summary Records of Discussion' of the twentieth meeting of the Scientific Advisory Committee to the Cabinet (SAC-C) held on 7th September, 2010 at New Delhi, is sent herewith for your kind information. This can also be viewed from our office website www.psa.gov.in.

This issues with the approval of the Principal Scientific Adviser to the Government of India and the Chairman, SAC-C.

With regards,

Yours sincerely,

(B. Rajendiran)

Encl.: As stated above

M20A3 ***Impact of R&D on Indian Chemical Industry by Dr. K.V. Raghavan, Principal Scientific Investigator, Reaction Engineering Laboratory, Indian Institute of Chemical Technology, Hyderabad (Appendix 'D').***

Dr. K.V. Raghavan, in his presentation, covered various aspects of R&D sector in chemical industry. Specifically, he brought out the details related to the following aspects.

- *R&D intensity (R&DI)*
- *IP management*
- *Government funded R&D utilization*
- *University-Industry linkage*
- *HR Management*
- *R&D for SMEs in clusters*
- *Launching new start-ups*

Important details presented were:

- *The R&DI, intensity which is defined as R&D expenditure expressed as share of industry output, has on the overall remained same from 1998-2008. However the R&DI of knowledge intensive pharma sector, had increased from 2.8 to 4.5%.*
- *Though the general R&DI for India is lowest at 0.75% the public sector contribution is the highest at 80%. However, in pharma industry, R&DI is 4.5% in India as against 16.7% in USA.*
- *Significant differences in turnover thresholds for R&D spending in chemical sector exist among the sub-sectors. For example R&D spending happens after a threshold*

turnover of about Rs. 50 crores in fertilizer sector as against Rs. 1 crore in agriculture sector.

- *In export/import performance of chemical sector, basic chemicals have not import whereas speciality chemicals and knowledge incentives have net exports.*
- *Indian chemical sector contribution to global research publication is 4.4% (9^{th} position) and in patents a very meager share of less than 0.6%.*
- *Among the S&T disciplines within the country, the chemical sector's share in publications is about 35% and in patents about 37%. However, contribution to patents is decreasing every year.*
- *Patenting and publications in organic chemistry are more as compared to other sectors in chemical industry.*
- *Product patents are less as compared to process patents.*
- *Major efforts are needed to attract industry participation in the research projects of academia.*
- *In SMEs, food, pharma and speciality chemical industries form the major segment of chemical sector. R&D intensity is very low in general except in pharma sector.*

Dr. R. Chidambaram appreciated the efforts made by the project team to collect and analyse enormous data on Indian Chemical industry.

During the discussions subsequent to this presentation, Dr. T. Ramasami commented that the size of the Indian chemical sector is big and heterogeneous. The size of knowledge intensive sectors like pharmaceuticals, biotechnology etc., is small and their overall impact will be marginal. The impact of current and future environmental regulations on Indian Chemical Sector need to be considered. The R&D in SMEs and corporate sector in Indian chemical industry operate on economies of scope and scale respectively and their R&D structure is accordingly very different. The corporate sector requires globally competitive generic technologies of high public consumption. It operates on global compulsions of investment. The Petroleum/ Petrochemical sector is generally low on R&D intensity. While evolving final recommendations on R&D impact on Indian chemical sector, there is need to select appropriate subsectors depending on their size and level of impact and particularly look at their natural advantage in India. The strategy for choice of sectors for R&D intensity growth should be on a disaggregated approach and the ratio of cost of material to product value could be one of the guiding factors. There is need to examine the value proposition of R&D in Indian chemical sector. There is better scope for R&D in sectors where raw material cost is less than 50% of operating cost.

Dr. S. Sivaram expressed the opinion that for several sectors of Indian chemical industry, their survival is not R&D dependent. A deeper analysis made by him on certain sectors had shown that the factors like better supply chain have much higher impact on the new investments as compared to R&D. As far as pharmaceutical sector is concerned, the R&D is both process and product oriented. This sector operates on growing global market and long term sustenance depends on it. He could foresee huge opportunities and space for speciality chemical sector to grow in India. The main problem is its highly scattered nature. Reengineering of products should be the main focus area for its growth in India. He suggested that there is a need to identify suitable resource bases for Indian chemical sector which are sustainable. As an example, he cited the availability of cellulose in abundance.

Prof. P. Balaram stated that as far research in India is concerned it should be based on maximization of originality and utility. The main roadblock in the case of former is lack of clarity on what to maximize.

Dr. Jamshed J. Irani mentioned that there is scope for consolidation in case of Indian SMEs. If not done, their life span can be curtailed. It will be interesting to study the rate of extinction of SMEs in Indian chemical sector.

The Chairman, SAC-C invited Dr. K.V. Raghavan to respond to the observations made by the members. While thanking the Chairman and members of SAC-C for their valuable suggestions, Dr. K.V. Raghavan stated the following:

- *The final analysis will be on sectoral basis and high impacting R&D areas with natural advantage to India will be prioritized. The heterogeneity of Indian chemical sector has received due attention.*
- *The impact on environmental regulations will receive attention.*
- *The Indian speciality chemical sector which has a flat R&D intensity profile during last 20 years definitely needs higher growth rate.*
- *Enhancing R&D intensity in petrochemical sector will be one of the major focus areas while formulating the final recommendations.*
- *Biotechnology sector with areas relevant to Indian chemical sector alone are being considered in the project study. Basic life science areas are outside the scope of the current studies.*
- *All efforts will be made to collect data on survival rate of SMEs in Indian chemical sector.*
- *The growth dynamics and market compulsions of each subsector of Indian chemical industry will also receive attention.*

ANNEXURE 1.6.5

POINTS NOTED FROM DISCUSSIONS ON IRICI-INAE PROJECT DURING

INAE ANNUAL CONVENTION – 2009

1. China's leapfrogging in IP generation need to be investigated
2. Viable recommendations to be made regarding attracting bright scientific talent to chemical R&D
3. Extent of FDI utilization for R&D in Indian chemical sector need to be studied
4. Quality of Indian Chemical research publications and patents vis a vis international quality to be studied
5. The nature of Chinese investments in Indian chemical sector to be examined
6. Concrete measures to be taken to improve academic-industry linkages for innovations / technology transfer to Indian chemical sector.
7. The nature and quality of Indian technical / Scientific / Engineering education and its relevance to Indian chemical sector
8. Management component of chemical R&D generation and commercialization need to be studied
9. Effect of Environment factors on the future growth of R&D and manufacturing activities in Indian chemical sector
10. The transformation from Process to Product oriented patenting – Nature of developments in Indian Chemical sector
11. Public and Private sector R&D in Indian Chemical sector – Their relative growth trends
12. Outsourced chemical R&D in India – Its status and future prospects
13. Is there any need for creation of Research Universities in India in chemical sector
14. Leveraging International linkage for strengthening collaborative Innovation for generating creative intellectual property.

ANNEXURE – 1.6.6

ICC – INAE INTERACTION MEETING WITH VAPI INDUSTRIES ASSOCIATION

Date : 17 Nov 2010
Venue : Mumbai
Time : 3.00 PM

Present:

Sri. R.D. Shroff

Mrs. Sandra R. Shroff

Sri D.P. Mishra, Head Marketing and Business Development TCE, Mumbai

Dr. B.C. Sharma, CEO, Vapi Waste and Effluent Management Co., Vapi

Sri. Bharat Anjaria, Valuer, Anjaria Enviro Tech, Pvt Ltd., Vapi

Sri. Nand Kumar Chodankar, Group CEO, Excel Industries Ltd.,

Sri. Hasit Anjaria, Anjaria Enviro tech Pvt Ltd., Vapi

Sri. Shashank Merchant, Director, Hema Dye Chem Pvt Ltd., Vapi

Sri. Nishit Merchant, Director, Hema Dye Chem Pvt Ltd., Vapi

Sri. Anil Bhai, Vapi Industries Association

Sri. R.R. Gokhale, Secretary, ICC, Mumbai

Sri. Anand, Centre of Excellence, Vapi Others.

Dr. B.C. Sarma invited the participants to the interaction session jointly sponsored by the ICC, Mumbai and INAE, Delhi. He made a powerpoint presentation on the centre of Excellence (COE), a Division of Vapi waste and Effluent Management Co. Ltd. The COE was established under the Industrial Infrastructure Development scheme (IIDS) of the Ministry of Commerce and Industry, Government of India with a 30 members staff at a cost of Rs. 43 crores. It is equipped with a state of art analytical laboratory, a multipurpose pilot plant and an Information Technology Centre to cater to the needs of 700 SME units at Vapi. The CEO has been designed to provide state of art facilities for process / product upgradation / development by the SME's at Vapi Industrial Estates. He also highlighted the challenges being faced by the CEO during its formative years including the problems faced by the CEO in HRD, establishing linkage with Universities, meeting working capital needs, and development appropriate business models. Dr. K.V. Raghavan and Sri. D.P. Mishra complimented the Vapi waste and Effluent Management Co Ltd., for this unique initiative for which there is no parallel effort in Indian Chemical Sector.

Sri. D.P. Mishra and Dr. K.V. Raghavan then briefed the participants about the INAE Project and its efforts to understand the R&D problems of SME's in Indian Chemical Sector. They invited the participants to offer their valuable ideas on the ways and means of improving the R&D scenario in SME segment of Indian Chemical Industry. Interesting discussions followed. The following are the highlights of the interactions:

1. There are bright prospects for consolidating and enlarging the scope of COE to make it a hub for innovative R&D to SME's at Vapi at affordable cost. The following have been identified as priorities.

(a) COE to be facilitator for establishing sustainable linkage between local universities and the SME's.

(b) To provide laboratory space with necessary infrastructure for interested SME units to conduct experimental investigations in association with or without R&D / academic institutions.

(c) The scope of Information centre can be enlarged to cover technology and patent marketing information with national and international relevance.

(d) The facilities at COE to be run on the technology incubation concept with COE establishing linkages with R&D / Academic institutions and experts in the relevant fields.

2. There is a strong need for the Government (State and Central) to evolving following support programmes to partially compensate the SME's in following type of endeavours.

(a) SME Technology Development Programme to facilitate financial support matching (grants) to reduce the cost burden of innovative R&D made available through Academic / R&D and industry joint initiatives with facilities at technology Incubators / COE's.

(b) The scope and magnitude of support from small Business Innovation Research Programmes of DST / DBT and other government Departments to be substantially enlarged to promote concept proving research during phase I and Developmental research during phase 2 through industry – academic / R&D initiatives.

(c) A special funding programme to encourage Technology Application and Product by the SME's to evolve innovative options tailored to national and international market needs for a value added manufacture.

(d) Programme specifically to strengthen SME's investments and expenditure on quality R&D Manpower Development to effectively enhance their technology absorption capabilities.

(e) A Business Development oriented programme to facilitate some of the innovative SMEs to develop their own product brands for regional, national and international markets.

3. There is a strong need to revamp the Diploma, Graduate, Post Graduate and doctoral research programmes to make them more relevant to Industrial needs.

4. The SME Sector has to appreciate the need for protecting the intellectual property developed by them through patenting. The SMEs can derive encouragement from the Indian chemical sector's overall impressive record in research publications and patents filed in India.

5. Organizations like National Cleaner Production Council (NCPC) to promote R&D related to ecofriendly technologies in chemical industry clusters.

6. Though maintaining the secrecy of process technologies is vital for the business success of SMEs, there is need to realize that there are several generic aspects of technologies which can be researched jointly by the SMEs and the results can later be applied to their specific cases.

7. The application of IT in chemical sector is vital for technology and production improvement.

8. There is need to finance high risk innovative projects from SMEs through Indian venture capital institutions.

9. The commercial banks have to take more proactive approaches to fund excellence in industrial research particularly resource starved but innovative SMEs.

Finally, Mr R D Shroff and Mrs Sandra R. Shroff complimented the efforts of ICC and INAE for the initiatives taken in the above matter and hoped that appropriate recommendations are made in the INAE Report to facilitate formulation of chemical industry friendly policies with reference to R&D funding.

ANNEXURE 1.6.7

TOPICS DISCUSSED AT

ICT INTERACTIONS ON 9TH NOV 2010

1. Statistical Information on ICT-Chemical industry linkages (1991-2010):

   As per the Director's statement there are about 800 projects the ICT has received from the Industry during 1991-2010. During the same period the faculty earn from around 1500 consultancy offers from the industry.

2. Major factors responsible for sustainable ICT-industry linkages:

   (i) The credibility of faculty members

   (ii) Sincerity and dedication of the scientists to the problems given by the industry.

   (iii) The deep understanding of the faculty members about the field and about problems given to them by the industry.

   (iv) The successful completion of the project during the stipulated period.

   (v) Reputation and legacy of the institute is also supposed to be one of the factors responsible for the confidence of the industry on the faculty.

3. Types and nature of linkages established:

   The industry approach the ICT with a particular problem either in the form of project or the faculty are invited for the consultancy job to resolve the problem. The linkage between the faculty and the industry is so strong that even after finalising the job the relation between the industry and the scientists continue. The faculty visit the industry and the scientists from the industry also visit the institute in case of any future trouble shooting. The industry are eager to offer scholarships and fellowships to students, one-time grants, visiting fellowships to faculty, various MoU with the industry, Entrepreneurship Development cells etc. The Institute invites industry scientists as adjunct professors for doing intense collaborations with them.

4. Type of R & D support provided by ICT to the industry

   a) Process development and generation of knowhow and technology packages

   The institute has a very strong group of chemical engineers. The industry gets direction regarding the process development for a new technology. As for example in 2008-2009 the industry have given projects related to "Modeling and design of cooling towers and their components for optimum approach temperature" , "Improvement of turbine-cycle heat rate through multi-compositionmonia liquor absorption unit" etc to ICT's Chemical Engineering department which have been successfully completed.

   Similarly generation of new technical knowhow for a novel type of technology have been made by the ICT teachers such as "Enzyme extraction from Vegetables", "Hydrogen production from CuCl cycle", and different types of novel chemicals, new drugs, innovative formulation systems etc by the faculty for the Indian chemical industry. ICT has implemented its technology of "Eco-Cookers" in jails, Anandvabans, Ashramshalas,

Balwadis and Anganwadis. From the industry, ICT has procured a sum of Rs1850.6982 in the form of research projects from 2004 to 2009.

The institute has recently developed the method of hydrogenation of organic compounds, synthesis of new molecules of Laser dyes, Process Development for Nitrate based Effluent Treatment in a continuous bioreactor, Ballast Water Treatment Technology, Integrated process for Sucralose, Process for isolation and purification of Artemisinin, Integrated process for purification of therapeutic grade Vitamin B_{12} from crude fermentation broth, Biodiesel from waste and acid oil with high FFA content, wire enamels for high temperature applications, Drying of Marine food products, fruits and vegetables. These are some of the developments and innovations on the the part of the institute.

b) Product development and application testing: As for example in 2008-2009 the faculty have developed many new products through industry partnerships and consultancies. Through personal interviews with Prof S.S.Bhagwat of Chemical Engineering Department and Prof P. Devarajan of Pharmaceutical Chemistry department it has been revealed that these professors from their experties on interfacial phenomena at the liquid interfaces and innovative drug delivery systems respectively have been able to make close relations with the relevant industries in India. The external revenue generation through the research and consultancy has been 50crores in 2008-2009 which is eight times of the Government support. Industries have come forward to finance various departments and various projects. Shri K.V.Mariwala, Shri Narottom Sekhsaria, Dr John Kapoor and others have provided liberal financial support to this institute in the form of establishing chair professors, infrastructural facilities, fellowships and other form of endowments.

The Institute now posseses some of the technologies with high potential for commercialisation: (i) Biodebradable polymers, (ii) Organic solvent replacement technologies, (iii) High purity Curcumin Antioxidant from Termeric, and (iv) Blends, nanocomposites and interpenetrating networks.

c) Trouble shooting: **The chemical and pharmaceutical industries have been enormously benefitted from the consultancies from the ICT faculties to resolve the industrial trouble shooting problems.**

d) Patent filing: **Because of the intensive collaborations between the institute and chemical and pharmaceutical industry, a large number of intellectual properties has been generated ion the institute. From 2004 to 2009 the ICT has been granted total amount of patents =132 which includes exclusive institutional patents and joint patents with the industry.**

e) Consultancy assignments for specific job execution: **The faculty of ICT have executed 330 consultancy jobs in the industry during the period 2004 to 2009. The institute allows the faculty to visit the industry once in a week and revenue generated out of the consultancy is shared in the ratio 80:20.**

f) Others: **In ICT it is substantially a teacher centric atmosphere. Respect from Industry and past students are very high all the times. The industry have very high level of confidence on the competence of the faculty members.**

5. Efforts made to protect the intellectual property jointly generated with the industry:

When an intellectual property is jointly generated with an industry, the industry comes forward to bear entire expenditure for submitting the patent. Under these circumstances, the patent is jointly assigned to the concerned industry and ICT.

6. Roles of institution and individuals while providing R & D support to the industry

a) ICT Management: **Management openly support the faculty's involvement in the industrial research. Faculties are encouraged to bring industrial projects and consultancy jobs. Management of ICT allows the teachers to visit the industry once in a week for consultancy. In some cases the ICT management gives bursary to the teachers for pursuing industrial research.**

b) Faculty: **Some faculty members take the industrial research as major task and seldom do any in-house research. These teachers have good rapport with the industry and the industry show a lot of confidence on them. Some faculty members do industrial projects and consultancy jobs as well as in-house research. Of course, there are very few teachers who do not like industrial research and are engaged only in the research in their laboratory.**

c) Students: **The post doc, doctoral and M.Tech students are involved in research under the guidance of faculty professors. In 2008-2009 the faculty and research students have published a record number of 225 research papers and have filed 8 new patents. The post graduate students are given industrial oriented research problems for their dissertation so that the students have mental bendings towords the industry problems. Some students who get endowment fellowships from the industry are, however, mostly involved in the research problems of those particular industry. Students involved in industry-sponsored research project are involved in the problems associated with the project.**

7. Nature of counterpart inputs/supports provided by the industry

a) Augmenting ICT infrastructure: **As mentioned earlier, the industry create chairs in the departments. M.M.Sharma Distinguished Professor of Chemical Engineering, Narotam Sekhsaria and R.A.Mashelkar chairs in the Chemical Engineering Department, J.G.Kane Chair in the Department of Oils, Oleochemicals and Surfactants and Dr John Kapoor Chair in the Department of Pharmaceutical Technology, R.T.Modi chair for the Professor of Chemical Technology are some of the very few examples.**

b) Financial compensation: **As mentioned earlier, the teachers get research projects from the industry and they earn money from the consultancy jobs also. This is a fabulous income on the part of the institute. In addition, the industry provides one-time grant to the institute for instituting a chair, buying costly instrument, establishment of infrastructural facility etc.**

c) Providing facilities at their work sites:

d) Licence fee and royalty payment: **When a patent is jointly granted to the institute and the concerned industry, the industry takes care of filing the patent as well as annual licence fees. The royalty is decided according to MoU between the two parties which varies from 80:20 to 50:50.**

e) Any other

8. Post technology transfer support provided by the ICT: **No data available**

9. Specific examples of highly successful R & D commercialization programmes by the ICT which led to:

a) Setting up of commercial plants:

Some successful commercial plants established by the alumni of ICT are: (i) Shri Mukesh Ambani of Reliance Industries Ltd., (ii) Shri Narotam Sekhsaria of Gujrat Ambuja, (iii)Dr K.H.Gharda of

Gharda Chemicals, (iv) Dr K Anji Reddy of Dr Reddy's Laboratory in Hyderabad. These alumni continue to assist ICT and participate in the activly in ICT's all round development.

b) Expansion of production capacities:

c) process/product improvement (quality and quantity):

d) Launching new products in the market:

The research output from the institute has resulted in technologies that have been adopted by the industry. The following technologies have already been commercialised.

(i) Hydrogenation of organic compounds (Process for Catalytic Hydrogenation)

(ii) Synthesis of new molecules of Laser Dyes (This class of dyes was never manufactured in India)

(iii) Process Development for Nitrate Based Effluent treatment in a continuous bioreactor. (Highly effective and relatively economical process)

(iv) Ballast Water Treatment Technology (Hydrodynamic cavitation as alternative technique to acoustic cavitation)

(v) Integrated Process for Sucralose (Rs100 cr plant is installed)

(vi) Process for isolation and purification of Artemisinin (Rs20Cr plant has been installed)

(vii) Integrated Process for Purification of Therapeutic grade vitamin B12from crude fermentation broth. (In the process of commercialisation)

(viii) Biodiesel from waste and acid oil with high FFA content (coomercialised at 300tons/day capacity)

(ix) Wire enamels for high temperature applications (Import substitute)

(x) Drying of Marine Food Products, fruits and vegetables (Value addition product)

e) Improvement in environmental pollution control:

The institute has developed eco-friendly cookers which have been set up in different places in the country. This has saved the country in the tune of Rs100Cr. The institute has sustained research programmes based on Green Technology. As for example it has developed "Organic Solvent Replacement Technologies". The institute has water and waste water treatment project, removal of heavy metal ions from waste water effluents, degradation of organic pollutants in aqueous environments, removal of dissolve TBP from water, water disinfection using hydrodynamic cavitation, environfriendly lubricants etc. These research projects are indication of the environment censusness of the faculty.

10. List of important industrial clients benefitted by the ICT technological inputs:

Names of some of the industrial clients who got benefitted from the ICT technological inputs:

Dr K.H.Gharda of Gharda Chemicals

Dr Adi Godrej, Godrej Industries Ltd.

Johnsons and Johnsons Ltd

Pidilite Industries Ltd.

NOCIL-Rubber Chemical Divn.

United Phosphorous Ltd.

Dr Anji Reddy, Dr Reddy's Laboratory

Mr K.V.Mariwala, Marico Ltd.

TATA Chemicals Ltd.

Cadila Pharma Pvt. Ltd.

ANNEXURE 2.4.1.1

DATA SHEET ON INDIAN PETROCHEMICAL SECTOR

R&D RATING	STRENGTHS / POSITION IN INDIAN CHEMICAL INDUSTRY					WEAKNESSES/CONSTRAINTS				OPPORTUNITIES
* *	Investment	Turnover	FDI INFLOWS	Production	Exports	Feed Stocks	Turnover Growth	Capacity Utilization	TECH GENERATIO N CAPABILITY	
RDI : 0.8	1	1	1	2	2	High Import Content	3.18% (03-09)	<90%	Low	• SEZs

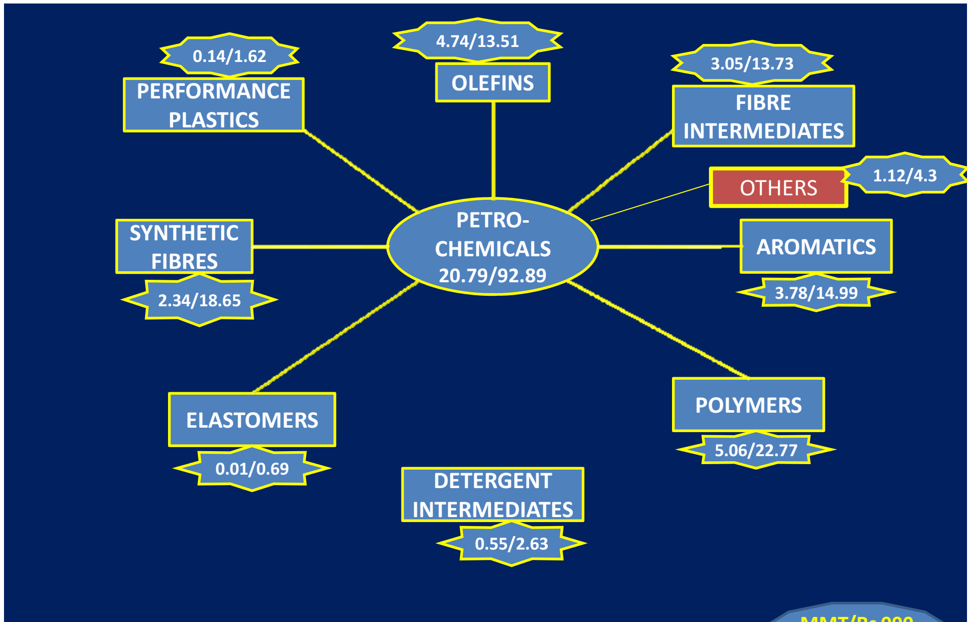


Fig: Production and Turnover of Petrochemicals (2008-09)

MMT: Millian Metric Tonnes * Turnover

IMPORTANT SEGMENTS

Synthetic Fibres / Intermediates
Polymers
Elastomers
Synthetic Detergent Intermediates
Performance Plastics
Olefins and Aromatics
Other Petrobased Chemicals

CHARACTERISTIC FEATURES

Fast growing with robust topline
Integral part of Indian energy and chemical chain
Undergoes cyclic upswings and down turns due to global effects
Subject to frequent pressures due to global petroleum prices dicated
By geopolitical factors.

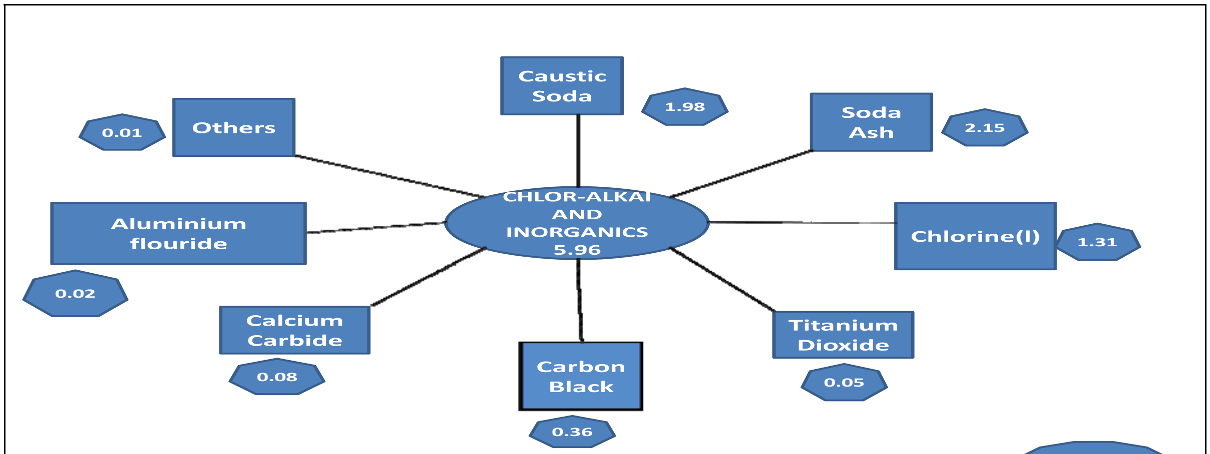
RESEARCH AND DEVELOPMENT		FUTURE PROSPECTS TO DRIVE R&D	ACTIONS NEEDED
CURRENT STATUS	**FUTURE PRIORITIES**		
• **R&D Units** - HPCL, CPCL, IOCL, RIL, IIP, CIPET, UPES • **Govt Funding** - PCRA, CHT, DSIR, DST, TDB • **Academic Contribution to Patents Highest in India** • **Rs.10,530 Crores Spent on Conservation R&D (1985-2002)** • **CHT completed Rs.200 crore worth R&D Projects**	• RM and energy efficiency Improvement • Process Intensification for greener industry • Recycling Technologies • Nanoscience for advanced polymers / elastomers / performance plastics • Alternate renewable feedstocks (biomass) • New application product development • R&D facilitated Indian initiative to develop total technology packages for new petrochemical plants through indo-overseas ventures	• Downstream petroproducts investments to increase by USD +5-20 billion (2010-20) • More rapid growth of synthetic fibre, automobile, lifestyle product and retail packaging sectors • India has potential to become regional petro product hub • Project engineering consultancy worth USD 8-10 billion (2010-15)	• New SEZs with world class R&D facilities under PCPIR Policy & GOI • Setting up centres of Excellence through Academic – R&D – industry – government joint initiative with focus on New application product discovery and development with high export potential • Global brand image development assistance to competent SMEs • Future petrochemical expansions to be based on global economic scale of operation level • More robust public – private joint ventures in R&D commercialization

GOVERNMENT POLICY SUPPORT TO INDIAN PETROCHEMICAL SECTOR

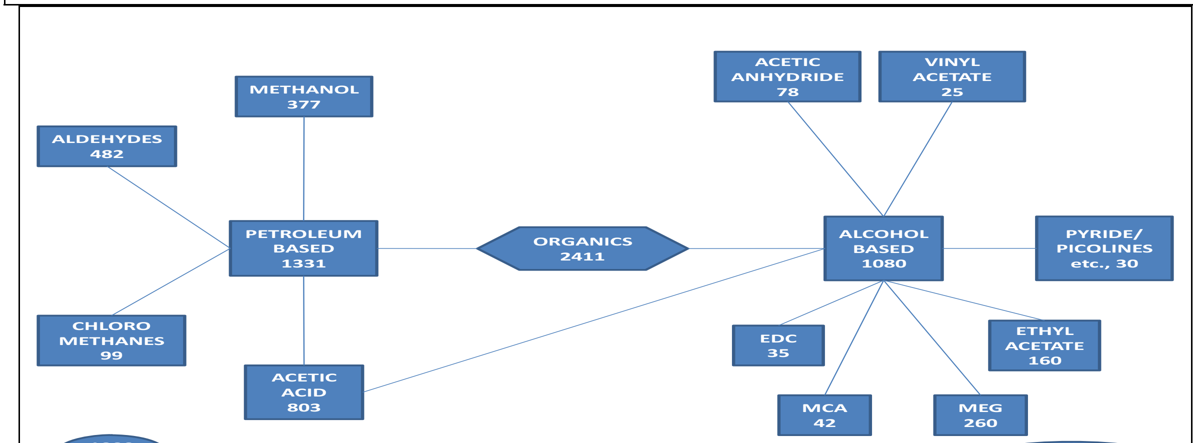
- GOI VISION
  - Development of value added and quality petrochemical products at globally competitive prices
  - Innovation at the forefront for development of newer application products
- 100% FDI allowed in manufacture
- Compulsory licensing restrictions only to hazardous chemicals like HCN, phosgene and isocynates and their derivatives
- Petroleum, chemical and Petrochemical Investment regions (PCPIRs) Policy to promote their expansion in an integrated and environment friendly location encouraging cositing, networking, common infrastructure / support services, environmental protection and external physical infrastructure and communication linkages.
- National Policy on Petrochemicals (2007) to promote
  - Increased investments and domestic demand
  - Facilitated new investments in emerging areas
  - Environmentally sustainable growth
  - Research and Human Resource Development
  - National Awards for Technology Innovations
  - Dedicated downstream product parks
- Setting of Centres of Excellence through R&D – academic – industry – Government joint initiative for promotion of
  - Innovative product design and development technology
  - Improvement in production processes
  - More efficient recycling process technology
  - Development of biodegradable application products
- Establishment of CHEMEXCIL for export promotion
- Facilitation to implement Registration, Evaluation, Authorization of chemicals (REACH) of EU (2007). Already 650 Indian companies have preregistered 7500 substances through CHEMEXCIL.

PRODUCTION BREAKUP OF

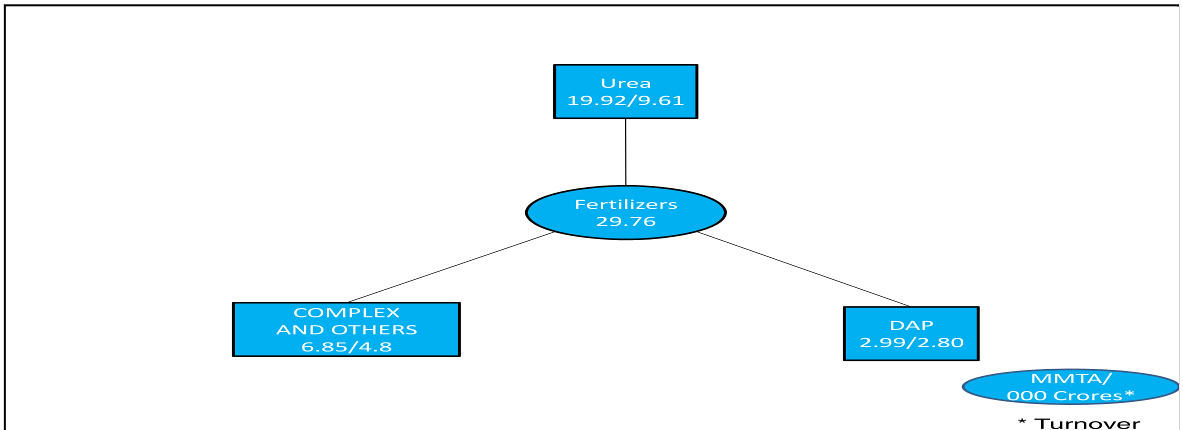
OTHER IMPORTANT BASIC CHEMICALS (2008-09)



Chloralkali and Inorganics



Organics (2008-09)



Fertilizers

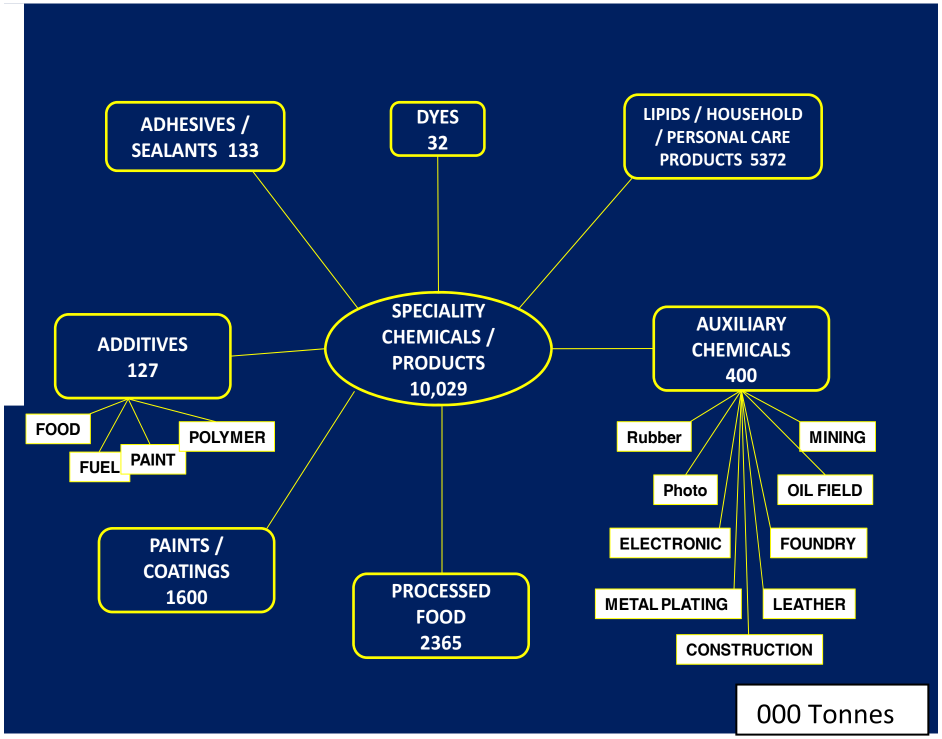
ANNEXURE 2.4.1.2

DATA SHEET ON INDIAN SPECIALITY CHEMICAL SECTOR

R&D Rating	Standing in Indian Chemical Sector					Constraints			Opportunities
	FDI Inflow	Turnover	Investment	Exports	Production	R&D Exp	R&DI	New Product Development	Opportunities
☆ ☆	20.3%	19.5%	19.1%	17.2%	14.5%	3.6%	0.8 (Average)	Low Success Rate	• Large domestic market • Customized applications

IMPORTANT SEGMENTS

- Dyes / Intermediates
- Food Processing
- Lipids / Personal Care Products
- Paints / Coatings
- Chemical Auxiliaries
- Adhesives / Sealants
- Additives



CHARACTERISTIC FEATURES

- ❖ Higher than average chemical industry growth rate
- ❖ Largely driven by robust domestic market demand
- ❖ Export based growth in select segments
- ❖ Predominantly product development driven
- ❖ Low Capital Intensity and higher profit margins

Research & Development		Future R&D Driving Factors	Implementable Actions
Current Status	**Future Priorities**		
▪ Low R&D Expenditure ▪ Poor access to common R&D facilities in clusters ▪ Lack of highly qualified R&D manpower for development high end specialities ▪ Current R&D attempts to develop India specific fragrances and perfumes ▪ R&D on modified starches for new range of adhesives ▪ R&D on food package material development to be intensified	▪ Revisiting product portfolios for improved global positioning ▪ Customized applications in electronics, automotive and intelligent systems ▪ Application of nanotechnology for highly selective specialities ▪ Water based speciality chemicals for environmentally clean applications ▪ Biotechnology applications for food and other sectors ▪ Advanced action additives for alternative fuel systems	▪ Globalization of supply chain capability ▪ Access to renewable feedstocks ▪ Customer intimacy driven innovations ▪ Environmental regulations for greener product / process options ▪ Outsourcing speciality chemical synthesis	▪ Reoptimization of production portfolios based on enviro economics ▪ Development of new formulations and blends with ecofriendly chemical and biopolymers ▪ Active product life cycle management to accommodate global legislations like REACH ▪ Attempting upstream integration for long term competitive advantage ▪ Development of industry foresight to cope with shifting product landscape

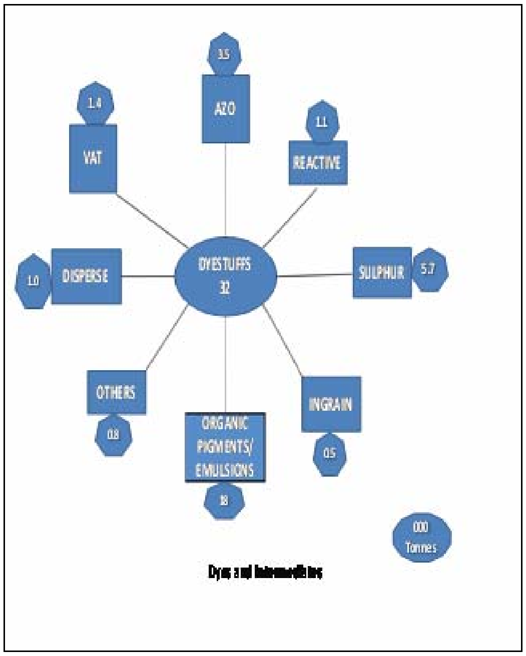
Government Support for Speciality Chemical Sector

- 100% FDI allowed
- PCPIR policy will also promote speciality chemical sector
- Government has already put in place sectoral specific policies for food processing, soaps and cosmetics, dyes / pigments etc.,
- Government of India has taken following actions to facilitate implementation of OPCW, Montreal Protocol, Stockholm Convention of Persistent Organic chemical and REACH by establishing:
  a) National Authority for CWC
  b) Ozone Cell for Montreal Protocol
  c) Ministry of Environment and Forests (MOEF) as the focal point for Stockholm Convention implementation
  d) CHEMEXCIL by Ministry of Commerce to represent interests of Indian chemical exporters for REACH implementation.

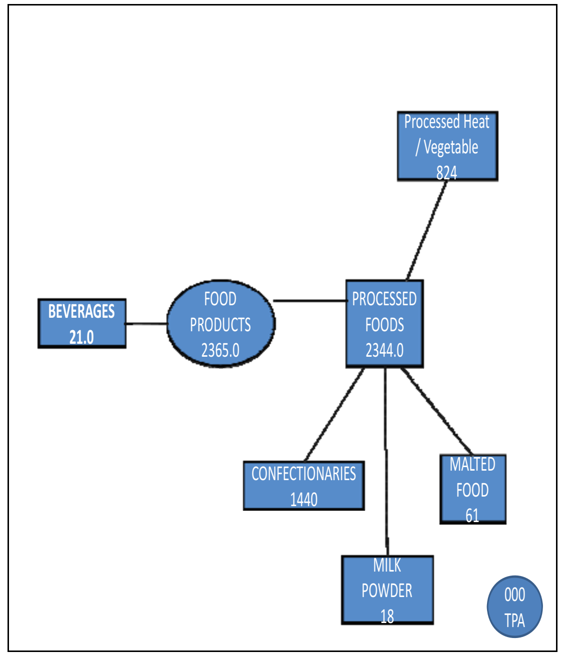
All above measures have been taken for regulatory tasks as well as assistance to industry to conform to the regulations

- The speciality chemical sector is keen that Government of India take more proactive measures for:
  - Incentivizing innovations
  - Facilitating R&D access in SME clusters

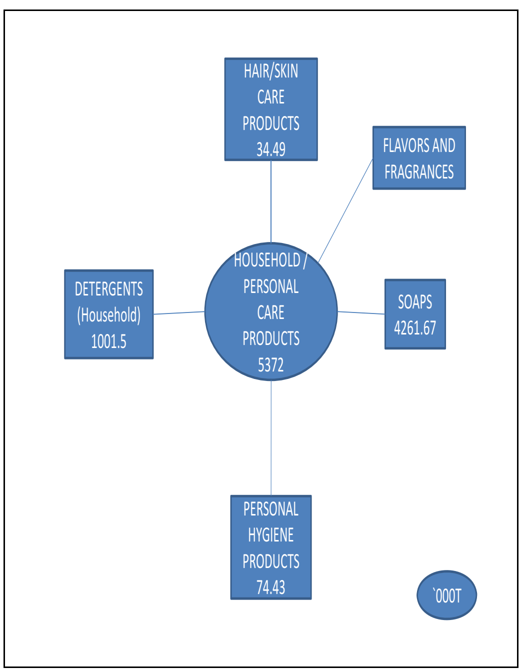
PRODUCTION BREAKUP OF IMPORTANT SPECIALITY CHEMICALS (2008-09)



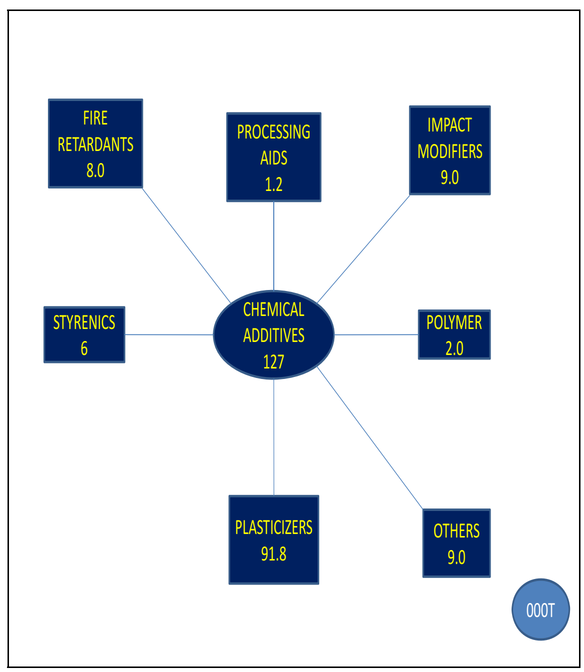
Dyes and Intermediates



Processed Food



Household/Personal Care Products

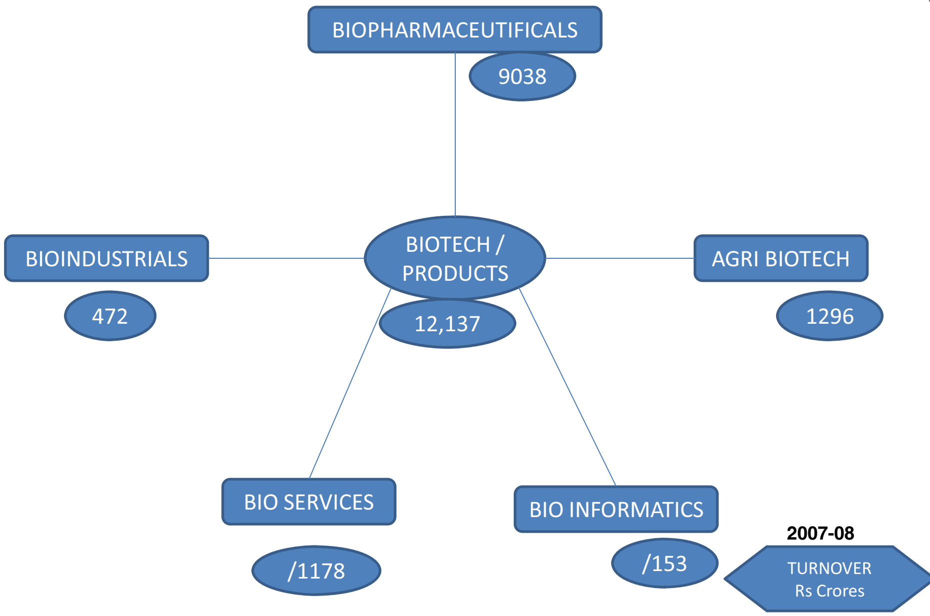


Chemical Additives

ANNEXURE 2.4.1.3

BIOTECHNOLOGY / PRODUCTS

R&D RATING	STRENGTHS / POSITION IN INDIAN CHEMICAL INDUSTRY					WEAKNESSES / CONSTRAINTS				OPPORTUNITIES
** ** RDI=20	GLOBAL DESTINATION	GLOBAL CLINICAL	GLOBAL BIOTECH CROP	EXPORTS	TURNOVER GROWTH	CAPACITY UTILIZATION	GENES DISCOVERY CAPABILITY	CUTTING EDGE TECH CAPABILITY	GROWTH IN DOLLAR TERMS	• Huge Domestic and global markets • High outsourcing prospects for Bioinformatics and vaccines
	12TH LARGEST	15%	4TH LARGEST	4	34% SINCE 2003	79%	LOW	MODERATE	SLOWING DOWN	



MAJOR SEGMENTS

- BIOPHARMA
- BIO SERVICES

- BIO AGRI
- BIO INDUSTRIAL
- BIO INFORMATICS

CHARACTERISTIC FEATURES

- FAST GROWING (18-20%)
- CLUSTER BASED GROWTH
- EXPORT DRIVEN (56% IN TOTAL BIOTECH)
- ABILITY TO ADAPT TO NEXT LEVEL OF CHANGE
- GOOD GROWTH IN GLOBAL PARTNERSHIP WITH INDIA
- MEDIUM SCALE COMPANESI REGISTERING IMPRESSIVE GROWTH
- GLOBALIZATION IS INDIA CENTRIC

RESEARCH AND DEVELOPMENT		FUTURE COMMERCIAL DRIVERS FOR R&D	ACTIONS NEEDED TO BOOST R&D
CURRENT STRENGTHS	FUTURE PRIORITIES		
• Biotech SMEs account for 35% of total R&D spending • 45% share in Indian Patents and 30% share in Research Publications • Favoured clinical R&D destination • Indian Companies providing R&D support to global pharma companies • DBT supported 35 projects worth Rs 142 crores during 2005-07 under SBIRI scheme • 1500 PhDs every year in Biotech • Bangalore and Hyderabad Biotech Clusters are R&D intensive • 185 biotech companies trained 665 post graudates and absorbed 27% of them by employing DBT biotech associate ships during 2004-08	• Biotech Crops • Biofuels and Biomass based CO generation for alternative energy • Electronic databasing of biological systems • Biopharmaceuticals • Bio services in terms of clinical trials • Most favoured Research Areas - Genetic Engg - DNA tech - Drug Delivery - Stem Cell - Bio informatics	• Biotech Turnover to cross Rs 40,000 crores by 2015 • Indian Companies expected to supply 90% of global demand for measles vaccines • Annual Investments will grow at 25% • To cross 1 million skill job potential by 2015 with high growth in R&D Manpower • Genomics, biopharmaceuticals and Industrial biotechnology are high growth sectors	• To enhance product patenting filings by the Indian companies for innovative Indian bioproducts for global markets • To further strengthen academic-R&D linkages to screen novel biomolecules • To employ reverse engineering capabilities on much wider scale for process development of new offpatent biopharmaceuticals • To establish new research hubs for MNCs • Public funded R&D institutes to focus on innovative contract research opportunities with global biopharma giants • More government incentives for promotion of science based biocluster development

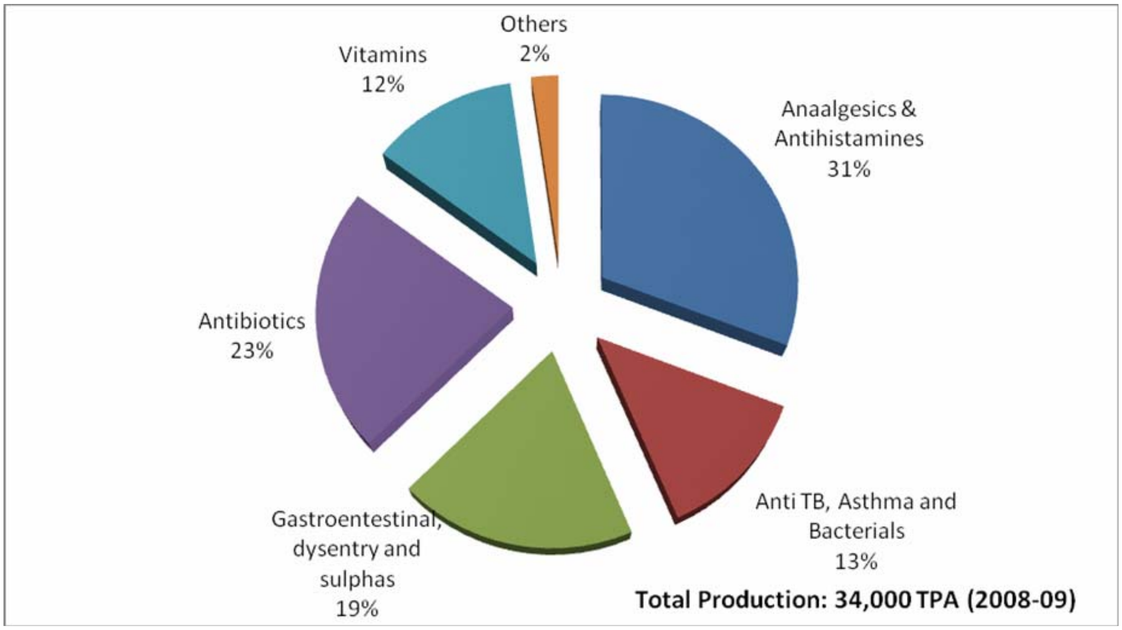
Major Government Support to Indian Biotech Sector

National Biotechnology Development Strategy (2007) to build coherence and connectivity between disciplines and bring together the varied skills across sectors to enhance synergy.

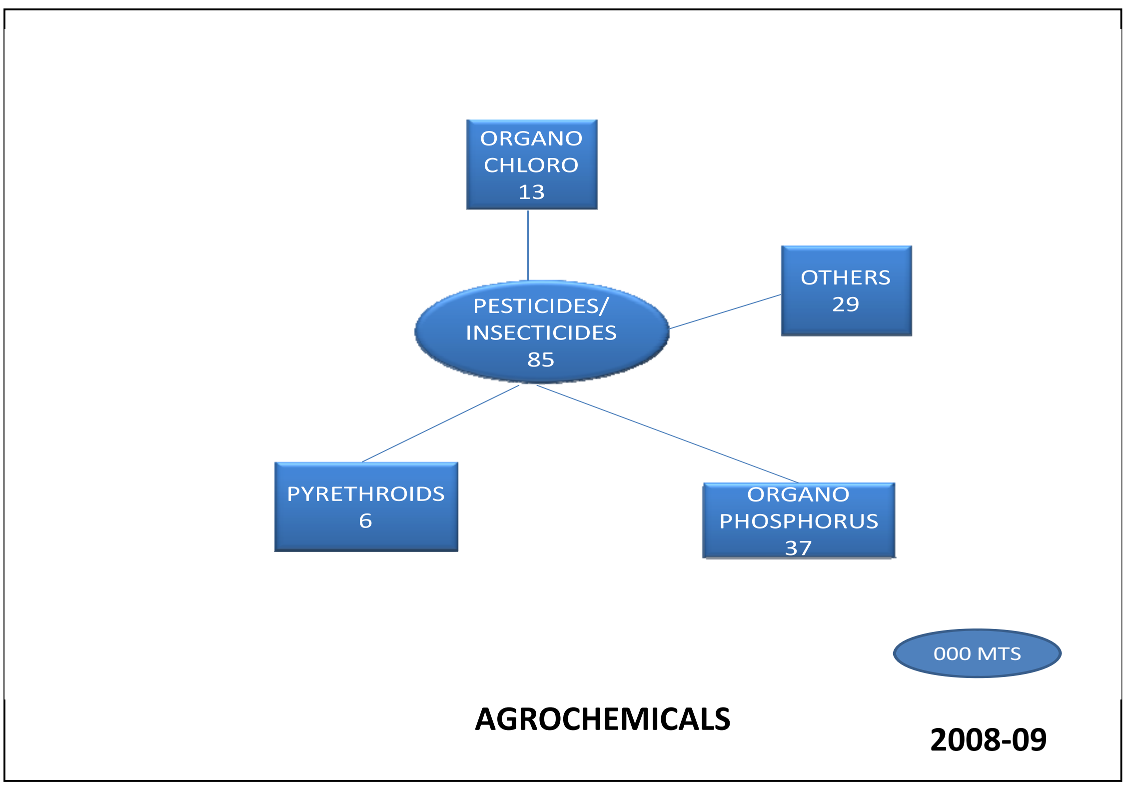
- Biotechnology Industry Partnership Programme (BIPP) for Rs 350 crores during 11th Five Year Plan to promote high risk and path breaking industry research in frontier areas for achieving technology leadership.
- Biotechnology Industry Research Assistance Programme (BIRAP) for bridging the gap between science and market place.
- DBT-Stanford Biodesign programme
- DBT Translational S&T Institute - MIT - Harvard Partnership programme
- Establishment of Stem cell Research Institute
- Biofuel Policy to promote blending of biodiesel with petroleum diesel by 2017
- Proposal to establish two biotech SEZs and 3 biotech parks by 2015
- Establishment of the UNESCO Regional Centre for Biotechnology at Faridabad by 2010
- DBT Fund (USD 39 million) for vaccines Research and USD 68.8 million funding for bio similar projects

PRODUCTION BREAKUP OF OTHER

IMPORTANT KNOWLEDGE INTENSIVE CHEMICALS (2008-09)



BULK DRUGS



ANNEXURE 2.4.1.4

SPECIAL REPORT ON

IMPACT OF R&D ON INDIAN PETROCHEMICAL SECTOR

: Current Status and Future Prospects

By

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1. INTRODUCTION

The world chemical industry is composed of a wide spectrum of products ranging from commodity chemicals to research driven specialty chemicals [1]. The chemical industry is briefly classified into three segments based which are:

a) Basic Chemicals
b) Specialty Chemicals
c) Knowledge intensive chemicals

Table 1: Classification of the chemical industry

Segments	Characteristics	Constituent industries
Basic	■ High volume, low value-added ■ Limited product differentiation across manufacturers ■ High entry barriers on account of high capital spend and stringent regulations	■ Petrochemicals ■ Fertilisers ■ Inorganic chemicals ■ Other industrial chemicals
Speciality	■ High product differentiation and value-addition ■ Typically smaller production units with more flexibility ■ Low capital investment levels	■ Adhesive sealants ■ Catalysts ■ Industrial gases ■ Plastic additives
Knowledge	■ Differentiated chemical and biological substances used to induce specific outcomes in humans, animals, plants and other life forms ■ High investments in R&D and marketing	■ Agrochemicals ■ Pharmaceuticals ■ Biotechnology

1.1 Petrochemicals

- Petrochemicals come under the class of basic chemicals and are derived from various chemical compounds, mainly from hydrocarbons [2]. These hydrocarbons are derived from crude oil and natural gas. Among the various fractions produced by distillation of crude oil: petroleum gases, naphtha, and kerosene and gas oil are the main feed-stocks for the petrochemical industry. Ethane and natural gas liquids obtained from natural gas are the other important feed stocks used in the petrochemical industry. Olefins (Ethylene, Propylene & Butadiene) and Aromatics (Benzene, Toluene & Xylenes) are the major building blocks from which most petrochemicals are produced.

- Petrochemical manufacturing involves manufacture of building blocks by cracking or reforming operations; conversion of building blocks into intermediates such as fiber intermediates (acrylonitrile, caprolactum, dimethyl terephthalate/purified terephthalic acid, mono-ethylene glycol); precursors (styrene, ethylene dichloride, vinyl chloride monomer, etc.) and other chemical intermediates and finally, production of synthetic fibres, plastics, elastomers, other chemicals and processing of plastics to produce consumer and industrial products.

- Petrochemical products namely, synthetic fibres cater to the clothing needs of mankind and are used in both apparel and non-apparel applications. Polymers find major applications in packaging for preservation of food articles, molded industrial and home appliances, furniture, extruded pipes, etc. Synthetic rubbers are used for making various types of tyres and non-tyre rubber goods and supplement natural rubber.

- Petrochemical downstream processing units are major contributors to employment generation and entrepreneurial development, thereby, serving a vital need of the economy. Starting from the raw material production to conversion into finished products, the employment potential (both direct and indirect) is generated in a cascading manner, which is currently estimated at over 3 million.

- The petrochemical industry is technology driven and for operation of sophisticated and modern petrochemical plants, skilled manpower is required.

- Some of the major units have R&D facilities but the expenditure towards R&D is very low. To meet the growing need of skilled manpower, emphasis is required to be given on training and human resource development.

- Among the various segments within the petrochemical industry, polymers or plastic raw materials are the most versatile. Polymers are used across sectors in the economy as the material of choice on account of its multiple benefits compared to substitute materials like glass, wood, metals, etc. Today plastics are used in a wide array of sectors ranging from agriculture and infrastructure to consumer durables and non-durables.

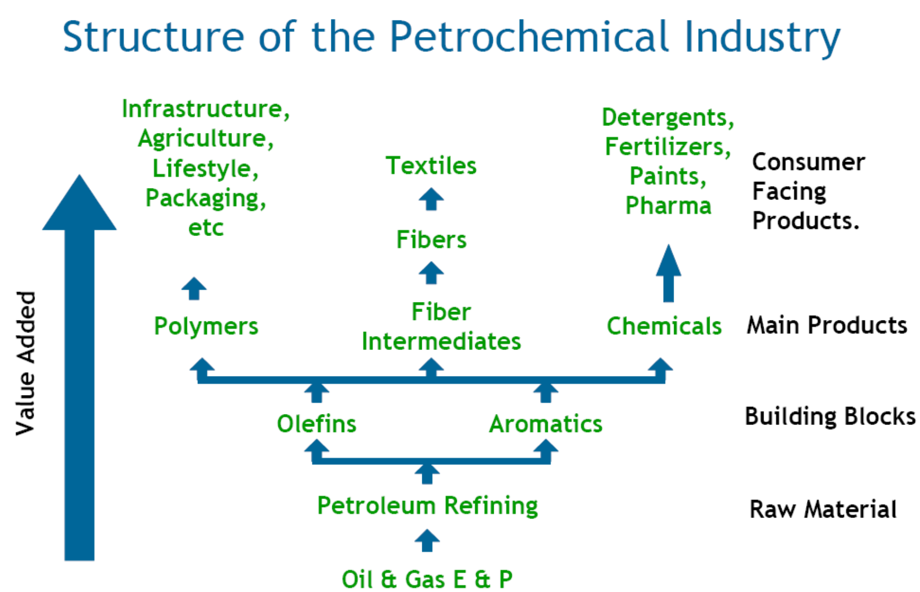

Fig. 1 : Figure showing the structure of the petrochemical industry

2. Global Scenario of Petrochemical Sector

Global chemicals market size is estimated to be around US $ 1.8 trillion in 2007-08. Petrochemicals constitute the single largest segment accounting for approximately 40 % (US $ 72 billion) [2].

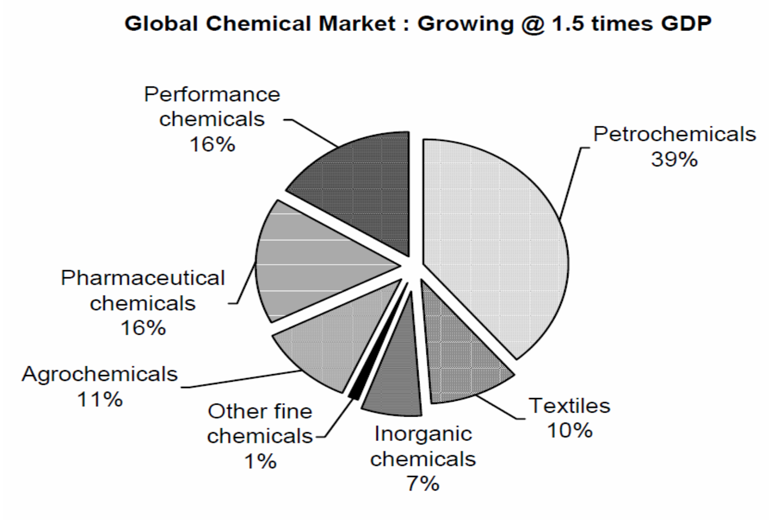

Fig 2: Global Chemical Market

Value addition in the petrochemical industry is very high – higher than most of the other industry sectors. When a barrel of oil valued at US$ 50 (Rs 2182) is used for fuel production, gasoline worth US$ 112 (Rs 4887) is produced with value addition of US$ 62 (Rs 2705) only. The same barrel of oil when used for petrochemicals production, US$ 1120 (Rs 48868) worth of finished goods is produced with a value addition of US$ 1070 (Rs46686) – more than 17 times that of fuel production.

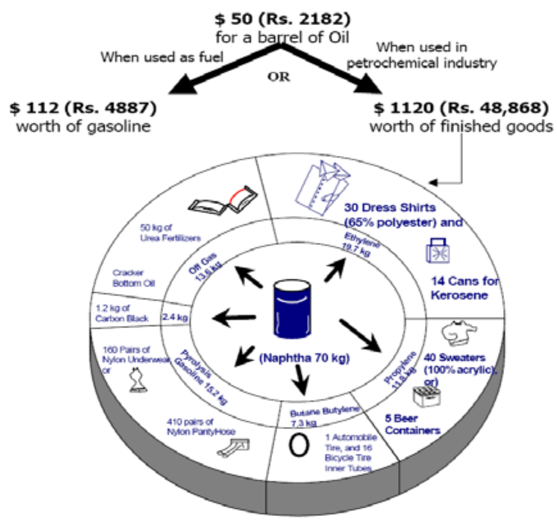

Fig 3: Petrochemical Value Addition

2.1 GLOBAL DYNAMICS

Globally, there are five regions which have witnessed significant growth in the refining and petrochemical industry. These regions include Brazil, Russia, India, China and the Middle East. Russia and the Middle East possess tremendous potential due to the availability of low cost feedstock. Brazil has successfully spear-headed a global bio-ethanol movement. India and China have substantially increased their refining capacities and have invested large sums of money into increasing profitability by integrating refining and petrochemical operations.

China, led by its two major players- Sinopec and CNPC, has built several world class refining and petrochemical centers in the past 15 years. Even with many new projects under development, the country will continue to import chemicals from other countries to fulfill its demand. It is estimated that China's demand for imports is going to nearly double from 22 MMTPA to 39 MMTPA by 2012 [3]. The projected growth in petrochemical industries in India has the potential to address these issues. A concern for the Chinese sector, however, has been the decline in its target market, particularly USA, which has resulted in a reduction in demand growth from 7.7% to 4.6% [4] because of economic slowdown in the recent past. This has led the government to draft special schemes to stimulate domestic consumption.

The market is expected to feel the next wave of capacity additions in the Middle East with four new steam crackers in Saudi Arabia. By 2012, Saudi Arabia and Iran are expected to add 13.5 MMTPA and 8.4 MMTPA of ethylene and 4.1 MMTPA and 1.4 MMTPA of propylene respectively to their existing capacities [5]. Apart from capacity additions, the Middle East holds the most advantageous position when it comes to polyethylene and polypropylene production, owing to their low-cost natural gas based feedstock.

Up until 2006, the Russian petrochemical industry was failing to keep up with the nation's economic expansion. Exports of Russian poly-ethylene amounted to 17.5% of production in 2006, down from 31.5% in 2000. At the same time, imports rose from 7.5% of consumption to 24.2%. The main weakness for investment in the petrochemicals sector was the absence of an industrial policy and a legislative framework aimed at overhauling the chemical sector, as well as foreign investment and its associated expertise, which limited the prospects for growth. The following table compares the demand for different petrochemicals like LLDPE, LDPE, PVC in Global (GL) and Asian (AS) countries [6].

Table 2 : Global Petrochemical Demand statistics 2007-2015, MMTPA.

Product	2007		2015	
	GL	AS	GL	AS
Ethylene	127	39	163	52
Propylene	82	34	101	43

Styrene	30	13	33	17
Para-xylene	29	19	38	26
Ethylene Oxide	22	7	27	8
LLDPE	21	6	32	14
LDPE	21	6	23	9
HDPE	35	11	47	19
PVC	40	21	46	22
PP	49	21	69	33
PS	15	8	15	7
MEG	20	7	26	18
DMT	4	1	2	1
SBR	5	2	5	2
Total	500	195	627	271
% Increase	25.40		38.97	
	(Global)		(Asia)	

3. Indian Scenario of Petrochemical Sector

The escalation of crude oil prices, demanding international environment protection standards and climate change have posed major challenges to the Petrochemical Sector. Clean Development Mechanism (CDM) has provided an impetus to reduce the greenhouse gas emission in the developing countries particularly in the chemical industry. The Indian petrochemical industry is one of the oldest industries and economic growth of India. The petrochemical industry in India has been one of the fastest growing industries in the country. Since the beginning, the Indian petrochemical industry has shown an enviable rate of growth. This industry also has immense importance in the growth of economy of the country and the growth and development of manufacturing industry as well [7].

The Indian petrochemical industry is a highly concentrated one and is oligopolistic in nature. Till recent years, only four major companies viz. Reliance Industries Ltd (RIL), Indian Petrochemicals Corporation Ltd. (IPCL), Gas Authority of India Ltd. (GAIL) and Haldia Petrochemicals Ltd. (HPL) used to dominate the industry at a large extent. The recent amalgamation of IPCL with RIL has made the industry more concentrated further, as they jointly account for over 70% of country's total petrochemical capacity. However, the scene is a bit different for the downstream petrochemical sector, which is highly fragmented in nature with over 40 companies exist in the market. Some facts regarding petrochemicals of India: [8]

- Petrochemicals contribute over 20% of total chemical sector output.
- Petrochemicals annual consumption growth is more than 10%.
- Polymer (63%) & synthetic fiber (29%) are major Petrochemicals.
- Polymer growth rate is more than 2 times of GDP growth rate in past five years.

As on April, 2010, India with 20 refineries had a total installed refinery capacity of ~185 MMTPA. Of this, 112.8 MTPA capacity was in the public sector and the rest in private sector. (Table -3)[9]

Table 3: Refining capacities of different companies in India.

Refinery	**State**	**Capacity MMTA**
Public sector Indian Oil Corporation Limited (IOCL)		
Guwahati	Assam	1.00
Barauni	Bihar	6.00
Koyali	Gujarat	13.70
Haldia	West Bengal	7.50
Mathura	Uttar Pradesh	8.00
Digboi	Assam	0.65
Panipat	Haryana	12.00
BRPL, Bongaigaon	Assam	2.35
CPCL, Manali	Tamil Nadu	9.50
CPCL, Narimanam	Tamil Nadu	1.00
Total (IOCL)		**61.70**
Hinudstan Petroleum Corporation Limited(HPCL)		

Mumbai	Maharashtra	6.50
Visakhapatnam	Andhra Pradesh	8.30
Total (HPCL)		**14.80**
Oil & Natural Gas Corporation (ONGC)		
Tatipaka	Tamil Nadu	0.08
MRPL, Mangalore	Karnataka	11.82
Total (ONGC)		**11.80**
Bharat Petroleum Corporation Limited (BPCL)		
BPCL, Mumbai	Maharashtra	12.00
KRL, Kochin	Kerala	9.50
NRL, Numaligarh	Assam	3.00
Total (BPCL)		**24.5**
Total (public sector)		112.80
Private sector		
RIL, Jamnagar	Gujarat	33.00
Essar Oil, Vadinar	Gujarat	10.50
RPL, Jamnagar	Gujarat	29.00
Total (private sector)		**62.50**
Grand total	**All India**	**185.30**

[Sources: publish by center of High Technology (CHT), 5th floor, core-6, scope complex, Lodhi Road, New Delhi- 11003]

3.1 Key Segments

Indian Petrochemical industry is constituted of the following key segments [7]:

- **Polymers:** The demand for polymers saw a growth of 13.4% during 2007, comparing to a demand growth of 5.6% in 2006. According to the prediction of Chemicals and Petrochemicals Manufacturers' Association (CPMA), the demand growth for polymer would further be augmented to over 15% in the coming year.

- **Polyester Intermediates:** The combined production of 5 fibre intermediates (ACN, DMT, Caprolactum, MEG and PTA was 3,417 KT during 2007. Among those, PTA and MEG accounted for 69% and 27% respectively, while the rest were DMT, Caprolactum and ACN.

- **Aromatics (Paraxylene):** The demand for Paraxylene (PX) saw a growth of 18% during 2007. According to the prediction of CPMA, it is expected to grow at the same rate in the coming year as well.

- **Benzene, Toluene, MX and OX:** The demands for Toluene and OX saw a contraction rate of 4% and 10% respectively during 2007. However, Benzene and MX saw a positive growth though.

3.2 Growth of the Indian petrochemical Industry

- The petrochemical industry in India came into existence during 1970s. The 1980s and 1990s saw some rapid growths for Indian petrochemical industry [7]. The biggest reason for this growth was the high demand for petrochemicals in India, which grew at an annual rate of 13 to 14% since late 90s. It also called for rapid expansion of capacity.

- The BMI forecast of average annual growth in India over 2007-2011 is 14 to 16%. However, the industry suffered setbacks during 2008 due to surge in the price of crude oil.

- Presently India has three gas-based and three naphtha-based cracker complexes with a combined annual capacity of 2.9 MMT of ethylene. Besides this, there are also 4 aromatic complexes with a capacity of 2.9 MMT of Xylenes.

- The production of 5.06 MMT polymers during FY09 accounted for around 62% of the total production of key petrochemicals. It also achieved 88.5% capacity utilization. The industry also produced 2.52 MMT of synthetic fibres during FY09 with a 73% of capacity utilization.

- The economic reforms initiated in 1991 brought major changes in the structure of the domestic petrochemical industry. Delicensing and deregulation allowed the market forces to determine growth and investment. Liberalization of trade policies and lowering of tariffs geared the domestic industry to align itself with the global petrochemical industry. Taking advantage of liberalization, the Indian petrochemical industry invested approximately Rs.350 billion in the 1990s, raising the domestic polymer capacity from less than 0.5 million tonnes to the current level of over 4 million tonnes. Mega sized cracker complexes using the state-of-the-art technologies were set up and the ethylene capacity increased from 0.22 million tonnes in 1990 to 2.51 million tonnes in 2004 as Figure 4 shows. [2]

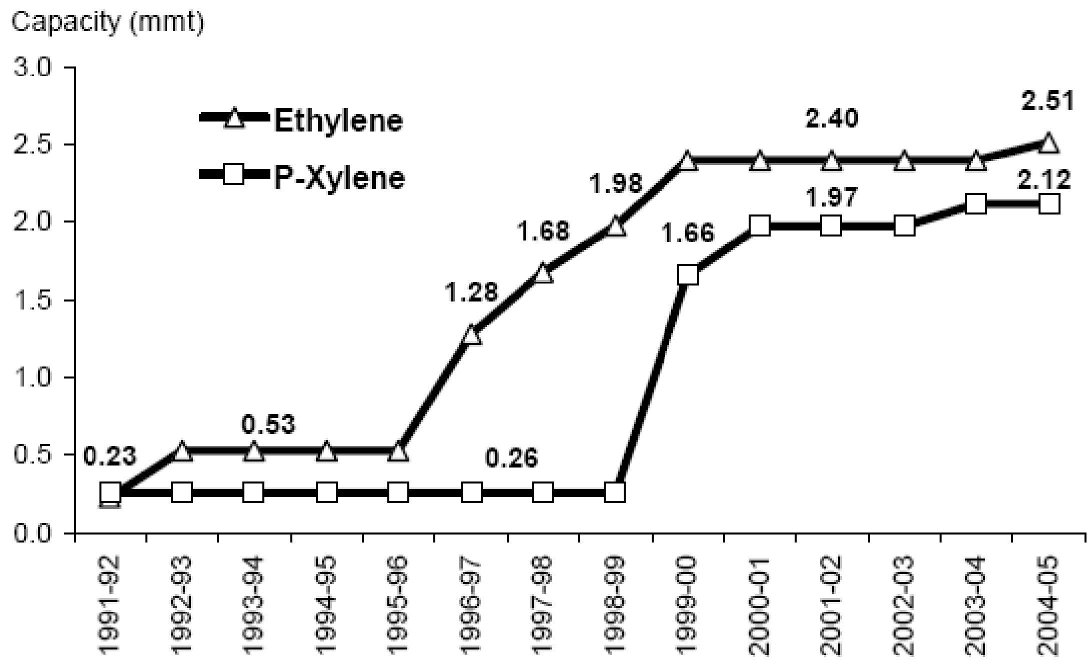

Fig 4: Ethylene and para-xylene Capacity build-up in India

- Despite the low per capita consumption of plastics in India the Indian plastic industry has not got the attention it deserves. As a result, the Indian polymer industry's growth has decelerated, in sharp contrast to the sustained rapid growth of 1.5-2.5 times GDP growth witnessed in the 1990s.

- Post reforms in 1991 there was major investment in petrochemical capacities, which have tapered off by Year 2001-2002. Due to this major capacity additions import dependency has been brought down substantially to 10% saving the country foreign exchange.

- Investment in the downstream petrochemical industry has also followed the same pattern where the capacity addition beyond 2001-02 has been mainly through debottlenecking as shown

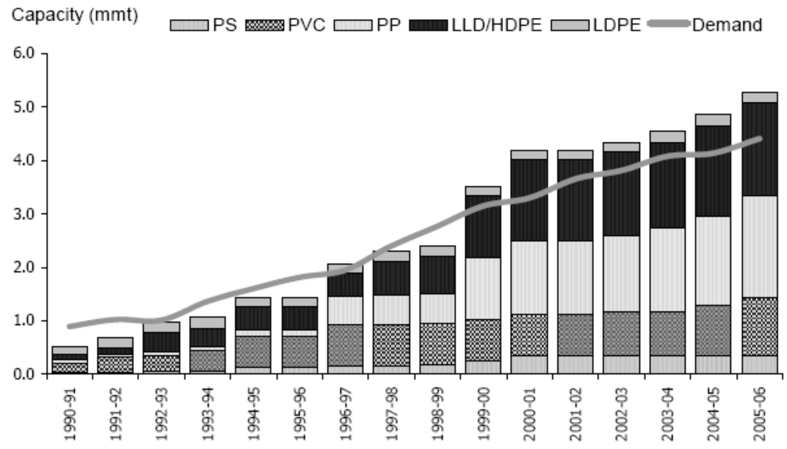

Fig. 5 : Polymer Capacity Build-up India

- Petrochemical Industry in India is a cyclical industry. This industry, not only in India but also across the world, is dominated by volatile feedstock prices and sulky demand. India has one of the lowest per capita consumptions of petrochemical products in the world. For example, the per capita consumption of polyester in India lies at 1.4 kg only comparing to 6.6 kg for China and 3.3 kg for the whole world. Similarly, the per capita consumption of polymers is 5 kg in India, whereas the per capita consumption is around 25 kg for the whole world.

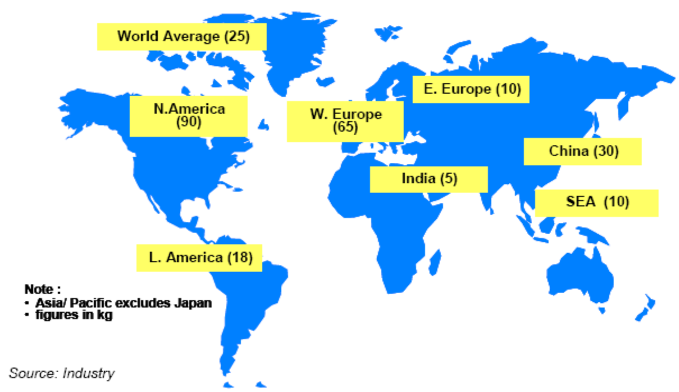

Fig. 6 : World Per Capita plastic consumption

4. Current status of the Indian Petrochemical Industry

The petrochemical industry, a relatively new entrant in the Indian industrial scene, had its inception in the 1960s and registered rapid growth in the 1970s, 1980s, 1990s and record growth in 21st Century so far. The major industry segments are synthetic fibers, polymers, elastomers, synthetic detergents, intermediates and performance plastics etc [2].

Production statistics as per Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilizers is as shown (2008-2010) in Table 4.

4.1 Intermediates

4.1.1 Olefins and Aromatics

The basic building blocks for the production of petrochemical derivatives include olefins like ethylene, propylene, butadiene and aromatics like benzene, toluene and xylenes. These building blocks comprise the foundation for the entire manufacturing industry. India appears to be self sufficient in the production of a few of the base petrochemicals while strikingly deficient in the rest. The following table compares the consumption and production of chemicals like ethylene, propylene, butadiene, benzene and toluene.

- **Ethylene:** Ethylene is used as a feedstock in the production of polymers such as polyethylene (PE), polyester, polyvinyl chloride (PVC), polystyrene, and other organic chemicals. The largest outlet, accounting for 60% of the global ethylene demand, is polyethylene. Figure 8 indicates self-sufficiency in the domestic production and consumption of ethylene.
- **Propylene:** The dominant outlet for propylene is polypropylene (PP), accounting for nearly 63% consumption. Other important propylene derivatives are acrylonitrile, propylene oxide, cumene and acrylic acid. As per Figure 8 till 2005-06, Indian production has been able to match up with the demand. However, the expected growth in demand over the next few decades demands adequate capacity enhancements. By 2011, Asia is expected to be a major consumer of propylene, accounting for nearly 46% of the global demand. The market is currently driven by china which is expected to account for three quarters of the total Asian growth over the next five years.

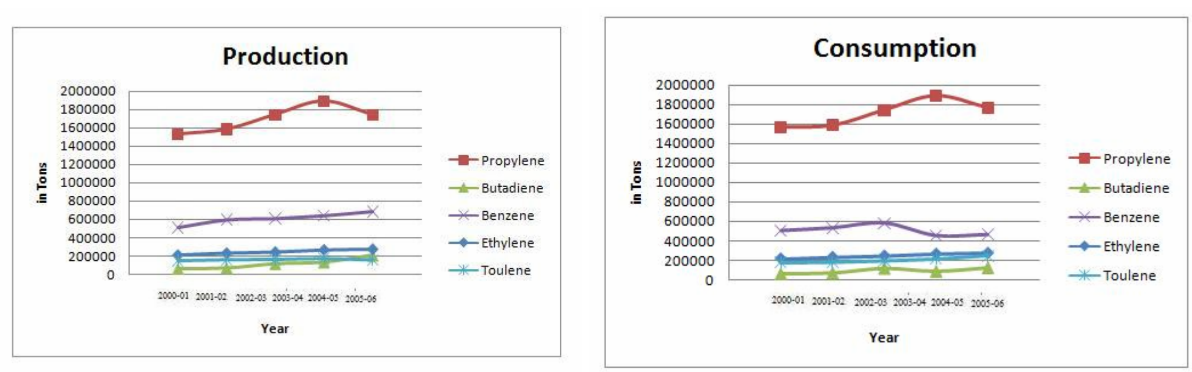

Fig. 7 : Performance of petrochemicals during 2000-06 [9].

Table 5 shows the Producer – Feedstock Sources for Ethylene and Propylene and the expected additions up to 2012. Ethylene capacity increased from 2690 KT in 2009 to 3697 KT by 2010. Capacity expansion of Haldia Petrochemicals Limited by 150 KT (Q1 2010) and 860 KT of Ethylene and 600 KT of Propylene additions by Indian Oil Corporation (Q2 2010) is expected. The production of Ethylene and Propylene was 2639 Tons and 1887 KT in 2008-09. Butadiene capacity of 279 KT will increase by 20 KT due to debottlenecking by Haldia Petrochemicals Ltd. in 2010.

Aromatics

Benzene

Benzene production during 2008-09 was 880 KTPA. There is an addition of 150 KT by IOC in Panipat in 2010. 350 KT was the net export after netting off imports for exports giving an apparent demand of 522 KT in 2008-09. Benzene demand is expected to grow at 2.6% and 2.4% in 2010 and 2011 respectively.

p-xylene

P-Xylene production during 2008-09 was 2155 KT. 256 KT was the net export after netting of imports from exports thereby giving an apparent demand of 1899 KT in 2008-09. P-Xylene demand is expected to grow at 32% in 2010 and at 3.39 in 2011 as the demand will grow for the new PTA plant of Mitsubishi. In 2010 and 2011 no new capacity is getting added except the full effect of the capacity of PX added and debottlenecking.

O-xylene

O-Xylene production during 2008-09 was 224 KT. 17 KT was the net export after netting of imports from exports thereby giving an apparent demand of 207 KT in 2008-09. No new capacity addition is expected.

4.1.2 Fiber Intermediates

Purified Terephthalic Acid (PTA) production during 2008-09 was 2154 KT. As per CPMA the production in 2009 was 2965 KT. MCC PTA India Corporation Pvt. Ltd., commissioned its second line of 800 KT in January 2010. MEG production during 2008-09 was 783 KT. IOC commissioned 325 KT MEG capacity plant at Panipat and the same is likely to begin production from April 2010 end. Large scale imports of MEG will continue to take place in foreseeable future. During 2008-09 difference between imports and exports was a net import of 490 KT resulting in an apparent demand of 1273 KT in 2008-09 for MEG. PTA/MEG demand is expected to grow by 9% in 2010 and 2011.

4.2 Other Petrochemicals

4.2.1 Phthalic anhydride (PAN)

PAN production during 2008-09 was 207 KT. 4 KT was the net export after netting of imports from exports thereby giving an apparent demand of 203 KT in 2008-09.

4.2.1 Commodity Polymers

- Commodity polymers exhibited a lower consumption trend during 2001-2007[2]
- External factors which led to this situation include, fluctuating oil prices and Global economic slowdown
- Internal factors which led to this situation include relatively high manufacturing costs, high incidence of tax and excise duty and accelerated tariff reduction
- Import led growth did not take place due to structural constrains in the processing sector.
- Exports of polymers were 0.7 to 1 million tons against the average imports of 0.4 million during 2002 to 2006.
- Commodity polymers registered a Compounded Annual Rate of Growth (CARG) of 6.1 % against the projected demand of 12 % (Level I) and 13 % in (Level II) in the Report of the Task Force on Petrochemicals. During the period polymers witnessed price increase due to crude oil prices, exports of Polypropylene, High Density Polyethylene (HDPE) and Polystyrene increased. Imports of polymers were decreasing, Polyvinyl Chloride imports increased. There was no major green field capacity addition after 2000-01. The capacity additions (CARG of 5 % between 2000-01 and 2005-06) were by way of substantial expansion and de-bottlenecking of the existing plant.

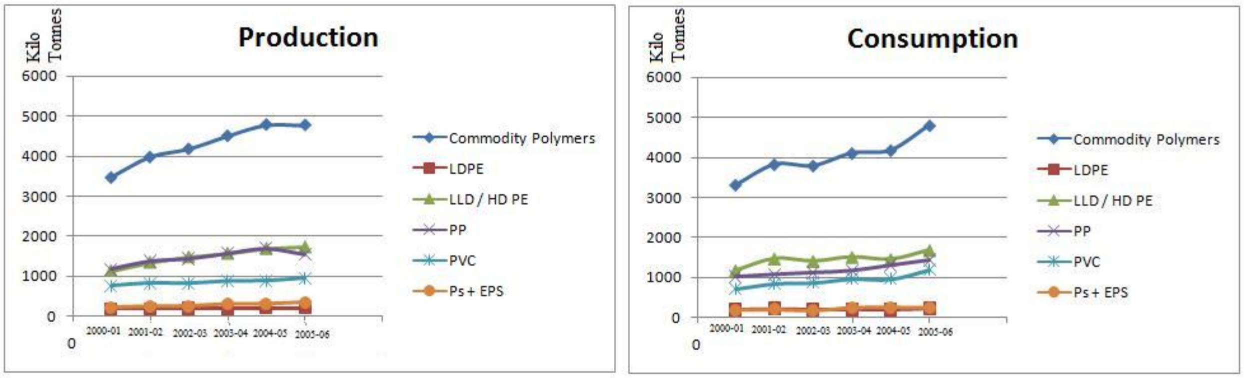

Fig. 8 : Performance of commodity polymers during 2000-06

Polyethylenes

Polyethylenes production during 2008-09 was 1949 KT. 646 KT was the net import after netting of imports from exports thereby giving an apparent demand of 2595 KT in 2008-09.

In 2010 major capacity addition is by 10 CL of 350 KT of LLDPE, 300 KT of HDPE. Haldia Petrochemicals in 2010 (Q1) increased LLDPE capacity by 100 KT and HDPE by 20 KT. In 2011, GAIL debottlenecking of HDPE by 40 KT and LLDPE by 20 KT. 10 CL is expected to debottleneck HDPE by 65 KT and LLDPE by 15 KT. In line with capacity expansion production increase is expected. Operating rate is expected to increase to 95% by 2011. PE will grow at 10.5% and 11.0% in 2010 and 2011 respectively.

Polypropylenes

Polypropylenes production during 2008-09 was 1949 KT. 130 KT was the net export after netting off imports from exports thereby giving an apparent demand of 1811 KT in 2008-09. PP is expected to grow at 12% and 11% in 2010 and 2011 respectively. Reliance's 900 KT PP capacity at Jamnagar came on stream in Q4 2009. 10C's 600 KT PP capacity is expected to come on stream by Q2 2010.

PVC

PVC production during 2008-09 was 1051 KT. 379 KT was the net imports after netting off exports thereby giving an apparent demand of 1430 KT in 2008-09. There was a new capacity addition of 220 KT of PVC in 2009 by Chemplast. PVC imports are likely to continue in the coming years.

4.2.2 SYNTHETIC DETERGENT INTERMEDIATES

Surfactant intermediates

- Surfactant intermediates[2] are used in the manufacture of detergents. Comprises of Linear Alkyl Benzene (LAB) and Ethylene Oxide (EO) .

- The estimated consumption trend is lower than the projected demand which can be attributed to the segmented nature of the industry and lack of advancement in the processing techniques.
- Synthetic detergent intermediates registered a growth of 16 % against the projected demand of 9.3 % in the Report of the Task Force on Petrochemicals

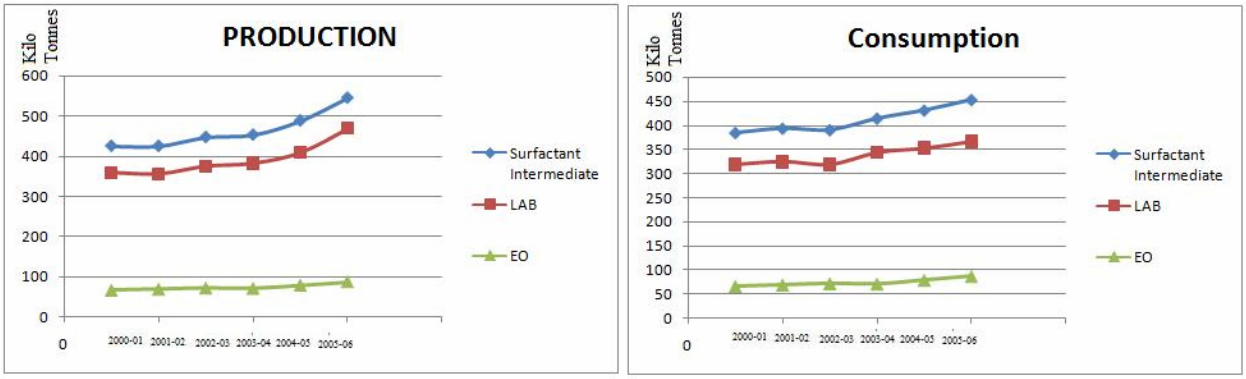

Fig. 9 : Performance of Surfactant intermediates during 2000-06

Linear alkyl Benzene (LAB)

LAB production during 2008-09 was 434 KT. 23 KT was the net export after netting imports thereby giving an apparent demand of 411 KT in 2008-09. The LAB capacity is expected to be 5.4% and 6.1% in 2010 and 2011 respectively.

Ethylene Oxide (EO)

EO production during 2008-09 was 117 KT. EO capacity is expected to remain unchanged till 2011. Demand growth for EO is expected to be 7% in 2010 and 2011. Some imports of EO are expected as the demand is likely to be in excess as compared to supply.

4.3 Synthetic Fibres

- Synthetic fiber consists of Acrylic Fiber, Nylon Filament Yarn and polyesters Fiber and Filament yarn.
- Polyesters constitute more than 85 % in the synthetic fiber / yarns. Even though natural fiber cotton has the major share in textile application, Synthetic fiber based fabric is common man's fabric.
- This segment of the industry has shown a good progress with estimated consumption greater than the projected demand.
- Synthetic Fiber registered a growth of 2.5 % against the projected demand of 6.4 % in the Report of the Task Force on Petrochemicals. Polyesters and Nylon Filament yarn demand exceeds the projected demand. During the period the excise duty on synthetic yarn / fiber reduced from 18/36 % to 8 % against the cotton excise duty of 4 %. These excise duty corrections improved the consumptions. The capacity additions (3.2 % CARG during 2000-01 to 2005-06) were expansion by the existing units.

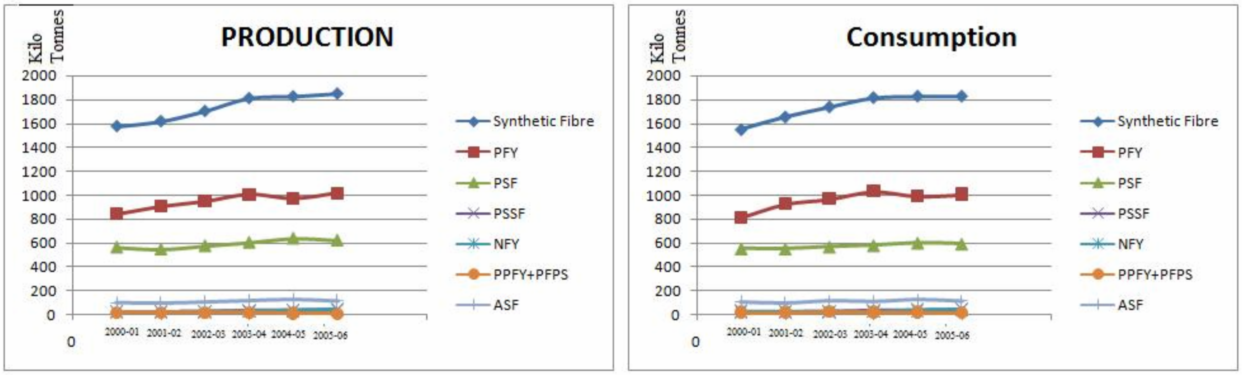

Fig. 10 : Performance of Synthetic fiber during 2000-06

Polyester Staple Fibre (PSF)

PSF production during 2008-09 was 843 KT. 120 KT was the net export after netting of imports thereby giving an apparent demand of 723 KT. Demand growth is expected to be 10% in 2010 and 2011.

Polyester Filament Yarn (PFY)

PFY production during 2008-09 was 1261.77 KT. Net export/import of PFY was negligible during the year. The capacity addition in case of PFY is mainly due to expansion of existing players and backward integration of downstream players. Demand growth is expected to be 10% in 2010 and 2011.

4.4 Synthetic Rubber

- Synthetic Rubbers are broadly classified in two categories [2] viz General Purpose (SBR/PBR) and special purpose synthetic rubber (NBR/ EVA/ EPDM/ BR).
- This sector has also performed better than expected with a CARG of 19% compared to the projected value of 10% during this period.
- Synthetic rubber registered a growth of 3.6 % against the projected demand of 8.2 % in the Report of the Task Force on Petrochemicals. M/s Indian Oil Corporation Ltd., commissioned 120 kilo ton Linear Alkyl Benzene Plant in 2004.

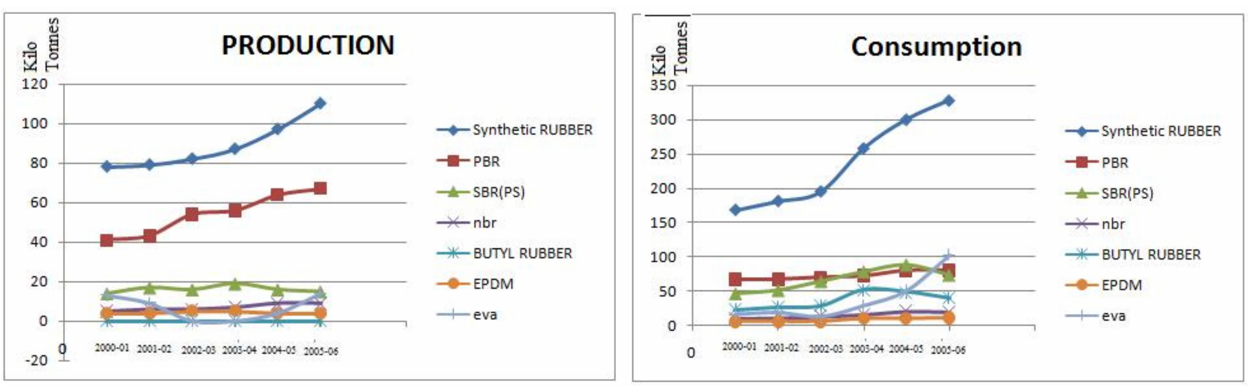

Fig. 11 : Performance of Synthetic Rubber during 2000-06

Table 4 : Product-wise production of major petrochemicals (figures in 000' mt)

PRODUCTS	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	"2009-10 (APR-DEC.'09)"
A : BASIC PETROCHEMICALS							
1. SYNTHETIC FIBRES							
ACRYLIC FIBRE	117.15	127.58	113.75	107.3	85.09	77.8	72.34
POLYESTER STAPLE FIBREFILL	38.84	39.82	47.43	47.06	44.82	51.39	40.29
NYLON FILAMENT YARN	30.96	36.77	39.56	32.43	27.81	28.25	22.38
NYLON INDUSTRIAL YARN/TYRE CORD	55.87	48.03	55.4	71.62	83.5	68.63	66.24
POLYESTER FILAMENT YARN	**1003.13**	**970.25**	**1014.99**	**1193.63**	**1349.85**	**1261.77**	**1008.86**
POLYESTER STAPLE FIBRE	603.7	638.73	623.14	784.62	919.27	842.89	728.72
POLYPROPYLENE FILAMENT YARN	15.34	11.28	8.8	9.7	9.83	9.14	6.79
POLYPROPYLENE STAPLE FIBRE	2.77	2.97	3.11	3.55	3.5	3.44	2.43
Total	**1867.75**	**1875.42**	**1906.19**	**2249.92**	**2523.68**	**2343.38**	**1948.06**
2. POLYMERS							
LOW DENSITY POLYETHYLENE	183.76	204.77	200.59	194.88	196.15	191.21	144.45
HIGH DENSITY POLYTHYLENE	958.07	1035.09	1034.75	958.39	973.61	941.59	644.15
PLYESTYRENE	274.02	275.2	310.53	284.88	274.49	239.98	196.66
POLYPROPYLENE (INC. CO-POLYMERS)	1567.22	1690.21	1540.92	2000.94	1978.23	1770.65	1303.06
EXPANDABLE POLYSTYRENE	31.43	35.71	39.23	45.82	44.19	49.27	46.49
POLYVINYL CHLORIDE	878.39	884.77	953.37	926.43	997.9	1050.93	781.58
LINEAR LOW DENSITY POLYTHYLENE	606.25	649.99	688.7	771.52	837.06	816.6	532.56
Total	**4499.17**	**4775.75**	**4768.05**	**5182.87**	**5303.61**	**5060.23**	**3548.94**
3. SYNTHETIC RUBBER							
STYRENE BUTADIENE RUBBER	18.88	16.06	15.45	13.12	17.4	13.5	13.59
POLYBUTADIENE RUBBER	55.75	64.14	67.34	71.69	74.4	71.98	54.57
ETHYLPROPYLENE DIMERS	5.45	3.53	4.13	3.54	0.51	0	0
ETHYL VINYL ACETATE	0	4.02	14.17	3	0	0	0
NITRILE BUTADIENE RUBBER	7.31	9.03	9.14	10.08	13.34	10.62	10.49
Total	**87.39**	**96.78**	**110.23**	**101.43**	**105.56**	**96.09**	**78.65**
4. SYNTHETIC DETERGENT INTERMEDIATES							
LINEAR ALKYL BENZENE	381.96	408.63	467.97	459.87	470.74	434.35	346.67
ETHYLENE OXIDE	71.42	79.26	87.51	96.44	114.08	117.35	114.62
Total	**453.38**	**487.9**	**555.47**	**556.31**	**584.82**	**551.69**	**461.29**
5. PERFORMANCE PLASTICS							
ABS RESIN	48.41	62.2	75.85	74.23	78.44	68.43	62.89
NYLON-6	10.36	11.71	11.75	13.41	12.98	11.37	8.84
POLYMETHYL METHACRYLATE	2.66	2.21	2.47	2.71	2.64	2.42	2
STYRENE ACRYLONITRILE	37.02	35.68	35.53	41.43	61.45	58.17	54.8
NYLON 6,6	0.81	1.03	1.07	1.27	1.28	0.93	0.86
Total	**99.26**	**112.83**	**126.68**	**133.05**	**156.79**	**141.32**	**129.38**
"Total Major Basic Petrochemicals (1 to 5)"	7006.94	7348.67	7466.67	8223.57	8674.45	8192.72	6166.32
B : INTERMEDIATES							
FIBRE INTERMEDIATES							
ACRYLONITRILE	36.4	38.76	33.24	37.02	39.01	30.46	29.67
CAPROLACTUM	110.29	122.07	116.78	121	86.48	84.46	90.4
DIMETHYL TEREPHTHALATE	216.77	238.64	197.41	27.53	3.56	0	0
MONOETHYLENE GLYCOL	651.92	713.87	881.37	872.47	922.77	783.2	550.43
PURIFIED TEREPHTHALIC ACID	1675.72	1738.03	1734.24	2379.24	2059.18	2154.02	2241.84
Total	**2691.1**	**2851.37**	**2963.04**	**3437.26**	**3110.99**	**3052.14**	**2912.34**
OLEFINS							
BUTADIENE	114.13	131.4	206.94	222.66	243.96	213.72	155.24
ETHYLENE	2421.25	2644.59	2719.18	2683.37	2810.47	2638.78	1893.41
PROPYLENE	1746.3	1891.9	1744.62	2089.3	2156.95	1887.46	1388.97
Total	**4281.67**	**4667.89**	**4670.74**	**4995.33**	**5211.38**	**4739.96**	**3437.62**

AROMATICS							
BENZENE	608.28	640.09	685.82	885.52	866.95	879.67	616.31
MIXED XYLENE	55.59	63.15	55.73	57.69	73.56	77.54	40.55
ORTHO-XYLENE	206.58	145.57	242.41	431.22	268.79	224.29	271.46
TOLUENE	165.53	177.23	158.89	147.18	141.79	138.77	102.38
PARAXYLENE	1388.98	1425.28	1393.7	1925.5	2136.96	2154.86	1678.55
Total	**2424.96**	**2451.31**	**2436.55**	**3447.11**	**3488.05**	**3475.12**	**2709.24**
C : OTHER PETROCHEMICALS							
DIETHYLENE GLYCOL	45.85	48.29	58.4	60.05	68.39	58.33	51.75
DIACETONE ALCOHOL	8.67	8.74	8.94	8.96	9	7.61	6.68
ETHYLENE DICHLORIDE	265.26	253.45	263.38	220.03	262.09	276.88	331.54
BUTANOL	12.25	12.52	14.76	14.44	13.64	11.46	7
2-ETHYL HEXANOL	**25.65**	**26.67**	**23.8**	**24.3**	**26.69**	**22.56**	**14.14**
VINYL CHLORIDE MONOMER	302.21	292.88	307.75	279.62	288.67	303.23	501.85
EPICHLOHYDRINE	9.42	10.62	11.14	9.75	8.97	7.83	5.38
PROPYLENE OXIDE	24.88	25.17	27.19	27.94	28.29	28.63	23.74
PROPYLENE GLYCOL	13.44	14.13	15.95	16.43	16.88	16.07	13.9
POLYVINYL ACETATE RESIN	0	9.86	11.71	10.43	11.44	10.13	3.1
METHYL METHACRYLATE	4.1	4.74	4.04	4.45	4.16	3.47	3.43
ISO-BUTANOL	3.36	3.42	4.15	3.68	2.71	2.73	3.06
C4-RAFFINATE	163.58	121.02	104.57	76.12	76.69	54.66	46.81
PHTHALIC ANHYDRIDE	181.25	183.03	191.62	232.97	244.43	206.61	170.83
VINYL ACETATE MONOMER	25.74	28.68	25.56	23.6	22.95	24.32	0

Source: Annual Report 2009-10, DCPC, Govt. of India

ANNEXURE - V PETROCHEMICALS

PRODUCER – FEEDSTOCK SOURCES

COMPANY	UNIT	FEEDSTOCK	ETHYLENE CAPACITY (KTPA)			PROPYLENE CAPACITY (KTPA)			ADDITIONS BY
			EXISTING	ADDITIONS	TOTAL	EXISTING	ADDITIONS	TOTAL	
RIL – Jamnagar, Hazira, Nagothane, Gandhar, Vadodara	Cracker/ PRU Refinery	Naphtha / Gas (C2-C3, Propane)	1950	-	1950	2800	-	2800	-
OPaL - Dahej	Cracker	Naphtha	-	1100	1100	-	340	340	2012
IOC - Panipat	Cracker/ PRU Refinery	Naphtha	-	860	860	-	600	600	2010
HALDIA	Cracker	Naphtha	540	130	670	260	70	330	2010
Others – GAIL, BPCL, HMEL, MRPL	Cracker/ PRU Refinery/ FCCU Refinery	Natural Gas (C2-C3) / PRU - Propylene	410	290	700	16	1240	956	2010 / 2012
TOTAL CAPACITY			**2900**	**2380**	**5280**	**3076**	**1950**	**5026**	

4.5 Naptha Crackers

- Refineries in India produce adequate quantity of Naphtha for meeting feedstock requirement of the petrochemical industry, which is expected to increase significantly as new refinery capacities are added.
- Naphtha availability is expected to increase significantly as new refinery capacity addition by 2012 is likely to be 155 million tons. These additional refining capacities will result in additional quantity of 17 million tons of naphtha
- The following table lists out the existing Ethylene cracker capacities in India. Of the 2.55 MMT total ethylene capacity in the country, ~61% is Naphtha-based & 39% is gas-based.

Table 5 : Ethylene cracker capacities in India

Plant	Ethylene Capacity	Feedstock Mix
NOCIL	60,000	Naphtha
IPCL, Baroda	130,000	Naphtha
IPCL, Gandhar	300,000	Ethane Propane mix
GAIL, Auraiya	300,000	Ethane Propane mix
IPCL, Nagothane	400,000	Ethane Propane mix
HPL, Haldia	520,000	Naphtha
RIL, Hazira	750,000	Naphtha

- During the 1990s, the trend of increasing average cracker size was witnessed in the Indian polymer industry also.
- The average size of ethylene crackers in India, which was 80 kTA in 1990-91, has increased to 350 kTA in 2004-05

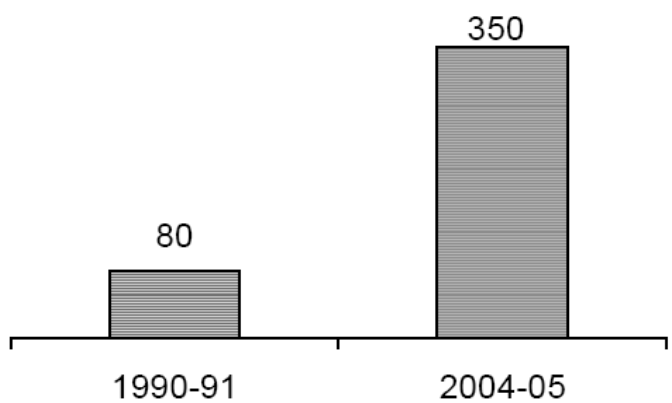

Fig. 12 : Average cracker size (Kta) in India

Since the commissioning of the first cracker in 1967, the petrochemical industry in India has come a long way. Among the various segments of the petrochemical industry, the plastics sector had emerged as the fastest growing sector.

The Indian petrochemicals industry is small by international standards, with ethylene capacity in India accounting for only 2.3% of global capacity. Polymers constitute the single largest segment within the Indian petrochemical industry but are rather small in the global context, accounting for only around 2.5% of the global production. India is ranked 13th in the world in, 2005 in terms of ethylene capacity. India's share in global capacity for some of the key petrochemicals is shown below in table 5.

Table 6: Building blocks and polymer capacities: India Vs World

(in KT)	India	World	India's share
Building Blocks			
Ethylene	2716	117645	2.3%
Propylene	1916	71228	2.7%
Polymers			
PE	1775	73396	2.4%
PP	1760	44368	4.0%
PVC	979	37406	2.6%
PS	365	15225	2.4%
ABS	76	8536	0.9%

4.6 Downstream Plastic Processing Industry [2]

- Downstream plastic processing industry is extremely fragmented.
- Plants are operating with outdated technology need major modernization and up gradation in both scales of operation and technology, which is inhibiting its international competitiveness.
- About 75% units are in the small scale sector.

4.7 Natural Gas [2]

4.7.1 *Natural Gas Availability in the Indian Petrochemical Market*

For industrial purposes in India, natural gas competes with liquid based fuel naphtha and other coal based fuels. Industries usually find it cost-effective and environmentally compatible to shift to gas based operation from oil based operation provided they can obtain natural gas supplies. Historically, however, these consumers have had difficulty securing gas supplies, which were allocated through a political process that gave priority to the power sector and fertilizer producers. Recent activities have shown that industrial consumers will readily consume gas, if it is made accessible. It is therefore evident that industrial demand for natural gas is directly related to the availability.

The Indian market is witnessing a transformation from a centrally managed system to one with a greater role for market forces. Since the first major gas supplies began flowing, gas has been produced entirely by the Oil and Natural Gas Corporation (ONGC) and transported and marketed by Gas Authority of India Limited (GAIL).

As per CEDIGAZ, January 1st 2008, the natural gas reserves in India are around 37.257 Trillion Cubic Feet.

But, the petrochemical sector remains lower in priority for allocation of domestic gas. This is so because the power and fertilizer sectors have traditionally been core consumers of natural gas. These two sectors together consume about 70% of the gas consumed in the country. Petrochemical industry adds tremendous value to the feedstock and hence, needs to receive a higher priority compared to sectors like fertilizers for which cheap sources of imports exist.

Table 7: Gas Production & Availability for Petrochemical Industry

(MMSCMD)	1990-91	1995-96	2000-01	2004-05
Gross Gas Production	18.0	22.6	29.5	31.813
Used by petrochemicals	0.4	0.5	0.8	1.2

4.7.2 Indian LNG Scenario

India began importing Liquefied Natural Gas (LNG) in 2004. In 2006, India imported 254 BCF of LNG, making it the seventh largest importer of LNG in the world. India's LNG imports came in 2006 came from Algeria, Egypt, Nigeria, Oman, Qatar, United Arab Emirates, Australia, and Malaysia. Qatar was by far the largest supplier in 2006, accounting for nearly 86 percent of imports. Currently, India has two operational LNG terminals – Dahej terminal and Hazira terminal.

5. Key Driving factors of the Indian petrochemical industry

- The Demand side is influenced by US demand and China demand. This reflects in the GDP, based on the elasticity the demand growth is affected.
- In the supply side the mergers and acquisitions to remain competitive, new investments, turnarounds and disruption are the key factors affecting supply.
- The prices are influenced by the crude price which in turn depends on world economy, Geopolitical situation, demand & supply, weather and future markets.
- The petrochemical prices are influenced by the Crude oil price and the operating rates of the plants.
- Petrochemical products follow a cyclic upswing and the downturns. In the past Petrochemicals have sparkled through several cycles and challenges
- The factors which influence the petrochemical cycles are Technology, market, capital cost, capacity build ups, oil price shocks, operating costs maturity of markets, feedstock availability, scale of operation, integration through mergers and accusations, location of the project, innovations, capital infusion, responsible care, environmental concerns and public perception

6. Projected future trend of the Indian petrochemical industry

In order to further strengthen the petrochemical industry in the context of emerging opportunities and challenges, the Government of India constituted a Task Force on Petrochemicals. The Task Force on Petrochemicals has identified the directions and broad contours of the national vision in the petrochemical sector. Demand projections were made for 10th and 11th Five Year Plan. The performance of the petrochemicals industry against the demand projections are as follows:

6.1 Overall demand projections

- If policy environment improves, demand for polymers has the potential to reach 12.5 MMT by the end of the 11th Five-Year Plan growing at a CARG of 18%.
- The above translates to an Ethylene equivalent deficit of ~5 MMT by 2012 necessitating commissioning of 5 additional crackers of 1 MMT average size with investments of US$ 8 billion (~Rs 40,000 crores).
- To keep in sync, ~US$ 6 billion (Rs 30,000 crores) investments would be required in the downstream plastic processing sector by 2011-12.

6.2 Future investment projections in the downstream petrochemical processing and polymer Industry:

Table 8: Projected future investment requirements in downstream petrochemical processing and polymer industry

Future Investment Requirements (Kt)					
	Capacity	**Demand**	**Deficit/Surplus**	**Avg/unit size**	**No. of Plants reqd.**
C2					
2006/07	2363	4933	-2570	700	4
2011/12	2363	8647	-6284	700	9
All Polymers					
2006/07	4687	5338	-651	200	3
2011/12	4687	9197	-4510	200	23

6.3 Naphtha Crackers

- In the domestic petrochemical industry, around 56% of ethylene cracking capacity is based on naphtha as a feedstock, the balance being met from gas
- The Ethylene deficit, which is projected at 1.2 MMT in 2006, is expected to increase steadily to 4.9 MMT in 2012. In order to meet the widening Ethylene deficit in India, augmentation of additional Ethylene capacity will be required.

Table 9: Projected refining capacity and additional Naphtha availability in India

	2005	2008	2010	2012
Refining Capacity	132.5	158.7	242.3	287.3
Addition in capacity		26.2	109.8	154.8
Additional Naphtha Availability		2.9	12.1	17.0

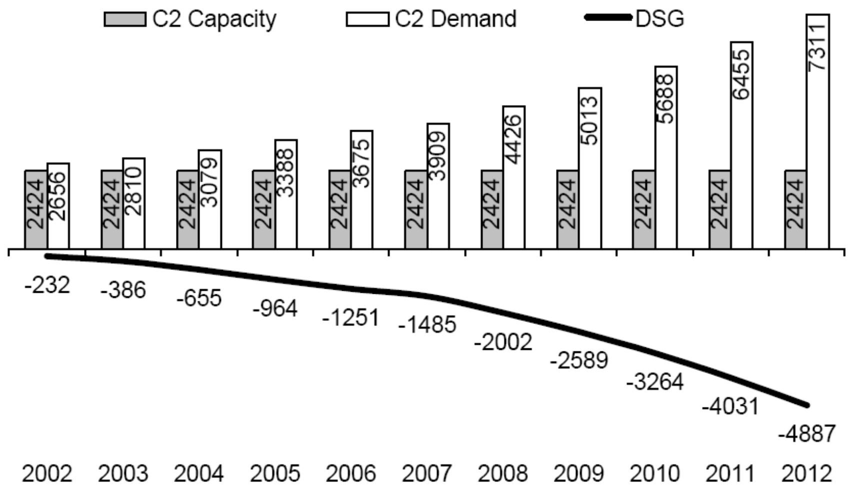

Fig 13 : Projected ethylene deficit in India

6.4 Commodity polymers

- In a facilitative policy environment, the domestic polymer industry is expected to grow at a compounded average rate of 15% between 2006-07 & 2011-12.
- Among the polymers, PVC is likely to grow most rapidly at a CARG of 17% followed by PP with a CARG of 16%.
- PS demand is predicted to register a CARG of 8% in the period 2006-07 to 2011-12.
- Demand for PE is expected to grow at the same rate as all polymers together or less. Within PE, demand for HDPE is projected to grow at the highest rate of 15% while LLDPE demand is expected show a CARG of 12%.
- Demand for LDPE is likely to grow at a CARG of 7% - much below the rates likely to be witnessed for other polymers.

Table 10 : Demand projections for commodity polymers

(in KT)	PE	PP	PVC	PS	Commodity Polymers	Task Force Projection		No. of Plants Required		
						Level-I (high Growth)	Level-II (Moderate growth)	Level-I	Level-II	Revised
2006-07	2124	1678	1214	282	5299	7281	6465	8	6	3
2011-12	4711	4627	2772	481	12591	14052	10844	25	17	16

6.5 Synthetic Rubber

- On account of strong economic growth, which is likely to be sustained during XI Plan period, overall demand for total rubber is expected to be strong.
- The auto sector, which accounts for over 50% of total rubber demand, is expected to maintain strong growth thus maintaining a strong demand for synthetic rubber.
- The demand of synthetic rubber depends upon availability of natural rubber. The availability of natural rubber is taken into consideration for deriving demand for synthetic rubber.
- The share of synthetic rubber in total rubber consumption is likely to increase significantly to 39% in 2011-12 as shown below with corresponding reductions in the share of natural rubber.

Table 11: Demand projections for Synthetic Rubber

	Total Rubber		Natural Rubber		Synthetic Rubber	
(in kT)	Demand	Growth	Demand	Growth	Demand	Growth
2006-07	1177	7%	816	4%	361	13%
2007-08	1261	7%	853	4%	408	13%
2008-09	1353	7%	891	4%	462	13%
2009-10	1448	7%	931	4%	516	12%
2010-11	1551	7%	973	4%	578	12%
2011-12	1664	7%	1017	5%	647	12%

	SBR	BR	EPDM	NBR	CR	Total
2000	55	50	6	6	5	122
2005	79	68	8	8	7	169
2006	85	73	8	9	7	182
2007	94	79	9	10	7	198
2008	107	90	10	11	7	225
2009	126	104	11	13	8	262
2010	146	118	13	14	8	299
% growth	13.1	11.8	10.8	11.3	3.8	12.1

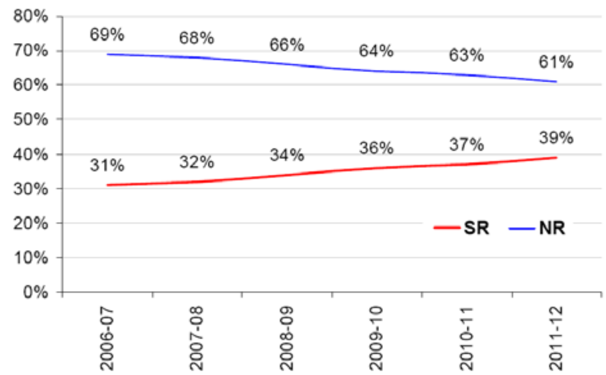

Fig 14 : Projected shares of NR and SR in total rubber consumption

6.6 Surfactants

- Linear Alkyl Benzene (LAB) and Ethylene Oxide (EO) are the major synthetic intermediates used in manufacture of detergents and surfactants.
- Indian industry made a modest beginning in the late 70's, when IPCL commissioned the first LAB plant. Subsequently Reliance Industries Ltd (RIL), Tamil Nadu Petrochemicals Limited (TPL) and Nirma Ltd. set up facilities for manufacture of LAB.
- Indian Oil Corporation Ltd (IOC), which commissioned a plant of capacity of 120 KTA with an investment of US$ 290 million in August 2004, is the latest entrant. The current installed capacity of LAB in India is 449 KTA
- The demand for LAB is forecast to register a CARG of 6 percent during the projected period.

Table 12: Projected LAB demand-supply

(in kT)	2007-08	2008-09	2009-10	2010-11	2011-12
Capacity	449	449	449	449	449
Operating Rate	110%	110%	110%	115%	115%
Production	493	493	493	516	516
Demand Growth	6%	6%	6%	6%	6%
Demand	392	416	440	467	490
Surplus/Deficit (-)	101	77	53	49	26

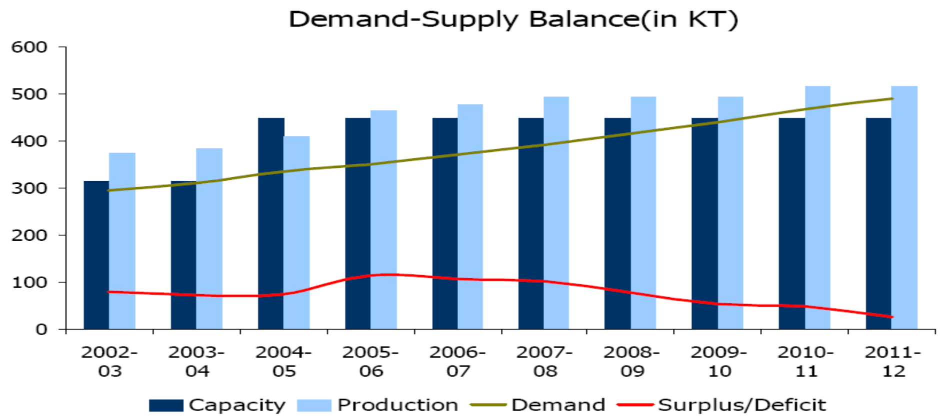

Fig 15 : Projected Demand-Supply balance of LAB

- Ethylene oxide (EO) is a versatile intermediate used in the production of Surfactants and other derivatives such as glycol ethers, polyethylene glycol, polyether polyols, Dye Intermediates, Drug Intermediates and ethanol amines. EO is produced by oxidation of ethylene.
- In India, cracking of naphtha natural gas fractions produces the bulk of ethylene. A small quantity of ethylene is also produced through alcohol route (ethyl alcohol).
- Current capacity of Ethylene Oxide is far in excess of demand.
- RIL is setting up an SEZ at Jamnagar, which includes a variety of Petrochemicals. The plans include a fresh EO capacity of 50 KTA. The Capacity estimates from 2009-10 onwards includes an estimated 50 KTA of EO capacity on this account.
- IOC is also setting up a Naphtha cracker along with downstream products at Panipat.
- The demand for EO is forecast to grow at CARG of 8 percent during XI Plan period.

Table 13: Projected EO demand-supply

(in kT)	2007-08	2008-09	2009-10	2010-11	2011-12
Capacity	148	148	198	198	198
Operating Rate	70%	76%	60%	66%	71%
Production	103	112	120	130	141
Demand Growth	8%	8%	8%	8%	8%
Demand	103	112	120	130	141
Capacity Surplus/ Deficit (-)	45	36	78	68	57

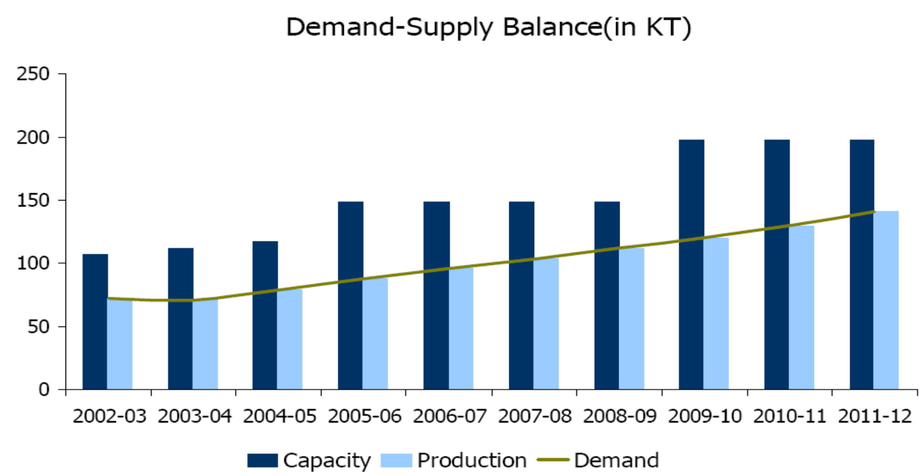

Fig 16: Projected Demand-Supply balance of EO

6.7 Downstream plastic processing

- The annual incremental investment required in the processing sector increases from ~Rs 1148 crores in 2005-06 to ~Rs 2529 crores in 2010-11.

- In the period till 2010-11 the total additional investments needed in the processing sector is estimated to be Rs 10790 crores.
- The fructification of investments would also depend on the enhancement of competitiveness of the downstream processing units through continuous R&D support.

Table 13 : Sector wise additional investments requires for processing (in Crores)

Sector	05-06	06-07	07-08	08-09	09-10	10-11	Total (05-11)
Monolayer	232.6	150.7	203.1	242.5	284.7	323.4	**1437.1**
Multilayer	49.1	64.1	87.5	113.4	151.8	119.3	**585.1**
Pipes	30.9	21.7	28.2	36.5	47.9	41.3	**206.4**
PP/HD Woven Sacks	114.4	109.0	126.5	133.0	139.7	146.8	**769.3**
Extr. Coating	9.6	12.0	15.1	15.1	18.3	21.5	**91.6**
PPTQ Film	1.4	9.9	5.0	7.1	4.6	5.0	**33.0**
PVC Pipe	86.9	92.1	108.2	129.0	138.4	121.1	**675.6**
Injection Moulding	460.8	632.3	750.8	1072.9	1335.9	1415.4	**5668.1**
Blow Moulding	32.1	32.6	35.9	49.1	53.4	41.0	**244.1**
Monofilaments	3.1	3.5	2.6	3.7	3.2	5.2	**21.3**
Calendered Sh.	39.1	24.8	26.1	18.4	19.4	61.2	**188.9**
BOPP Film	50.0	50.0	50.0	99.9	149.9	149.9	**549.5**
Fibres & Fil.	19.6	15.7	22.5	36.2	51.7	48.5	**194.1**
PVC Wire & Cables	0.7	1.4	1.5	1.9	2.7	3.7	**11.8**
PVC Blown Film & Sheet	2.6	1.4	1.0	0.7	0.5	0.0	**6.2**
Sheet Lines	6.0	6.1	5.3	8.1	16.2	21.3	**63.0**
Other Extrusion ETC.	8.9	7.0	7.1	9.3	8.2	4.4	**44.8**
Extrusion Overall	654.9	569.2	689.6	854.7	1037.0	1072.5	**4877.9**
Total **	**1147.8**	**1234.1**	**1476.4**	**1976.8**	**2426.2**	**2528.8**	**10790.0**

6.8 Natural Gas

- The total gas availability in the country may increase to around 244 -314 MMSCMD by 2010-11.
- As against the above total gas availability, the total projected demand of natural gas is 327 MMSCMD by 2010-11.
- The expected commission of Natural gas by Indian Industries is slated to rise from current levels of 6bcm (billion cubic meters) to 16bcm by 2015 and further to 26 bcm by 2025.

A joint study conducted by A.T. Kearney and Stanford (Program on Energy and Sustainable Development) modeled the future capabilities of natural gas to meet the demands of the industry. The model assumed a constant natural gas price of $5.5/MMBTU [11]. Figure 17 graphically displays the results.

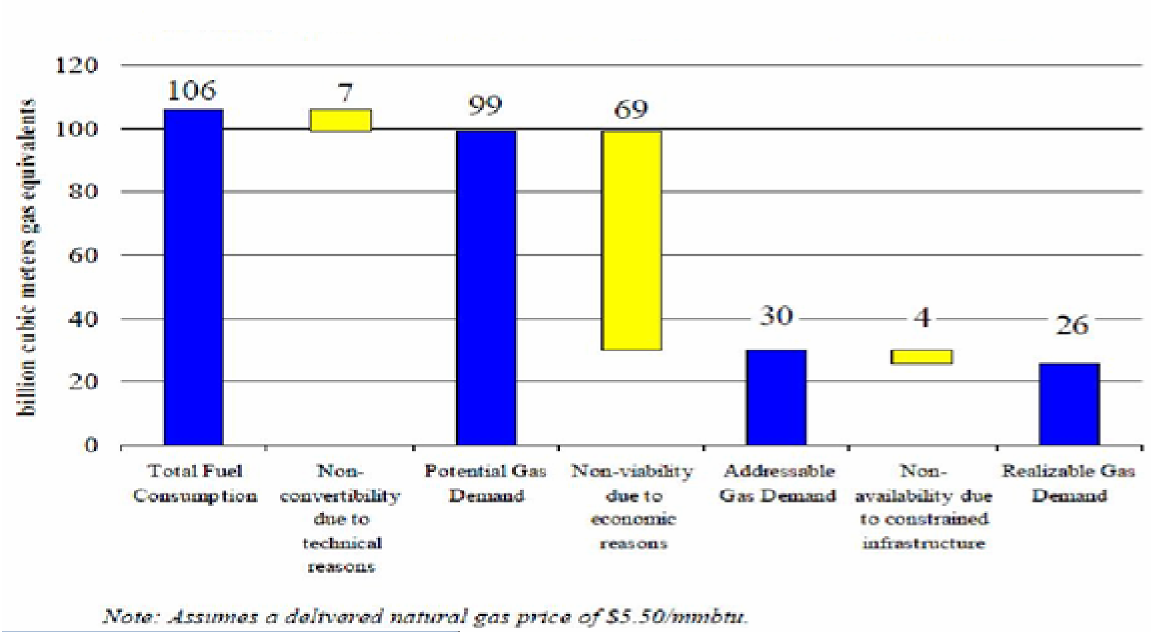

Fig 17 : Projected Realizable Natural Gas Demand for 2025

It is evident from the graph that the industry is capable of meeting most of its demand. The major competitor of natural gas is coal, with its high availability and economical pricing. A major portion of the growth, therefore, is accounted for by the refining and petrochemical sector, where coal use is low. These sectors also find the use of natural gas, even at high prices, much cheaper than the use of oil. This explains the willingness of the industrial sector to purchase gas from the LNG importers at the extremely volatile market prices.

7. An overview of Petrochemical R&D in India

- R&D is the key factor for the growth of the chemical industry and its focus varies across different sectors of the industry. Typically petrochemicals being a basic chemical industry the chief focus will be on optimizing the processes to reduce cost and application development to boost demand. A huge amount of effort is also directed towards energy management since energy is the significant element of conversion cost. In petrochemical sector application R&D is very critical as new applications have to be identified in order to synthesize new and advanced class of polymers. India has been making considerable effort in strengthening its R&D potential. In a recent UNCTAD report India was highlighted as one of the most preferred R&D destinations outside the US. In the last 2-3 yrs has seen a preponderance of companies looking at India as an R&D destination.

- In India, in the field of petrochemical sector, the main institutions or companies which are doing continuous, significant amount of R&D are Indian Institute of Petroleum (IIP), National Chemical Laboratory (NCL), Indian Institute of Chemical Technology (IICT), National Institute for Interdisciplinary Science & Technology (NIIST), North East Institute of Science & Technology (NEIST-Jorhat), Reliance Industries Limited (RIL), Oil and Natural Gas Corporation (ONGC), Hindustan Petroleum Corporation Limited (HPCL), Chennai Petroleum Corporation Limited (CPCL), Indian Oil Corporation Limited (IOCL) etc. Of all the above institutions, IIP has contributed a lot to the petrochemical sector in research. We will look at various ongoing projects which are being conducted in companies and in institutions.

The following is a case study of these organizations. The approach to measure the impact has been to quantify the impact of these organizations using parameters like, the number of new technologies developed and their impact, papers published, patents filed and various other factors which will act as a measure of the impact the R&D of these organizations:

8. Government agencies for funding R&D in Petrochemical sector

- Petroleum Conservation and Research Association (PCRA)
- Centre for High Technology (CHT)
- Department of Scientific and Industrial Research (DSIR)
- New Millennium Indian Technology Leadership Initiative (NMITLI)
- Department of Science and Technology (DST)
    - Technology System Development (TSD)
    - Technology Development Board (TDB)

8.1 Petroleum Conservation and Research Association (PCRA)

One of the major objectives of PCRA [12] is "To promote Research, Development and deployment efforts aimed at petroleum conservation and environment protection, support and facilitate efforts aimed at petroleum conservation and environment protection, support and facilitate efforts for adoption and dissemination of fuel efficient technologies and substitution of petroleum products with alternate fuels, and renewable. Its aim is also to establish synergistic institutional linkages at the national & international levels in the areas of petroleum conservation and environment protection.

The various R & D activities carried out by PCRA are as under:

- To invite and sponsor Research and Development projects on prestigious Research Institution, Technical Institutions, CSIR Laboratories etc. primarily aimed at petroleum conservation and environmental protection through development of fuel efficient technologies, processes, equipment's, appliances etc.

- To promote inter fuel substitution: Substitution of petroleum products with non-petroleum products and promotion of renewable sources of energy.

8.1.1 Overall impact in terms of savings achieved due to the conservation measures developed

Table 15: Savings obtained due to the activities undertaken by PCRA

	Savings	
Year	Quantity ('000 Tonnes)	Value (Rs. Crores)
1985-86	80	32
1986-87	167	69
1987-88	251	102
1988-89	329	131
1989-90	424	165
1990-91	470	198
1991-92	592	261
1992-93	693	332
1993-94	838	417
1994-95	968	491
1995-96	1102	570
1996-97	1236	675
1997-98	1497	863
1998-99	1768	1049
1999-2000	2133	1425
2000-01	2436	1782
2001-02	2702	2066

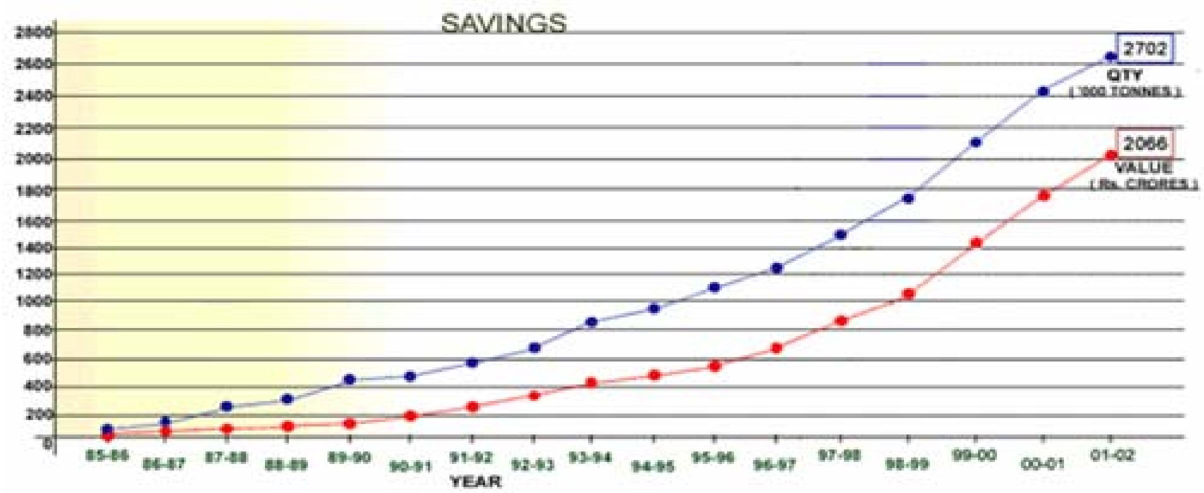

Fig 18 : Growing trend of the Savings obtained due to the activities undertaken by PCRA

8.1.2 R&D Projects (Completed) in petrochemical sector

Development of a multi fuel cooking stoves.	
Developed by	IIT, Guwahati
Cost in Lacks (Rs.)	Rs.2.60 lakh.
Year of award	2005
Actual completion date	2006
Whether commercialized	In-Progress
Benefits	The average thermal efficiency of the develop stove is 63% and fuel can be saved after 14%.

8.1.3 R&D Projects (Ongoing) in petrochemical sector

Table 16 : List of Ongoing Petrochemical R&D undertaken by PCRA

Sl.No.	Name of the Project	Developed by	Cost of the project (in Lakhs)	Date of start	Expected Benefits
1	Generation of biogas through bio methanation of de- oiled cake of Jatropha seeds.	MERADO, Ludhiana	16.3	Jun-07.	1. Generation of fuel gas would support dwindling energy source. 2. Other benefits are energy security, better quality of fuel & reduce pollution.
2	Production and Performance Evaluation of Biodiesel from tree based oils.	IIT Kharagpur	11.62	Mar-07	Use of biodiesel in diesel engines will help in saving diesel consumption.
3	Generation of syngas through plasma gasification of plastic waste	Central Mechanical Engineering Research Institute, Durgapur	37.48	Aug-07	Decomposition of waste in to energy rich fuel. Replacement of petroleum fuel for net energy output. Plasma converted gas would be used in gas turbine.
4	Flue gas analysis in the Oil & Gas Fired Shuttle & Tunnel kilns in Khurja	Central Glass & Ceramic Research Institute, Khurja.	10.39	Nov-08	Material and energy savings, improvement in productivity, yield, efficiency and quality etc.
5	Feasibility study of utilization of 10 % Pre-treated Non-edible vegetable oils in stationary Diesel Engine	Indian Institute of Petroleum, Dehradun	17	Feb-09	Study would lead to utilization of 10 % non-edible, pre-treated oil for the stationary diesel engines.
6	Utilization of glycerol to 1,3 / 1,2 Propane diol	Indian Institute of Petroleum, Dehradun	36.96	Jan-09	By product utilization obtained in the process of biodiesel preparation and it also reduces the cost of production of biodiesel.

8.2 Centre for High Technology (CHT)

Centre for High Technology (CHT) is an organization under administrative control of the Ministry of Petroleum & Natural Gas, Government of India. CHT works in the field of Petroleum Refining and Storage, Handling, and transportation of crude oil and Petroleum products and Gas[13]. The main vision of the organisation is to:

1. Strive for the development of indigenous capabilities to attain technological competence and self-reliance in the hydrocarbon Sector.
2. Assess the operational performance of the refineries and develop programmes in consultation with the industry for improvement.
3. Promote dissemination of information and develop a centralized pool of data & information in specific fields for use by the oil industry.

8.2.1 R&D Projects (completed) in petrochemical sector

The following are some of the completed R&D projects by CHT:

Table 17: List of petrochemical R&D projects completed by CHT

S.No.	Name of the Project	Executing Agency	Total Actual Project Cost(Rs. in lakh)
1	Assessment of residual life of turbine oil – Phase-II	IIT, Delhi	24.96
2	Technology development for hydrodynamics of Trickle Bed Reactors & Cold Flow Studies for scale-up – Phase-II	IIT, Delhi EIL(R&D), IOC(R&D)	359.62
3	Technology development for hydrodynamics of Trickle Bed Reactors & Cold Flow Studies for scale-up – Phase-I	IIT, Delhi EIL(R&D), IOC(R&D)	50
4	Development of catalytic process for isomerisation of waxy stocks into lube oils	NCL, Pune	27.01
5	Catalyst and technology development for hydro treatment of diesel and vacuum gas oil	IIP	178.32
6	Hydrocracker Pilot Plant/Laboratory Project	IOC(R&D)	34.35

7	Etherification of C5 olefins and light FCC gasoline	IIP	57.49
8	Burner performance testing and development	EIL	197.79
9	Heat transfer enhancement by tube inserts	EIL	28.61
10	Diesel fuel quality : requirements for future emissions standard	IIP	94.97
11	Development of cooling tower technology	EIL	87.89
12	Cold flow model studies in FCCU	EIL	83.09
13	Effect of dewaxing aids on crystal morphology	IIP	8.23
14	Optimization of dewaxing operations	IIP	15
15	Studies on effect of soaker geometrics and internals of visbreaking process	IIP	13.69
16	Studies on application of modern packing in liquid extraction	EIL(R&D)	21.14
17	Development of low metal / skewed reforming catalyst	IIP	78
18	Use of multifunctional gasoline additives in 2 stroke engine vehicles	IIP	1.9
19	Development of high performance internals for distillation	EIL(R&D)	21.12
20	Development of high capacity trays	EIL(R&D)	24
21	Development of multipurpose dynamic simulator	EIL(R&D)	39.92
22	Furnace efficiency studies	EIL(R&D)	24
23	Alkylation of isobutane	IIT, Bombay	5.07
24	Assessment of residual life of turbine oil	IIT, Delhi	9.47
25	Synthesis, characterization and evaluation of Vinyl Polymer	NCL, Pune	9.5

26	Installation of thin film short path distillation unit	AOD, Digboi	13.15
27	Catalytic converter technology for auto exhaust	NEERI	21.31
28	Study on hydrostabilisation of Coker distillates	IIP	5
29	Development of tower internals	EIL	77.01
30	Microbial desulphurization of petroleum	RRL, Jorhat	3.8
31	Spare charge for bimetallic reforming catalyst	CPCL	199.55
32	Visbreaker studies	IIP	3.15
33	Preparation of guidelines for environment review of oil sector	NEERI	0.68
34	Solvent extraction studies on prehydrotreated lube distillates	IIP	2.25
35	Feasibility Studies on feed stocks for paraffin wax production	IIP	6.45
36	Literature Survey on Hydro cracking / Liquid Membranes	IIP	1.5

8.3 Department of Scientific and Industrial Research (DSIR)

The Department of Scientific and Industrial Research (DSIR), part of the Ministry of Science and Technology, has a mandate to carry out the activities relating to indigenous technology promotion, development, utilization and transfer [14]. The primary endeavor of DSIR is to promote R&D by the industries, support a larger cross section of small and medium industrial units to develop state-of-the art globally competitive technologies of high commercial potential, catalyze faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in overall exports, strengthen industrial consultancy & technology management capabilities and establish user friendly information network to facilitate scientific and industrial research in the country. It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).

8.3.1 R&D Projects in petrochemical sector funded through DSIR

- Intelligent LP Gas Detector (IGD), IIT Kanpur, supported through TePP of DSIR:

The Intelligent LP Gas Detector is safety product for LP Gas users and has been expected to have a huge vertical market. IGD module can be easily incorporated over the existing LPG gas with a high preset-able sensitive range (500-10,000 ppm). It gives alarm in the first stage safety when the ppm level of the LP gas exceeds the first threshold, if the LP gas crosses the second threshold then the IGD will switch out the gas flow totally through the supply system.

- Study on Status of Technology in Castor Oil & its Derivatives in India supported by Technology Management programme (TMP) of DSIR.

- Technology Status and Prospects of Biodegradable Plastics in India supported by Technology Management programme (TMP) of DSIR.

8.4 New Millennium Indian Technology Leadership Initiative (NMITLI)

The New Millennium Indian Technology Leadership Initiative (NMITLI) is the largest public-private-partnership effort within the R&D domain in the country. It looks beyond today's technology and thus seeks to build, capture and retain for India a leadership position by synergizing the best competencies of publicly funded R&D institutions, academia and private industry. NMITLI has so far evolved 57 largely networked projects in diverse areas viz. Agriculture & Plant Biotechnology, General Biotechnology, Bioinformatics, Drugs & Pharmaceuticals, Chemicals, Materials, Information and Communication Technology and Energy.

8.4.1 NMITLI Objective

NMITLI seeks to catalyze innovation centered scientific and technological developments as a vehicle to attain for Indian industry a global leadership position, in selected niche areas in a true 'Team India' spirit, by synergizing the best competencies of publicly funded R&D institutions, academia and private industry.

8.4.2 R&D projects funded through NMITLI in petrochemical sector

Some of the petrochemical projects sponsored under NMITLI are:

- Nano-material catalysts and associated process technology for alkylation/ acylation/ nitration of well identified industrial chemicals, pre-reforming of hydro-carbons and sulphur removal (<50ppm) from petroleum fuels.
- Defunctionalisation of carbohydrates as a feed stock to manufacture well identified industrial chemicals.
- Functionalisation of alkanes.
- Value added polymeric materials from renewable resources: lactic acid and lactic acid based polymers.
- Genetic improvement of Jatropha curcas for adaptability and oil yield.

8.5 Department of Science and Technology (DST)

8.5.1 Technology System Development (TSD)

Department of Science and Technology (DST) is implementing a Technology System Development Programme (TSD).Technology Systems Development (TSD) Programme supports activities aimed at developing and integrating technologies to evolve technology systems both in the advanced/emerging areas and in traditional sectors/areas. Under the Programme, feasibility of fresh ideas/ concepts is assessed for their potential conversion into useful technology/product. Application of R&D for socio-economic benefits is consciously promoted under this programme.

8.5.1.1 Objectives

The primary objective of the Programme is to facilitate and support development of products or techniques/technology aimed at specific end use. The Programme stresses on clearly identifying the needs for development of the technology so that the developmental effort could be useful to the target beneficiary. It envisages active user involvement and association in the development effort. The intention is that the products/technologies developed under the Programme become useful for the benefit of the people at large.

The specific objectives of the Programme are to

- develop and integrate technologies following a holistic approach in identified areas;
- promote application of modern/advanced technologies to socio-economic problem solving;
- promote modernization of traditional technologies, tools and skills;
- facilitate enhancing quality and performance of the traditional/non-traditional items;
- encourage developments in application of R&D activities; and
- promote activities aimed at improving technology, technique, material, methods and other appropriate activities conducive for development of technology status in identified areas.

8.5.1.2 List of Major Completed / Ongoing Petrochemical projects supported under Technology System Development (TSD)

Table 18 : List of completed / ongoing petrochemical projects supported through TSD of DST

S. No.	Project Title	Organization
1	Feasibility of blending of Straight vegetable Oil (SVO) In petro diesel and its utilization in IDI engine.	University of Petroleum & Energy Studies, Dehradun.
2	Intrigated project for development of process/technology for value added products from Karanja Leaves, flowers, Bark, Oil and cake	Indian Institute of Chemical Technology, Hyderabad.

8.5.2 Technology Development Board (TDB)

The Government of India constituted the Technology Development Board (TDB) in September 1996, under the Technology Development Board Act, 1995, as a statutory body, to promote development and commercialization of indigenous technology and adaptation of imported technology for wider application [15]. The board consists of 11 Board members.

The TDB is the first organization of its kind within the government framework with the sole objective of commercializing the fruit of indigenous research. The Board plays a pro active role by encouraging enterprises to take up technology oriented products.

8.5.2.1 Objective

Technology development board aims at accelerating the development and commercialization of indigenous technology or adapting imported technology to wider domestic application.

8.5.2.2 Activities

With its pro active stance, the Board:

- Facilitates interaction between industry, scientists, technocrats and specialists;
- Fosters and innovation culture through contract and cooperative research between industry and institutions;
- provides an interface with financial institutions and commercial banks for leveraging funds;
- facilitates the creation of new generation of entrepreneurs;
- assists partnerships with other, similar technology financing bodies;
- provides vistas for venturing into hi-tech areas;
- creates new job opportunities

8.5.2.3 Distribution of Funds

The following table indicates the modes of financial assistance provided by TDB up to 31st March 2010.

Table 19 : Category-Wise Coverage Of Funds (Rs. in Crores)

Category	Number of Agreements	Total cost	Sanctioned by the Board
Public Ltd. Companies	115	1821.82	515.17
Private Ltd. Companies	89	691.71	244.65
Public/Joint sector undertakings	5	81.81	34.7
Co-Operatives	1	11.6	1.7
Other Agencies	23	805.21	255.8
Total	233	3412.15	1052.02

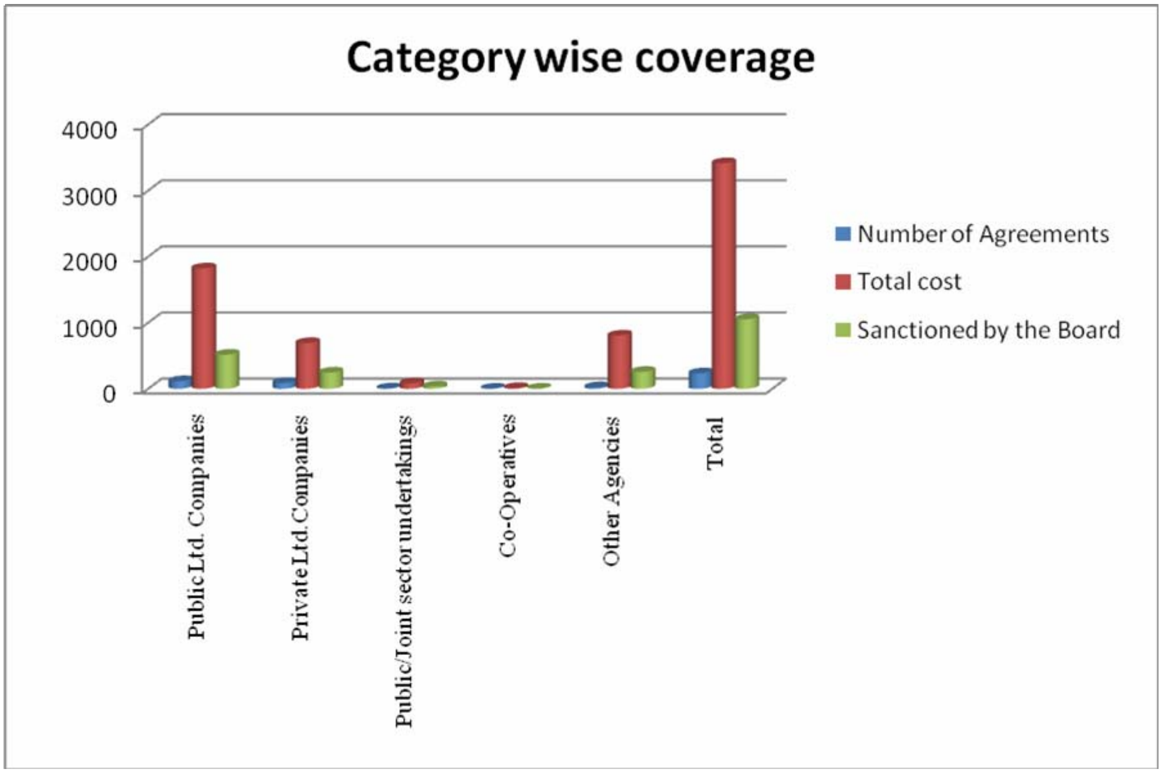

Fig 19 : Figure showing Category wise coverage of funds

8.6 Scientific Advisory Committee (SAC)[16]

The Scientific Advisory Committee (SAC) on Hydrocarbons was set up in 1981 and has been making suitable recommendations to the Ministry of Petroleum and Natural Gas in respect of development of indigenous technologies, fuel quality improvement and other issues relevant to the technological upgradation of the hydrocarbon sector.

8.6.1 Role of Scientific Advisory Committee (SAC) in R&D commercialization

The SAC played a crucial role in setting up of many R&D organizations – setting up of EIL-R&D Centre to support R&D work of national laboratories; modernization of research facilities, equipment and setting up of pilot plants at IIP; setting up of in-house R&D centre in CPCL; setting up of catalyst development and testing facilities at IPCL; setting up of CHT in 1987, etc.

The major technologies recommended by SAC, which have been implemented include:

1) Aromatic extraction for benzene and toluene at BPCL, which was a joint project of IIP and EIL.
2) Food grade Hexane at BPCL, CPCL, HPCL, ONGC – Hazira, which was also a joint project of IIP and EIL.

3) Bimetallic reforming catalyst, one of the earliest projects funded by CHT which was implemented at CPCL and IPCL.
4) NMP extraction at IOCL-Haldia Refinery for a plant of 350,000 tones capacity.
5) Delayed Coker at BRPL and NRL.
6) Visbreaker (soaker mode) at several refineries.
7) Processing of short residue using SPD technology, which had gone on stream at IOCL Digboi Refinery.
8) Commercialization of reverse osmosis membrane for setting up a pilot plant at CPCL for treating one lakh liters per day of sewerage water.

9. List of Petrochemical (ongoing and completed) R&D projects in industries, universities and institutes.

9.1 Chennai Petroleum Corporation Limited (CPCL)

CPCL established an in-house R&D Centre in 1986, to provide technological support to refinery operations and to carry out research in the development of processes and catalysts related to petroleum refining in collaboration with National laboratories and Academic Institutions [17]. CPCL has invested about Rs. 20 crore to establish pilot plants and analytical facilities in the last two decades and has been recognized as a leading research facility in the area of Petroleum refining in India.

9.1.1 Ongoing R&D Collaborations' in the company

The following table lists Ongoing R&D Collaborative petrochemical projects in the company

Table 20 : Ongoing R&D Collaborative projects

S.No.	Name of the Project	Cost of the Project (in Lakhs)
1	Feasibility study of changeover of solvent to NMP in hexane unit at COCP, Manali (part-ii)	6.61800
2	Development of polymer modified bituminous binder	43.38099
3	Processing of light neutral distillate in NMP lube extraction unit at CPCL	23.82032

9.1.2 Completed Petrochemical R&D Projects in the company

The following table lists completed R&D petrochemical projects in the company.

Table 21: Completed R&D projects in petrochemical sector

S.No.	Name of the Project	Cost of the Project (in Lakhs)
1	DEVELOPMENT OF CATALYST FOR REDUCING SULFUR IN FCC GASOLINE	64.15000
2	Upgradation of FCC recycle oil through solvent extraction	74.00000
3	Preparation of Carbon spheres from petroleum pitch	9.92

9.2 Hindustan Petroleum Corporation Limited

HPCL is a Fortune 500 company, with an annual turnover of Rs. 1,16,428 Crores and sales/income from operations of Rs 1,31,802 Crores (US$ 25,618 Millions) during FY 2008-09, having about 20% Marketing share in India and a strong market infrastructure [18]. They are in the process of setting up a brand new R&D facility at Bangalore.

HPCL operates 2 major refineries producing a wide variety of petroleum fuels & specialties, one in Mumbai (West Coast) of **6.5** Million Metric Tons Per Annum **(MMTPA)** capacity and the other in Vishakhapatnam, (East Coast) with a capacity of 7.5 MMTPA.

HPCL has collaborated with several academic / research institutions to come up with innovative results enhancing the production capacity and other industrial parameters. The details of the projects (particularly the partners in collaboration) are given below:

9.2.1 Ongoing R&D collaborations in the company

1. Bio desulphurization of petroleum with Gandhi Institute of Technology and Management (GITAM), Visakhapatnam:

The projects contemplated with GITAM are as follows:

- Effect of Nano-particle inclusion in the lubricating properties of lubricants to be completed within 2 years.
- Bioremediation: Bio desulphurization of petroleum oil by non- pathogenic micro-organisms slated to be completed within one year.
- Production of Bioremediation of petroleum oil by non pathogenic microorganisms within a time frame of 1 year.

2. Characterization of bottom streams with Central Institute for Mining and Fuel Research (CIMFR, erstwhile CFRI), Dhanbad

The project involves the characterization of 3 bottom streams viz. Vacuum Tower Bottom (VTB), Fluid Catalytic Cracking (FCC) and PDA bottoms utilizing the pilot plant available at CIMFR. A proposed 100 kg/hr plant is slated for installation. A fully self sufficient Corporate R&D centre is going to be established with the integrated facilities of designing, commissioning supervision, interpretation of data generated development of protocols for operating and testing of the plants.

3. Optimization studies of food grade Hexane manufacturing unit and feasibility study for producing polymer-grade Hexane (With IIP)

Study was initiated along with IIP during 2004-05 for optimizing the existing Mumbai Refinery Hexane plant operating conditions to explore the possibility of producing Polymer grade Hexane, which have more stringent quality specifications with respect to sulfur & benzene content and has got marketing demand.

4. Optimization studies of NMP Lube Extraction Unit (With IIP)

Study was initiated along with IIP during 2004-05 to optimize Mumbai Refinery NMP Lube Extraction Unit operating parameters to obtain specific product quality & output maximization. Improvement in colour, sulfur and saturates is also expected by increasing the severity of hydro fining and selection of suitable catalyst. A substantial energy saving is also expected by pinch analysis of heat exchangers in the unit.

5. Membrane Separation Study to recover Propylene from Visakha Refinery Gas Mixture & LPG (With IICT Hyderabad):

Collaborative R&D is in progress with IICT Hyderabad for membrane separation of propylene from LPG. Validation of Membrane and test run with pure gas was done. Test run with gas mixture is being carried out for different membranes. IICT is in process of writing simulation program for determining the number of stages for achieving desired propylene purity and membrane area requirement based on feed capacity and composition of C3 fraction.

9.3 Indian Oil Corporation Limited

Indian Oil Corporation Limited is India’s flagship national oil company and downstream petroleum major company [19]. It is India's largest commercial enterprise, with a sales turnover of Rs. 2, 85,337 crore – the highest-ever for an Indian company – and a net profit of Rs. 2, 950 crore for the year 2008-09. Indian Oil is also the highest ranked Indian company in the prestigious Fortune 'Global 500' listing, having moved up 11 places to the 105th position in 2009. Indian Oil and its subsidiaries account for approximately 48% petroleum products market share, 34% national refining capacity and 71% downstream sector pipelines capacity in India. The Indian Oil Group of companies owns and operates 10 of India's 20 refineries with a combined refining capacity of 60.2 million metric tons per annum (MMTPA, .i.e. 1.2 million barrels per day). These include two refineries of subsidiary Chennai Petroleum Corporation Ltd.

Indian Oil is investing Rs. 43,400 crore (US $10.8 billion) during the period 2007-12 in augmentation of refining and pipeline capacities, expansion of marketing infrastructure and product quality up gradation as well as in integration and diversification projects.

9.4 Central Institute of Plastics Engineering & Technology (CIPET)

Central Institute of Plastics Engineering & Technology (CIPET), Chennai, and Tamil Nadu is a premier institution devoted to manpower training and technical services to the plastics and allied industries [20]. CIPET has been accredited with ISO 9001:2000 certification on "*Design, development and conduct of specialized training courses in plastics engineering & technology and rendering technical/ consultancy services in design, tooling, plastics processing & testing to the plastics & allied industry*".

9.4.1 R&D projects undertaken by CIPET in petrochemical sector:

Some of the R&D projects undertaken by CIPET are mentioned below:

Table 22: Projects taken by CIPET

S.No.	Title of the Project	Project Objectives
1	Development of Bitumen packaging poly bags in association with CRRI, New Delhi	Application development of appropriate material/blend for producing poly bags for Bitumen packaging
2	Development of mechanically and thermally stable biodegradable plastic composites.	The project envisages to develop biodegradable polymer composites prepared from natural fibers and biodegradable plastics matrices
3	Development of High Performance Thermoplastics & Thermosetting Nano composites	To Develop different types of thermoplastics and thermosetting based nano composites for High performance applications
4	Development of polyolefin based nano composites.	The project envisages developing and characterizing polyolefin based nano-composites and studying the commercial viability of the developed composites.
5	New curing systems for thermoplastics toughened, thermo set epoxies.	The project is an Indo-US Joint Initiative to develop silicon based multifunctional epoxies and curing agents to investigate Tg values and other properties with and without thermoplastics modifiers.

9.5 National Chemical Laboratory-Pune

National Chemical Laboratory (NCL), Pune, is a research, development and consulting organization with a focus on chemistry and chemical engineering. It has a successful record of research partnership with industry.

9.5.1 Vision

1) To be a globally recognized and respected R&D organization in the area of chemical sciences and engineering.

2) To become an organization that will contribute significantly towards assisting the Indian chemical and related industries in transforming themselves into globally competitive organizations.

3) To become an organization that will generate opportunities for wealth creation for the nation and, thereby, enhance the quality of life for its people.

Currently, NCL-Pune is working on the following R&D projects in the field of petrochemical sector:

1) Modeling & simulation of coal gasification

2) Adsorptive sulfur removal from transportation fuels

Some of the works that has been recently published or patented by scientists at NCL in the field of petrochemical sector

1) Highly Efficient Solid Catalysts for Production of Biodiesel and Bio lubricants

2) Conversion of Methane and Methanol into Gasoline

9.6 Indian Institute of Chemical Technology

Indian Institute of Chemical Technology (IICT), Hyderabad is a premier R&D Institute in India. The Institute had its origin as the Central Laboratories for Scientific & Industrial Research (CLSIR), established in 1944 by the then Government of Hyderabad State. Major areas of research at IICT are: Natural Products Chemistry, Agrochemicals, Drugs & Intermediates, Specialty and Fine Chemicals, Fluoro organics, Inorganic & Physical Chemistry (Catalysis & Material Science), Lipid Sciences & Technology, Coal, Gas & Energy, Chemical Engineering and Design & Engineering.

9.6.1 Objective

IICT 's basic objectives have always been to carry out research in the chemical sciences leading to innovative processes for a variety of products necessary for human welfare such as food, health and energy and the conduct of R&D work is fully geared to meet the requirements of technology development, transfer and commercialization.

9.6.2 Projects Completed in Petrochemical Sector

1) Atmospheric Fluid bed gasification to produce fuel gas from coal

2) Moving bed pressure gasification of low-grade coals

3) Coal tar hydrogenation to middle distillates

4)F-T Synthesis to produce liquid fuels from coal

5)Hydro-cracking of tar to paraffins, naphthalene's etc

6)Coal-tar distillation

7)CO_2 Removal from Natural Gas (Joint project with EIL/ ONGC)

9.6.3 Current Research Areas in Petrochemical Sector

1)Hydrogen production by Catalytic Reforming of Methanol

2)Chemical Characterization of Coal / Coal-derived products

3)Direct sourcing of value added chemicals from coal

4)Development of Technologies for synthetic Aviation Lubricants from renewable feed stocks.

9.7 North East Institute of Science and Technology

North East Institute of Science and Technology (NEIST), Jorhat (formerly Regional Research Laboratory) is a constituent establishment of the Council of Scientific and Industrial Research (CSIR), a premier R&D organization of India. This laboratory was established in 1961 under the chemical science group of CSIR and originally its main aim was to develop indigenous technologies by utilizing the immense natural resources of northeastern India like Petroleum, Natural Gas, Minerals, Tea, Aromatic and Medicinal plants.

9.7.1 Activities

Presently, NEIST is a full fledged multidisciplinary research institution having research areas like Medicinal Chemistry, Natural Products Chemistry, Synthetic Organic Chemistry, Biotechnology, Medicinal, Aromatic and Economic plants, Geo science, Petroleum and Natural Gas, Applied Civil Engineering, Chemical Engineering, General Engineering, Cellulose, Pulp and Paper, Material Science, Coal, etc. Over the years, the laboratory has produced more than 100 technologies in the areas of Agro technology, Biological and Oil Field Chemicals.

NEIST is working on the following projects in the field of petrochemical sector

1)Recovery and fractionation of microcrystalline wax from crude oil tank bottom sludge and pipeline scrapping using short path distillation

2)Development of thermoplastic polymers having good biodegradability and their characterization.

9.8 Indian Institute of petroleum (IIP)

Indian Institute of Petroleum (IIP) [21], one of the leading constituent laboratories of the Council of Scientific & Industrial Research (CSIR), is devoted to multidisciplinary areas of Research and Development in the downstream sector of hydrocarbon and related industry. The Institute has undertaken

R & D work in petroleum refining, natural gas, alternative fuels, petrochemicals and utilization of petroleum products in IC engines and in industries. It has continued its efforts to grow into an internationally renowned R&D organization, providing quality research and innovative technologies for the national and international market place and to produce technical support to the in market demand surveys and techno-economic feasibility studies for related products.

Some of the achievements of the institute are:

1) Institute has developed a large number of processes and technologies. Thirty two technologies having licensed capacity around 25 million tonnes per anum transferred to the petrochemical industry.
2) Almost every refinery in the country has technologies licensed by the institute.
3) Test techniques developed for evaluation of petroleum products included in BIS specifications.

9.8.1 Areas of research of IIP

The main areas/topics on which IIP research is focussed on are:

1) Advanced Separation Processes
2) Advanced Refining Technologies
3) Petrochemicals, Specialty Chemicals
4) Petroleum Product Applications
5) Crude Oil & Products Evaluation
6) Alternate Fuels

9.8.2 List of completed R&D Projects in petrochemical sector by IIP after 2000.

The following table shows the list of completed R&D projects in petrochemical sector by IIP, (CSIR).

Table 23 : Completed R&D Projects in petrochemical sector since last 10 years at IIP

Sl. No	PROJECT TITLE	SPONSORED BY	PROJECT COST
1	Catalytic bitumen studies	BPCL	5.15000
2	Developement of new generation fcc catalyst	IOC(R&D)	16.50000
3	Characterisation of short residue from AOD refinery and its short path distillate cut	CHT	5.00000
4	Proficiency testing program for diesel oil	DST	1.03500
5	Base cetane no. And physicochemical evaluation of HSD & naptha	BPCL	5.40000
6	Analysis of diesel & motor gasoline samples	NCT	4.72000
7	Evaluation of unleaded gasoline & diesel samples	SIAM	13.06000
8	Analysis of hsd & napthta samples	BPCL	1.31200

9	Dev. of technology for manufacture of long chain mfas for fuels	DSIR/TPL/IIP	57.20000
10	Development of technology for manufacture of long chain c10-c14 secondary alcohols by oxidation of c10-c14 n-paraffins	DSIR/TPL	34.00000
11	DEVELOPMENT OF CORRELATION BETWEEN FEED AND COMPOSITION OF ppds	INDOFIL CHE.	9.00000
12	Analysis on gasoline samples	SPC	2.12400
13	Removal of bad odour from pyrolysis gasoline and revamping of existing distillation unit	MECK	4.50000
14	Development of indigenous catalytic converters	DST	54.56000
15	Pilot plant studies for the separation of lao from coker distillates and sulpholation of alpha olefins to alpha olefins sulphonates	BRPL	29.00000
16	Work order of market potential of naptha cut and aromatic extract	ONGC,HAZIRA	5.00000
17	Pollution control & energy saving devices in the dhds plant of bpcl	BPCL	1.05000
18	Detailed evaluation of assam crude mix	NUMALIGARH REFINER	10.35000
19	Characterisation of diesel samples form l.c.b, nagpur	LCB,NAGPUR	0.70000
20	Nmp extraction of pwd & hwo streams and feasibility studies on impreganating pitch production	IOC, AOD	19.60000
21	Process engineering for high temp. Antioxidants	TRIA	17.50000
22	Process scale-up and technology transfer for isooctane	CHPL	4.40000
23	Evaluation of HSD streams from bpcl refinary	BPCL	6.85000
24	Evaluation of fcc gasoline streams for bpcl refinery	BPCL	2.20000

25	Analysis of oil samples collected by mpcb form containers lying at jnpt, mear mumbai	MPCB,MUMBAI	2.25000
26	Optimization and evaluation of additive for naptha fuel	BPCL	10.00000
27	Evaluation of bituminous cores for fatigue (itft)	CRRI, NEW DELHI	0.67500
28	Characterisation of solvent(hydro carbon oil) samples received form control excise noida	CANTRAL EXCISE	1.35000
29	Characterisation of visbreaking naphtha form mathura refinery	MATHURA FEFINERY	0.63000
30	Characterisation of pink kerosine & lco from rpl refinery jam nagar	RPL, JAMNAGAR	1.37600
31	Evaluation of lubricity in naphta with 5403 additive	NALCO	2.10000
32	Evaluation of lubricants	HINDUSTAN PETROLEU	0.80000
33	Evaluation of turbine oil	ELF LUBRICANTS	0.96000
34	Deve. Of catalysts technology & process know how for the conversion of c5-c6 non cyclic praffins rich light naphtha cut to maximise field of aromatics +c4 & prod.of catalyst & formulations	CHT/BPCL/IIP	57.00000
35	Characterisation of solvent (hydrocarbon oil)	CENTRAL EXCISE	1.35000
36	Feasibility cum process optimisation study for production of wax	NUMALIGARH REF.LTD	15.00000
37	Identification of development of marker for sbp naphta solvent	GAIL	4.50000

38	Evaluation of lubricity in naphtha with dorf 4351 additive	DORF KETAL CHE.	2.12500
39	Effect of addition of mtbe in gasolone on requlated exhaust mass emissions	BPCL	30.00000
40	Characterization of gasoline samples	MERCEDES BENZ	1.00000
41	Study for microcrystalline wax production from vacuum residue at nrl	NUMALIGARH REFINER	8.40000
42	Evaluation of assam crude oil form oil india ltd.	OIL INDIA LTD.	14.60000
43	Tbp distillation of hydrotreated diesel	RELIANCE PETROLEUM	0.70000
44	Evaluation of naphtha fractions from panipat refinery	IOC	0.75000
45	Devl. Of eco-friendly / biodegradable lubricants/ base fluids	CHT	11.00000
46	Polycyclic aromatic hydrocarbon residue in edible oils	TMOP&M	25.32000
47	Characterisation of gasoline samples	MU LTD	2.50000
48	Performance evaluation of diesel engine oil through tata cummins diesel engine	CASTROL	36.00000
49	Evaluation of lubricity in diesel with ec 5465 a additive	NALCO	1.20000
50	Evaluation of crude oils form ongc ltd.1) north gujart, 2) south gujrat, 3) canvery asset	ONGC	13.50000
51	Development of catalyst & technology for deep catalytic cracking	CHT	25.00000
52	Evaluation of lubricity in diesel	KOCHI REF. LTD	0.84000
53	Dev. Of zeolite base reforming catalyst for aromatic production	CHT	45.71000

54	Study on suitability of lpg recovered from natural gas and refinery lpg for automotive use	GAIL	6.00000
55	Evaluation of crude oil sample: (borhalla, geleki, ongc)	ONGC	13.50000
56	Studies on nmp extraction & deoiling of spd disttilate for mcw recovery & value addition of nmp extract	CHT/CSIR	9.55000
57	Preparation of process engineering pacakage for the production of fgh and sbp solvent from aromatic rich naphtha	ONGC(HAZIRA)	25.00000
58	Studies for dev. Of pressure swing adsorption (psa) tech. For purification of crude helium and design estimates for pilot plant.	DEP. OF Sc.& TECH	56.82000
59	Charactrization of gasoline samples from mul	MUL	3.93750
60	Study on lubricity of additive 5403 in lco streame	NALCO	1.36080
61	Preparation of process design package for the revamp of kerosene refining unit phase - ii	IOC	68.00000
62	Characterizatiion of crude oils from ahmedabad asset of ongc for organic chloride estimation	ONGC LTD	1.78200
63	Performance evaluation of engine krankcase oil by crrl-ltd test	IOC	6.48000
64	Certification of defance engine oils as per is-13656-2002 specification	IOC	4.86000
65	Study of optimization of lubricity characteristics of naphtha	GE BETZ INDIA	3.78000
66	Short evaluation of crude oil samples	OIL INDIA LTD	5.94000
67	Soaker visbreaking studies on bombay high residue	BHARAT PETROLEUM C	16.00000

68	Comparative study on solvent deoiling of hwd and pwd raffinates vs distillates ex digboi refinery for paraffin wax production	INDIAN OIL CORPORA	9.80000
69	Study of lubricity characteristics of additive 5403 in naphtha	ONDEO NALCO, KOLKA	1.03680
70	Characterization of SYN crude	OIL, ASSAM	6.37200
71	Studies on identification & estimation of polycyclic aromatic hydrocarbons in diesel fuels	CHT	50.90000
72	Evaluation of "thermol-p" fuel additive on gasoline passenger car and motorcycle	PCRA, NEW DELHI	4.10400
73	Detailed evaluation of crude oil from ongc with an emphasis on studying the potential of value addition of straight run products	ONGC, MUMBAI	84.78000
74	Studies on the naphthas from gas fractionators of gail (india) ltd.	OCHEMICAL INDUSTRY	2.64080
75	Development of catalyst for reducing sulfur in fcc gasoline	CHT/ CPC LTD	64.15000
76	Studies on the naphtha from numaligarh refinery and sbp solvents from lakwa and gandhar plant of gail (india) ltd.	GAIL	3.14070
77	Detailed evaluation studies on a crude oil from ongc	ONGC, NEW DELHI	17.41160
78	Sulphur reduction in the naphtha product obtained by fluidized catalytic cracking (fcc)	SINTEF, NORWAY	85.14000
79	Development of polymer modified bitumen	MSC-C&C P. LTD.	1.76320

80	Pinch analysis of crude unit	RELIANCE IND. LTD.	5.89200
81	Detailed evaluation studies on crude oils from indian oil corporation limited	IOCL, N. DELHI	34.56000
82	Study of shear stability property of hydraulic oils	BPCL, MUMBAI	8.10000
83	Short evaluation studies on crude oil sample from kanwara field, gujarat	HERAMEC LTD. HYD	6.94260
84	Studies on the quality of the HSD samples as per bis 1460:2005 (bs-ii) and composition of sediments.	SINGARENI COLLIERS	2.41503
85	Catalyst development for isomerisation of light naphtha	CHT & IOC	55.44000
86	Studies on the naphtha samples of cpf gandhar and lpg plant ankleshwar	ONGCL, ANKLESHWAR	3.36720
87	Preparation of carbon spheres from petroleum pitch precursor	DMSRDE, KANPUR	9.92000
88	Dev. Of catalysts for ultra deep desulphurisation of gas oil	CHT	53.20000
89	Sulphur reduction in naphtha product obtained by fluid catalytic cracking (part ii)	INPIC, NCAER	7.25000
90	Feasibility of producing high specification aromatics from straight run naphtha using iip's nmp extraction technology	HUNTSMAN PET. UK	69.58000
91	Analysis of feed oil, light diesel oil and superior kerosene samples as per bis specification	CID, PANCHKULA	1.42400
92	Delayed coking studies on ril feedstocks for the production of anode/needle grade coke	RIL, JAMNAGAR	20.70000
93	Pinch analysis of fcc units	PCRA, NEW DELHI	23.15000

94	Development of catalyst and proces for the conversion of waste plastic & low polymer wax into value added hydrocarbon	GAIL + IIP	91.90000
95	Fcc catalyst/additive characterization and evaluation	RIL JAMNAGAR	43.48220
96	Optimization studies of compatibility studies of blending of reprocessed vegetable oil sample with the automotive diesel fuel (HSD) of bharat stage ii	BPL, BANGALORE	3.10000
97	Studies on nmp extraction of wide cut used oil and its distillates (stage-i : basic feasibility)	ULOC, SAUDI ARABIA	12.80000
98	Short evaluation adsorbent for panipat refinery	IOCL, PANIPAT	5.33998
99	Optimization studies of hpcl nmp lube extraction unit (phase-i)	HPCL, MUMBAI	38.57000
100	Development of process for oxidative desulphurization of diesel	CHT, NEW DELHI	68.20000
101	Delayed coking studies on ril blended feedstocks for the production of anode/needle grade coke	RIL, JAMNAGAR	9.59368
102	Delayed coking studies for hpcl (m) refinery	HPCL, MUMBAI	18.00000

9.8.3 List of Ongoing R&D Projects in petrochemical sector by IIP after 2000.

The following table shows the list of ongoing R&D projects in petrochemical sector by IIP, (CSIR).

Table 24 : Ongoing R&D projects in petrochemical sector at IIP

S. No.	**Project title**	**Total Cost (Rs. in Lakh)**
1	New absorption-based approaches for co2 recovery	145.00000

2	Optimization study on food grade hexane production unit at hpcl, Mumbai	16.53000
3	Synthesis of room temperature ionic liquids and to study their applications for extraction of sulfur, nitrogen & aromatic compounds from petroleum feedstock	65.40000
4	Development of low carbon emitting adsorption technology for ultra low sulphur diesel (ulsd) production	98.79000
5	Pinch analysis of crude distillation unit (cdu) and delayed coking unit (dcu)	21.11000
6	Feasibility study for identifying feed stocks for petrochemicals	10.77850
7	Column targeting studies for pru revamp at hpcl, visakha refinery	10.48094
8	Scale up studies for conversion of waste plastic & low polymer wax to value added hydrocarbons	121.00000
9	Feasibility study of changeover of solvent to nmp in hexane unit at cocp, manali (part-ii)	6.61800
10	Development of polymer modified bituminous binder	43.38099
11	Study for processing light vacuum gas oil from Mumbai high and nile crude to produce paraffin wax at mrpl	12.58432
12	Processing of light neutral distillate in nmp lube extraction unit at cpcl	23.82032
13	Study for processing of lvgo & hvgo stocks for production paraffin & microcrystalline wax at nrl	12.24330
14	Studies on crud formation during nmp extraction of wco and feed quality variation on nmp extraction of wco	5.31000

15	Studies on formation of mesophase during conversion of petroleum refinery streams into pitch for needle coke production	9.70640
16	Studies to assess the characteristics of modified bitumen (crumb rubber, elastomer, plastomer) and anti-stripping effect	3.16782
17	Development of solid acid catalyst for alkylation of isobutane with alkenes to form alkylates as gasoline blend	77.21000
18	Catalyst development for isomerisation of c7+ hydrocarbons with industrial feed stocks	73.40246
19	Hierarchical nanoporous materials for petroleum, biodiesel refining and for future applications to energy and environmental problems	19.85400
20	Mat testing of catalyst samples from hpcl, visakh	1.10300
21	Delayed coking studies on ril blended feed stocks	10.75000
22	Boundary lubrication capabilities of ionic liquids and their futuristic applications to lubricant development	10.44000
23	Development of low capacity lap burners for ceramic/pottery industry at khurja	13.50000
24	An alternate to paraffin wax from waste polyolefins	25.900
25	Development of carbon wool from petroleum pitches / residues	33.500
26	Development of new fixed bed sweetening catalyst and commercialization of lpg sweetening catalyst	75.000
27	Exploratory studies of hydrodenitrogenatin (hdn) catalyst for refinery stream	40.000
28	Blending effect of bio oil with conventional fuels and its performance	46.000
29	Catalyst development for conversion of light naphtha to diesel	42.000
30	To develop know-how and technology for environmental friendly conversion and utilization of biomass to fuels, lubricants and additives	**3500.000**
31	Hydrogen production from glycerol	50.000
32	Development of catalyst for production of ethers from glycerol	65.000
33	Process & technology for the production of liquid and gaseous fuels by fast pyrolysis of biomass	246.250
34	Upgradation of bio-oils to future fuels	150.500

35	Gasification technology development for production of synthesis gas from carbonaceous feed stocks for downstream utilization	165.000

10. Impact of R&D on Indian Petrochemical Sector

10.1 List of commercialized technologies in petrochemical sector by IIP after 1990.

The following table shows the list of commercialized technologies in petrochemical sector by IIP, Council of Scientific & Industrial Research (CSIR).

Table 25: Commercialized technologies in petrochemical sector by IIP after 1990

Sl.No.	In Collaboration with	Name of Technology	Details	Year of first adoption	Licensed Capacity (TPA)	Remarks / commercially used in
1.	EIL	Food grade Hexane	Used for production of food grade hexane Better product quality compared to oleum treatment process and use of non toxic and non corrosive solvent	1992	25,000 25,000 50,000	BPCL, Mumbai CPCL, Chennai HPCL, Mumbai
2.	IPCL	Bimetallic Reforming catalyst	Bimetallic catalyst IPR-2001 is for octane boosting & aromatic production.	1990	90,000 6.2(Cat.) 110,000 6.8(Cat.)	CPCL, Chennai IPCL, Vadodara
3.	--	Conversion of Light Naphtha to LPG and High octane gasoline	Used for production of LPG from C_5 rich stream High LPG yield with high octane gasoline by product	2000	8,000	GAIL, N.Delhi
4.	EIL, MRL	LOBS through NMP Extraction	Production of quality lubes oil base stocks.	2000	400,000 350,000	IOC, Barauni IOC, Haldia
5.	EIL	Delayed coking	Delayed coking of petroleum residues is done for production of Metallurgical grade petroleum coke, more lighter fractions and up gradation of residual fractions	1999	500,000 306,000	BRPL, Bongaigaon NRL, Numaligarh
6.		Na/Ca Sulphonate	Feed stock for detergents / dispersant additives for automotive lubricants, rust inhibitors etc.	2000	1100	NAL, Hyderabad
7.	-	EP Additive	Industrial Gear oil	2000		NAL, Hyderabad
8.	AEC	High Temp. Antioxidants	To produce ODBHC and PDBHC from 2 6- di-test butyl phenol, methyl acrylate and steryl alcohol/pentaerythritol Anti oxidant for plastics	1995		TFCL, Mumbai
9.		Sulpholane Production	It is a good solvent for many classes of organic compounds and polymers. Finds application in extraction processes, acid gas treatment, extractive distillation, etc;	1991	300	CHPL, Ahmadabad
10.	---	Hot Rolling oil	Used in Steel rolling plants for hot rolling process	1991	1,000	Lubrizol India Ltd, Mumbai
11.	M/s Dorf-Ketal, Mumbai	Deoiling / Dewaxing additive for Lubricating oil	. Comb type Polymeric Additive Tailored to Enhance Slurry Filterability during Dewaxing Operation for Lube Oil Production	2000	30-40	Being commercially produced by M/s Dorf-Ketal and being used in CPCL/Haldia refineries. Also being exported
12.	EIL	Propane Deasphalting	The solvent deasphalting is being widely used for recovering extra heavy viscosity lube oil and additional		50,000 Bright Stocks	HPCL, Mumbai CPCL,

			feed stocks for secondary conversion units like FCC or Hydro cracking from vacuum residues.			Chennai
13	EIL & CPCL	Lube oil Refining	NMP Based Lube refining technology is capable of producing high quality LOBS and CBFS simultaneously	2000	20,000	This Technology is currently in operation at IOC Haldia Refinery
14.		Improved Jaggery making Plant	IIP has improved the design of furnace and chimney system of existing gur bhattis. Due to proper combustion inside the furnace the fuel (bagasse) consumption is reduced up to 10%. The chimney smoke has come down and there is increase in gur production also. The charging of bagasse into the furnace is easier in the new design	2005	Further up gradation is under planning. 6-8 qtl/day	Uttarakhand State (3nos) Uttarpradesh (19 nos) PCRA, New Delhi is awarding financial subsidy to gur bhatti improvers
15.	BPCL	Sweetening Catalyst	Technology for production of catalyst Thoxcat ES for sweetening of LPG and lighter petroleum fractions was transferred to Lona Industries Ltd, Mumbai in September, 2007	2007	-	Lona Industries, Mumbai
16.		Conversion of Vegetable oil feed stock to esters using solid heterogeneous catalyst	Under Process		-	Armaco Consultant Pvt. Ltd., Mumbai
17.	HPCL & EIL	Hexane production using NMP solvent	NMP Extraction Technology for dearomatisation of Straight Run Naphtha is used for production of Food Grade Hexane, special low boiling point solvents, feed stocks for petrochemicals and fertilizers.	1997		Since commissioning the unit is operating successfully
18.	CPCL HPCL EIL, CHT	Up gradation of FCC recycle oil through Solvent Extraction using NMP solvent	FCC distillate yield is improved by integrating solvent extraction process that removes polyaromatics (precursors for coke) from FCC feed. The process also lower the coke buildup on the catalyst			The raffinates, a good quality of VGO are used as FCCU feed. The extract has high BMCI of about 140 & is premium quality CBFS.
19.	EIL, HPCL, CHT	Energy efficient De-asphalting process using supercritical solvent recovery	HPCL is operating EIL Designed Propane De-Asphalting (PDA) Unit since 1995. Propane and DAO is separated by conventional flash vaporization in this unit. HPCL carried out the test run under the supercritical conditions for separation of propane & DAO in Sept 2006. This resulted in saving of about 3.0–3.5 T/hr steam equivalent to savings of Rs. 3.0-3.5 Crore/year		.	The same can be offered to various Indian refineries for revamping their PDA units & setting up new PDA unit having supercritical Separation

20.	IFP	Gas Oil HDS			224,000	CPCL, Chennai
21.	IFP	Pyrolysis Gasoline Hydrogenation			111,560 230,000 474,160 264,000	IPCL, Vadodara HCL, Haldia RIL, Mumbai NOCIL, Mumbai
22.	IFP	Naphtha Pre-Heater(HDS)			140,000 215,000 128,000	Zuari Agro ,Goa SPIC, Tuticorin IPCL, Vadodara
23.	IFP	Catalytic Reformer (Including Naphtha Pre-Heater)			196,000 80,000 90,000 300,000 500,000 500,00	IOC, Haldia BRPL, Bongaigaon IOC, Barauni IOC, Mathura(CCR) IOC, Panipat(CCR) Essar, Jamnagar(CCR)
24.	IFP	Kerosene HDS			577,600	IOC, Haldia
25.	IFP	Diesel Hydro-Desulphurization			1,800,000 1,800,000 2,000,000 1,200,000 900,000 3,300,000 1,600,000	CPCL, Chennai HPCL, Vizag KRL, Kochi IOC, Mathura IOC, Panipat Essar Oil, Jamnagar Bharat, Oman
26.	IFP	Delayed Coker, Naphtha Pre-Hydro Treater			300,000	Essar Oil, Jamnagar

10.2 List of Technologies commercialized in petrochemical sector through Technology Development Board (TDB)

The following table shows the list of commercialized technologies in petrochemical sector through Technology Development Board (TDB).

Table 26 : List of commercialized technologies in petrochemical sector through TDB

S.No.	Name of the industry	Product commercialized	Total cost (in Lakhs)
1	Naveen Additives Limited, Hyderabad	Sulfonates and lubricants	674
2	Goodwill Organics Private Limited, Mumbai	Meta Di Chloro Benzene	380
3	Somaiya Organics Limited, Mumbai	1,3 Butylene glycol	377
4	Pushkar Chem. Limited, Mumbai	Anti-Oxidants	350
5	Filtra Catalysts and Chemicals, Thane	Cresols and Xylenols	530
6	Jubilant Organosys Limited, Gajrauala	Manufacture of 2-vinyl Pyridine Monomer	1636
7	M/S National Moulding Company Ltd, Kolkata	Development and commercialization of B_2B R-PET resin & Polymeric Plasticizer	2142

10.3 Energy saving activities in petrochemical industries identified by PCRA

A large variety of opportunities exist within petroleum refineries to reduce energy consumption while maintaining or enhancing the productivity of the plant. Studies by several companies in the petroleum refining industry have demonstrated the existence of a substantial potential for energy efficiency improvement in almost all facilities. Major areas for energy efficiency improvement are utilities (30%), fired heaters (10%), process optimization (15%), heat exchangers (15%), motor and motor applications (10%), and other areas (10%). Of these areas, optimization of utilities, heat exchangers, and fired heaters offer the most low investment opportunities, while other opportunities may require higher investments. PCRA has identified energy saving activities in various processes in petrochemical industries. The following table shows some of those activities

Table 27 : Energy saving activities in petrochemical industries identified by PCRA

S.No.	Name of the case study	Investment amount	Improvement effect	Payback period
1	Reduction of top pressure of Pre flash Drum (PFD) of crude distillation unit	Nil	Rs. 2.4 Crores/year	Immediate
2	Energy Efficiency improvement through crude preheat train optimization in the refinery	Rs. 34.6 Crores	Rs. 11.6 Crores/year	3 years

3	Reduction of injection steam in vacuum column by recycling overhead steam.	6 Crores	8 Crores/year	9 months
4	Use of controlled hot refrigerant gas by-passing SDU Plant Chiller	Rs. 10 Lakhs	Rs. 30 Lakhs/year	4 months
5	De-staging of 6 stages to 5 stages of HGU reformer boiler fuel pump.	Rs. 45,000/- (for de-staging)	Rs. 41,000/- /year	1.1 year
6	Use of H_2 rich gas catalytic reformer unit (via HGU) for recycling in Catalytic Reforming Unit (CRU) in place of use of pure H2 ex HGU and PSA.	Rs. 6 Lakhs	Rs. 18 Lakhs/year	4 months
7	Energy saving by reducing the pressure inside the regeneration column of FCCU.	Rs. 14.5 Lakhs	Rs. 4.9 Lakhs	3 years

10.4 Impact of completed R&D projects in IOCL

The following table shows the list of completed R&D projects in petrochemical sector and their benefits.

Table 28: List of Completed projects by IOCL

Sl.No.	Name of the Project completed	Benefits
1	A novel process for conversation of Naphtha to LPG - (IOC).	1) It is used for converting various naphtha streams to LPG and gasoline 2) The catalyst can upgrade straight run naphtha also due to its modified acid strength
2	Cationic bitumen - (IOC).	1) Cationic emulsions are preferred over anionic emulsion due to their stability for use with almost all kinds of aggregates. 2) Cationic bitumen is released into the market with the trade name of Indemul.
3	Crum Rubber Modified Bitumen (CRMB) - (IOC).	1) CRMB usage can improve pavement condition from high temperature rutting, cold temperature cracking under increased traffic intensity, axial loads and varying climate conditions.

4	DHDS/DHDT Catalyst - (IOC & Sud Chemie India Ltd.).	With the help of this technology, the ppm level of sulphur of distillates came down to 50 ppm meeting Euro-IV level specifications.
5	Diesel Fuel Lubricity Improver - (IOC).	1) SERVO-LI restores the lubricity of ultra low sulpher diesel 2) It is obtained from a bio-degradable source and exhibits good storage stability.
6	Diesel Hydro Treating Technology (DHDT)-(EIL & IOCL)	The technology shall upgrade feed to achieve product sulphur specification of less than 35 ppm and cetane improvement close to 10 points.
7	H2S/ Mercaptan Removal and Sweetening Processes - (IOC)	1) Removal of H2S from LPG, naphtha and gasoline. 2) Removal of Mercaptans from LPG, naphtha, gasoline and ATF/Kero. 3) Removal of Naphthenic acids from diesel.
8	Hydroprocessing Catalyst Management - (IOC)	HC-MOD, DHDS-MOD are various simulation models developed by IOC - R&D and these models work based on process chemistry and kinetics.
9	i-MAX FCC Catalyst Additive for Boosting LPG Yield - (IOC)	1) i-Max boosts LPG yield in FCC/RFCC units (2.5-3.6 wt%) at a concentration of only 5 wt% on catalyst 2) Increases the octane number of gasoline 3) Decreases the bottom yield by 0.7-1.5 wt%
10	INDALINE Technology - (IOC).	1) INDALINE is a catalytic cracking process for upgradation of low value naphtha, kerosene and gas oil fractions to very high yield of LPG. 2) INDALINE process produces very high yield of LPG up to 45 wt %.
11	Inde Treat and Inde Sweat Technologies - (IOC & EIL)	1) Hydrocarbon streams with higher H2S and mercaptans can be treated by these technologies.
12	"INDMAX" - Residue Upgradation to LPG,Light Olefins & High Octane Gasoline - (IOC)	1) High LPG Yield (40-65wt%of fresh feed. 2) High Propylene (17-25 wt% of fresh feed) and butylene yields (10-15 wt% of fresh feed).
13	Instrumented Pig (IPIG) - (IOC & BARC).	"Instrumented Pig" is a device for inline inspection of buried pipelines to monitor their health and assess the risk associated with their operation.

14	Light Naphtha Isomerisation Technology - (IOC & EIL)	1) Isomerisation of light naphtha converts C5, C6 paraffins (Pentane and Hexane) to corresponding branch isomers. 2) In this process, benzene is saturated to cyclohexane.
15	LPG Treatment using Continuous Film Contractor (CFC) - (EIL & IOC)	1) Removal of H2S and other extractible sulphur compounds can be done by treating LPG using CFC.
16	Lubricant Formulation Technology - (IOC).	Indian Oil, till date, developed over 3500 lubricant formulations out of which around 800 grades are in the market for a variety of applications in the area of Automotive, marine, Railroads, metalworking, Greases and Defence lubricants under the name of Servo R.
17	Maximization of LPG Yield in FCC Units - (IOC)	1) Increase in the yield of LPG from 10-20% to 25-35 wt% of feed and propylene from 4.5 to 12 wt % of feed 2) Maximization of LPG yield without any major revamp of the RFCC unit
18	N- Methyl Pyrrolidine (NMP) Co-Solvent Extraction Technology - (IOC).	By replacing steam stripping in NMP unit with Nitrogen stripping unit for the removal of aromatics from lube distillates, the process has the following benefits i) Increases raffinate yield. Ii) Emission reduction by more than 40 %. Iii) Energy saving by more than 40 %.
19	Needle Coke (IOC)	1) Production of highly crystalline needle coke for manufacturing graphite electrodes 2) It can withstand temperatures as high as 2800 C
20	Novel Antioxidant for Gasoline - (IOC)	"SERVO-AO" is used as a high performance antioxidant for preserving various types of modern gasoline blends, including thermally and catalytically cracked components from FCCUs, Cokers.
21	Novel Antioxidant for Gasoline - (IOC).	"SERVO-AO" is used as a high performance antioxidant for preserving various types of modern gasoline blends, including thermally and catalytically cracked components from FCCUs, Cokers.

22	Novel Models/Simulators for Refinery Processes - (IOC)	1) HC MOD can be used for simulation studies for process optimization i.e., selection of optimum operating parameters for maximization of desirable product slates.
23	"Oilivorous- S"- Bioremediation for Disposal of Oily Sludge - (IOC, Balmer Lawrie).	"Oilovorous-S", a blend of five specific microbes is used to biodegrade a wide range of hydrocarbon contaminants of oily sludges.
24	Reactive Adsorption Process (INDAdept) for deep desulphurization of diesel (INDAdeptD) and Gasoline (INDAdeptG) - (IOC & EIL).	Indian Oil R&D has developed a proprietary adsorbent as well as a process in 2008 for reducing refractory sulphur from diesel (INDAdeptD) and total sulphur from cracked gasoline (INDAdeptG) for production of low sulphur fuels meeting Euro V (10 ppm S content) specification.
25	Technology for Diesel Multifunctional Additive (MFA) - (IOC).	MFAs developed are added to diesel i) to improve base fuel quality w.r.t specification ii) to reduce air pollution. Iii) To prevent damage to distribution system.
26	Technology for Diesel Stabilizer. (IOC).	Developed diesel stabilizer works very well in all types of diesel fuels. 2) Developed stabilizer resulted in substantial savings and it prevented IOCL industries from importing high cost stabilizers.
27	Technology for the production of Food Grade Hexane (FGH) / Polymer Grade Hexane (PGH) - (EIL & IOC).	1) By Hydrogenation process, unsaturated content in raw hexane can be reduced to meet the food grade specifications. 2) By this process, we can achieve very low benzene content (<100 ppm) in the product. 3) The capacity of FGH units ranges from 25,000 to 30,000 tons/annum.
28	VGO Hydrocracking Catalyst for Maximization of HSD & LPG	1) Increase of LPG yield by >5wt%. 2) Higher activity than typical catalysts (same conversation at lower temperature) by using IZV catalysts.

10.5 Technologies developed by EIL

The following table lists technologies developed by EIL in petrochemical sector

Table 29 : Technologies developed by EIL in petrochemical sector

Sl.No.	Name of the Technology developed	Benefits	Development / Commercialization
1	C_2/C_3 Recovery from Natural Gas as well as LPG	C2/C3 recovery unit extracts ethane / propane from natural gas	The recoveries of C_2 achieved are 95 % with C_3 and C_4 being more than 99%.
2	Crude & Vaccum Distillation Unit Technology	1) Operating & Configurating parameters are selected to maximize the yield of desired distillate products. 2) Designed units employ pinch technology & composite curve techniques for energy efficient design.	More than 35 CDU / VDU units designed and revamped by EIL are in operation with capacities varying from 0.5 MMTPA to 11 MMTPA.
3	Gas Sweetening for Natural Gas	Acid gases such as C02 and H2S present in natural gas are removed to very low concentrations.	Commercialized at ONGC - Hazira, GSPC - Gandhinagar.
4	Sulphur recovery using Claus process	Sulphur Recovery Unit (SRU) converts H_2S and sour gases from Sour Water Stripper Unit (SWSU) to elemental Sulphur.	EIL has carried out design and engineering of several units which have capacity range from 5 TPD to 360 TPD and with sulphur recovery ranging between 96 % to 99.9 %

10.6 Intellectual Property Generation in Petrochemical Sector

Patenting activity in the domestic patent system based on patents accepted by Indian Patent Organization (IPO) is examined for the period (1990-2002). Patents filed by domestic organizations are termed as Indian Owned Patents (IOP). IOP included all organizations that had an Indian address. Patents were categorized into 9 main sectors and 43 sub sectors[22]. Of the 9 main sectors, 'Chemicals' and 'Pharmaceuticals' are the major sectors of the patents, account for 55 % of total share of patents, filed by Indian Owned Patents in IPO.

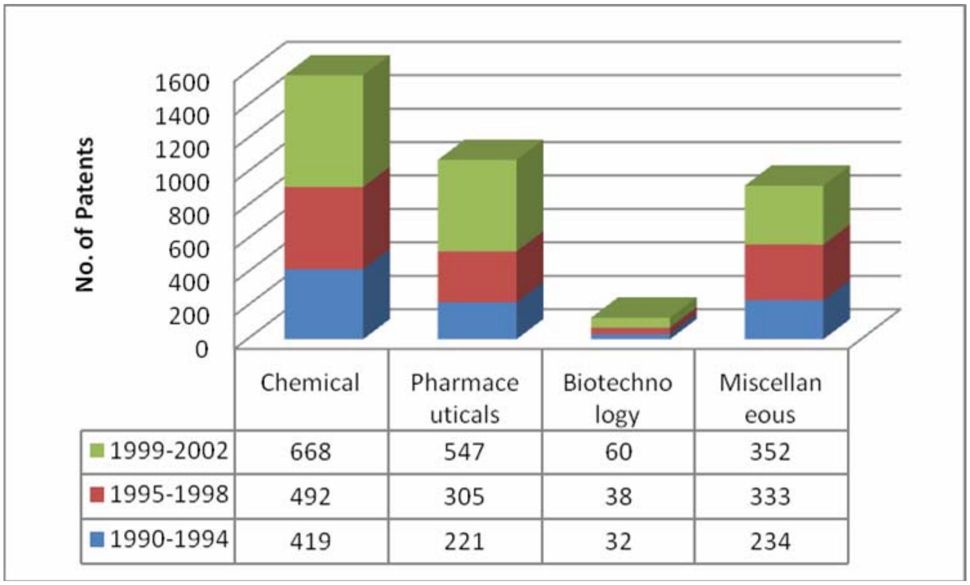

Fig. 20: Patenting activity in IPO in different sectors from 1990-2002

10.6.1 Sector activity of prolific organizations

Patenting activity in various sub sectors by different prolific institutes is identified and tabulated below. The following table shows that CSIR, IOCL & HLL have major share of patents in chemicals.

Table 30 : Sector wise Activity of prolific organizations from 1990-2002 in IPO

Organization	Sectors		
	Chemical	Pharmaceuticals	Miscellaneous
Council of Scientific & Industrial Research	662	406	304
Indian Oil Corporation Limited	33	-	4
Indian Petrochemical Limited	29	3	-
Hindustan Lever Limited	271	159	88

10.6.2 Indian Owned Patents in United States Patent and Trade Organization (USPTO)

The following table shows the number of Indian Owned patents filed in USPTO from 1990-2002 in different sectors. Pharmaceuticals and Chemicals are the major areas of patenting activity.

Table 31: Indian owned Patents filed in USPTO in different sectors from 1990-2002

Sectors	No. of patents (1990-1994)	No. of patents (1995-1998)	No. of patents (1999-2002)	Total Patents (1990-2002)
Chemical	24	42	166	232
Pharmaceuticals	9	48	227	284
Biotechnology	0	7	46	53
Miscellaneous	8	15	42	65

10.6.3 Activity under various sub-sectors

In the chemical sector, the main area is in 'Basic Chemicals' followed by 'Pesticide & Agro chemical Products'. The following table shows the details of Indian Owned patents, in different sub-sectors, filed in USPTO.

Table 32: IOP in USPTO in sub sectors from 1990-2002

Sub – Sectors	No. of patents (1990-1994)	No. of patents (1995-1998)	No. of patents (1999-2002)	Total Patents (1990-2002)
Chemical / Basic chemical	21	35	139	195
Chemical / Pesticides, Agro-chemical products	1	5	18	24
Miscellaneous / Basic metals	2	2	8	12
Miscellaneous / Petroleum products, nuclear fuel	2	2	5	9

10.7 From the industry perspective and their R&D requirements

In order to estimate the impact of the R&D activities undertaken by the above mentioned organizations, an understanding of the petrochemical industry scenario, trends and its necessities is important. To understand these factors and their implications on the impact of R&D, a survey has been conducted and a questionnaire has been sent to various selected industries. The response from these industries is complied below and will serve as a pointer which will help in identifying the thrust areas where we need to focus our R&D efforts.

Table 33 : Feedback from various petrochemical companies

S.no.	Name of the company	Type of Products of the company	Technology Source for the company	Fields in which company wants to collaborate with any R&D/ Academic Institute	Fields in which company's R&D is focusing on	No. of Processes/Technology developed by the R&D of the company (Since last decade)
1	HEG Limited	Graphite Electrode & Specialties	SERS - France	High Performance Graphite Electrode, Carbon Fiber	Activated Carbon Spheres, Porous Conducting Carbon Paper	7
2	Oil India Limited, Assam	Crude Oil, Natural Gas, LPG.	Imported and Indigenous	Paraffin remediation, Surfactant development	N /A	2
3	Bharat Petroleum Corporation Limited - Kochi Refinery	Basic Chemicals	Various technology licensors	-	Bio fuels	2
4	Engineers India Limited, Gurgaon	N / A	N / A	Coal to Liquid Technology, Clean Energy & Environment	Coal to Liquid Technology	12

5	Numaligarh Refinery Limited, Assam	Petroleum products , Sulphur	EIL, Denmark - Hydrogen Unit SWADELA, USA- Coke Calcination Unit Axens.	Value addition to surplus Naphtha, specialties products like MTBE, TAME.	-	-
6	Hindustan Petroleum Corporation Limited, Mumbai	Petroleum products	UOP, AXENS, EXXON	-	Bio fuels & Biotechnologies, nano technology, CO2 sequestration.	Nil
7	Nagarjuna Oil Corporation Limited, Chennai	Fuel products (LPG, Naphtha, Gasoline, Diesel...)	Diesel Hydro Upgrader- Axens, Delayed Coker Unit - Lummus	-	-	-
8	Tata Chemicals Limited, Babrala.	Fertilizer (Urea)	M/s Haldor Topsoe, Denmark for ammonia plant M/s Shamprogetti, Italy for Urea plan	Energy conservation & SHE Improvement	N /A	-
9	Chennai Petroleum Corporation Limited, Chennai	LPG, Superior Kerosene, Aviation Turbine Fuel, Bitumen, Lube Base stocks	UOP- USA, EXXON - USA, ABB Lummus etc.	-	Fuel quality Up gradation, Bio fuels and Resin Up gradation	1
10	Oil and Natural Gas Corporation Limited, New Delhi	Crude Oil, Natural Gas, LPG.	Predominantly in-house.	Exploration and Production of Hydrocarbons.	Exploration & Development of Oil fields.	-
11	Reliance Industries Limited, Mumbai	Petrochemicals, Refinery products, Oil and Gas exploration	Imported	Crude Refining, Alternative sources of Energy like Fuel cell, Solar, Biofuel, C1 chemistry.	Bio fuels, Solar Nanotechnology, Fuel cells, Catalysis, Adsorption separations.	10

11. Future R&D Vision of the Indian Petrochemical Industry

- Efficiency improvement in raw material usage, energy efficiency and reuse of recycled materials.
- Process operation improvement with efficient management of supply chain.
- Environmental impacts and project viability economic should be balanced.
- Commitment to long term R & D investment and innovation.
- Technology forecasting and identification of emerging technology fusion areas.
- Recycling technologies and recycled product development.
- Collaborative investment in public private partnership in technology development by Government, Academic Institutions and Industry in a targeted R & D Initiatives which will have long term impact.
- Innovative plastic processing technologies, new process technologies for high performance polymers (green processes, etc.)
- Thrust on new platforms – bio- nano sciences as enabler for improved polymer advance materials.
- R & D Thrust in Capital goods, development of moulds, dyes and tools.
- Development of world class R & D Centre for appropriate material / technology. Networking of institutes / R & D institutions for integrated research projects.
- Knowledge alliances and networking. Initiative to add value to IPR from know-how/ knowledge.
- Generation & management of intellectual property rights, awareness, development, protection and utilization and enforcement programmes.
- Product application, design development centers.

11.1 Need for alternate feed stocks

Naphtha is the major feedstock used in the petrochemical industry. With fertilizer industry shifting to natural gas and refiners expanding their nameplate capacities availability of naphtha is bound to increase in the near future. However, limited crude and natural gas resources and the volatility of crude oil prices have posted a threat to long term availability of naphtha. For e.g. the 2nd quarter (08-09) saw a sharp increase in crude oil prices. The producers were unable to pass on the increase to their end consumers. In the 3rd Quarter, oil prices fell precipitously and it has been observed across cycles both in India and overseas that when petrochemical prices move in steady direction upward or downward, consumers tend to postpone their purchase decision to avoid the shift of burden to the end consumers. This indicates that sooner or later there is an urgent need to look for alternatives failing which growth of petrochemical demand will be difficult to sustain.

11.2 Alternate Feed stocks to petrochemical industry

Basic petrochemicals such as ethylene, propylene and aromatics are the building blocks of the petrochemical industry. Currently, most of them are produced via conventional process routes utilizing naphtha (derived from crude oil) and Ethane (derived from Natural gas). These building blocks can also be produced from alternate sources. The following are the various alternate feed stocks to petrochemical industry:

- ➢Biomass
- ➢Vegetable oils
- ➢Waste plastics
- ➢Lignocellulosic Biomass
- ➢Coal

12. Ways & Means of Strengthening R&D

- **Infrastructure Development is very essential for R & D Growth in the country [2]. This includes**

a) Creation of World class R&D centers for improved efficiencies and speed.
b) World-class knowledge centre's with digital access to latest scientific and technical literature and patents.
c) Networking of all research labs/institutes for integrated research.

- **Need of highly knowledgeable, skilled and qualified professionals**

a) For promoting higher education. E.g. Ph.D.
b) Retain scientific talent for research.
c) Attract best Indian professionals from abroad for research.

- **Basic research**

a) Partnership with Universities/Institutes across boundaries to accelerate development.
b) Commitment to build a synergy between educational institution & Polymer industry

• **Applied Research**

a) Trained professionals for technology management.
b) Foster a climate for best innovation processes.

• **IPR Policies in conformance with International practices.**

a) Creating a pool of specialized professionals/lawyers with necessary experience and expertise in IPR.
b) Strict enforcement of IPR compliance.
c) Speedy resolution of IPR issues in the legal system.

• **Programs to sustain continuous knowledge up gradation.**

a) Improve participation in National/International conference.
b) Create online/e-based knowledge up gradation portals.
c) Making re-certification mandatory for practicing professionals.

• **Collaborative research for leapfrogging technologies.**

a) Research collaborations with best institutes on frontier technologies.
b) Avoid sequential R&D development. Embrace quantum jumps in technologies to speed up R&D growth.
c) R&D funding as a percentage of GDP to be benchmarked with the global best.

13. New initiatives undertaken to achieve the R&D objectives

The major initiatives taken to meet the R&D objectives include [2]

1)Petroleum Research and Development Fund
2)Plastic Development Council
3)Petrochemicals competitiveness initiatives
4)Setting up of centers for excellence in polymer technology
5)Developing of Bio-Degradable Polymers
6)Development of plastic applications in thrust areas
7)Fiscal benefits for the petrochemical sector

13.1 Petroleum Research and Development Fund

- The feasibility of setting up a new scheme of Petrochemical Research and Development Fund (PRDF) which would cater to the projects of R&D in up gradation and modernization of existing technology, waste management, recycling and development of biopolymers and biodegradable polymers is proposed to be evaluated in Public Private Partnership (PPP) Mode.
- This feasibility will take into account the existing initiatives of the Government on Technology Development and Technology Leadership in India and work out mechanism to dovetail with the existing schemes or suggest sector specific new initiatives.
- Special focus will be given to supporting research and development in new and emerging areas of petrochemicals technology.

13.2 Plastic Development Council

- Plastic development council will be an advisory body with members from industry, academia and the Government.
- This will work for a sustained development of plastics processing sector including technology and R & D Initiatives.

13.3 Petrochemicals competitiveness initiatives

- Dedicated plastic parks will be evaluated to promote cluster approach in the areas of development of plastic applications and plastic recycling.
- Steps to augment the existing testing centers and promoting new testing centers in PPP Mode to act as certifying agencies for testing plastic products and raw materials to meet international as well as BIS standards.

13.4 Setting up of centers for excellence in polymer technology

- Centers of Excellence will be set up in existing educational and research institutions working in the field of polymers viz. National Chemical Laboratory, CSIR, Indian Institute of Chemical Technology, Indian Institutes of Technology, National Institutes of Technology and other established R & D set ups.
- The initiative will also include setting up of new world class R & D set ups in Public Private Partnership. These initiatives will be prioritized and phased out during the 11th Five Year Plan

- The major objectives of these centers are :
  - Thrust on R & D in capital goods for plastic processing dies and mould developments.
  - Recycling process technology, innovative collection, segregation, cleaning and development of recycled products
  - Product and application developments using engineering polymers/ compounds /blends /alloys
  - Alternate sources of feedstock for petrochemicals and maximizing hydrocarbon utilization in the value addition chain for feedstock securitization

13.5 Developing Bio-Degradable polymers

- In view of the growing environmental concerns arising due to the non degradable nature of plastics, particularly carry bags, there is an urgent need to develop biodegradable polymers.
- Biodegradable polymers have also been identified as one of the core research areas under the New Millennium Initiative Technology Leadership India (NMITLI), in the Ministry of Science and Technology.

13.6 Development of plastics application in thrust areas

- The thrust areas will focus on resource conservation. Plastics are light in weight and save energy in the manufacturing and transportation. It also provides cost effective substitutes for the conventional and natural materials.
- In respect of plasticulture there is a need to establish a linkage between the National Committee on Plasticulture Applications in Horticulture (NCPAH) and the proposed Plastic Development Council (PDC) which may be responsible for overall coordination, monitoring, technology support and quality control in the field of plasticulture.

13.7 Fiscal Benefits to sustain and improve the growth of the Indian petrochemical sector

- Joint initiatives may be worked out by DSIR and the Department of Chemicals & Petrochemicals for developing innovative approaches in industrial R&D to encourage industry to aggressively undertake technology/intellectual property acquisitions.
- The government has provided a number of fiscal incentives and other support measures for promoting R&D in industry and increased utilization of locally available R&D options for industrial development. These include the following:

- Write off of capital expenditure on R&D in the year the expenditure is incurred;
- Weighted tax deduction of 125% for sponsored research programmes in approved national laboratories, Universities functioning under the aegis of the Indian Council of Agricultural Research (ICAR), Indian Council of Medical Research (ICMR), Council of Scientific and Industrial Research (CSIR), Defense Research & Development organization (DRDO), Department of Electronics, Department of Biotechnology, Department of Atomic Energy, Universities and IITs is available to the sponsor. The Head of the concerned National Laboratory or the University or the Indian Institute of Technology can give the requisite approval of the sponsored research programs with effect from 1 October 1996. Prior to this DSIR was the nodal scientific department to administer this incentive.

- Weighted tax deduction @ 125% (raised to 150% by the Finance Act 2000) on R&D expenditure to companies engaged in the business of bio-technology or in the business of manufacture or production of drugs, pharmaceuticals, electronic equipment, computers, telecommunication equipment, automobile and its components, chemicals, manufacture of aircraft's and helicopters in government approved in-house R&D centers. Expenditure on scientific research in relation to drugs and pharmaceuticals, shall include expenditure incurred on clinical drug trials
- Obtaining approvals from any regulatory authority under any Central, State or Provincial Act and filing an application for a patent under the Patents Act, 1970 (39 of 1970).
- Income-tax exemption @ 125% to donations made to approved Scientific and Industrial Research Organizations.
- Accelerated depreciation allowance for investment on plant and machinery made on the basis of indigenous technology.
- Customs duty exemption to public funded R&D institutions and privately funded scientific and industrial research organizations, both for capital equipment and consumables needed for R&D.
- Excise duty exemption to public funded R&D institutions and privately funded scientific and industrial research organizations, both for capital, dated 1st March 1997.
- Excise duty exemption for 3 years on goods designed and developed by a wholly owned Indian company and patented in any two countries out of: India, USA, Japan and any one country of European Union.
- Exemption from customs duty on imports made for R&D projects funded by Government in industry.

14. Thrust Areas of R&D to be focused to sustain and improve the growth of the Indian Petrochemical sector

- There is a need to have a thrust on the research & development for the capital goods for plastic processing and petrochemical industry.
- A concerted effort needs to be made for development of such capital goods by supporting the manufacturers of machinery for petrochemical industry and plastic/polymer processing industry. DSIR can actively participate in such development projects.
- Use the modern computational technique for analyzing processes. Specific thrust on supporting R&D for development of degradable / biodegradable plastics, promoting scientific and state of art plastics waste recycling technologies.
- The key for the success of India's petrochemical sector also lies in the ability to achieve greater energy efficiency, carbon capture and storage, new feedstock sources - including clean coal and bio feeds - and a new generation of products and production technologies.

15. Perception of R&D impact on Indian Petrochemical sector

India's average petroleum products exports grew from 0.77 million barrels a day in Jan 2009 to one million barrels a day in August 2009. In the current year, the average oil products exports from India stand at 1.07 million barrels while South Korea exports average 0.88 million barrels. In fact, India's refining capacity at 3.69 million barrels a day is the third largest in Asia after China and Japan, which have a refining capacity of 9.6 million bpd and 4.64 million bpd respectively.

Both Reliance Industries Jamnagar and Essar's Vadinar refineries contribute more than 90% of the petroleum products export while the rest is by public sector oil companies. Public sector companies, which are obliged to serve the domestic market adding refinery capacity, will help private players to free up more capacity for exports. Petroleum products exports from India holds great potential as both Reliance Industries and Essar have highly complex refineries which make products that meet Euro IV and Euro V standards. Europe, US and Africa are identified major markets for Indian refineries.

As brought out in this report, the Indian Petrochemical sector has grown immensely, both in terms of its capacity as well as in terms of it diversity. Further the impact of indigenous R&D on the Indian Petrochemical sector has not been to the extent with respect to its growth. This is further elaborated below:

The era of coal-based chemicals flourished until, late fifties, when ethanol made from agricultural products like beet and sugar cane became an important feed stock for a variety of chemicals, including ethylene and downstream products. Scattered small producers and consumers characterized this period, even though producers like Union Carbide led the agro-based chemicals production.

With the advent of petroleum from the early sixties, the use of petroleum and natural gas as a less expensive and cleaner source for organic raw materials began to replace coal and the latter receded into its use primarily for energy. The era of petroleum and natural gas began in the twenties in the US, but India did not embrace this route till the sixties. India's first naphtha cracker and basic petrochemicals production began at NOCIL in the mid-sixties. In the early years, the scale of operation in India was miniscule compared with world plants. Nevertheless, the era of coal-based chemicals gave way to the era of petrochemicals that began to dominate the chemical industry progressively. Today India boasts of world scale plants, thanks to the enterprising spirit of modern day industrial houses like Reliance, Tatas, Birlas, IOCL etc. and several others of lesser dominance.

It was in the early sixties that polymers came of age, and, we can truly call the seventies as the start of the polymer age. ICI, Du Pont, Bayer and General Electric led the global thrust in polymers with advances in PE, PP, PS, PVC and a host of other commodity and high performance polymers. These came to Indian plants and today most consumer merchandise has at least some part of a polymer. Agrochemicals like fertilizers, pesticides, insecticides also became downstream derivatives of the petrochemical industry.

During the late 60s and early 70s, when the Petrochemical industry was in its infancy there was generally a research climate in the country for importing substitution. Thus the government encouraged several technologies to be developed which has already developed abroad in order to avoid the import of oil and technologies and thus to save precious foreign exchange. The tables that have been given on page no.74 of this report, amply demonstrate the development and commercialization of several research technologies. A few that we would like to mention are catalytic reforming, naphtha isomerization, aromatic extraction, propane deasphalting etc.

The 80s and 90s was the period of massive growth and emergence of internationalization of R&D where the industry neither had the patience nor the research institutions had the technologies that are readily available for its use. Further, it is pretended to mention that the expertise know-how which had been *developed in the leading research institutions used to evaluate and select several of foreign technologies. In fact, the Petrochemical industry was able to demand and get state-of-the-art technology and catalyst because of such expertise, which is otherwise perhaps deny to some extents to the others to developing country.*

Further, Globalization of R&D, liberalization phase and reforms to Indian chemical industry provide oil and Petrochemical as Navratna status as well as because of the entry of the private sectors the technologies and ability and its use become open competitive and the Indian research organizations had to then compete with the best in the world to sell their technologies accepting of few successful examples, the use of indigenous technology, because international competition has taken a severe bidding.

The escalation of crude oil prices, demanding international environment protection standards and climate change have posed major challenges to the chemical industry. Clean Development Mechanism (CDM) has provided an impetus to reduce the green house gas emission in the developing countries particularly in the petrochemical industry.

The Indian petrochemical industry grew in response to the argument that (i) it will lead to acquisition of advanced technical skills and (ii) its absence will lead to shortage of industrial raw materials. A large part of Indian industry is within the transnational corporations (TNCs) system and the technology transfer was totally packaged with little impact on local technical skills. The only public sector firm found it difficult to buy technologies, and the transfer process was also highly 'packaged', and incomplete. An oligopolistic market for petrochemical technology thwarted the industry's links with engineering and equipment fabrication sectors.

At the state at which the Indian Petrochemical sector is based on the expected growth and as well as severe competition are bound to face from the middle east countries, I personally believe that indigenous R&D will play a major role in the future for the Indian Petrochemical industry to remain competitive, these research efforts should not only be directed towards fossil fuel but also in use of alternative feed stocks , use of nano materials and chemistry, environmental friendly path ways, value addition to bio-products and significant improvement in energy performance efficiency. The future technologies will embody a trend towards structured, high performance, specialty, formulated materials, accompanied by processing flexibility, product/ process integration, quality control and quicker commercialization. The technology evolution must be accompanied by a corresponding engineering evolution.

16. Conclusion and Policy Implication

The mammoth changes that have occurred in India's technological capability since the onset of market reforms in 1991 are having and will continue to have positive consequences for the Indian economy. The impact is felt especially in terms of :

- learning competitive practices;
- learning through experience;
- learning from failures; and
- developing cognitive skills for improving conceptual knowledge.

Technological alliances, high technology exports, joint ventures abroad and learning through global R&D projects are some of the major developments that have occurred. Most of these had not been attempted earlier. The major change has been the evolution of cognitive responses for meeting competition and for exploiting evolving global opportunities. Indian firm have evolved, at least the select band of firms indicated in this report, organizational capabilities to respond to technoglobalism.

Liberalization has induced competition and entrepreneurial firms have started exploiting it through an integrated set of technological and organizational responses. The changes observed in the Indian economy are just beginning. Accumulation of technological knowledge and the commercial utilization of innovations have become more widespread and this has resulted in increase in technology based new ventures. A major turning point is the transformation of mindset towards business R&D. The Indian economy is becoming increasingly integrated with the global economy and more firms are leveraging the opportunities arising out of technoglobalism.

Many of the Indian Petrochemical companies are enhancing their new product management capability. These companies are strengthening the R&D management system using tools such as concurrent engineering, target costing, quality function deployment, R&D audit, R&D road maps, imagination engineering, etc.

In conclusion, it is argued that inward-looking policies do not aid productivity growth and international competitiveness. While it is important that opening up policies are carefully planned and orchestrated systematically and gradually in line with the strengths of an economy, it is clear that market liberalization is crucial for achieving technological capability and economic development in a rapidly-globalizing world.

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Glossary

ABS	Acrylonitrile butadiene styrene
CAN	Acrylonitrile
DMT	Di Methyl Terephthalate
EO	Ethylene Oxide
EPDM	Ethylene Propylene Diene Monomer
EVA	Ethylene vinyl acetate
HDPE	High Density Poly Ethylene
LAB	Linear Alkyl Benzene
LDPE	Low Density Poly Ethylene
LLDPE	Linear Low Density Poly Ethylene
MEG	Mono Ethylene Glycol

MMTPA	Million Metric Tone Per Annum
MX	Meta Xylene
NBR	Nitrile butadiene rubber
NMP	N-Methyl-2-pyrrolidone
NR	Natural Rubber
OX	Ortho Xylene
PBR	Poly Butadiene Rubber
PP	Poly Propylene
PS	Poly Styrene
PTA	Purified Terephthalic Acid
PVC	Poly Vinyl Chloride
SBR	Styrene Butadiene Rubber
SEZ	Special Economic Zone
SR	Synthetic Rubber

ANNEXURE 2.4.1.5

ROLE OF ENGINEERING CONSULTANCY ORGANISATION
IN
COMMERCIALISATION OF TECHNOLOGY

1. The R&D Intensity in Chemical Industry is aimed at bringing out the innovation in technology and then successfully commercially employs the same in growth of the industry. In commercialization of the indigenous Technology the Engineering Consultancy Organisations in India can play a catalytic role.

2. The Scope of Engineering Consultancy Organisation (ECO) in Commercialization of Technology consists of the following:

- Pre Project Activities
- Project Execution Activities
- Owner's Engineer
- Lender's Engineer

3. Pre Project Activities

The following activities are included under the above category:

- Conceptualisation of the Project
- Pre Feasibility Study
- Design of Pilot Plant & Operation of same
- Techno Economic Feasibility Report
- Environmental Clearance
- Assistance in obtaining Loan Capital

As may be observed these activities commence after R&D Team have declared the success of their effort by producing the desired product on a Bench Scale acceptable commercially. Many unknown parameters remain latent and some of them appear when a pilot plant, designed and constructed based on R&D results, are put to operation. It is essential to see that cost of production by the Technology employed is commercially competitive.

3.1 Conceptualisation of Project

Preliminary Know How Package available from R&D Team shall consist of following:

- Product Quality
- Process Flow Sheet
- Material and Heat Balance
- Co product and Effluent Quality

Based on above ECO undertakes the following activities for Conceptualisation of Project:

- Prepares Market Study
- Determines Price Cycle
- Raw Material Availability & Price Cycle

- Comparison of proposed Technology with available Technologies
- Ratio Analysis of Competing Products

Conceptualisation Study establishes the Product and Price and preliminary status of Technology which helps in attracting an investor or the Parent Company.

3.2 Pre Feasibility Study

Once the Concept note is approved by the Company, ECO is asked to prepare a Pre Feasibility Study which will include the following:

- Market Study
- Price Trend Analysis
- Comparison of Proposed Technology vis-à-vis Available Technology
- Additional Data expected from Pilot Plant
- Site Location (Preliminary)
- Capital Cost Estimate (Order of Magnitude)
- Profitability Analysis (Preliminary)

The above study is expected to assist the Management of the Company to have internal decision to go forward for the Project.

3.3 Pilot Plant

A Pilot Plant is must for establishing the Technology Commercially. Once the Pilot Plant operates successfully, the Commercial Plant can be scaled up to 100:1 Ratio for proper design and operation. The Company can assign ECO to design the Pilot Plant in association with R&D Team. Scope of ECO is to implement the Pilot Plant on Engineering Procurement Assistance and Construction Management (EPCM) basis which shall include:

- Basic Engineering
- Detailed Engineering
- Procurement Assistance
- Supervision of Civil Works & Erection
- Commissioning Assistance

3.4 Techno Economic Feasibility Report (TEFR)

Once the Pilot Plant has operated successfully the Company shall engage ECO to prepare Techno Economic Feasibility Report which shall have Capital Cost Estimate (+/- 10% Accuracy). This scope of work for a TEFR is detailed in Annexure-1. TEFR is extremely important from the point of view of finally going ahead of the project. It will bring out following conclusions:

a) Superiority of Technology or otherwise

b) Site Location and the logistics

c) Environment Compliance

d) Capital Cost Estimate which will finally become the Control Cost Estimate at the time of Execution of Project

e) Ratio Analysis to provide the comfort to Company and its Lenders that the Project has all the financial strength to go forward

TEFR is dealing on Technology which is an embodiment of Complex Combinations which are marketable and have both ec0nomic and political values. It will establish the superiority of locally generated technologies as against the general preference in India for Imported Technologies even today.

3.5 Environmental Compliance

Essential requirement of setting up a Chemical Project is environmental Compliance. Not only the Company but also the stake holders as well as the locality that is proximate to site needs to be assured of the emissions both liquid and gases from the Project are properly treated meeting the desired norms of emissions. The scope of work by ECO shall include the following:

- Preparation of Environment Impact Assessment Report.
- Application to Pollution Control Board/ Ministry of Environment and Forests for receipt of No Objection Certificate to build the Project.
- Hazop Analysis for the Project.
- Assisting Company during Public Hearing.
- Receipt of No Objection Certificate from Pollution Control Board.
- Design of Effluent Treatment Plant for solids, Liquids and Gaseous Emission.
- Design of Green Belt around the Plant.

3.6 Technical Assistance for Term Loan

As may be observed from earlier paragraphs ECO is engaged to prepare TEFR which includes Capital Cost Estimate to +/- 10% accuracy. Based on the Capital required the TEFR determines Equity and Debt Capital, the later being available from Merchant Banks which the Company will submit the Application for Term Loan to Merchant Banks, but the Bankers will need ECO to defend their estimate as well as confidence in newly developed technology. It is Merchant Bankers Confidence on Company and ECO which help in steering Application for Term Loan.

4.0 Phase II – Execution of Project

Once the Company management and the lenders agree to go ahead with the project that is the best moment for R&D success. ECO's Catalytic Role for the event needs appreciation. But this is the main phase which is entirely the domain of ECO for R&D success to be commercialized. Company enters in to Agreement with ECO and the Scope of Work of ECO has been detailed in Annexure-2. This is more fully elaborated in the following paragraphs:

4.1 Know How & Basic Engineering

A standard Schedule `A' package for Basic Engineering based on Know How by R&D organisation shall consist of details per Annexure-3. ECO undertakes the scale up based on results of Pilot Plant Scale up factor is expected to be within 100. These are main process engineering documents based on which the project will be executed. The capital Cost of the project is generally controlled by the Basic Engineering Package.

4.2 Detailed Engineering of the Project

Assuming the same ECO to be responsible for Detailed Engineering, the Detailed Engineering can commence earlier than Completion of Basic Engineering Package. The Plant Layout on completion allows the site preparation work to commence by Site Contractors selected by ECO. The ECO starts ordering of equipment on behalf of Company particularly for long delivery equipment. This helps in getting detailed engineering information from vendors enabling ECO to commence detailed engineering for Civil, Static & Rotary Equipment, Piping, Electricals, Instruments and Controls. ECO takes up the total engineering activities and thanks to the tools of Project Management PRIMA VERA available. ECO controls the project within time schedule and project cost. The Detailed Engineering is today executed on 3D PDS/ PDMS which helps saving in purchase of bulk materials.

4.3 Procurement Assistance

Procurement Assistance for a Project includes "Buying" "Inspection" and "Expediting". The knowledge of ECO and Data Bank it maintains for Vendors enables ECO to provide excellent services for Procurement and brings savings in Project Cost. "Buying" includes Preparation of Tender Documents, Short Listing of Vendors, Issue and Receipt of Tender Documents and Recommendation to Company of Vendor for placement of Purchase Order. Once Company finalizes the Vendor, ECO submits Draft Purchase order which Company signs and places same on Vendor. ECO thereafter provides stage wise Inspection Services till the equipment is finally accepted. "Expediting" Services by ECO ensures timely delivery of equipment.

4.4 Project Management

The Company depends on ECO for Proper Project Management so that the Project is executed on time and within cost. An experienced Project Manager by ECO with the help of modern tools of Project Management can accomplish the objectives of the Company with a small team of Project Engineers, Planning and Scheduling Engineer and Cost Estimator/ Controller. Project Manager is the Lead of the Project on behalf of ECO and takes major decisions for the Project be it Technical or Commercial. His job ends with the successfully commissioning of the Project.

4.5 Construction Management

With the finalization of Layout and receipt of NOC from Pollution Control Board, the Resident Construction Manager of ECO moves to Site and places order on Site Preparation Contractor for proper Preparation of Site. The Civil works Contractor selected thereafter undertakes execution of Piling and thereafter Civil works. Contracts are awarded by ECO for erection of Mechanical Equipment, Electricals, Piping and Instrument and then are coordinated and managed by ECO's Resident Construction Manager. As and when the works get erected the ECO accepts them after proper Inspection. Project Manager coordinates with Resident Construction Manager responsible for Construction and Safety. As soon as the entire Plant gets mechanically complete after proper Pre Commissioning Tests, the Plant is handed over to Commissioning Engineers of Company.

4.6 Commissioning Assistance

Commissioning is the most critical step of a Process. Once the Plant is ready for commissioning it is passed on to Commissioning team led by R&D Lead which will include Plant Key Operating personnel. ECO will assist the Commissioning team in providing technical details which is used to design the Plant. Commissioning Team will follow the Operating and Maintenance Manual written by ECO in association n with R&D team. Commissioning trials get completed when 72 hour guarantee test is conducted successfully proving the results as per declared yields, Consumption Data and Product Quality. The Plant is thereafter left to Operating Personnel.

5.0 ECO's Long Term Agreement with R&D Company

With the success of Commissioning of Project executed on EPCM basis by ECO it will be to the benefit of R&D Company to have long term agreement with ECO for the following:

- Preparation of Basic Engineering Package
- Preparation of TEFR
- Execution of Project on EPCM basis
- Marketing of Technology developed

Based on credentials of successful ECOs Investors both Public and Private generally have confidence in ECO who can successfully market the technology and demonstrate by execution of Project on EPCM basis.

6.0 List of Engineering Consultancy Organisations

List of Engineering Consultancy Organisation who can assist R&D organisation (CSIR, DRDO and Private) in Chemical Industry has been listed in Annexure only care need to be exercised in working with Multi National Engineering Consultancy Organisations if the Product developed is strategic to India. Generally the Fee for EPCM of a Project by an ECO shall not exceed 6-7% of Erected Cost of Project and as the Investments increase to Rs.1000 crores, the Fee will reduce to 3-5%.

7.0 Recommendations

It is recommended that once R&D organisations succeed in developing technology on Bench Scale they need to pick up an Engineering Consultancy organisation from the list of Organisations in Annexure 4. The ECO then will be involved in design of Pilot Plant, Preparation of TEFR and execution of Project on EPCM basis. The success of Commercialization of Technology indigenously developed will enhance the acceptance of indigenously developed technology.

ANNEXURE - 1

TECHNO ECONOMIC FEASIBILITY REPORT

- Product End Use
- Market Study
- Selection of Technology
- Description of Process with Process Flow Sheet
- List of Equipment & Brief Specification
- Requirement and availability of Raw Material
- Requirement of Utilities and description of Utility facilities
- Site Location
- Layout & Civil works
- Manpower Requirement
- Project Execution Schedule
- Quantity of Quality of Effluents
- Capital Cost Estimate (+/- 10% accuracy)
- Operating Cost Estimate
- Profitability Analysis
- Ratio Analysis

ANNEXURE – 2

PROJECT EXECUTION – EPCM MODE

- Know How
- Basic Engineering
- Detailed Engineering
- Project Management
- Construction Supervision / Management
- Commissioning Assistance
- Civil Works
- Erection of Equipment / Supplies

ANNEXURE - 3

BASIC ENGINEERING PACKAGE

1. Product Quality and Specifications.
2. Co-Product Quality and Specifications.
3. Process Flow Sheet along with description of Process.
4. Material Balance.
5. Heat Balance.
6. Preliminary P&I Diagram.
7. Estimated Requirement of Raw Materials and Utilities.
8. Instrument Schedule and Specifications.
9. Piping Class & Specifications.
10. Equipment Arrangement Drawing.
11. Plant Layout
12. Building Specifications.
13. Preliminary Piping General Arrangement Drawing.
14. Operating Manual.
15. Maintenance Manual.

ANNEXURE - 4

LIST OF ENGINEERING CONSULTANCY ORGANISATIONS IN CHEMICAL INDUSTRY

EPCM

PRIVATE SECTOR

- Tata Consulting Engineers Limited
- Jacobs H&G *
- Aeker Solutions *
- Technimont ICB *
- Toyo India *
- Uhde India *
- Chemtex *
- Technip India *
- Lurgi India *
- Mott McDonald *
- L&T Chiyoda *
- Development Consultants Ltd.

PUBLIC SECTOR

- Engineers India Ltd.
- Mecon
- PDIL

***Multi National Companies in India**

ANNEXURE 4.6.1

Redefining the Role of NRDC

In the Changing paradigms in Innovations

Report of the Task Force

January, 2011

National Research Development Corporation

New Delhi – 110 048

FOREWORD

It is praiseworthy that the NRDC took the initiative in 2008 to study the innovation programmes and policies being pursued in the Republic of Korea, China and Taiwan particularly with reference to SMEs and the experiences which can be shared and implemented by the Indian Industry as well as the, government and other stakeholders. A Taskforce consisting of eminent scientists and economists was formed under my chairmanship to study the relevant issues.

The committee formally met seven times and the chairman and members informally interacted on several occasions on the issue of fostering technological innovation and diffusion relevant to Indian SMEs. Three teams of the Taskforce visited China, Republic of Korea and Taiwan during December 2009 and January 2010to study their systems and policies to promote innovation in their SMEs.

The experience gained by the Taskforce during the study visits and interactive sessions with experts has been of great value while formulating the final recommendations of this report. Though the main focus of the present study is to redefine the role of NRDC with the changing paradigms in innovation in various S&T sectors, an attempt has also been made to propose Indian specific recommendations which can contribute to realignment of government policies to enhance the impact of innovative R&D on the SME sector.

The Taskforce has particularly noted with concern the persisting weak linkage between Indian SMEs and the Universities inspite of notable private sector entry into Indian technical education system and government's commitment to significantly enhance the research funding to public and private R&D / academic institutions. This aspect has been adequately dealt in this report.

On behalf of the Taskforce, I wish to convey our deep sense of appreciation to the wholehearted support provided by Sri Somenath Ghosh, CMD of NRDC, his dedicated Senior Executives and the supporting staff. I hope the Taskforce recommendation will receive due attention by the DSIR and the NRDC Management for further improving the innovation culture of Indian SMEs

K V Raghavan

INAE Distinguished Professor &

Chairman, NRDC Taskforce

Date : 23.12.2010

Place: Hyderabad

1. Introduction

National Research Development Corporation was established in 1953 as a Public Sector Enterprise (PSE) under the Ministry of Science and Technology. As a Public Sector Enterprise, the corporation entered into a MoU with the Department of Public Enterprise (DPE), Government of India at the beginning of the financial year. The MoU among others outlines the performance indicators. During the Syndicate Group discussion for executing the MOU in 2008, the group had suggested that NRDC take up a study on how technological innovations are being promoted and managed in Asian countries, particularly with respect to SMEs and how these could be beneficially emulated by NRDC in the Indian context.

2. Constitution of the Committee

In light of the suggestion of DPE, NRDC had constituted a committee to undertake the study of innovation systems in select Asian countries, specifically, Republic of Korea, China and Taiwan under the chairmanship of Dr. K.V. Raghavan, INAE Distinguished Professor, IICT, Hyderabad. The other members of the committee are:

1.	Dr. D. Yogeswara Rao, Scientist 'G', IICT, Hyderabad	Member
2.	Dr. Parthasarathi Banerjee, Director, National Institute of Science Technology and Development Studies (NISTADS), New Delhi	Member
3.	Prof. Mihir Kumar Ravel, Visiting Professor, International Institute of Information Technology (IIIT), Bangalore	Member
4.	Dr. Kirankumar Momaya, Professor, Shailesh J Mehta School of Management Studies, IIT Powai, Mumbai	Member
5.	Dr. Rajeev Anantaram, Senior Fellow, Indian Council for Research on International Economic Relations (ICRIER), New Delhi	Member
6.	Mr. Somenath Ghosh, Chairman & Managing Director, NRDC	Member-convener

NRDC officials, Mr. V.K. Manchanda, General Manager, Mr. C. M. Gaind, Chief (IPR), and Mr. Bijay Kumar Sahu, Scientific Officer (IPR) have assisted the committee.

3. Terms of Reference

The study has to focus and analyse the S&T policies of the Asian countries, particularly the initiatives that were instrumental in fostering technological innovation as well as diffusion and their relevance to the Indian context. If found relevant, how could these be adapted to foster innovation growth in India? The study would also compare and contrast the National Innovation System (NIS) of these countries with the Indian system so as to provide a framework for institutional arrangements for the growth of industry and particularly the SME sector. The broad terms of reference of the committee are as follows:

- Study the Government policies of neighboring Asian countries in fostering technological innovation and diffusion;

- Identify specific models followed for innovative technology development including joint initiatives (financial/technical) in these countries;
- Role of research organizations, academic institutions and universities in development of innovative technologies and types of linkages established with industry and nature of incentives for fostering close linkages in these countries;
- Technology transfer models adopted by these countries;
- Intellectual Property Protection (IPP) Systems and their accessibility to SMEs in these countries;
- Identify typical successful cases of innovative technologies in these countries; and
- Compare and contrast the study with reference to Indian system and make specific recommendations in the context of NRDC.

4. Approach adopted by the Committee

The committee met seven times and adopted a multi-pronged approach in accomplishing the task. On one hand it had studied the current activities of NRDC, its capabilities and manpower strength as well as current business models and performed a SWOT analysis for the corporation. On the other hand it had examined the national innovation system and current initiatives of Government in encouraging the innovation among the industries, particularly the SME sector. It had examined the available information on this subject, such as, (i) Science and Technology Policy of the Government of India with reference to technological innovations in the SME sector; (ii) The role of Public-Private Partnership (PPP) in commercialisation of R&D and technological advancement of Indian SMEs; (iii) Current status of University – SME linkage in India with reference to innovative technology transfer; and (iv) Comparison of R&D capabilities of SMEs in India, China, South Korea and Taiwan in specific sectors. Specialist presentations were arranged on select topics - (i) "*Technology Innovation in Emerging Asia"* by Prof. Mihir K. Ravel, (ii) "*R&D Commercialisations through Public-Private Partnership – Techno-managerial Aspects"* by Dr K. V. Raghavan, and (iii) *"Overview on Innovation in China, South Korea and Taiwan" by* Dr. Rajeev Anantaram. These efforts were strengthened by study visits to China (food processing industry), Taiwan (Speciality products including pharmaceuticals) and South Korea (automobile components). However, the visits were largely general in nature.

5. Assessment of the Committee

5.1 NRDC

5.1.1 National Research Development Corporation (NRDC) was incorporated as a section 25 company under the Ministry of Science and Technology, Government of India in 1953. Its primary mandate was to transfer technologies that were developed by the R&D organisations in the public domain, academic institutions and universities. As a complementary activity, it was also engaged in promoting indigenous technology development and its commercialization through third party licensing. In fulfilling its mandate the corporation interacted with a large number of research organisations, it entered into MoUs with a number of institutions, developed a portfolio of technologies, further developed technologies by adding value to the laboratory technologies to a level acceptable to industries, interfaced between the research organisations and industry and facilitated transfer of large number of technologies. The large number of technologies so transferred includes almost all sectors of industries, viz. agriculture, agro-processing & food technology, chemicals, mechanical, electrical & electronics, biotechnology, drugs and pharmaceuticals, waste management. With Inventions and Innovations becoming the central theme of Research Organisations in the last two decades, NRDC has built strong expertise in intellectual property related activities and positioned itself to provide services.

5.1.2 The Corporation's activities can broadly be classified as commercial and promotional. The former primarily aims at sourcing the technologies, developing technology packages and licensing these to industries and entrepreneurs. The promotional activities have two sub-components viz., (i) Invention Promotion Programme (IPP) and (ii) Technology Promotion Programme (TPP). Invention Promotion Program endeavours to stimulate the spirit of inventivity not only among scientific & technical personnel and industrial workers but also amongst craftsmen, artisans and the youth. Under TPP, the Corporation takes wide ranging initiatives including rural and household technologies, export of Indian technologies and executing turnkey projects abroad, Time bound Technology Development Programmes (TDP) based on market potential, etc. The promotional activities bring in the much needed industrial contacts to the corporation. Usually, the promotional activities are supported to the extent of 70 to 80% by various government departments and the rest is met by the corporation.

5.1.3 Currently, the Corporation has a staff strength of approximately 94, which is almost equally distributed between executives (45) and non-executive category (49). The average age of the staff is being in the forties. During this year, the Corporation's total income was Rs. 10.86 core, as compared to Rs 12.20 core in the previous year. The Corporation had a Surplus before Tax of Rs. 15.38 lakhs in 2009-10 as compared to Rs. 61.81 lakhs in the previous year. The Corporation has been striving to become a world-class organisation in the field of technology transfer and associated service provider.

5.1.4 The committee noted that NRDC's revenue generation is mostly from Premia and Royalty from the technologies licensed. Of late, there has been a decline in licensing activity of technologies. Added to this, there has been a sharp decline in supply of technologies from publicly funded organisations in recent years, resulting fewer technologies coming into the NRDC's portfolio for licensing. On the contrary, there is a growing demand from SME sector for new technologies. Therefore there is a need to capture the opportunities emerging from the SME sector. NRDC is yet to enter into IP marketing space, although it has built good strength in this area. The promotional activities, presently, are having a telling effect on both human and financial resources. The funds provided by the sponsoring organisations are at times inadequate to meet the actual expenses, and the organisation supplements these funds with its internal resources. It also puts severe strain on the human resources (technical) of the organisation, which are already in decline. The promotional activities wherever carried out by NRDC must be effectively managed and leveraged the activity towards business development. The strengthening of human resources, particularly with younger technically qualified people is not taking place at periodic intervals.

5.1.5 The SWOT analysis of the organisation has brought out the following points:

Strengths

- Adequate financial health;
- Close association with large number of public R&D organisations / institutions and thereby access to new developments;
- Good portfolio of proven technologies in various sectors;

- Rich experience in technology transfer, IP management and project consultancy;
- Wide Contacts with industries and research institutions;

Weakness

- Lack of efficient process for technology evaluation and assessment mechanism;
- Inadequate deployment of IT tools to speed up business process activities;
- Depleting and ageing technical manpower;
- Absence of strategic tie ups with venture capital/incubators;

Opportunities

- Increasing emphasis on IP protection and management;
- Disappearing geographical boundaries for sourcing technologies;
- Translational research gaining importance in converting IP into commercialisable knowledge;
- Increasing venture capital fund and incubators to help budding entrepreneurs
- Emergence of IP marketing

Threats

- Shifting emphasis of publicly funded research institutions from technology development to IP space;
- Declining supply of technologies;
- Import of technologies made easy with opening up of economy;
- Government is encouraging publicly funded R&D organisations to set up in-house technology transfer units.

5.2 Indian Innovation System

5.2.1 Since economic liberalization, the country's National Innovation System (NIS) had undergone perceptible changes. The Indian Government has taken several measures to create an innovation eco-system as development of innovation is critical to the nation's competitiveness. This has reflected in India's impressive growth in GDP. The Indian economy is currently growing at 6-8% per annum with Indian exports growing at 30% CAGR with several Indian companies successfully competing against tough international competitors. A good part of these exports have come from SMEs. Though Indian industry is scaling up to global competitiveness, it has a long way to go. Thus, in the growth of the Indian economy, Innovation has emerged as a key factor although it is not apparent and visible.

5.2.2 India's R&D expenditure as percentage of GDP was marginally increased between 2003 and 2007, from 0.80% to 0.88%. But, in absolute figures it had significantly grown from about Rs. 18,000 crore to close to Rs. 40,000 crore. During this period the share of industrial sector R&D expenditure has improved from 18% to an estimated 28%. The 10% rise in the industrial R&D expenditure is an indicator of industry's realization of importance of the innovation.

5.2.3 In the Indian context the innovation system include, the Research institutions (state and central), Academic Institutions, universities, in-house R&D laboratories of industry and non-profit organizations such SIROs. These knowledge generators are ably supported with liberal funding by various S&T agencies of government such as DST, DBT, DSIR, DRDO, DAE, DoS, ICAR, economic ministries etc. Broadly, the Indian innovations are occurring more in the process technologies as compared to product technologies. The latter is vital for achieving a leadership position at national and global levels.

5.2.4 The **Science & Technology Policy** 2003 outlines a number of policy objectives that include "enhancing S&T governance and investment, further development of S&T infrastructure, finding new funding mechanisms for basic research, developing human resources, increasing industry and scientific R&D, encouraging indigenous resources and traditional knowledge, and strengthening generation and management of intellectual property. The report is far more ambitious in the gamut of activities it seeks to address, but is short on detail. For example, while the plan envisions an increase in national R&D intensity (R&D as a proportion of GDP) from the current level of 0.8 per cent to 2 per cent by the end of 2011, it provides no clear roadmap for achieving this.

5.2.5 India's Scientific and Technical (S&T) manpower constitutes one of the major input resources to scientific and technological activities. It is also an indirect measurement of the strength of the country because of its activities. India possesses a massive science and technology infrastructure spread across the country. With over 200 universities, 1500 research institutions and 5000 Ph.D.s being turned out every year, India is in an enviable position with regard to the S&T manpower. Scientific institutions have been set up and nurtured in many diverse sectors. These have included agriculture, atomic energy, electronics, environment, ocean, space, biotechnology, non-conventional energy sources, defence, health, and more.

5.2.6 In the recent past the Government had set up many Indian Institute of Technologies, Indian institute of Science and Education research and R&D institutions that are expected to carry out innovation activities, besides training qualified manpower. A significant growth has also taken place in the in-house R&D units of the industry. Foreign R&D centres have grown from fewer than 100 in 2003 to about 750 by the end of 2009. Most of these R&D centres relate to information and communication technologies (ICTs) and the automotive and pharmaceutical industries. The Government had also enhanced the international cooperation in S&T with developed countries. The internationalization of R&D has positively impacted India, in that complex and specialized R&D related activity is increasingly being located in India.

5.2.7 As a signatory to WTO, India had put in place IPR laws that are on par with the international regimes. IP protection is becoming increasingly important to knowledge based industries because of the mounting costs of R&D for new products and processes, shortening of product life cycles, rapid growth in international trade in high-tech products and internationalization of the research process. The government had created patent facilitation centres particularly for SME sector. However, the IP generation capacity of Indian system is low in terms of concrete revenue generation and new asset creation. There is lack of emphasis on creativity, problem solving, designing and experimentation opportunities in Indian education system.

5.2.8 To foster and promote innovation, Government of India launched several novel programmes that support research projects. Some of these are: Pharmaceuticals Research and Development programme (DST), New Millennium Indian Technology Leadership Initiative, NMITLI (CSIR), Small Business Innovation Research Initiative, SBIRI (DBT), Biotechnology Industry Partnership Programme, BIPP (DBT), Technopreneur Promotion Programme, TePP (DSIR & TIFAC), National Innovation Foundation, NIF (DST), Technology Development and Demonstration Programme,TDDP (DSIR), Home Grown Technology Programme, HGTP (TIFAC-DST), Technology Development Board, TDB (DST), Sectoral Mission Programmes and Vision 2020 programmes (TIFAC-DST) etc. Many of these programmes encourage innovation development in public-private-partnership mode. However the worrying factor is the lack of effective collaborations between the large number of Indian R&D and Academic institutions as well as universities spread over the length and breadth of the country and the industry, particularly SMEs. A very small percentage of Indian SMEs is participating in these programmes, as the innovation potential of this segment is not high.

5.2.9 In addition Government of India has recently approved several measures that encourage development of innovation. To name a few of these are: (i) permitting the researchers to have an equity stake in scientific enterprises / spin offs while in professional employment with their research and academic organizations; (ii) permitting the scientific Establishments to invest knowledge as equity in the enterprises; (iii) Encouraging the Scientific Establishment to set up incubation centres; (iv) Facilitating the mobility of researchers between industry and scientific establishment; (v) Protection and Utilization of Public funded Intellectual Property Bill (under consideration of Parliament; and (vi) setting up of National Innovation Council (NIC). These measures are expected to further foster the innovation eco-system in the country.

5.2.10 Innovation is an effort that requires the optimal use of the built-in capabilities of the Indian industry, particularly SMEs, the government, the academic institutional system and R&D institutions. Their coordinated functioning is vital to make innovation, which is lacking in the Indian system.

5.3 Study Visits

5.3.1 Three sub-teams of the Taskforce visited China, South Korea and Taiwan to study the innovation models followed by these countries for industrial development, with reference to Government policies in fostering technological innovation and diffusion, the ability of industry in absorbing innovative technologies, institutional linkages established for technology transfer, and role of universities, academic and research institutions in development of innovations. Although the study tour attempted to focus on the three specific industrial sectors viz., agro based products (China), speciality products including pharmaceuticals (Taiwan) and auto components (S. Korea), the visits are general in nature. A detailed Study Report on "Innovation Policies in the Republic of Korea, China and Taiwan: Learnings for India" is appended to this Committee Report. The institutions / organisations visited in these countries are appended as Table 1. Highlights of the findings are presented in following paras.

5.3.2 The three countries included in the study have made impressive economic strides over the past few decades on the strength of manufacturing sector based, export- led growth. While the timelines for rapid take off in the three countries differed, the trajectories followed by the three countries are broadly similar. Korea and Taiwan in particular followed bottom-up development models, starting with wide-ranging reforms in the agricultural sector, accompanied by extensive investments in physical and human capital that permitted an economic expansion based on manufacturing led economic growth. As a result of these policies, Taiwan reached the ‘take off’ stage in the mid 1960s, while Korea followed in the early 1970s.

5.3.3 While all three countries have been classified as late comer economies, in the science and technology and development literature particularly in relation to the traditionally developed economies of North America and Europe, China has been a relative latecomer even compared to Taiwan and Korea, with economic takeoff dating back to the mid 1980s. Since then, China has quickly scaled heights and emerged as a global manufacturing hub, thanks to its deep links with global manufacturing supply chains, though in terms of value-addition of its products it compares poorly to Taiwan and Korea, especially the latter. Korea especially has made rapid strides in manufacturing, ranked number one globally in ship building and DRAM production, while ranked among the top five global producers of automobiles, electronics and steel. Taiwan, on the other hand, has emerged as the world’s leading producer of computer hardware and is among the leading producers of semiconductors and specialty chemicals. China’s predominance is still in low-end manufactured products, though the composition of exports is changing largely as a result of the extensive involvement of Foreign Funded Enterprises **(FFEs)** in the country’s economy.

5.3.4 The limitations of the manufacturing-based, export led growth model followed in East Asia are becoming clear, with the emergence of competition from other low wage producers, particularly in South East Asia. While this was clear in the case of Korea and Taiwan as early as the late 1980s, this is becoming increasingly apparent in the case of China over the past few years. Accordingly, the three countries have aggressively adopted an innovation-led approach to growth. This includes an increased emphasis on indigenous basic and applied research, revamping of the National Innovation system, particularly the development of inter-institutional linkages, greater incentives for private sector participation, particularly the Small & Medium Enterprise Sector that has traditionally been the backbone of the economy in Taiwan, but has only recently been the subject of policy emphasis in China and Korea.

5.3.5 While three countries have broad similarities in their development trajectories, there are some vital differences as well, especially in the approach to innovation policy that seek to build on each country’s inbuilt strengths. The government has been a vital player in setting development priorities, especially in the early stages of development. This largely continues through industrial and sector targeting, though the private sector is increasingly being involved in the formulation of S&T related policies.

5.3.6 The R&D investment as % of GDP is currently 1.42 per cent in China, approximately 2 per cent in Taiwan and 3.42 per cent in Korea. The R&D intensity of GDP for Korea is among the world’s highest, though in absolute terms China’s spending is higher because of a much larger GDP.

5.3.7 Foreign Direct Investment (FDI) has been traditionally discouraged in Korea, which preferred arms-length arrangements with foreign technology suppliers. This policy changed marginally in the late 1980s, when the Korean government allowed greater foreign participation to bridge the technology gap that was opening up, especially with the United States and Japan. Taiwan adopted a more moderate approach to FDI, allowing FDI in carefully selected sectors, whereas China has relied heavily on FDI to drive economic expansion. The contribution of FDI to technological deepening within China is very limited and a source of great disappointment to Chinese policy makers. While FFEs contribute 59 % of China’s manufacturing exports and a staggering 85% of China’s high-tech exports, transfer of technology by FFEs and its subsequent diffusion within China remains limited, even in situations where the FFE is in a joint venture with a domestic Chinese enterprise.

5.3.8 The National Innovation Systems of the three countries that were largely designed for manufacturing led growth that at best adapted standardized technologies obtained from developed countries has proved inadequate for nurturing innovation led research. This shortcoming is manifested most acutely in the virtual absence of basic research and embryonic applied research (though Taiwan and Korea are making rapid strides in the latter). While basic research in the three countries has virtually been absent, the Government Research Institutions (GRIs) were the nucleus of applied research, especially in Korea and China. The absence of well-developed inter-institutional linkages meant that the knowledge generated within the laboratories was not widely diffused within the respective countries. China, which had the most extensive array of GRIs among the three countries, is revamping the institutional network under the Chinese Academy of Sciences based on a performance audit that has already led to the shutting down of non-productive institutions, resulting in a smaller but more compact structure.

5.3.9 The overall innovation environment in China, S Korea and Taiwan have been fuelled by massive investments in higher technical education, R&D infrastructure and science parks to promote clusters of SMEs in different industrial fields, promotion of university – industry linkage and positive role of local firms including multinationals in nurturing ancillary industries. The university – industry linkage promotion efforts, however, are of recent origin and a lot more needs to be done in this area.

5.3.10 The mandate and scope of public funded R&D institutions and universities have been expanded in a well planned manner to serve as (i) catalysts for generation, protection and utilization of intellectual property (ii) competent channels for technology transfer to SMEs and (iii) facilitators for setting up science parks and technology incubators which are run on the basis of public-private partnership.

5.3.11 The recent experience of S Korea in the development of small business innovation research system is worth making a detailed study by India for possible adoption on a larger scale.

5.3.12 Internationalization of innovation (as opposed to manufacturing) remains a limitation of firms in all three countries. This prevents firms in the three countries from leveraging innovation related infrastructure in other countries, despite considerable international presence. However internationalization of R&D is an extremely complex activity, something that even firms from the EU, Japan and the US are just coming to terms with. Firms from the three countries are beginning to internationalize not just production, but R&D as well, mainly through Mergers and Acquisitions in developed countries, but the global footprint to date is limited.

5.3.13 Though the three countries enjoy near universal literacy, they are handicapped by the absence of a critical mass of researchers at the cutting edge, in comparison to the EU, the US and Japan. Thus in certain critical areas of high technology, the technology gap with the west is widening. Universities, the second leg of the 'triple helix' are in some ways the weak link in the endeavor to scale up technologically. This has largely to do with the culture of universities which were traditionally perceived as pedagogical institutions with little role to play in knowledge generation. Recent policy changes in the three countries are attempting to change this. A new tier of' '*research*' universities, well-funded through both public and private support and staffed predominantly with returning diaspora with extensive international experience are being established in the three countries. This has created a two-tier structure in universities, with a few well-funded and equipped research universities on the one hand and traditional universities, whose main mandate is teaching, on the other.

5.3.14 The private sector is increasingly involved in R&D related activities, though the actors differ widely across countries. Most private R&D in Korea is still performed by the *chaebols*, the large conglomerates, who were heavily favored by the government since the 1970s, as part of Korea's industrial policy. Despite Government efforts to diversify R&D activity by involving smaller firms, *chaebols* remain the principal actors in Korea's private S&T space. The situation is not very different in China with most domestic R&D activity performed by the large State Owned Enterprises. As stated above, in the case of China, even when the firm is 'private', there is often considerable government ownership in the form of 'golden shares', making a clean classification of private R&D activity in China difficult.

5.3.15 The manufacturing economy in Taiwan has been driven by the Small and Medium Enterprise Sector that continues to occupy an important role. Manufacturing firms from Taiwan are mainly known for supplying middle to high end components to international firms, though since the mid 1970s, they also engaged in Own Design Manufacture (ODM). However, the small size of the firms and the lack of scale economies also mean that resources for R&D remain limited. This explains the importance of innovation clusters in Taiwan, where universities, GRIS and private firms co-exist in close proximity allowing the benefits of agglomeration to be shared by small firms, which do not have the resources to perform such activities on their own. The NRDC team visited one such cluster at Hsinchu, which boasts of a large number of sophisticated R&D institutions and was responsible for spawning a number of high tech enterprises, the most famous being the *Taiwan Semiconductor Manufacturing Corporation (TSMC)* founded by a former alumnus, Morris Chang.

5.3.16 The SME sector is currently *less* important in the economies of China and Korea despite recent efforts to aggressively boost the productivity of SMEs. As with universities, recent policy changes beginning the late 1990s in Korea and more recently in China have led to the emergence of a two-tier system within the SME sector, with a small core of well-funded, high technology start-ups working in niche technologies, whereas the majority of firms are undercapitalized and perform highly routine manufacturing activities. Most government and private programs aiming to revitalize the SME sector are directed at the former, thereby creating a dualist structure of high tech and obsolescent firms.

5.3.17 Technology Clusters have emerged as an important facet of the S&T infrastructure in China and Korea as well, in a bid to replicate the global success of manufacturing clusters. However, the experience of the three countries in reaping the benefits of agglomeration is limited. It has been observed that many firms within clusters are performing virtually no R&D, but are largely engaged in high end manufacturing. This could be explained in terms of the transition time to change a firm's mindset from high end manufacturing to IP generating activities. However, technology clusters have performed a useful role in incubating start up firms. Incubation involves enabling firms (typically small start ups) to *develop a business plan, secure government or venture capital funding, develop their technology, and commercialize it.* Firms within the technology or knowledge clusters have limited tenure (typically 3-5 years) following which they leave the knowledge cluster, though in Korea, efforts have been made to ensure that 'graduating' firms retain their links with the knowledge cluster that nurtured them.

5.3.18 As part of the effort to develop a modern, innovation based economy, a series of institutions performing auxiliary activities that augment innovation have been set up in the three countries. These firms are often, but not always part of the technology clusters discussed above. These institutions perform important activities like *global technological search (enabling local firms to find the best source of technology they are seeking), technological dissemination (enabling local firms to find buyers for technologies they develop), patent sourcing for domestic firms, steering domestic firms through the patenting process among others*. In this connection, the NRDC research team had the opportunity to visit two institutions—Industrial Technology Research Institute (ITRI) in Taipei and the Shanghai Technology Transfer Center (STTC) in Shanghai.

5.3.19 In general, the transition to an innovation led economy is proving difficult for the three countries, particularly in comparison to the rapid progress made in ramping up domestic manufacturing capabilities. This is understandable, given the vastly more complex nature of innovation and knowledge intensive growth in general. This was generally acknowledged by S&T experts during field visits. At the Science and Technology Policy Institute (STEPI) in Seoul, the need for a "second catch up" in Korea, before sustainable innovation led growth could begin was stated. Overall, any adoption of policy changes in India would have to be context specific, given the vastly different economic and institutional conditions in India.

6. Recommendations of the Committee

After extensive interactions, study visits, discussions and deliberations the committee arrived at its recommendations. For ease of presentation these recommendations were divided into two parts viz. (i) Country specific recommendations and (ii) NRDC specific recommendations as stated below.

6.1 Specific Recommendations for the Nation

6.1.1 Alignment of Government Policies for encouraging and enhancing innovation in SME sector:

The study visits to China, South Korea and Taiwan have revealed that the Governments of these countries have played a significant role in creating an innovation eco-system for expanding the technological capabilities of SME sector. Towards this, the governments of these countries are aligning their S&T Policies dynamically to suit broader industrial goals, specifically SME sector. Some of these are:

i. Facilitated and funded technology imports through hard currency for specified Export oriented sectors;

ii. Assisted development including reverse engineering of equipments / machinery to move away from exclusive dependence on imports. Also encouraged deployment of innovations as well as national capabilities to expand the technical superiority of such developments;

iii. Encouraged and promoted Foreign Direct Investment flows into SME sector for technological up gradation and modernization. Also aligned the policies for attracting Foreign Direct Investment into SME sector;

iv. Promoted partnership between government, universities, R&D institutions and private sector industry, particularly SME sector to develop innovations;

v. Facilitated development of Technology parks to promote new start-ups.

vi. Supported SMEs to develop their own Brands for product marketing rather remain as simple intermediaries supplier through technological upgradation;

The Committee noted that Indian Government has also taken some initiatives in the recent past to enhance the innovation quotient among the diverse industry sectors. It had launched many schemes, such as NMITLI (CSIR), DPRP (DST), SBIRI (DBT), BIPP (DBT) etc to encourage Public-Private partnership. It had also announced policy measures permitting (i) the universities, Academic and Research Institutions to set up Technology Incubation centres and (ii) transfer the knowledge for equity. Many of these measures are expected to bear fruit in coming years. However, there is no specific scheme that focuses on the SME sector. Further, as the R&D intensity in the SME sector is low, these industries can not compete with established industries in the above mentioned schemes. Therefore the committee recommends setting up a special scheme exclusively focussing on the SME sector funded by Government. The scheme may cover the aspects of (i), (ii), (iv) and (vi) mentioned above. The scheme may be initiated, formulated and operated by either DST or DSIR or through one their arms.

6.1.2 Universities setting up Industry Oriented Academic Programmes

The Universities have been given the necessary freedom to formulate academic programmes at diploma, undergraduate and post graduate levels in Taiwan which can match the technological needs of the industry in the concerned region. This is helping in exchange of personnel between the universities and SME's. Similarly, the Academic and research institutes have acted as intermediary institutions to facilitate the development of research by SME's. Taking a clue from such initiatives, the Committee recommends, on an experimental basis, select universities/ IITs may be permitted to start industry oriented programmes as well as act as intermediaries for the SME sector. Based on their experience, the initiative could be further expanded and deepened to other institutes. Further it recommends that a committee be constituted to continuously monitor the developments and take necessary steps to dynamically position the relationship.

6.1.3 Incentives to University Faculty to Promote Academic – Industry Interactions

Industry oriented career incentives are being introduced in these countries for enhancing the performance of University faculty. They include recognition of R&D reports of industry oriented work as academic outputs for consideration of appointment or promotion of faculty, short term deputations to the industry and sharing of consultancy fee and royalties pertaining to industry projects. The committee observed that whilst the short term deputations to industry and vice versa is permitted by Government under 'mobility scheme', sharing of consultancy fee and royalties pertaining to industry projects are under consideration of Parliament. However, recognition of R&D reports of industry oriented work as academic output will go a long way in encouraging applied research by Academic & R&D institutions. The Committee, therefore, recommends needed measures may be put in place by Government to recognise R&D reports of industry as academic outputs.

6.1.4 The SBIR Initiative

The Small Business Innovation Research (SBIR) Programme attracted over 3000 applications from Taiwanese SME's in 2009 with funding support to the extent of NT$ 6.3 billion. This has risen the SME R&D spending to NT$ 12 billion. The programmes also made a major contribution towards the upgrading and transformation of Taiwan's traditional industries. The Innovative Technology Applications and Services (ITAS) programme of MOEA encourages SME's to develop innovative high value added manufacturing and knowledge intensive enterprises. The recently formulated New Leading Product Development and Assistance Project of MOEA, Taiwan approved 433 projects (56.7% of the total) with NT$ 5.96 billion in subsidies to enable SME's to raise NT$ 29.8 billion R&D expenditure. On an average, each subsidized R&D project developed 3.78 items of new technology of which 1.76 could be classified as innovative technology component and 2.02 as patent component. Every NT$ 1 of government subsidy stimulated an additional NT$ 1.64 in R&D spending plus a further NT 5.18 in follow up R&D expenditure in 3 years after project termination. The Committee observed that Department of Biotechnology (DBT) had initiated a Programme viz. SBIRI on similar lines exclusively to serve the needs of biotechnology industries. In order to broad base such benefits, the Committee recommends a similar or modified programme to be initiated by Ministry of Science & Technology under its **Technology Development Board** to cater to all other SME sectors.

6.1.5 Mechanisms for Quick acquisition of infrastructure / Resources for SMEs

The taskforce's experience in South Korea, China and Taiwan indicate the need for establishing proactive service platforms specifically for SMEs at national, state and local levels to speed up the processes related to financing, infrastructure creation, production technology, R&D support systems, marketing and HR recruitment. Some of the tools, which have become popular in the above countries are, SME trouble shooting centres, SME concern hotlines and proactive service teams from central government ministries and agencies to guide SMEs properly on establishing new ventures. Taking a clue from such successful initiatives, the Committee recommends a similar SME Proactive Technology Centres may be established at select locations by Ministry of Small & Medium Enterprises, preferably in association with NRDC. The latter would act as a link between the industry and the Research institutes and effectively hand hold them.

6.2 NRDC Specific Recommendations

Significant changes are taking place in knowledge marketing. Development of complete technologies is giving way to innovations and IP, particularly in publicly funded organizations. NRDC needs to sharpen its expertise and capabilities as well as reorient its operations to be relevant in the changing paradigm. It has to shed some of the activities which are not profitable, for example some of the promotional activities, and take up new operations that are relevant to enhance its performance. In this context, the following specific recommendations are being made.

6.2.1 Accelerated Innovation Translation Fund (ITF)

The Indian R&D has undergone a paradigm shift over the last one and half decades, with focus shifting from reverse engineering to innovation. Indeed, innovation has become the central theme of most knowledge generators and IP protection has become the by-word. Often, an innovation needs to be further worked upon to translate it into a commercialisable product or process or service to derive economic benefit. Such translation is usually associated with high risk and involves substantial upfront financial investment. Many Indian industries, leave alone the SMEs, due to their size and low profitability are not in a position to make such investments. Further it is widely believed that the next phase of economic development globally would depend on the application of generated innovations. Therefore, a system of nurturing the innovations into commercially innovative products is the need of the hour and NRDC with its significant reach to the knowledge generators on one hand and industry, particularly SMEs, on the other, can play a significant role. The Committee therefore recommends that an Accelerated Innovation Translation Fund (AITF) may be set up at NRDC with a yearly grant of Rs. 50 crore through the XII Five Year Plan. The fund size could be enhanced or decreased based on the performance. It is to be made available to industry as well as new entrepreneurs on a competitive basis by evolving a transparent system. NRDC may also leverage this fund to partner with banks, financial institutions, venture capital funds, TDB and related instruments to support the translational research in a syndicate mode. The committee feels that the demand for such translational activities may pick up with the Government's recent initiative of permitting researchers to have an equity stake in scientific enterprises.

6.2.2 Intellectual Property Management for Commercialization of Research

The S&T Policy 2003 emphasized the development of skills and competence to manage IPR and leveraging it in strengthening the national competitiveness and development and transfer of technologies. Over the years NRDC has built excellent capabilities in intellectual property related issues. The committee thus recommends that:

(i) NRDC should expand further on this strength and enter into IP valuation and marketing as its main focus and slowly move away from technology marketing per se, as the latter is declining among the publicly funded research organizations in preference to innovation and IP;

(ii) The concept of patent auctioning, pooling and developing IP portfolios around selected niche technological areas is gaining ground. Towards this, the corporation may acquire patents from domestic or foreign sources and add value to these IP portfolios, which may include acquiring complementary patents, IP or technologies and/or through cross licensing and offer such knowledgebase to clients; and

(iii) The corporation should partner with technology transfer centers of universities, academic institutions and other R&D institutions that would come up once the Parliament approves the `Protection and Utilization of Public Funded Intellectual Property Bill, 2008'. NRDC may even set up independent centers for IP facilitation in strategic locations. These centers should develop capacities to advice on IP identification, creating of IP value addition, identify the technological opportunities and generally act as a facilitator for IP protection and commercialization, on the lines of Taiwan's Industrial Technology Research Institute (ITRI)'s Technology Transfer Centre.

The committee feels that these initiatives complement the Accelerated Innovation Translation Fund and together will become excellent new core strength for NRDC.

6.2.3 Partnering Technology Business Incubators (TBI)

Technology business incubators (TBI) have served well in moving innovations to market place not only in developed countries but also in countries like China, Korea and Taiwan. The TBIs promoted new technopreneurs and sustained these scientific enterprises in the initial phase to translate the innovations into products / processes / high value services. The Chungnam Techno Park (CTP) in Korea is a high-tech industrial cluster focused on information technology, multimedia, advanced industrial design and auto ancillaries. The Korean government provides the seed money for the development of 'next level' emerging technologies within such parks. Recognizing the stellar role that the TBIs play in enhancing the National Competitiveness and application of innovations, the Government of India recently permitted universities, academic institutions and R&D institutions to set up incubation centers within their premises. This measure is expected to provide further fillip to innovation and its translation in the country. However these initiatives need appropriate and effective support in the form of seed money, business support services and managerial hand holding etc. Since NRDC is an advantageous position to offer such services, the committee recommends that setting up of Technology Incubation Centers or partnering with Universities, Academic institutions and R&D institutions. The committee feels that this should form a major initiative of NRDC to enhance commercialization of IP, new technologies and services. For this purpose NRDC should develop new business teams to expedite creation of such incubators and new businesses. Innovative ways should also be found to take an equity stake in start-ups that will be incubated in such TBIs.

6.2.4 Establishing Technology Mart by NRDC

The concept of Technology Mart is beginning to take shape in IP and technology markets in several countries like USA, China etc. The Shanghai Technology Transfer & Exchange (STTE) has established initiatives for international technology transfer wherein it co-ordinates with technology transfer organizations across the globe and markets the IP and technologies along with associated services. NRDC can also gain competitive advantage by establishing such technology mart that facilitates interactions among technology buyers and patent/technology holders along with technology seekers at one place. NRDC may take a lead in setting up such Technology Mart at the national level and hold technology related information and provide specific business support by creating an effective platform for interactions. This may include facilitating negotiations for the signing of contract. NRDC may in turn get a commission for an effective and smooth transaction.

6.2.5 Partnering Technology Transfer Centres (TTCs) in Universities and Academic Institutions

Generation and management of Intellectual Property is recognized as an effective policy instrument to safe guard the knowledge generated by R&D organizations both in public and private sectors. The Science and Technology Policy 2003 of the Government of India, has recognized the significance of incentives to innovators in order to undertake application of innovations towards commercialization and economic development. The `Protection and utilization of public funded intellectual property bill, 2008' is presently before the Parliament. Once approved, it is likely to enhance the commercialization of research from the universities and research institutions, receiving funds from government. For this purpose, the creation of Technology Transfer Centres (TTCs) in universities shall become necessary in providing guidance for effective IP management and transfer of technology. The committee recommends that NRDC with its vast experience in transfer of technology and IP management, may partner in setting up of Technology Transfer Centres in select universities and promote IP and technology commercialization.

6.2.6 Internal changes

The committee further recommends the following internal changes in the organization:

(i) The corporation may bring out a 'Tech-Opportunities' news letter at regular intervals highlighting the availability of new IP and technologies for exploitation. These news letters should widely be circulated among the industries including SMEs. The corporation should also maintain an extensive data base of industries and their performance, future growth prospects and intelligence insights.

(ii) the IT penetration in the organization is rather limited and the corporation should enhance the usage of IT and initiate the IT enabled services;

(iii) The Human Resource of organization is ageing and several senior staff is superannuated. Such a position could be viewed as an opportunity to give a directional change to the corporation. Efforts therefore should be made to recruit young and dynamic technical people to take up several of the new initiatives;

(iv) The present location of the NRDC is not industry friendly and suggests that the corporation may look for a better place by disposing of the existing facilities and investing the derived proceeds. In addition it may set up minimal staff offices at strategic locations or at industrial clusters to provide services.

The committee feels that NRDC is a unique organization that has served well the nation so far. It needs to be further strengthened and rejuvenated. Its performance can be enhanced by taking appropriate measures on the recommendations.

Appendix 1

Table 1.2 : Task Force Team Study Visits, China, Korea & Taiwan

Teams	Date	Places Visited
Team 1: South Korea Dr Rajeev Anantaram	9th Dec –12 Dec 2009	Science and Technology Policy Institute (STEPI), Seoul; Korea Institute for Industrial Economics and Trade, (KIET), Seoul and Chungnam Technopark (CTP), Chungnam
Team 2 to China Dr Rajeev Anantaram Shri Bijay Kumar Sahu	13th to 20th Dec 2010	China Science and Technology Exchange Center, Ministry of S&T, China, Chinese Academy of Science and Technology for Development, Beijing, Institute of Agro-food Science and Technology, Chinese Academy of Agricultural Sciences, Beijing, College of Food Science and Nutritional Engineering (CFSNE) China Agricultural University (CAU), Beijing, China Research Institute for Science Popularisation (CRISP), Beijing, Shanghai Technology Transfer and Exchange (STTE), Shanghai, Shandong S&T Bureau, Jinan, Jinan Productivity Centre, Jinan, Institute for Automation Shandong Academy of Science, Jinan
Team 3 to Taiwan Dr KV Raghavan Dr Rajeev Anantaram Shri Bijay Kumar Sahu	17th – 22nd January 2010	Small and Medium Enterprise Administration (SMEA), Ministry of Economic Affairs (MOEA), Taiwan, National Taiwan University of Science and Technology, Taipei, Hsinhu Science Park, Hsinchu, Material and Chemical Laboratories (MCL), Institute of Technology Research Institute (ITRI), Hsinhu, Technology Transfer Center & Intellectual Property Management Division, Institute of Technology Research Institute (ITRI), Hsinhu, Taiwan Intellectual Property Office (TIPO), Ministry of Economic Affairs (MOEA), Da-an, Biotechnology & Pharmaceuticals Industries Programme Office (BPIPO), Ministry of Economic Affairs, Nangang, Medical & Pharmaceutical Industry Technology and Development Centre (PITDC), Wuhu Shiang, Wugu Industry Park, Department of Industrial Technology, Ministry of Economic Affairs, Taipei

ANNEXURE 5.2.2 (a)

Top 10 Indian Institutions in Organic Chemistry Research Papers

Institute	Rank	1995 No. of Pub / Avg IF	Rank	2000 No. of Papers / Avg IF	Rank	2005 No. of Papers / Avg IF	Rank	2009 No. of Papers / Avg IF
IITs	1	53 / 2.3	2	80 / 2.9	2	144 / 3.0	2	152 / 3.08
NCL	2	37 / 2.06	3	48 / 2.52	4	78 / 2.83	4	60 / 2.69
IICT	3	31 / 2.3	1	101 / 2.2	1	172 / 2.35	1	197 / 2.72
CDRI	4	28 / 1.25	7	23 / 2.22	3	85 / 2.61	3	73 / 2.46
IISc	5	28 / 2.7	4	43 / 2.84	5	51 / 2.68	5	45 / 2.94
IACS	6	22 / 2.1	9	18 / 2.97	7	30 / 2.87		
Uni.Hyd	7	20 / 2.5	5	24 / 1.61				
Uni Delhi	8	22 / 0.77	10	16 / 1.36	8	28 / 2.05	8	37 / 2.21
Uni Mad	9	11 / 1.7			6	31 / 2.58	7	38 / 2.08
BARC	10	10 / 2.28						
CSIR			6	23 / 2.58	9	27 / 3.04	10	27 / 3.7
RRL			8	21 / 2.28				
Uni Rajas					10	10 / 0.68		
Uni Kalyani							6	38 / 2.5
CLRI							9	10 / 2.39
		262 / 2.04		**397 / 2.44**		**656 / 2.63**		**677 / 2.75**

Avg. IF: Average Impact Factor

Annexure 5.2.2(b)

Top 10 Indian Institutions in Pharmaceutical Science* Research Papers

Institute	Rank	1995 No. of Pub / Avg IF	Rank	2000 No. of Papers / Avg IF	Rank	2005 No. of Papers / Avg IF	Rank	2009 No. of Papers / Avg IF
BHU	1	12 / 1.6	3	18 / 1.33	-		6	28 / 1.88
CDRI	2	10 / 1.48	2	21 / 2.69	5	23 / 3.2	8	25 / 1.85
Jadav Uni	3	8 / 1.45	1	24 / 2.04	3	24 / 1.7	4	37 / 1.0
Uni Punjab	4	7 / 2.04	10	8 / 1.37	2	25 / 2.22	1	57 / 1.8
Dr HBG V	5	5 / 2.1			-		-	
PGIME	6	5 / 1.43			-		-	
ITRC	7	4 / 1.65			-		-	
KU	8	4 / 0.88	9	8 / 1.5	-		-	
KMC, Manipal	9	4 / 1.51	-		-		-	
NIMH	10	4 / 4.0	-		-		-	
Uni Madras			¤	14 / 2.8	1	42 / 1.8	5	35 / 1.96
AIIMS			5	13 / 1.78	8	19 / 2.57	-	
Uni Calcutta			6	11 / 2.16	-		-	
IICB			7	9 / 2.75	-		-	
A ndhra Univ			8	8 / 1.84	-		-	
Annamala i Uni					¤	23 / 1.63	3	37 / 1.84
Mh Siaji Rao Uni					6	20 / 1.77	-	
NIPER					7	20 / 2.43	-	
H Univ					9	19 / 1.78	7	26 / 1.36
Bharathi Vidyalaya					10	15 / 2.23	-	
Uni Delhi							10	25 / 2.27
IIT							9	25 / 2.05
Jamia Hamdard							2	39 / 1.67
		63 / 1.74		**134 / 2.07**		**230 / 2.10**		**334 / 1.75**

Avg. IF: Average Impact Factor * including pharmacy and pharmacology

Annexure 5.2.2 (c)

Top 10 Indian Institutions in Biotechnology Research Papers

Institute	Rank	1995 No. of Pub / Avg IF	Rank	2000 No. of Pub / Avg IF	Rank	2005 No. of Pub / Avg IF	Rank	2009 No. of Pub / Avg IF
IIT	1	32 / 0.84	1	53 / 1.1	1	66 / 2.8	1	82 / 2.54
NCL	2	14 / 1.53	8	8 / 2.06			6	18 / 1.9
Uni Bom	3	4 / 2.2						
CFTRI	4	12 / 1.7	2	24 / 2.23	4	17 / 2.7	5	22 / 1.9
IMTECH	5	9 / 1.74	3	22 / 2.66				
BARC	6	7 / 2.0					9	16 / 2.8
CSIR	7	7 / 1.98			3	21 / 2.8	2	42 / 2.51
BHU	8	6 / 1.3	5	11 / 1.15			3	28 / 2.75
Anna Uni	9	5 / 1.5	7	8 / 0.13	10	8 / 1.8		
Madhurai Kam Uni	10	5 / 3.1						
OU			4	12 / 1.82				
Uni Delhi			6	10 / 2.28	2	23 / 2.44	4	23 / 2.9
TERI			9	8 / 2.1				
Punjab Uni			10	8 / 3.14	9	9 / 1.43		
IARI					5	16 / 1.5		
IISc					6	12 / 2.99	8	17 / 3.0
IICT					8	11 / 2.13		
A Muslim Uni							7	17 / 1.91
Annamalai Uni							10	15 / 1.15
		111 / 1.56		**164 / 1.75**		**183 / 2.5**		**280 / 2.42**

No.of Pub: Number of Publications

Avg. IF: Average Impact Factor

Annexure – 5.2.2(d)

Top 10 Indian Institutions in Chemical Engineering Research Papers

Institute	Rank	1995	Rank	2000	Rank	2005	Rank	2009
		No. of Pub / Avg IF		No. of Pub / Avg IF		No. of Pub / Avg IF		No. of Pub / Avg IF
IITs	1	81 / 1.53	1	90 / 1.2	1	167 / 1.93	1	230 / 1.8
Univ Bombay	2	24 / 1.28	3	18 / 1.65	4	32 / 1.68		
NCL	3	19 / 2.19	2	21 / 2.26	3	32 / 3.23	6	31 / 2.03
IICT	4	12 / 1.73	10	9 / 1.60	2	32 / 2.03	9	19 / 1.87
RRL	5	11 / 1.44	6	13 / 1.5				
SVU, TPTY	6	10 / 1.96	8	10 / 0.96				
BHU	7	9 / 1.54						
BHU	8	8 / 0.97						
IISc	9	8 / 1.11			7	14 / 1.57	7	25 / 1.4
Anna Uni	**10**	6 / **0.75**	4	17 / 0.67	5	29 / 1.7	3	39 / 1.63
CSIR			5	13 / 1.26			4	32 / 1.9
Univ Mumbai			7	12 / 1.67				
CFTRI			**9**	9 / **1.60**	6	14 / 2.18		
Aligarh M Univ					8	13 / 1.3		
BARC					9	13 / 1.4	5	31 / 1.94
CSMCRI					**10**	11 / **2.7**		
NIT							2	43 / 1.2
Inst Chem Tech							8	21 / 1.78
Univ Calcutta							**10**	19 / **1.23**

No.of Pub: Number of Publications

Avg. IF: Average Impact Factor

Annexure 5.2.5(e)

Top 10 Indian Institutions in Nanoscience & Nanotechnology Research Papers

Institute	Rank	1995 No. of Pub / Avg IF	Rank	2000 No. of Pub / Avg IF	Rank	2005 No. of Pub / Avg IF	Rank	2009 No. of Pub / Avg IF
Meerut Uni	1	6 / 1.12						
IISc	2	5 / 1.9	2	8 / 4.5	3	13 / 2.63	2	65 / 2.97
IIT	3	5 / 1.2	1	19 / 2.0	1	54 / 1.87	1	120 / 2.5
PTRS Uni	4	4 / 1.12						
BHU	5	3 / 1.12	7	3 / 1.53	6	10 / 1.73	6	20 / 3.12
CEERI	6	1 / 1.12	8	2 / 1.12				
DMRL	7	1 / 1.9	3	6 / 2.08	5	11 / 2.09		
ISI	8	1 / 1.12						
IBS, UP	9	1 / 1.12						
JNTU	10	1 / 1.12						
BARC			4	5 / 1.9	2	17 / 2.95	4	33 / 2.84
IGCAR			5	5 / 2.11				
NCL			6	5 / 2.65	4	12 / 4.55	5	25 / 3.08
IICT			9	2 / 2.65				
Inst. Phy			10	2 / 1.46				
CSIR					7	9 / 2.79	7	19 / 3.54
JNCAR					8	8 / 3.42	10	15 / 3.63
Jadavpur Uni					9	7 / 2.0	9	17 / 1.64
NPL					10	7 / 2.23	8	18 / 2.4
IACS							3	34 / 3.54
		28 / 36.44		**57 / 124.83**		**148 / 368.98**		**366 / 962.39**

No.of Pub: Number of Publications

Avg. IF: Average Impact Factor

NATIONAL SURVEY REPORT

Impact of R&D on the Indian Chemical Industry

Dr. Nirmalya Bagchi & Dr. M Chandrasekhar

2011

National Survey Report

Impact of R&D on the Indian Chemical Industry

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Introduction

This report is based on the survey conducted to understand the impact of research and development on Indian chemical industry. In order to perform this study the team has conducted both primary and secondary research. Apart from literature survey, the team collected relevant data from the Prowess database to understand the effect of Research and Development Intensity (RDI) in Indian Chemical Industry. Data was collected for different categories of chemical companies for the last 20 years. An analysis was performed on the data to find out the research and development intensity of chemical companies in different categories. From this analysis the top 20% of companies in each category was identified for primary survey. A questionnaire was developed based on the research objectives and a pilot survey was done in Hyderabad. Based on the feedback received on the pilot questionnaire the instrument was modified and the final instrument was sent to 310 companies in India. Later 300 more companies were identified and the same questionnaire was sent to them. Lastly, 200 companies more companies were identified and the questionnaire was sent to them.

The response however, of the companies has not been very encouraging. This report presents the findings of the primary survey. The findings of the secondary research has already been submitted which dealt with RDI at length. Hence the findings from secondary research are not part of this report. The data has also been analyzed after grouping the respondent companies.

42 companies responded to the questionnaire that was sent by the team. Table 1, gives the name, year of incorporation of the responding companies.

Table 1: Details of Respondents (Companies)

S.No.	Name of the Company	Year of incorporation
1	Elder Pharmaceuticals Ltd.	1989
2	Madras Fertilisers	
3	Premiere Explosives Ltd.	1980
4	Indofil Chemicals Company	1962
5	Jupiter Bioscience Ltd	1985
6	USV Limited	1962
7	Daichi Karkaria Ltd	1960
8	Nocil Limited	1975
9	Jubilant Organosys Ltd	1978
10	Crystal Phosphates Ltd.	1997
11	Asian PPG Industries Ltd.	1997
12	Excel Industries Limited	1960
13	Godrej Industries Limited	1988
14	India Glycols Limited	1986
15	The Fertilisers and Chemicals Travancore Limited	1944
16	Rashtriya Chemicals & Fertilizers Ltd	1965
17	Solaris Chemtech Industries Ltd.	2001
18	Krishak Bharati Cooperative Ltd	1980
19	Wanbury Limited	1988
20	Brahmaputra Valley Fertilizer Corporation Limited	
21	Eskay Dyestuffs & Organic Chemicals Pvt. Ltd.	1982
22	Shodhana Laboratories	2000
23	Vayajayanthi Drugs	1995
24	Cromo Labs	2006

25	Nandan Biomatrix	1999
26	Synpure	2008
27	Sainor Lab	2004
28	Swen Pharma	2004
29	Sparsha	2008
30	Unique Biotech	2001
31	AMINES & PLASTICIZERS LTD.	1973
32	Deepak Nitrite Limited	1970
33	Galaxy Surfactants Limited	1986
34	GHARDA CHEMICALS LIMITED	1971
35	Godavari Biorefineries Limited.	1939
36	GODREJ INDUSTRIES LIMITED	1988
37	Haldia Petrochemicals Ltd.	1985
38	Hindustan Polyamides & Fibres Ltd.	1965
39	National Peroxide Limited.	1976
40	M/S SOUTH ASIAN PETROCHEM LIMITED	1996
41	Sudarshan Chemical Industries Ltd.	1951
42	Thirumalai Chemicals Limited	1972

The 42 companies fall into different sales turnover brackets. 13 fall in the over – Rs. 500 crores category, 9 companies fall in the category of Rs. 250 – 500 crores, 7 companies are in the Rs. 100-250 crores bracket, 5 are in the Rs. 50-100 crores category and 7 companies fall in the Rs. 10-50 crores category.

Table 2: Respondents segmented on the basis of sales turnover

Above Rs. 500 Crore turnover	
S.No.	**Name of the Company**
1	Elder Pharmaceuticals Ltd.
2	Madras Fertilisers
3	USV Limited
4	Jubilant Organosys Ltd
5	Godrej Industries Limited
6	India Glycols Limited
7	The Fertilisers and Chemicals Travancore Limited
8	Krishak Bharati Cooperative Ltd
9	GHARDA CHEMICALS LIMITED
10	Godavari Biorefineries Limited.
11	GODREJ INDUSTRIES LIMITED
12	Haldia Petrochemicals Ltd.
13	M/S SOUTH ASIAN PETROCHEM LIMITED
Between Rs 250 and Rs.500 crore turnover	
S.No.	**Name of the Company**
1	Indofil Chemicals Company
2	Nocil Limited
3	Crystal Phosphates Ltd.

4	Asian PPG Industries Ltd.
5	Wanbury Limited
6	Deepak Nitrite Limited
7	Galaxy Surfactants Limited
8	Sudarshan Chemical Industries Ltd.
9	Thirumalai Chemicals Limited
Between Rs. 100 and Rs. 250 Crores turnover	
S.No.	**Name of the Company**
1	Jupiter Bioscience Ltd
2	Excel Industries Limited
3	Rashtriya Chemicals & Fertilizers Ltd
4	Solaris Chemtech Industries Ltd.
5	Nandan Biomatrix
6	AMINES & PLASTICIZERS LTD.
7	Hindustan Polyamides & Fibres Ltd.
Between Rs. 50 and Rs. 100 crore turnover	
S.No.	**Name of the Company**
1	Premiere Explosives Ltd.
2	Daichi Karkaria Ltd
3	Eskay Dyestuffs & Organic Chemicals Pvt. Ltd.
4	Shodhana Laboratories
5	Sainor Lab
Between Rs. 10 and Rs. 50 Crore turnover	
S.No.	**Name of the Company**
1	Unique Biotech
2	National Peroxide Limited.
3	Swen Pharma
4	Vayajayanthi Drugs
5	Cromo Labs
6	Synpure
7	Sparsha

When the companies are segmented according to their type of output, the companies can also be categorized into

- Organics
- Knowledge intensive
- Specialty chemicals
- Fertilizer
- Petrochemicals

The table 3 given below gives a segmentation of the different companies into their types.

Table 3 : Respondent companies by type

Basic Chemicals: **a) Organics**	
Sl.No.	Name of the Company
1. (3)	Premier Explosives Ltd
2. (4)	Indofil Chemical Ltd
3. (7)	Daichi Karkaria Ltd
4. (8)	Nocil Ltd
5. (9)	Jubilant Organosys Ltd
6. (14)	India Glycols Ltd
7. (17)	Solaris Chemtech Industries Ltd
8. (27)	Sainor Lab
9. (31)	Amines & Plasticizers Ltd
10.(32)	Deepak Nitrite Ltd
11.(34)	Gharda Chemicals Ltd
12.(35)	Godavari Biorefineries Ltd
13.(36)	Godrej Industries Ltd
14.(39)	Natinal Peroxide Ltd
15.(42)	Thirumalai Cemicals Ltd
b) Fertilizers	
16. (2)	Madras Fertilizers
17. (10)	Crystal Phosphates Ltd.
18. (15)	The Fertilizers and Chemicals Travancore Limited
19. (16)	Rashtriya Chemicals & Fertilizers Ltd
20. (18)	Krishak Bharati Cooperative Ltd
21. (20)	Brahmaputra Valley Fertilizer Corporation Limited
c) Petrochemicals	
22. (37)	Haldia Petrochemicals Ltd
23. (38)	Hindustan Polyamides & Fibres Ltd
24. (40)	M/s South Asian Petrochem Ltd
2. Speciality Chemicals	
25. (11)	Asian PPG Industries Ltd
26. (12)	Excel Industries Ltd
27. (13)	Godrej industries Ltd
28. (21)	Eskay Dyestuffs & Organic Chemicals Pvt Ltd.
29. (22)	Shodhana Laboratories
30. (33)	Galaxy Surafactants Ltd
31. (41)	Sudharshan Chemical Industries Ltd
3. Knowledge Intensive	
32. (1)	Elder Pharmaceuticals Ltd
33. (5)	Jupiter Bioscience Ltd
34. (6)	USV Ltd
35. (19)	Wanbury Ltd
36. (23)	Vayajayanthi Drugs
37. (24)	Cromo Labs
38. (25)	Nandan Biomatrix
39. (26)	Synpure
40. (28)	Suven Pharma
41. (29)	Sparsha
42. (30)	Unique Biotech

Research Methodology

The research methodology involved secondary research and primary research techniques. The methodology followed was as given below

Step 1: Collection of data of Indian chemical companies from Prowess database

Step 2: Analysis of the data to find out the R&D Intensity of chemical companies in India

Step 3: Give recommendations to INAE project team under supervision of Dr. Raghavan on RDI in chemical industry in India and also in different sub groups and categories of the chemical industry.

Step 4: Select the top 20% of chemical companies in each category based on their RDI. Prepare questionnaire and make a pilot run of the questionnaire in Hyderabad. Factor in the changes suggested in the questionnaire to prepare a final questionnaire.

Step 5: Send questionnaire to a select group of such 20% companies. Total 312 such companies were short listed and questionnaire was sent to their registered offices.

Step 6: After poor initial response, another set of reminders were sent to about 280 companies

Step 7: After poor response another set of 200 questionnaires were sent to the nest 10 % of the companies ie. The next decile of the initially selected companies based on RDI ranking

Step 8: After poor response, selected known companies were approached for data and questionnaire was circulated to 30 companies with known track record of R&D. Only few responses were received.

Step 9: Based on suggestion of INAE project team another set of 100 questionnaire were sent but none responded. One company expressed interest in the questionnaire but after it was sent, the company did not respond with the data.

Step 10: Analysis of data of a parallel survey effort showed that some common responses were present. Those responses were factored into the survey.

Step 11: Data analysis of the responses was carried out

Step 12: Draft report was prepared from the analysis.

Survey Results

The survey covers 42 companies in different categories of sales turnover and from different types of the chemical industry in India. It also shows that the median number of in house technologies is 20 and products/outputs from such technology is 9. The median value of in house R&D was reported as Rs. 58 crores. The response to questions on collaboration with government labs is very poor. Indeed in most of such questions, the respondents did not give any response. In some questions the response is so limited that it may not be statistically correct to take such responses into consideration for a national level study as this one. Most have indicated that they have utilized the benefits of income tax deductions on R&D. With regard questions on other collaborations also, most respondent companies did not provide any responses. In most such questions all have left the responses as blank. On transfer of technology the survey yielded that the median number of technologies sourced from outside was 1.5 (even though 30 respondents did not respond to this) and most respondents replied in the affirmative when asked whether the technology package included comprehensive transfer. Responses for detailed questions on lab scale or bench scales demonstration of the technology sourced from outside were few but most agreed that transfer of technology from R&D to production stage has been smooth. Most respondents also pointed out that some improvements were brought about at the time of actual productions but their response on process reengineering was not conclusive.

Further analysis of the data is given below in separate sub heads.

RDI

The analysis of the data of sales turnover and R&D expenditure of all the 42 responding companies reveal that overall the RDI for this set of companies shows an increasing trend. Now since this set of 42 companies is a representative sample of the industry, it may be fair to assume that the RDI for the overall industry is also showing increasing trend. The Figure 1 given below gives a graphical representation of the analyzed data on RDI.

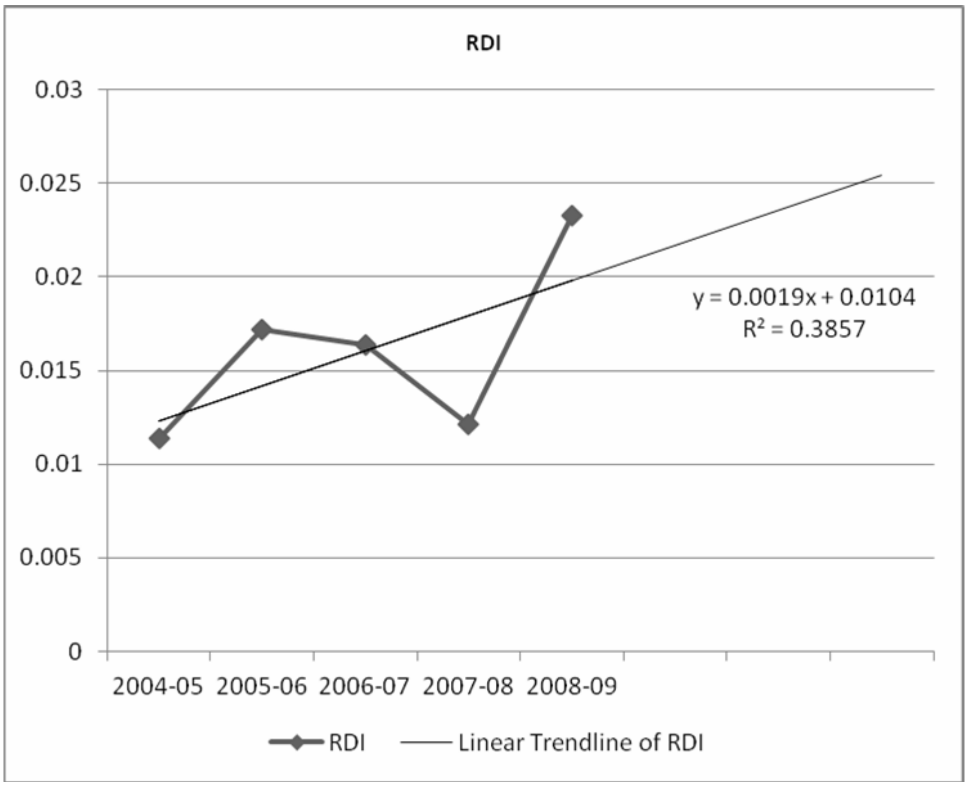
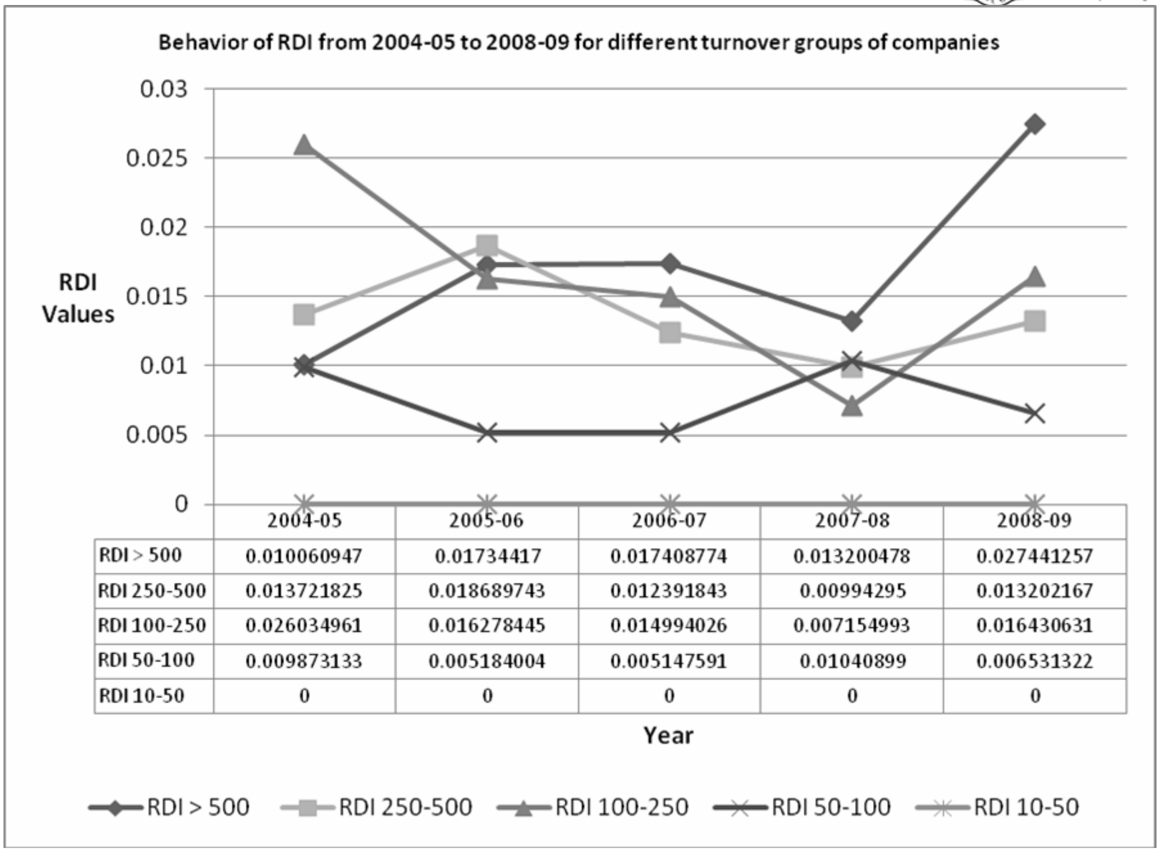


Figure 1 : Overall RDI of all respondents

A further analysis of the data after segmenting the companies according to their sales turnover groups show (as given in Figure 2) that the RDI is not showing an increasing trend in all segments but in only companies that have sales turnover above Rs. 500 crores. In the segment of companies with turnover between Rs. 50-100 crores, the trend is neither increasing nor decreasing but flat and parallel to the axis. In all other segments the RDI shows a decreasing trend. Of course in the Rs. 10-50 crore, segment no trend is detected as the RDI values in this segment is zero



	2004-05	2005-06	2006-07	2007-08	2008-09
RDI > 500	0.010060947	0.01734417	0.017408774	0.013200478	0.027441257
RDI 250-500	0.013721825	0.018689743	0.012391843	0.00994295	0.013202167
RDI 100-250	0.026034961	0.016278445	0.014994026	0.007154993	0.016430631
RDI 50-100	0.009873133	0.005184004	0.005147591	0.01040899	0.006531322
RDI 10-50	0	0	0	0	0

Figure 2 : Behavior of RDI from 2004-05 to 2008-09 for different turnover groups of companies

A further analysis of the data after disaggregating the data into different industry types, we find that the RDI in the organic chemicals category shows an increasing trend along with a slightly increasing trend in the specialty chemicals category. In the knowledge intensive chemicals category, RDI shows decreasing trend. In both petrochemicals and fertilizers category, the trend is flat. Figure 3, shows the behavior of RDI from 2004-05 to 2008-09 for different categories of companies.

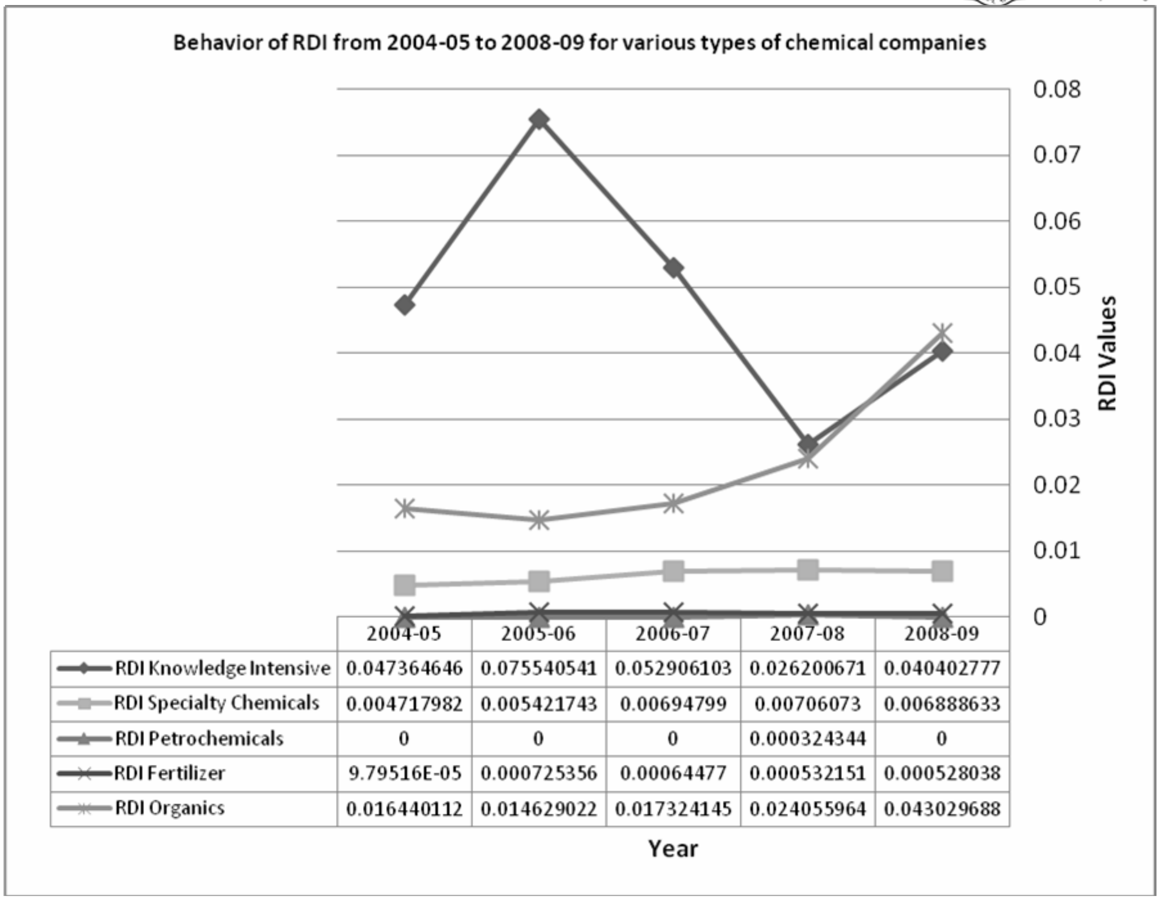


Figure 3 : Behavior of RDI from 2004-05 to 2008-09 for different categories of companies

R&D Expenditure and Facility

Overall, the responding companies have reported that they not spend much on R&D. The R&D expenditure of these 42 companies when taken together is as given in Table 4. An analysis of the R&D spending of responding companies show that the median R&D expenditure as a percentage of their median sales turnover is less than even 2%. However, even though the responding companies do not spend much on R&D, they have adequate R&D facilities.

Table 4: R&D Expenditure in last 5 years

	R&D Expenditure (2008-09) (Rs. In lakhs)	R&D Expenditure (2007-08) (Rs. In lakhs)	R&D Expenditure (2006-07) (Rs. In lakhs)	R&D Expenditure (2005-06) (Rs. In lakhs)	R&D Expenditure (2004-05) (Rs. In lakhs)
Respondent Companies	16	27	17	15	15
Median	208.455	248	264.45	201.14	175.11

The current value of R&D assets as reported (by the 15 respondents out of 42) was Rs. 3.197 crores and around 74% of responding companies (14 of the 19 responding companies out of a total of 42 companies) stated that they did utilize the income tax benefit given to R&D by the government. Most of the companies also report a satisfactory state of affairs with respect to the availability of research facility. The Table 5 gives a snapshot of the R&D facility as reported by the companies.

Table 5: Availability Research Facility

	Availability of well-equipped analytical lab	Are lab/bench-scale reaction equipment and downstream facilities available?	Is there a pilot-plant with adequate scale-up facilities?	Library Facility Available
Respondents	27	21	22	27
Yes	26	21	18	15
No	1	0	4	12
No Response (Blank)	15	21	20	15

Figure 4, gives a diagrammatic representation of the ratio of respondents having access to analytical facility, bench scale facility and pilot plant facility. Clearly, the Specialty Chemicals category is most favorably endowed with such facilities and the Fertilizer category the worst. None of the companies in the Petrochemical category responded to these questions. Overall, around 50% of the responding companies reported to having such facilities.

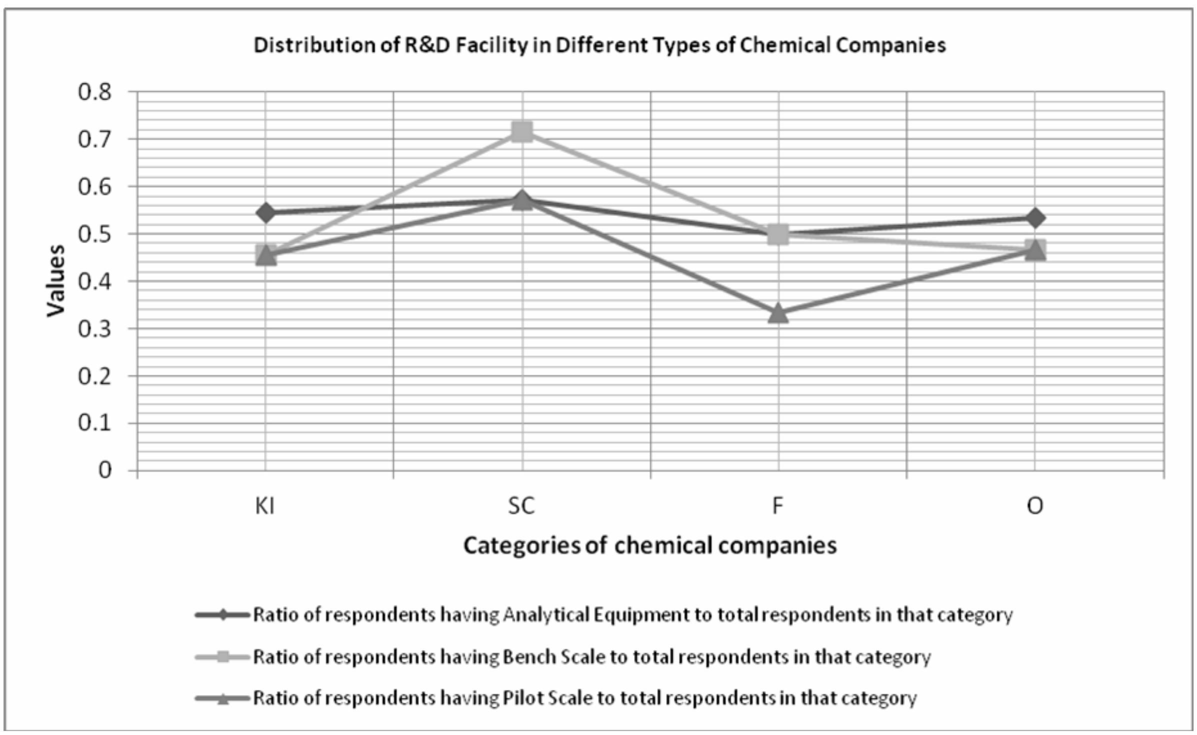


Figure 4 : R&D Facility across different categories of chemical companies

Also, 75% of the respondents reported availability of centralized effluent treatment facility as the Figure 5 shows

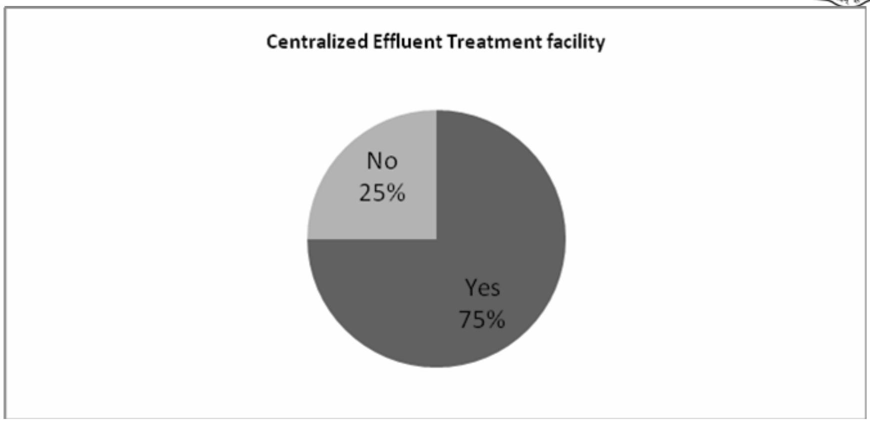


Figure 5: CET

The Figure 6 gives a diagrammatic representation of the value of R&D assets in different category of chemical industry. Even though the Petrochemical and Knowledge Intensive industry category companies did not report any data on this indicator but the figure clearly shows that the Organic chemical sector is most favorably endowed with R&D assets and the Fertilizer companies are least endowed.

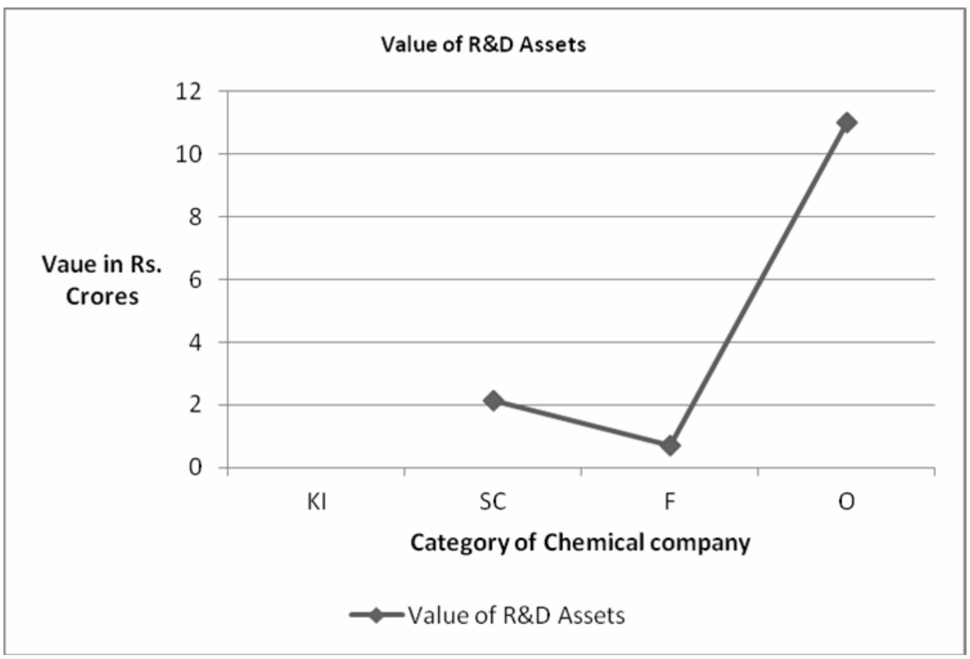


Figure 6: Value of R&D assets across different category of chemical companies

Performance of In-house R&D

The response of the companies surveyed with regard to performance of in-house R&D is given in Table 6 below. The median number of in-house technologies developed by the responding companies is 20 and their value in Rupee terms in Rs. 58 crores. A median of 9 products are developed in-house by the responding companies.

Table 6: Performance of In-house R&D

	In-house R&D (No. of technologies)	In-house R&D (No. of Products / Outputs using the said technologies)	In-house R&D (Annual Aggregate Volume of the Outputs (approx.) MT	In-house R&D (Value of the Outputs (approx. in Rs. Lakh))
Responses	**13**	**17**	**12**	**10**
Median	**20**	**9**	**2250**	**5862**
No Response (Blank)	**29**	**25**	**30**	**32**

The respondent companies also stated that the average number of months required to reach full production scale when conducting improvement in the process took on an average 8 months (13 responses out of 42) and the average benefit to them for each such improvements were around Rs. 2 crores (based on 7 responses out of 42). However, they have not suffered any significant loss during such improvement procedures (15 responses out of 42 and 14 said they did not incur significant loss).

To implement the improvements, 15 companies responded to the need for any additional equipment, machinery, instrumentation etc. required as given in the pie chart below.

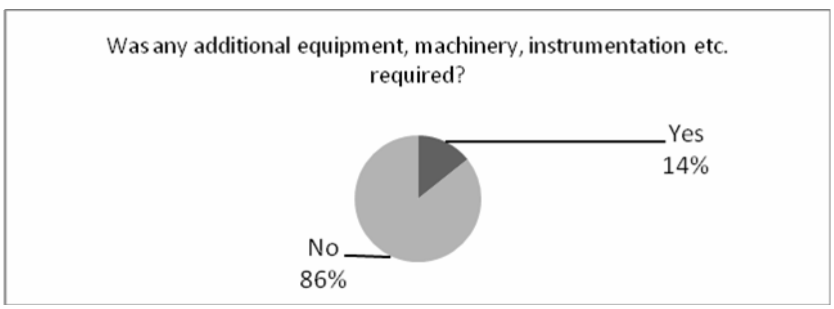


Figure 7: Need for additional equipment for effecting improvements

14 companies responded to the question on the need for any extra R&D for implementing improvement and 54% said yes to the question. The figure 7 given below gives a graphical representation of the analysis

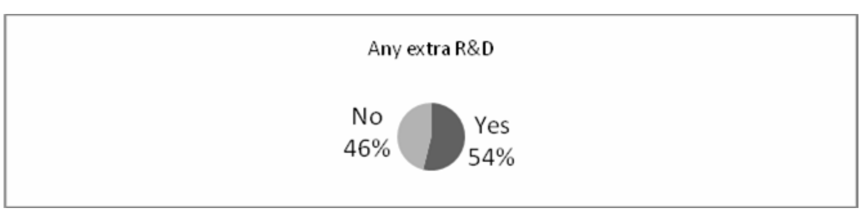


Figure 8: Need for any extra R&D for implementing the improvements

Also, none of the companies reported any major accident in their companies. 17 companies responded to whether FDI was augmenting the R&D base and all 17 have responded that FDI did not augment R&D base of their companies

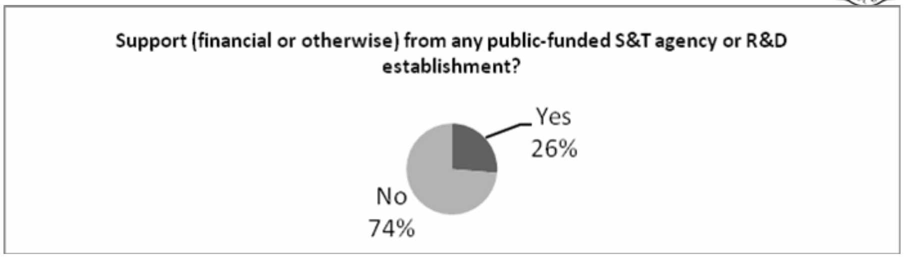


Figure 9 : Support (financial or otherwise) from any public-funded S&T agency or R&D establishment?

The figure 10 given below represents the performance of in house technologies in different categories of companies. It shows that knowledge intensive companies have the highest number of both in house technologies and products from such technologies. The worst performers are fertilizer and specialty chemical companies. The situation of organic chemical companies in somewhere in between these two performance levels.

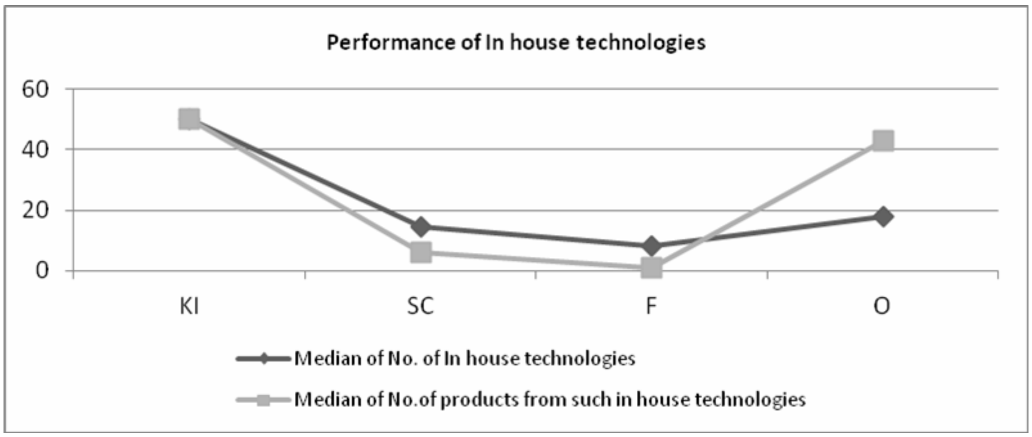


Figure 10: Performance of In house technologies

The median values of the different categories of companies show that knowledge intensive companies produce the highest value of in house R&D, followed by specialty chemicals and organic chemicals.

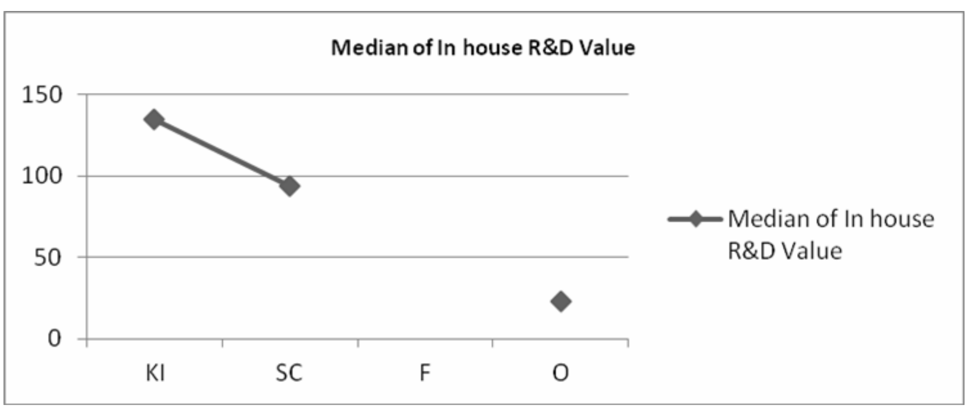


Figure 11: Behavior of Median of In house R&D Value

The different categories of companies also report different average times to reach commercial scale of production. Figure 12 gives a clear picture of the average time taken by each category to reach commercial scale of production. The overall average time to reach commercial scale of production as reported by all companies put together is 8 months.

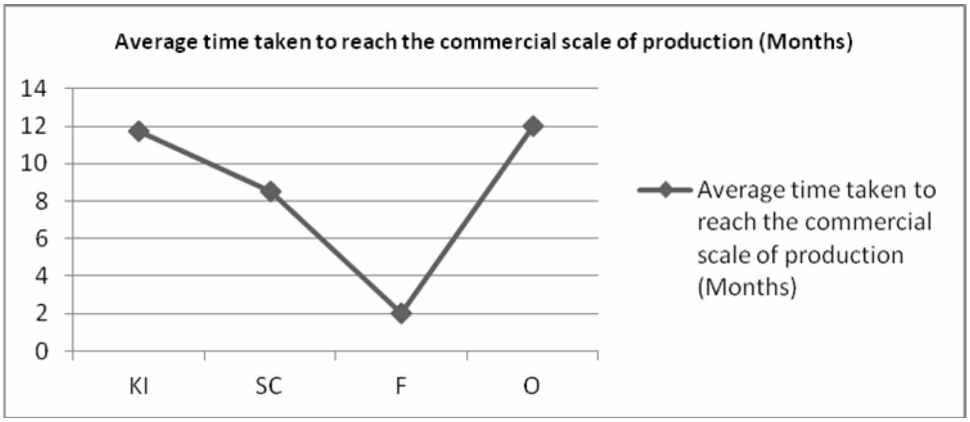


Figure 12: Median of average time taken to reach commercial scale of production

Key determinants for sourcing external technology acquisition?

- The technology was proven (6)
- The technology package was comprehensive/attractive (3)
- The technology provider has successful track record of transferring several technologies to the industry (5)
- There is a buy-back arrangement with the collaborator (2)
- The technology tie-up is exclusive to the Company (5)
- The pricing of the technology is competitive (3)
- The technology is new and of pioneering nature (It offered early mover / first-to-market advantages) (2)
- There was exclusivity and intellectual property (IP) protection against imitation (2)
- There were tax/duty exemptions and holidays, rebates and subsidies available for using the technology (0)
- Other reasons (such as novelty, uniqueness, higher functionality, greater ease of use, lesser maintenance, better serviceability, better compatibility, better trial ability, better observability, safer, simpler, more efficient, etc. in comparison with competing technologies) (3)

primary reasons for gaps/glitches in transfer of any technology or its scale up

- The technology transfer agreement(s) did not have provision for hand-holding during trials
- The services of the key technology-resource personnel were no longer available
- The quality parameters and characterization that came out in actual production were vastly different from those originally projected/demonstrated at the time of technology-transfer (1)
- There were serious design and process problems related to technology (1)
- The were issues with the technical feasibility and/or the commercial viability of the technology
- Other reasons (3)
- Request for no reply – (7)

(The figures in parenthesis represents the number of times respondents have cited this reason)

Most of respondents also stated that the Commercial Terms for Technology Acquisition was mostly by lump sum upfront payment or by lump sum payments linked to milestones or Royalty on sales. Only one respondent stated Time-based lump sum payments and other types of commercial terms.

Patent Generation, Acquisition and Utilization

The survey also throws some light on the manner in which companies are patenting. Table 7 gives an account of the patents of the total respondents and their value. As can be seen clearly, less than half of the patents that have been granted to a company are being used commercially. Also, the median of total estimate of income from such patents till date stands at a meager Rs. 1.3 crores. Hence it is clear that the companies are filing for patents not just for its financial value but for other reasons as well.

Table7: Patents and their Value

	No. of patents granted to the Company till date	Number of patents granted to the Company that are still in force	Number of patents granted to the Company, which are assigned	Number of patients granted to the Company that were or are being used commercially	Number of pending patent applications	What in your estimate is the total income (in Rs. Lakh) from patents (till date)?	The top 20% of the Company's patents account for how much percentage of the net income from all such patents till date? (in lakhs)
Responses	18	17	4	9	13	6	3
Median	7.5	8	5.5	3	4	130	1
No Responses (Blank)	24	25	38	33	29	36	39

Some of the other critical information about patents that throw some light on the cost of patenting, the total time required to patent from the conception of an idea, efforts towards the perfection of "know how" from the patented technology are presented in the figure 13 as given below.

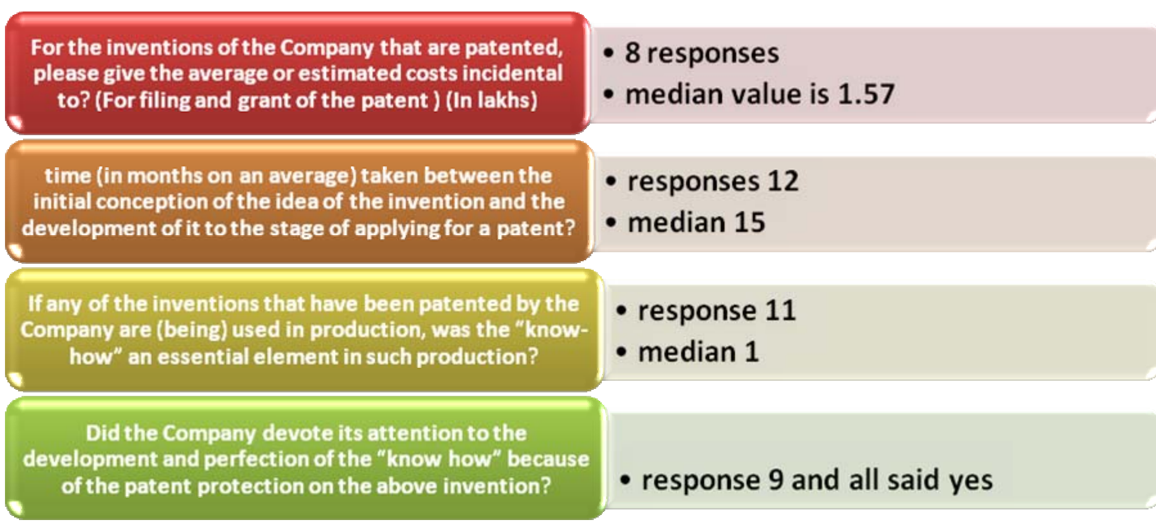
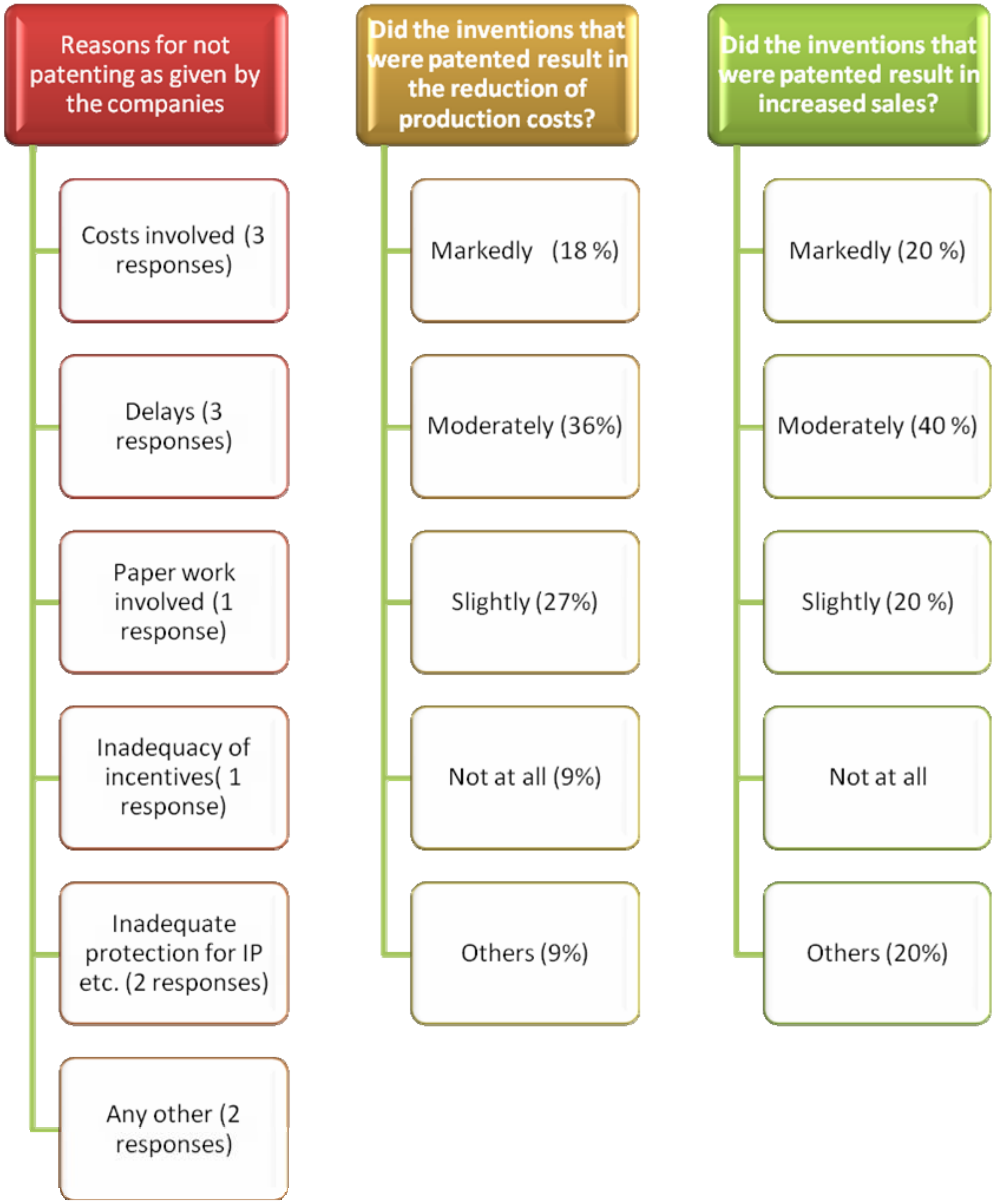
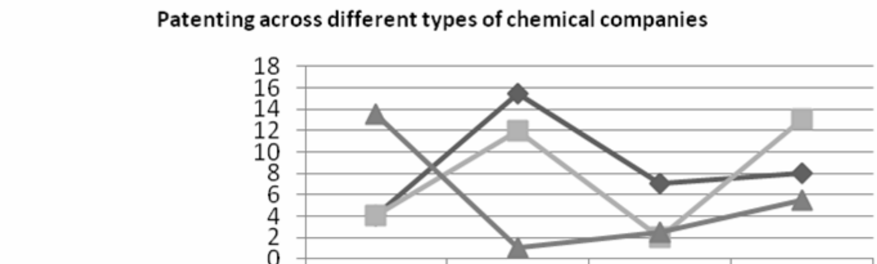


Figure 13: Additional information about patents

Also, some other additional information is presented in the figure 14 that give us a clearer picture of the reasons for not patenting, performance of patented technologies in terms of reducing production costs and increasing sales.



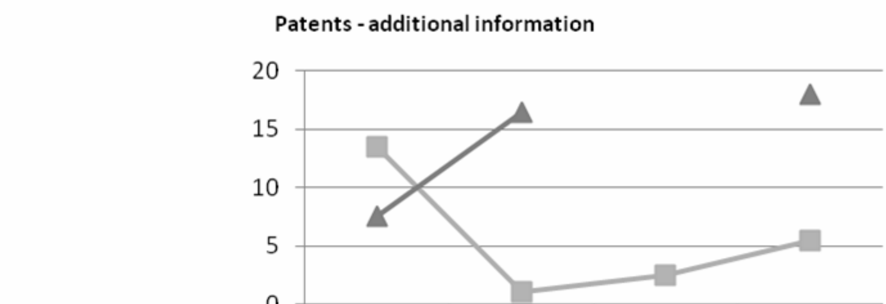
When we analyze the patent data by dividing the data into groups of categories of companies that have similar type of outputs, we find that the median number of patents granted is highest for specialty chemicals category, while the highest median number of patent applications in knowledge intensive category.



	KI	SC	F	O
No. of Patents Granted	4	15.5	7	8
Median of No. of Patents still in force	4	12	2	13
Median of No. of pending patent applications	13.5	1	2.5	5.5

Figure 15: Patenting across different categories

We also see that the organic chemicals companies take highest time from conception to patenting and the highest median number of pending patent applications in with the knowledge intensive category.



	KI	SC	F	O
Median of No. of pending patent applications	13.5	1	2.5	5.5
Median of Time elapsed from ideation to patenting	7.5	16.5		18

Figure 16: Patents in different categories - some additional information

Figure 17 shows the distribution of Median Estimated Income from Patents till date for each category of company. Clearly, the organic chemicals category earns most from its patents. No data was available for with knowledge intensive or petrochemical companies.

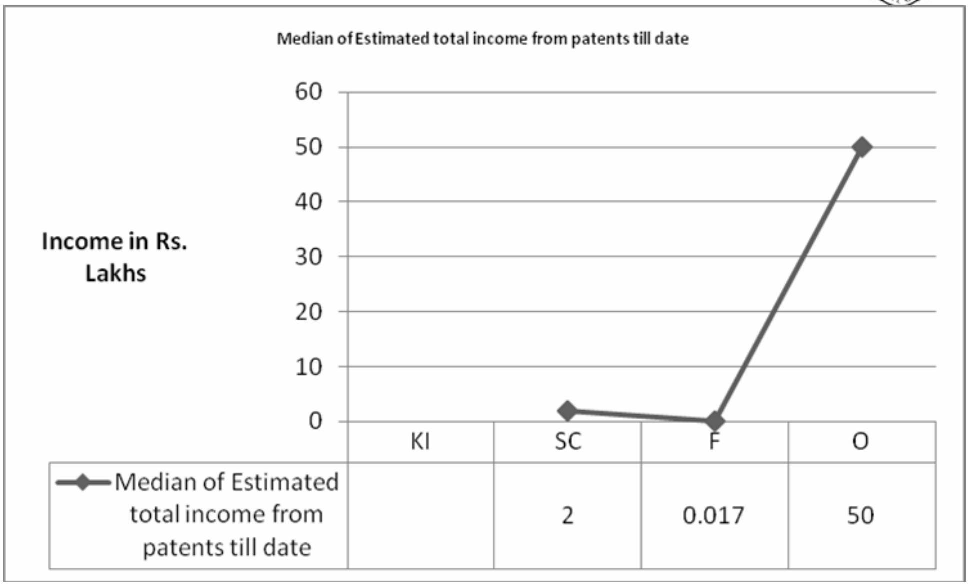


Figure 17: Income from patents

R&D Manpower

R&D manpower has also been captured and analyzed in this survey. Table 8 shows some critical information about R&D manpower. The median number of graduates and post graduates in the responding companies is 52 (17 responses) and 68 (15 responses) respectively. Also out of the scientific manpower a median of 3 persons (responses 18) is involved in publications and patents. Also, the 11 companies reported in affirmative (and 5 in negative) when asked "After the Company had stabilized on production, has there been a loss of key personnel?" There were 16 responses for this question. When asked further that "If Yes, did the Company suffer any leakage of technology or IP?" 13 companies responded to this question with 4 saying "yes" and 9 reporting as "no".

Also, the average period of stay (in years) for highly qualified personnel such as Doctoral degree holders and Post-doctoral fellows in the responding companies was 9.06 years (15 responses).

Figure 18 gives some critical information about the training imparted in responding companies to the S&T manpower.

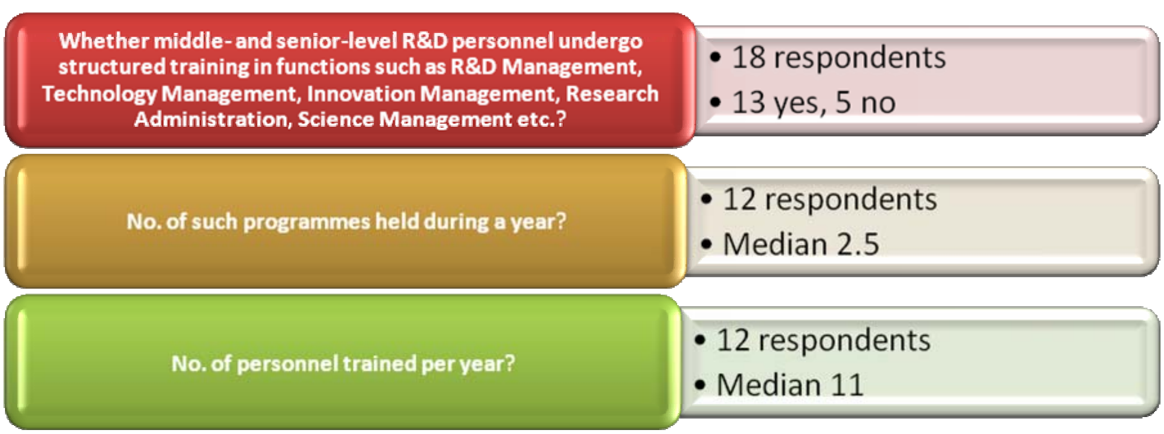


Figure 18: Training information

Table 8: R&D Manpower

	Total Manpower in the Company - Executive /Officer / Supervisory - Scientific	Total Manpower in the Company - Executive /Officer / Supervisory - Technical	Total Manpower in the Company - Executive /Officer / Supervisory - Administrative	Total Manpower in the Company - Non-executive /Non-supervisory - Scientific	Total Manpower in the Company - Non-executive /Non-supervisory - Technical	Total Manpower in the Company - Non-executive /Non-supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Scientific	Of the above, how many are in the in-house R&D Unit?- Executive /Officer / Supervisory - Technical
Responses	18	14	15	4	9	10	14	9
Median	60	158.5	71	192	203	45.5	29.5	21
No Responses (Blank)	24	28	27	38	33	32	28	33

Tables 9 to 14 give the disaggregated data of R&D manpower for companies in different sales turnover categories.

Table 9: R&D Manpower of companies above 500 crore turnover

	Total Manpower in the Company - Executive /Officer / Supervisory - Scientific	Total Manpower in the Company - Executive /Officer / Supervisory - Technical	Total Manpower in the Company - Executive /Officer / Supervisory - Administrative	Total Manpower in the Company - Non-executive /Non-supervisory - Scientific	Total Manpower in the Company - Non-executive /Non-supervisory - Technical	Total Manpower in the Company - Non-executive /Non-supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Scientific	Of the above, how many are in the in-house R&D Unit?- Executive /Officer / Supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Scientific	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Administrative	Of the above personnel in the in-house R&D Unit, approx. what percentage of personnel is involved in publications and patents? - Executive /Officer / Supervisory - Scientific
Median	181.5	591	941	7	202	12	38	33	17.5	6	12	3	65
Max	493	2076	1595	7	894	908	243	108	34	7	18	15	100
Min	7	200	10	7	170	6	6	2	1	1	3	1	8

Table 10: R&D Manpower of companies beween 250 - 500 crore turnover

	Total Manpower in the Company - Executive /Officer / Supervisory - Scientific	Total Manpower in the Company - Executive /Officer / Supervisory - Technical	Total Manpower in the Company - Executive /Officer / Supervisory - Administrative	Total Manpower in the Company - Non-executive /Non-supervisory - Scientific	Total Manpower in the Company - Non-executive /Non-supervisory - Technical	Total Manpower in the Company - Non-executive /Non-supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Scientific	Of the above, how many are in the in-house R&D Unit?- Executive /Officer / Supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Scientific	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Administrative	Of the above personnel in the in-house R&D Unit, approx. what percentage of personnel is involved in publications and patents? - Executive /Officer / Supervisory - Scientific
Median	106.25	83.75	59.75		176.5	29.5	40	25.25	2		18	1.5	2.72
Max	32.5	81	64.5		176.5	29.5	41	25	2		18	1.5	2
Min	350	171	90	0	203	50	50	48	3	0	18	2	6
Median	10	2	20	0	150	9	28	3	1	0	18	1	0.16

Table11: R&D Manpower of companies between 100-250 crore turnover

	Total Manpower in the Company - Executive /Officer / Supervisory - Scientific	Total Manpower in the Company - Executive /Officer / Supervisory - Technical	Total Manpower in the Company - Executive /Officer / Supervisory - Administrative	Total Manpower in the Company - Non-executive /Non-supervisory - Scientific	Total Manpower in the Company - Non-executive /Non-supervisory - Technical	Total Manpower in the Company - Non-executive /Non-supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Scientific	Of the above, how many are in the in-house R&D Unit?- Executive /Officer / Supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Scientific	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Administrative	Of the above personnel in the in-house R&D Unit, approx. what percentage of personnel is involved in publications and patents? - Executive /Officer / Supervisory - Scientific
Median	151.75	236.5	187.25	313.3333	327.25	531.25	20	9.5	5	48.33333	2.666667	5	25
Max	80	144.5	112.5	377	350	65.5	18	9.5	5	3	2	3	25
Min	426	642	504	558	561	1953	31	15	5	140	5	10	25
Median	21	15	20	5	48	41	13	4	5	2	1	2	25

Table 12: R&D Manpower of companies between 50-100 crore turnover

	Total Manpower in the Company - Executive /Officer / Supervisory - Scientific	Total Manpower in the Company - Executive /Officer / Supervisory - Technical	Total Manpower in the Company - Executive /Officer / Supervisory - Administrative	Total Manpower in the Company - Non-executive /Non-supervisory - Scientific	Total Manpower in the Company - Non-executive /Non-supervisory - Technical	Total Manpower in the Company - Non-executive /Non-supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Scientific	Of the above, how many are in the in-house R&D Unit?- Executive /Officer / Supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Executive /Officer / Supervisory - Administrative	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Scientific	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Technical	Of the above, how many are in the in-house R&D Unit? - Non-executive /Non-supervisory - Administrative	Of the above personnel in the in-house R&D Unit, approx. what percentage of personnel is involved in publications and patents? - Executive /Officer / Supervisory - Scientific
Median	46	6	19.5			1	25						
Max	25	6	19.5			1	25						
Min	110	6	34	0	0	1	25	0	0	0	0	0	0
Median	3	6	5	0	0	1	25	0	0	0	0	0	0

Data of companies with 10-50 crores turnover is limited and hence not fit for any analysis

Conclusion

The survey was conducted with a lot of expectations and some of the objectives of the survey have been met. However, the team had no control over the respondents and hence only a few companies responded to the survey. The responding companies have reported that they do not spend much on R&D even though they have good facilities for R&D. The performance of in house R&D is also not uniform across the industry and more intervention needs to be made in this area. Also, the technology transfer is not very smooth. Patenting culture is not same across the entire industry and more works needs to be done in chemical industry to promote patenting. The process of patenting also seems to be another obstacle as many companies are wary of the process. The analysis of each indicator is given in separate sections and a detailed interpretation also accompanies the analysis in each section.

Appendix 1: Questionnaire

Notes:

1. The purpose of this Research Study is to analyze the impact of R&D on the Indian chemical industry in the post-liberalization era (i.e. over the past 2 decades, particularly during 2000-10). The findings and inferences from the Study would be used as policy inputs for the future.

2. The identity and responses of the individual companies would be held in confidence. Only synthesized data and aggregated information would be used for study and analysis.

3. If the principal/parent company is not in India, data pertaining to Indian operations may please be provided.

4. Please tick (√) or fill the responses as applicable. Please add extra sheets if needed.

5. Please post-mail or e-mail the questionnaires to:

The Principal Investigator (INAE-IRICI Project)
C/o The Centre for Innovation & Technology
Administrative Staff College of India
Bella Vista, Rajbhavan Road
Hyderabad – 500 082
Phone: 040 – 6653 4268; 6653 4210
Fax: 040 – 6653 4356; 2331 3882
E-mail: inae.irici@gmail.com

Module-I: **R&D Impcat on Indian Chemical Sector – Holistic View**

Section-I: **General Information**

1) Name of the Company:

____

____

2) Year of incorporation: ____________

3) Location of the Registered Office:

- City/Town: ____________
- State: ____________

4) Website: ____________

5) Sales Turnover (In Rs. Lakh):

- 2008-09 ____________
- 2007-08 ____________
- 2006-07 ____________
- 2005-06 ____________
- 2004-05 ____________

6) R&D Expenditure (In Rs. Lakh)

- 2008-09 ____________
- 2007-08 ____________
- 2006-07 ____________
- 2005-06 ____________
- 2004-05 ____________

7) The Company manufactures: [Please tick (√) as many as applicable]

Basic chemicals
- € Organics, Inorganics and Intermediates
- € Fertilizers
- € Petroleum and Petrochemicals
- € Gas-based chemicals
- € Others

Specialty products
- € Plastics and polymers
- € Coatings and colorants
- € Sealants and adhesives
- € Construction chemicals
- € Lipids and cosmetics
- € Oil-well additives
- € Food additives
- € Others

Knowledge-intensive chemicals
- € Bulk Drugs
- € Pharmaceuticals
- € Agrochemicals
- € High-spectrum bio-products
- € Others

8) Type of in-house R&D setup:

a. In which year was the in-house R&D unit established? _____________

b. Does the R&D unit have a well-equipped analytical lab?

Yes
No

c. Are lab/bench-scale reaction equipment and downstream facilities available?

Yes
No

d. Is there a pilot-plant with adequate scale-up facilities?

Yes
No

e. Is there a well-endowed library with handbooks, manuals, journals and electronic information systems including access to web-resources?

Yes
No

9) What is the current value (approx.) of the R&D assets (excluding IP assets) of the Company in Rs. lakhs? ______________________

10) Does the Company utilize the benefits of income tax deduction available on expenditure incurred on scientific research undertaken by the in-house R&D unit?

Yes
No

11) What are the deficient areas (if any) of the R&D unit?

____

____

____

____

Section-II: R&D Resource Acquisition, Adoption & Absorption Capabilities

12) Looking at the past 10 years, what has been the principal source of technologies for the Company?

Source of technologies	No. of technologies	No. of Products / Outputs using the said technologies	Annual Aggregate Volume of the Outputs (approx.)	Value of the Outputs (approx. in Rs. Lakh)
Internal Source (In-house R&D):				
Invented / developed in-house (home-grown R&D)				
External Source (Bought, acquired, in-licensed etc.):				
Govt. laboratories				
Collaborators (Indian)				
Collaborators (Foreign)				
Independent research / technology Consultants				
Individual research / technology Consultants				

13) If technologies were sourced from outside by the Company, what were the key determinants of acquisition?

1. The technology was proven
2. The technology package was comprehensive/attractive
3. The technology provider has successful track record of transferring several technologies to the industry
4. There is a buy-back arrangement with the collaborator
5. The technology tie-up is exclusive to the Company
6. The pricing of the technology is competitive
7. The technology is new and of pioneering nature (It offered early mover / first-to-market advantages)
8. There was exclusivity and intellectual property (IP) protection against imitation
9. There were tax/duty exemptions and holidays, rebates and subsidies available for using the technology
10. Other reasons (such as novelty, uniqueness, higher functionality, greater ease of use, lesser maintenance, better serviceability, better compatibility, better trialability, better observability, safer, simpler, more efficient, etc. in comparison with competing technologies)

____

____

14) Did the technology-package(s) include comprehensive transfer of technical know-how, IP, process, designs, drawings, documentation etc.?

Yes
No. If so, what did it exclude?

____

____

15) What were the commercial terms of acquisition of technology?
1. Lumpsum upfront payment
2. Lumpsum payments linked to milestones
3. Time-based lumpsum payments
4. Royalty on sales
5. Others, such as ____

____

16) At what scale did the technology-providers demonstrate the processes that the Company acquired?

Lab scale No. of processes: ___________
Bench scale No. of processes: ___________
Pilot scale No. of processes: ___________

17) Have the transfer of technologies from R&D to production and their scale up been smooth?

Yes
No. If so, please answer the next question.

18) If there were gaps/glitches in transfer of any technology or its scale up, the primary reasons were:

1. The technology transfer agreement(s) did not have provision for hand-holding during trials
2. The services of the key technology-resource personnel were no longer available
3. The quality parameters and characterization that came out in actual production were vastly different from those originally projected/demonstrated at the time of technology-transfer
4. There were serious design and process problems related to technology
5. The were issues with the technical feasibility and/or the commercial viability of the technology
6. Other reasons such as: ___________________________________

____

19) Was there in any instance, re-engineering of the process or substitution of raw materials carried out in production, vis-à-vis the 'as-transferred' technology scenario?

No
Yes. If so, please answer the next question.

20) What are the details of the improvements brought in at the time of actual production?

Nature of improvement	Result / Impact of the improvement	Approx. (Estimated) Annual Monetary Benefit (in Rs. Lakh) accruing from the Improvement
(Please add extra sheets if need be)		

21) How long (in months) did it take on an average for the Company to reach the commercial scale of production? ________________________

22) Were the losses suffered significant (in terms of raw material wastages, lost production-batches etc.) before the production stabilized?

No
Yes. If so, what were the reasons?

____

____

____

____

23) Was any additional equipment, machinery, instrumentation etc. required in production, which was not originally envisaged at the time of developing/acquiring the technologies (i.e. not specified initially by the technology-providers)?

No
Yes. If so, of what nature?

____

____

24) Did the Company have to do any extra R&D on its own (after the technology was adopted) to improve the compliance with anti-pollution norms?

No
Yes. If so, of what nature?

Effluent volume reduction
Effluent treatment (Recycling, Recovery etc.)
Solvent extraction
Reduction of emissions
Others, such as: _________________________________

____

____

25) Was safety analysis carried out and on-site/off-site emergency plans prepared for all technologies before commercial implementation?

Yes
No

26) Is the plant connected to any Centralized Effluent Treatment facility?

Yes
No

27) Has any major accident occurred in the Company during the last 10 years, which could be ascribed to inherent deficiencies in the technology/design or non-availability of critical information from the technology-provider at the time of need?

Yes
No

Section-III: R&D Outputs, their Utilization & Impact

28) What are the R&D Outputs (quantity) [Please tick (√) as many as applicable]:

Technology / know-how packages: ________________

Research papers

- International: ________________
- National: ________________

Prototypes: ________________

Design packages: ________________

Patents:

- Process:
  - Indian: ________________
  - Overseas ________________
- Product:
  - Indian: ________________
  - Overseas ________________

29) In what respects has the R&D helped the Company [Please tick (√) as many as applicable]

- ❑ Expanding the existing product lines
- ❑ Adding new product lines
- ❑ Setting up new plant(s)
  - ❑ In India
  - ❑ Abroad
- ❑ Effecting improvements in existing products
- ❑ Making the production-processes more efficient
- ❑ Reducing the costs of end-products
- ❑ Improving the image of the Company
- ❑ Enhancing the Company's turnover
- ❑ Establishing a joint venture with an Indian partner
- ❑ Establishing a joint venture with a foreign partner

30) Has the Company attracted any Foreign Direct Investment for augmenting its R&D base?

Yes
No

31) Has the Company won in the past 10 years, any national / international awards for its R&D excellence?

No
Yes. If so, of what nature?

Year	Name of the Award	Instituted by (which Agency)	Nature of Recognition	First time / Repeat Award

32) What percentage of increase in yearly revenues would the Company ascribe to new technologies emerging from R&D? ____________

33) If the Company is listed on the stock markets, has the acquisition of the new technology impacted the stock price?

No
Yes. If so, by what approx. percentage on an average? ________

34) On the whole, how would the Company rate the impact of R&D on the Indian chemical industry?

Nil / negligible	(A rating of <= 1 out of 5)
Below average	(A rating of <= 2 out of 5)
Average	(A rating of <= 3 out of 5)
Above average	(A rating of <=4 out of 5)
To a great / significant extent	(A rating of >4 out of 5)

Module-II: **Utilization of Public-funded R&D for Commercialization**

1) Did the Company utilize support (financial or otherwise) from any public-funded S&T agency or R&D establishment?

No.
Yes. If so, please answer the following questions.

2) From which Government establishment/agency did the Company utilize support? [Please tick (√) as many as applicable]

Dept. of Science & Technology (DST), GoI
Dept. of Bio-technology (DBT), GoI
Dept. of Scientific & Industrial Research (DSIR), GoI
Council of Scientific & Industrial Research (CSIR), GoI
Ministry of Chemicals & Fertilizers, GoI
Technology Development Board (TDB), DST, GoI
National Science & Technology Entrepreneurship Development Board (NSTEDB), DST, GoI
Technology Information, Forecasting and Assessment Council (TIFAC), DST, GoI
National Laboratory (Please specify): ________________________
National Institute (Please specify): __________________________
University Dept. : ____
Other agencies (Please specify): _____________________________

3) What was the nature of support/assistance availed? [Please tick (√) as many as applicable]

Financial
- Soft loan
- Grant-in-Aid
- Venture capital
- Any other: ____

Scientific/Technical/Analytical
- Proof-of-concept
- Process development
- Product development
- Scaling up
- Prototyping
- Setting up pilot plant
- Characterization
- Capacity augmentation
- New equipment / infrastructure for regulatory compliance
- Setting-up / augmenting the Laboratory
- Other reasons such as ____________________________

4) Has the Company utilized the benefits of income tax deduction available on sums paid to approved associations, universities, institutions, laboratories etc. for undertaking scientific research?

Yes
No

5) What has been the nature/structure of R&D Public-Private Partnerships (PPP)?

Nature of partnership	Number of partnerships	Average duration in years
Contractual partnership		
Special-purpose vehicle		
Network membership		
Registered society		
Joint sector company		
Others: *(Please Specify)*		

6) Constraints (if any) of the PPP in the programme(s) implemented by the Company:

____

____

____

7) Average processing time (in months) taken by the Government for obtaining the project approvals: ______

8) Average duration of delays (in months) in project-execution by the Company: ________

9) Is the intellectual property generated through PPP patented?

Yes
No. If so, what are the major reasons?

____

____

____

In such a case, how credits are shared?

____

____

10) Has the Company got any specific comments to offer on the Project Monitoring Systems in place, as part of the PPP initiatives?

No
Yes. For example,

____

____

____

Module-III: **Utilization of Patents**

1) Patent data:
   a) Number of patents granted to the Company till date ______
   b) Number of patents granted to the Company that are still in force_______
   c) Number of patents granted to the Company, which are assigned ____________.

Name of the Assignee	No. of Patents
1.	
2.	

   d) Number of patients granted to the Company that were or are being used commercially_______
   e) Number of pending patent applications: __________

2) In what manner the above patents have been used by the Company?
   Process protection
   Product protection
   Any other. (Please specify) _______________________

3) What in your estimate is the total income (in Rs. Lakh) from patents (till date)? _______________

4) The top 20% of the Company's patents account for how much percentage of the net income from all such patents till date (Please give % values like 80%, 60% etc.) ______

5) What is the profile of the Company's patented inventions?

Field of Chemical Industry	No. of Patented Inventions
Basic chemicals	
€ Organics, Inorganics and Intermediates	_____________
€ Fertilizers	_____________
€ Petroleum and Petrochemicals	_____________
€ Gas-based chemicals	_____________
€ Others	_____________
Specialty products	
€ Plastics and polymers	_____________
€ Coatings and colorants	_____________
€ Sealants and adhesives	_____________
€ Construction chemicals	_____________
€ Lipids and cosmetics	_____________
€ Oil-well additives	_____________
€ Food additives	_____________
€ Others	_____________

Field of Chemical Industry | No. of Patented Inventions

Knowledge-intensive chemicals

- € Bulk Drugs ______________
- € Pharmaceuticals ______________
- € Agrochemicals ______________
- € High-spectrum bio-products ______________
- € Others ______________

6) Has the Company made any inventions which are not yet patented?
   - ❑ No
   - ❑ Yes. If so, any of the specific reasons?
     - ❑ Costs involved
     - ❑ Delays
     - ❑ Paper work involved
     - ❑ Inadequacy of incentives
     - ❑ Inadequate protection for IP etc.
     - ❑ Any other

____

____

7) For the inventions of the Company that are patented, please give the average or estimated costs incidental to -
   - a. The conception, research and all other expenditures incurred including the cost of patenting (exclusive of any separate costs for commercial exploitation)_____________
   - b. For filing and grant of the patent ________
   - c. In trying to interest others to purchase or use the patent(s) or to develop means for producing and marketing it ________

8) Has there been any litigation or threat of litigation with respect to the patents?
   - ❑ Yes
   - ❑ No

9) What percentage of the patents is under any such litigation or threat of litigation? _________________

10) If the Company has purchased any patent-rights from others, please specify the number of such patents in the last 10 years ________

11) Has the Company licensed out its patents to other countries?
   - ❑ No
   - ❑ Yes . If so, please indicate the foreign countries to which licensed

____

____

12) If the Company has purchased any rights for any patents,

a. What is the approx. number of such patents?
b. What is the approx. total value of such acquisition(s) in Rs. Lakh? ___

13) How much time (in months on an average) does it take between the initial conception of the idea of the invention and the development of it to the stage of applying for a patent? _________

14) If the inventions that were patented are not being used now in production, what are the reasons?

Lack of market demand
Availability of better competing technologies/products
Competitively at a disadvantage (in price, quality etc.)
Patent doesn't provide sufficient protection
Shortage of (venture/start-up) capital
Others (Please specify) _______________________________

15) If any of the inventions that have been patented by the Company are (being) used in production, was the "know-how" an essential element in such production?

- ❑ Yes. If so, what percentage of your patents falls in this category? ___
- ❑ No
- ❑ Others (Please specify)____________

16) Did the Company devote its attention to the development and perfection of the "know how" because of the patent protection on the above invention? (Please comment)

____

____

17) Did the inventions that were patented result in increased sales?

Markedly
Moderately
Slightly
Not at all
Others (Please specify) _______

18) Did the inventions that were patented result in the reduction of production costs?

Markedly
Moderately
Slightly
Not at all
Others (Please specify)_______

19) Describe any other benefits, which have been derived or expected to be derived from the Company's IP right(s) in patents

____

____

Module-IV: **Quality & Mobility of Manpower in Indian Chemical Sector**

1) Manpower strength in the Company:

Manpower	Category	Scientific	Technical	Administrative
Total Manpower in the Company	Executive / Officer / Supervisory			
	Non-executive / Non-supervisory			
Of the above, how many are in the in-house R&D Unit?	Executive / Officer / Supervisory			
	Non-executive / Non-supervisory			
Of the above personnel in the in-house R&D Unit, approx. what percentage of personnel is involved in publications and patents?	Executive / Officer / Supervisory			
	Non-executive / Non-supervisory			

2) Qualifications of scientific/technical manpower?

- How many Doctoral degree holders? :_____________
- How many Post-graduates? :_____________
- How many Graduates? :_____________
- How many others? :_____________

3) On an average, at any point of time, what percentage of scientific manpower of the Company is pursuing higher professional qualifications? __________

4) What is the nature of such academic pursuits / manpower quality improvement programmes (QIP)?

Higher degrees through external registration with universities
Full-time deputation to academic institutions for acquiring higher degrees
Joint initiative with academic institutions for onsite education

5) Nature of incentives available for scientific personnel acquiring higher professional qualifications [Please tick (√) as many as applicable]

Additional increments
Promotions / elevations
Higher scientific responsibilities
Awards, Merit certificates, Commendation letters etc.
Cash rewards
Foreign training
Foreign posting
Others, such as: ____

6) Nature of special incentives available for scientific personnel for creative/innovative research outputs [Please tick (√) as many as applicable]

Additional increments
Promotions / elevations
Higher responsibilities
Awards / Merit certificates, Commendation letters etc.
Cash rewards
Foreign training
Sharing of royalties / fee
Others, such as: ____

7) Whether middle- and senior-level R&D personnel undergo structured training in functions such as R&D Management, Technology Management, Innovation Management, Research Administration, Science Management etc.?

No
Yes. If so, what percentage of total S&T staff? __________

8) If Yes, <u>on an average</u>, what is the

No. of such programmes held during a year? ________
Ratio of such training programmes (Internal : External)? ______
Duration (in days) of each programme? ______
No. of training days per person per year? ___________
No. of personnel trained per year? _______________

9) After the Company had stabilized on production, has there been a loss of key personnel?

No
Yes

10) If Yes, did the Company suffer any leakage of technology or IP?

Yes
No

11) In which disciplines has it been difficult to get qualified, trained and/or experience manpower?

____

____

____

12) What is the average period of stay (in years) for highly qualified personnel such as Doctoral degree holders and Post-doctoral fellows? ____________

(Thank you for your cooperation and support for this Research Study)