R&D Agency - Industry Partnership for Technology Development and Transfer: An Assessment Study

THESIS

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CERTIFICATE

This is to certify that the thesis entitled "R&D Agency - Industry Partnership for Technology Development and Transfer: An Assessment Study" submitted by Ms. Rama Swami, ID. No. 2001PHXF412 for award of Ph.D. Degree of the Institute embodies original work done by her under my supervision.

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ABSTRACT

Technology capability is a seminal factor to the prosperity and economic progress of a nation. R&D agency – industry partnerships are essential for building technology capability. The governments in many developed countries, and some countries with fast emerging economies, have taken deliberate policy initiatives and have launched schemes and programmes to promote such partnerships. India also has been making endeavours in this direction with an aim to leverage the impressive S&T infrastructure built over the years after the independence. In recent years, the policy makers, technology providers, technology takers and the intermediaries facilitating technology partnerships too are extensively brainstorming on this issue. Realising that these partnerships improve returns from public investments in research, there is a concerted effort by the Government and related agencies to work out a suitable framework and formulate a mechanism that is effective and sustainable on a long-term basis.

In the above backdrop, the present investigation on the topic 'R&D Agency – Industry Partnership for Technology Development and Transfer: An Assessment Study' has been undertaken with an overall objective of studying and examining the R&D agency – industry partnership for technology development and transfer and making appropriate recommendations to improve the role of stakeholders and interface between them and partnership building processes in Indian context. The scope of the study, which was partially arrived at through experiences on inter-governmental cooperation programmes in science and technology and partially through the literature survey on the dynamics of technology transfer processes and the evaluation reports on facilitating mechanisms, includes (a) understanding R&D agency – industry partnership systems followed in other countries and in India and correlating them; (b) investigating and analysing the success and failure in existing partnerships; and (c) suggesting possible improvements towards enhancing sustainable R&D agency – industry partnerships in India for technology development and transfer. The present study does not attempt to enter into the depth of the financial aspects, except in an indirect manner.

The research plan, to begin with, aims at making critical appraisal and assessment of the experiences and practices of the select developed countries as well as countries with fast emerging economies in promoting partnerships between R&D agencies and industry. The selected countries are the USA, Germany, Japan, UK, Republic of Korea, China and Brazil

and the plan study covers the policies, S&T structure and organisation, roles of stakeholders and associated problems of interfacing amongst them, socio-economic reasons for partnering, processes of building partnerships and specific features of chosen initiatives. The Indian government policies adopted since independence and status of linkages between R&D agencies and industry in India, particularly, the facilitating institutionalised mechanisms of the government S&T departments and agencies and R&D institutions are reviewed. The experiences in partnership promoting efforts of the select countries have been compared with those in India, and efforts are made to understand the gaps and issues requiring attention.

The literature survey and review indicated that India is at par with the select countries in terms of its current initiatives for promoting technology development through partnerships. However, the country has been less successful possibly due to problems in operationalisation of these endeavours. This underscored the need to further study the perceptions of key stakeholders on partnership building processes, their roles and problems associated with interfacing amongst them for technology development and transfer in Indian context, which has been accomplished by using the methods of 'case study' and 'survey through questionnaires'.

Fifteen collaborative projects have been chosen as case studies reflecting different facets of partnerships and experiences of stakeholders and probe into the processes of building partnerships, some of the reasons for success and failure, and constraints faced by the stakeholders in interfacing for technology development, its transfer and commercialisation.

Further, in the present work the responses of the stakeholders to the questionnaires in regard to their partnership related activities, experiences on building / facilitating partnerships, and their perceptions on the changes required to re-model the existing partnerships have been scientifically analysed to propound relevant suggestions for enhancing the partnerships. For the purpose of the present investigation these questionnaires were specifically designed for individual groups of stakeholders, viz. those working in the R&D agencies (including academia), industries and intermediary bodies supporting / facilitating the R&D agency - industry partnership for technology development and transfer.

It has emerged from this study that for its success, the technology partnership must be carefully designed and managed so as to engage partners with different cultures, management practices and objectives. Partnership programmes should fit into national innovation systems while balancing public and private objectives and fully involve SMEs in the national programmes; financing arrangement should be optimised; there should be overall commitment; appropriate international linkages should be created; and programmes should be periodically monitored and evaluated. Some specific and significant recommendations are:

- The structure of R&D agency should be facilitative, flexible and faster decision-making. Researches should be not only inquisitiveness driven, but also demand and milestone-driven. The agency should make business plans in addition to R&D plans and should monitor and periodically review them and their implementation for setting the priorities and meeting the objectives. The research programmes should include application and demonstration of technologies for their validation and techo-economic feasibility study to substantiate the claims made by them to the industry. The agency should develop assessment systems and performance indicators to estimate benefits delivered to the society as a whole as a result of public investments in S&T.

- To facilitate marketing of knowledge products, forging alliances and transfer of technology, each R&D agency should have a Business Development Group with capability to acquire elaborate techno-commercial information for necessary techno-economic analysis of the technology and industrial contacts both in the country and abroad. It should either have its own legal experts to interpret the patents, or outsource the legal and other necessary expertise.

- R&D agency should make appropriate projection of its past performance and accomplishments through mechanisms such as licensing information, brochures, exhibitions, Internet and informal meets to make industry aware of its R&D capability and competences.

- The culture of partnership with industry should become an integral part of every R&D agency, which should establish business type interaction with industry, ensure confidentiality of information, value time, and also be aware that industry does not have loads of money for each and every project. Researchers should be placed in the industry environment for real time home exposure.

- Industry should treat R&D at par with production in terms of budget allocation, manpower and other resources. Apart from profit motive it should focus on supporting R&D efforts on emerging areas of development in S&T. It should be clear of its requirements and should identify suitable processes and technologies for implementation and make appropriate plans for long-term commercialisation. Management should take commercial trials and risks.

Industry should take up large-scale projects of benefit to society in the sectors of health, agriculture, energy and rural infrastructure development to increase employment opportunities.

- Industry should make long-term research plans and associate the R&D agencies for their implementation. It should partner with R&D agencies in adapting technologies. There should be mutual trust, commitment and frequent interactions between the partners besides clarity of agreements. For enhanced research-industry interactions industry should proactively work and come to R&D agencies and intermediaries such as TDB, who should interface the partnership with equity.

- Formal partnerships should be forged as they help meeting the defined targets in fixed time. Integral plans be made between the partners for enhancement and sustainability of the partnership and there should be more interaction and brain storming sessions between the two to identify effective links and mechanisms. For example Industry could form an association of similar companies, which adopt an R&D agency for a longer period identifying itself with the goals of R&D agency. Industry should work with the R&D agency attached to it for its technology development and up gradation.

- Intermediaries promoting partnerships through institutionalised programmes should revisit the ongoing partnership programmes for evaluating their efficacy and introducing necessary modifications for achieving enhanced impact and stimulating participation of industry. This should include (a) revisiting the administrative guidelines for reducing bureaucracy and bringing transparency; (b) revisiting the financial guidelines for introducing flexible funding mechanisms; and (c) appropriate selection and monitoring the guidelines. The institutionalised programmes of the government and public institutions should carry out exhaustive survey on the industrial needs and technology requirements; keep track of the current IP policies; carry out technology foresight and assessment at the national and global levels to catch up with the latest technology trends and access to market information; and create awareness about challenges and opportunities being unfolded by the emerging trends.

- The policy makers should ensure that the three major aspects of the technology policy, i.e., technology acquisition, technology generation and technology diffusion, are well balanced and consistent with the industrial policies. The national policy should provide for award and incentive structure to encourage entrepreneurship by academicians and researchers and encourage them to produce industry-oriented output. Appropriate laws in line with tl Bayh-Dole Act of the USA should be enacted to allow the researchers to get involved with th industry to exploit research outcome and allowing its benefits to be received by the researcher concerned. IPR rules should be relaxed to an extent to attract researchers and industry.

- The policy makers should back up and encouraged the industry to invest in R&D through attractive fiscal incentives. They should facilitate and provide incentives for closer cooperation between R&D agencies and industry. R&D agency may even be made a part of the industry for carrying out R&D programmes useful for the growth of the industry.

- The partnership promoting programmes of different departments and agencies should be linked to provide a coordinated effort for supporting the innovation from idea to commercialisation stage to make enhanced outcome and impact. In addition, new programmes for supporting idea generation to commercialisation on the lines of NMITLI in all S&T disciplines as well as in specific sectors should be initiated. Special schemes for networking the universities with industry should be launched and mobility of researchers and industry personnel to each other's institutions should be encouraged. The government should encourage greater participation of SMEs in the national programmes. Networking between R&D agencies and industry should be stimulated through cluster development in different regions in strategic areas of innovation.

- India should take steps to further improve its innovation system, not only by taking advantage of the new knowledge created at home, but also by tapping knowledge from abroad and disseminating it for greater economic and social development. It should also improve the efficiency of public R&D and increase private R&D, as well as encourage greater university - national laboratory - industry linkages.

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LIST OF ABBREVIATIONS / SYMBOLS

AAAS	American Association for the Advancement of Science
ABPI	Association of the British Pharmaceutical Industry
ADB	Asian Development Bank
AEP	American Electric Power Company
AiF	Association of Joint Industrial Research, Germany
AIIMS	All India Institute of Medical Sciences
AIST	National Institute of Advanced Industrial Science and Technology, Japan
APCTT	Asia and Pacific Centre for Transfer of Technology
ARC-I	International Advanced Research Centre for Powder Metallurgy and New Materials
ASIC	Application Specific Integrated Circuits
ASTC	Association of Science Technology Centres
ATP	Advanced Technology Program, USA
AURP	Association of University Research Parks
AVS	Arya Vaidya Sala
BBSRC	Biotechnology and Biological Sciences Research Council, UK
BHU	Banaras Hindu University
BMBF	Federal Ministry of Education and Research, Germany
BMWA	Federal Ministry of Economics and Labour, Germany
BMWi	Federal Ministry of Economics and Technology, Germany
BTG	British Technology Group
CAPES	Committee for Post-Graduate Courses in Higher Education, Brazil
CCMB	Centre for Cellular and Molecular Biology, Hyderabad
CCRUM	Central Council of Research in Unani Medicine
CEERI	Central Electronics Engineering Research Institute, Pilani
CEO	Chief Executive Officer
CFTRI	Central Food Technological Research Institute, Mysore
CII	Confederation of Indian Industry
CIMAP	Central Institute of Medicinal and Aromatic Plants, Lucknow
CLRI	Central Leather Research Institute, Chennai
CMERI	Central Mechanical Engineering Research Institute, Durgapur
CNPq	National Council for Scientific and Technological Development, Brazil
CNRS	*Centre National de la Recherché Scientifique*, France
CORE	Centre of Relevance and Excellence
CRADA	Cooperative Research and Development Agreement, USA
Cr.	Crore (1,00,00,000) = 10 millions
CSIO	Central Scientific Instruments Organization, Chandigarh

CSIR	Council of Scientific and Industrial Research
CSMCRI	Central Salt & Marine Chemicals Research Institute, Bhavnagar
DAE	Department of Atomic Energy
DBT	Department of Biotechnology
DFG	German Research Society
DLR	Deutschen Zentrum für Luft- und Raumfahrt, Germany
DMRL	Defense Metallurgical Research Laboratory, Hyderabad
DOD	Department of Ocean Development
DOE	Department of Electronics
DOS	Department of Space
DPRD	Drugs & Pharma Research Programme
DRDO	Defence Research & Development Organisation
DSIR	Department of Science and Industrial research
DST	Department of Science & Technology
DTI	Department of Trade and Industry, UK
ECF	External Cash Flow
EDC	Entrepreneurship Development Cell
EDI	Entrepreneurship Development Institute
EEPC	Engineering Export Promotion Council
EES	European Evaluation Society
EIF	European Investment Fund
EIL	Engineers India Ltd
EMBRAPA	Brazilian Agricultural Research Corporation
ERC	Engineering Research Centre, Korea
ESCAP	UN Economic and Social Commission for Asia and the Pacific
FADESP	Fundação de Amparo e Desenvolvimento da Pesquisa, Brazil
FAPEAL	Fundação de Amparo à Pesquisa do Estado de Alagoas, Brazil
FAPEMIG	Fundação de Amparo à Pesquisa do Estado de Minas Gerais, Brazil
FAPEPI	Fundação de Amparo à Pesquisa do Estado do Piauí, Brazil
FAPERJ	Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro, Brazil
FAPESP	Foundation of Support to the Research of the State of São Paulo, Brazil
FDA	Food and Drug Administration
FDI	Foreign Direct Investment
FEM	Finite Element Method
FhG	Fraunhofer Society, Germany
FI	Financial Institutions
FINEP	Projects Funding Body, Brazil
FITT	Foundation for Innovation and Technology Transfer of IIT, Delhi
FICCI	Federation of Indian Chambers of Commerce and Industry

FNDCT	National Science and Technology Development Fund, Brazil
FUNTEC	Fund for Technical and Scientific Development, Brazil
FZJ	Forschungszentrum Jülich, Germany
GATT	General Agreement on Tariffs and Trade
GCL	Gharada Chemical Limited
GDP	Gross Domestic Production
GE	General Electric
GNP	Gross National Product
GOI	Government of India
GPS	Geographical Positioning Systems
GRI.	Government Research Institute
GUI	Graphical User Interface
GVFL	Gujarat Venture Finance Limited
HAL	Hindustan Aeronautics Limited
HAN	Highly Advanced National (Projects), Korea
HEI	Higher Education Institutes
HEIF	Higher Education Innovation Fund
HEROBC	Higher Education Reach Out to Business and the Community, UK
HGF	Helmholtz Association of National Research Centres, Germany
HGT	Home Grown Technology
HMSO	HMSO Publishers, UK
HPLC	High Performance Liquid Chromatography
HRB	Plain Rice Husk Board
HRD	Human Resource Development
IARI	Indian Agricultural Research Institute
IASP	International Association of Science Parks
ICAR	Indian Council of Agricultural Research
ICICI	Industrial Credit and Investment Corporation of India Ltd
ICMR	Indian Council of Medical Research
ICRIER	Indian Council for Research on International Economic Relations
ICT	Information and communication technology
IDBI	Industrial Development Bank of India
IFCI	Industrial Finance Corporation of India
IGCAR	Indira Gandhi Centre for Atomic Research, Kalpakkam
IGF	Programme for Promotion of Industrial Co-operative R&D
IGIB	The Institute of Genomics & Integrative Biology, New Delhi
IICT	Indian Institute of Chemical Technology, Hyderabad
IISc	Indian Institute of Science, Bangalore
IIT	Indian Institute of Technology

IIT-D	Indian Institute of Technology, Delhi
IMT	Institute of Microbial Technology, Chandigarh
INPA	National Institute of Research of Amazonia, Brazil
INPE	National Institute of Space Research, Brazil
INPI	National Institute for Industrial Property, Brazil
INSAT	Indian National Satellite System
INT	National Technology Institute, Brazil
INTES	*Ingenieurgesellschaft für technische Software*, Germany
IP	Intellectual Property
IPHQ	Property Headquarters and Centre to Promote University-Industry Collaboration, Japan
IPR	Intellectual Property Rights
IRC	Innovation Relay Centre
ISAAA	International Service for the Acquisition of Agri-biotech Applications
ISR	Institute for Safety Research and Reactor Technology, Germany
ISRO	Indian Space Research Organisation
IVCA	Indian Venture Capital Association
JGN	Japan Gigabit Network
JILA	Joint Institute for Laboratory Astrophysics, USA
KIST	Korea Institute of Science and Technology
KIT	Korea Institute of Technology
Lakhs	1,00,000 = 100 thousand
LINK	Government Programme to support Collaborative Research & Development Projects between Business and Research Base, UK
LSI	Large Scale Industry
MCT	Ministry of Science and Technology, Brazil
MD	Managing Director
MERDO	Mechanical Engineering Research & Development Organisation, Ludhiana
METI	Ministry of Economy Trade and Industry, Japan
MEXT	Ministry of Education, Culture, Sports, Science and Technology, Japan
MIT	Ministry of Information Technology
MITI	Ministry of International Trade & Industry, Japan
MNC	Multi National Company
MNES	Ministry of Non-Conventional Energy Sources
MOE	Ministry of Education, Japan
MoEF	Ministry of Environment and Forests
MOST	Ministry of Science and Technology, Korea
MoU	Memorandum of Understanding
MPG	Max-Planck Society, Germany

MPHPT	Ministry of Public Management, Home Affairs, Posts and Telecommunications, Japan
MRC	Medical Research Council, UK
MSI	Medium Scale Industry
MTP	Micropropagation Technology Parks
MW	Mega Watt
NAL	National Aerospace Laboratories, Bangalore
NALCO	The National Aluminium Company
NASA	National Aeronautics and Space Administration, USA
NBRI	National Botanical Research Institute, Lucknow
NCE	New Chemical Entities
NCL	National Chemical Laboratory, Pune
NCSM	National Council of Science Museums
NDDB	National Dairy Development Board
NEDO	New Energy and Industrial Development Organization, Japan
NEERI	National Environmental Engineering Research Institute, Nagpur
NERC	Natural Environment Research Council, UK
NGO	Non-Governmental Organisation
NGRI	National Geophysical Research Institute, Hyderabad
NIH	National Institute of Health, USA
NIS	National Innovation System
NISSAT'	National Information System for Science and Technology, New Delhi
NIST	National Institute of Standards and Technology, USA
NISTEP	National Institute of S&T Policy, Japan
NMITLI	New Millennium Indian Technology Leadership Initiative
NNSFC	National Science Foundation of China
NPL	National Physical Laboratory, New Delhi
NRDC	National Research and Development Corporation
NRP	National R&D Programme
NSB	National Science Board, USA
NSF	National Science Foundation, USA
NSTC	National Science and Technology Council, USA
NSTEDB	National Science and Technology Entrepreneurship Development Board
NSTMIS	National Science & Technology Management Information System
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget, USA
OST	Office of Science and Technology, USA
OSTP	Office of Science and Technology Policy, USA

PATSER	Programme aimed at Technological Self Reliance
PCAST	President's Council of Advisors on Science and Technology, USA
PCR	Polymerase Chain Reaction
PCT	Programme Comprehension Tool
PFC	Patent Facilitating Centre
PID	Publications & Information Directorate
PPARC	Particle Physics and Astronomy Research Council, UK
PPP	Public Private Partnership
PRDSF	Pharmaceuticals Research and Development Support Fund of DST, India
PRO INNO	Programme Innovation Competence for SMEs
PSRE	Public sector research establishments sector, UK
PSU	Public Sector Units
PVC	Polyvinyl chloride
R&D	Research & Development
RDG	Research Development Grant scheme
RDI	Research & Development by Industry
rDNA	Recombinant DNA
REACH	Relevance & Excellence in Achieving New Heights in Educational Institutions
REIL	Rajasthan Electronic Information Ltd
RESCO	Resources Engineering & Services Co.
RHB	Rice Husk Boards
RRC	Regional Research Centre
RRL	Regional Research Laboratory
RRL-T	Regional Research Laboratory, Thiruvananthapuram
rSK	Recombinant Streptokinase
RTDT	Rural Technology Demonstration Centre
RTP	Research Triangle Park
S&T	Science and Technology
SBI	State Bank of India
SCST	State Commission for Science and Technology, China
SEBI	Securities and Exchange Board of India
SEETOT	Scheme to Enhance the Efficacy of Transfer of Technology
SERC	Science and Engineering Research Council
SETEC	Secretariat for Technological Development, Brazil
SID	Society for Innovation and Development of IISc, Bangalore
SID	Satellite Imagery Digitisation
SIDBI	Small Industries Development Bank of India
SIRO	Scientific and Industrial Research Organisation

SK	Streptokinase
SMAS	2-Methlyallyl Sulfonic Acid Sodium Salt
SME	Small and Medium Enterprises
SNDCT	National Science and Technology Development System, Brazil
SPREAD	Sponsored Research and Development Programme
SPRU	S&T Policy Research, University of Sussex, UK
SRC	Science Research Centre, UK
SRF	Senior Research Fellowship
SSI	Small Scale Industries
SSTC	State Science and Technology Commission, China
STA	Science and Technology Agency, Japan
STEP	Science and Technology Entrepreneurship Parks
STI	Science, Technology, Innovation
STTR	Small Business Technology Transfer Programme
T/H	Tonnes / hour
TAC	Technology Advisory Cell
TAO	Telecommunications Advancement Organization, Japan
TAP	Technology Advisory Point
TATT	Transfer and Trading in Technology
TBA	Tertiary Butyl Acrylamida
TBI	Technology Business Incubators
TBT	Information on Technical Barriers to Trade
TCS	Teaching Company Scheme
TDB	Technology Development Board
TDDP	Technology Development and Demonstration Programme
TDF	Technology Development Fund
TDICI	Technical Development and Information Corporation of India
TDMF	Technology Development and Modernisation Fund
TePP	Technopreneur Promotion Programme
TERI	The Energy and Resources Institute (formerly known as Tata Energy Research Institute)
TIFAC	Technology Information Forecasting and Assessment Council
TLO	Technology Licensing / Management Office / Organisation
TPA	Tonnes Per Annum
TPA	Tissue Pasminogen Activator
TPDU	Technology Promotion Development and Utilization
TQM	Total Quality Management
TRIPS	Trade-Related Intellectual Property Rights
TSM	Traditional Systems of Medicine

TT	Technology Transfer
TTO	Technology Transfer Offices
UFMG	Fundep linked with the Minas Gerais Federal University, Brazil
UFRJ	Rio de Janeiro Federal University, Brazil
UK	Urokinase
UKSPA	United Kingdom Science Park Association
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
Unicamp	Campinas State University, Brazil
URDIP	Unit for Research and Development of Information Products
USA	United States of America
USAID	United States Agency for International Development
UTI	Unit Trust of India
VBL	Venture Business Laboratory
VCF	Venture Capital Funds
VOL	Vinati Organics Limited
WB	World Bank
WIPO	World Intellectual Property Organisation
WITT	Waterfalls Institute of Technology Transfer, New Delhi
WTO	World Trade Organisation
YRP	Yokosuka Research Park, Japan

Chapter 1

Introduction

Science and Technology (S&T) has always enjoyed a very special and distinct place in all sectors of economy due to its universal character. The increasing globalisation of national economies has brought into focus the way in which the relationships between science, technology and innovation are perceived and implemented. The new competition that is now emerging on the S&T front can be sustained and contested only by increasing innovations, bringing in creativity and adding more to the peaks of excellence, thus reducing the time gap between the development of a new concept to its full commercial potential. The development of technology, its transfer and commercialisation is at the core of such developments; the success of which depends upon the effectiveness of partnerships between the technology developers and the technology takers or users. As technology developers, Research & Development (R&D) agencies are generally perceived as self-perpetuating academic organisations of high intellect, comprising distinguished researchers dedicated to the furtherance of S&T and to its use for general welfare of the society. One of the essential pre-requisites of which is a well-conceived process that is coherent and leads to smooth transfer of technology to the appropriate industry. The aim of all aspects of research is to enable its eventual commercialisation for technological and economic growth, which essentially is implemented through involvement of technology users in the industry.

1.1 Public - Private Partnership

A robust national innovation system (NIS) lies at the heart of any growing economy, health, environment and national security. It supports the ability / capacity of a country to innovate, especially to adapt and create S&T for economic and societal use. Thus, despite the fact that it requires increased investment to continue R&D activities, it is necessary to maintain strengths and vigour of the R&D. Ingredients of a NIS are people, policy environment, infrastructure, institutions and especially the political will **[1]**. From the national perspective there are a number of constituent partners of NIS, including the national laboratories, research institutes, universities and industries, who need to interact, cooperate and collaborate in this battle for supremacy **[2]**. Competition and industrial regulation policies, education systems, labour laws and the attitude of trade unions, industrial strategies, entrepreneurial motivation and the links between these are just some of the components of NIS. The interactions between these partners lead to a certain level of originality [3]. From an economic perspective the increase in globalisation has resulted in some dilution of the importance of the Nation - State boundaries, but the NIS continues to be an important determinant of the economic performance of a country.

There are a number of mechanisms that exist for achieving integration of the diverse participants in the innovation system. One of the methods is through partnership that provides an institutional structure with financial and policy incentives within which the national laboratories, research institutes, universities and industries can cooperate to accelerate the development of promising technologies [4]. In this context 'public-private partnerships' are referred to as being the collaboration between public bodies belonging to the local authorities or central government, and private companies or industry. These can be forged through a voluntary association of two or more persons for the purpose of doing business for profit and can be either a formal or informal arrangement governing general or specific objectives in research or commercialisation and involving two or more actors like in consortia. While informal arrangements exceed the formal partnerships, such arrangements become more structured when costs and benefits are directly accountable, either in kind or direct. Formal agreements are globally universal whenever money changes hands [5]. Scientific and industrial partnerships help structure the creation of new knowledge, enhance mutual awareness and understanding, and facilitate the pathway from scientific discovery to marketplace [6].

1.2 Issues and Parameters of Partnership

1.2.1 Partnership: New Driving Forces

Scientific and technology partnerships generally benefit all the partners - the R&D agencies that include academic and research institutions, industries and the society. In the past such partnerships have often resulted in spin off companies. The new issues such as IPR now exhibit a direct bearing on the emerging public - private technology partnerships. Moreover there are a number of new factors that too have come in play to become instrumental in increasing such partnerships. These can be related to such aspects that drive the increase in private R&D and market-driven alliances between private industries. Three of the main factors driving a public-private partnership, in particular R&D agency - industry partnership, at present are: i) increased speed of transition to the knowledge-based economy; ii) increased globalisation and competition; and iii) budgetary constraints faced by governments and their impact on patterns of funding of research as well as the higher costs of research in general.

In addition to the above listed factors there are many others that would affect the decisions of industry for partnership with R&D agencies, such as shorter product cycles and hence shorter time horizons for R&D; outsourcing of generic research including to public research bodies; convergence of technologies; and changes in intellectual property (IP) rules governing publicly funded research. In the present context, the industry has four main goals associated with participating in R&D agency – industry partnership, viz. knowledge goals; exploitation goals; networking goals; and stewardship goals such as cost reduction and sound R&D management [7]. Industry chooses the partnership over other approaches to R&D for a variety of reasons, one of the most compelling being the ability to access scientific excellence and a broad range of high quality resources. Although cost sharing is generally considered a main motivation for partnering in R&D, survey evidence from partnerships in advanced technology programmes suggests that knowledge goals rank highest among participating industries. This may reflect greater heterogeneity among the partners since issues such as cost sharing are more important among similar industries [8].

Some of the significant motivations for R&D agencies to enter into partnership with industry include maintaining research momentum; applying knowledge by identifying significant, interesting and relevant problems leading to sponsored research projects or consulting opportunities; learning business processes and gaining first hand industrial experience; and enhancing regional economic development.

For the government, the rationale for promoting partnership in the context of innovation and technology policy is dual, to correct for the market failure that results in under-investment in R&D by the industry, and to improve the 'efficiency' of public support to R&D.

1.2.2 Classification of Partnership

From the existing literature partnership may be sorted under various categories. As mentioned by Branscomb [9], "The easiest way to think about the types of partnerships is to recognise that they are found among all combinations of the three most important types of research institutions: universities, national laboratories and industrial laboratories. If you imagine a triangle with each type of research institutions at the vertices, there are important links among each pair. Sometimes, you will want to imagine government - both federal and state - agencies in the centre of the triangle, using their influence and resources to encourage the various links in the triangle". Thus public - private partnership can be classified according to the types and characteristics of the actors involved, such as a) university-industry partnership; b) research institute-industry partnership; and c) a combination of these, like those linking multiple government research institutes to one another and to industry.

According to yet another study public-private partnership can also be classified according to the functional objectives and goals of governments, such as support for strategic research and technology development; improving the mechanisms for commercialisation and technology diffusion; and generating spin-offs of technology-based industries. In addition, providing access to innovation financing and training, and stimulating networking among innovation actors have become more explicit objectives of partnership. The importance of one form or another of public - private partnership reflects different institutional structures and research specialisation.

If one goes by the experience of countries, while the partnership of industry with research institutes is more common in some countries, it is widespread with universities in some other countries. This probably reflects the divide between countries where universities play a major role in both basic and applied research including mission R&D (e.g. Austria, Belgium, Canada, Sweden, the UK and the USA) and countries where public research institutes play a rather substantial role in both basic and applied research (e.g. France, Germany, the Netherlands, Norway, Japan and Korea).

Thus for example, the predominance of university-industry partnerships in the USA reflects the specific national characteristics and embedded structures of university research financing. Scientists pursuing basic research in the US universities largely depend on competitive grants from extramural funds. In many European countries belonging to the Organisation for Economic Co-operation and Development (OECD), university research has traditionally been supported by 'internal' university research funds, although tighter budgets for higher education research have led universities in countries such as Belgium, the Netherlands and the United Kingdom to diversify their sources of funds. On the other hand, in France the institutes under *Centre National de la Recherché Scientifique* (CNRS) and specialized research agencies like the *Commissariat a l'énergie atomique* and *Institut national* *de la recherché agronomique* are generally more active than universities and other higher education establishments in partnering with industry. In case of Germany, partnerships have been characterised by industry collaboration with both universities and applied research institutes such as the centres under the Fraunhofer Gesselshaft and Steinbeis Foundation **[10]**. However, there has been a recent shift from the 'institution-based' collaborations towards the 'project-based' ones (for example, *Bioregio* projects) in partnership policies that involve multiple actors in the innovation system **[11]**. While public research institutes in France, Germany and the Netherlands have generally benefited from stable and permanent research funding, this situation is changing as institutes rely more on industry support. In Korea, where there is a weak tradition of research in universities, the government research institutes are the main vehicles through which public-private partnerships are promoted. Another study which concerns the evaluations of the partnerships in the OECD countries **[12]** suggests that despite the fact that the laboratory technologies can be readily commercialised, the government laboratories in general have not been as successful in comparison to the universities in licensing technology as they could have been. This may perhaps be due to a) their late entry, and b) lack of experience in cooperating with industry. Laboratories are likely to have less flexibility in partnering with industry given that their objectives are pre-set by agency missions or national R&D plans and the bulk of their funding is generally allocated on a discretionary basis rather than through competition and peer review **[5]**. In Indian context, the partnership of the Government with industry generally brings together research bodies that are funded by the central government with large, medium and small industries functioning in specific sectors.

1.2.3 Modes of Partnership

Partnership in the past has been viewed as more than simply a contract research mechanism for subsidising industrial R&D **[13]**. R&D agencies and industry have a long tradition of collaborative R&D through common modes of partnership such as the mobility of experts; formal/informal exchange of data/information on new scientific and technological advances; sharing infrastructure; sub-contracting; sponsored research, consortia, informal involvement of R&D agencies in industries activities, etc. In university-industry partnership, its most acceptable popular mode is general grants and fellowships through specific contract research, collaborative research and consortia agreements, training, mobility of experts etc.

Joint research ventures of government laboratories with the industry are commonly known form of government-industry partnership. In research institute - industry partnership, the most popular modes are specific contract research, collaborative research, consultancy, licensing of intellectual property, consortia agreements, training, mobility of experts etc. Following the privatisation of the government research establishments in the UK, contract research became a source of funds for them as well as for the Research Councils. In Canada, external advisory boards have made public laboratories more applied and client-oriented. In the USA, legislative changes in the 1980s spurred the creation of the Cooperative Research and Development Agreements (CRADAs), which are not collaborative technology programmes per se, but rather a mechanism that allows federal laboratories to enter into partnership with industry as a way to commercialise dual-use technologies **[14]**.

1.2.4 Trends in Partnership

R&D agency - industry partnership arrangements are not limited to big projects but increasingly target small and medium-sized enterprises (SMEs), often linking together the groups of small industries and multiple public research providers. There are two reasons for this. Firstly, that successful innovation in industry will increase the number of competitors, leading to improved performance in product markets and consequently job creation. The second reason relates to the general perception that SMEs face higher risk and uncertainty in technological innovation because of their more limited R&D portfolios and lack of resources such as information, human and financial capital. Market failures may also arise in product markets when the dominant position of large industries or the oligopolistic structure of a given market, where there is a limited competition, impedes innovation by SMEs. As the evaluation of Spain's Centre for Technology and Industrial Development (CDTI), which provides financial support to SMEs, suggests, the financing of research partnerships with small industries may be appropriate in cases where venture capital or other sources of innovation financing are underdeveloped **[15]**.

Trends of many partnerships indicate of the participation of non-traditional actors such as industry associations, libraries, vocational and technical colleges and even museums. Even within government, partnerships increasingly involve co-ordination and cooperation across various ministries and agencies. The implementation of the UK 'Technology Foresight' exercise involved cooperation among several government departments as well as external consultants **[16]**.

Lastly, there is also an international dimension to partnerships with cross-border relations increasingly being promoted as part of national partnership schemes or specific international programmes. While industries have long maintained commercial and R&D alliances, joint research ventures and other forms of market-driven collaboration, governments are keen to promote international partnerships. Traditionally, there have been three main objectives of publicly supported international partnerships: a) tackling global-scale issues such as climate change, oceanography, renewable energy and space exploration, that are essentially in mega-science project dimension; b) promoting socio-economic and regional cooperation in R&D through bilateral agreements; and c) technology transfer and cooperation mainly between advanced and developing countries and as part of commercial/trade agreements.

1.2.5 Conditions for Successful Partnership

It should be recognised that a partnership is not cost-free. First, it requires sunk costs to get started and involves significant transaction costs for both industrial and public research actors. Identifying and selecting partners generates time and information costs. There are also organisational costs associated with partnering. In the USA, there has been a move to reduce administrative requirements (e.g. federal accounting methods in reporting inputs and outcomes) that increase the costs of participation to industries.

The main challenge in designing partnerships through a Memorandum of Understanding (MoU) gets addressed to accommodate the various objectives of the actors involved. The attitudes of management also matter in implementing partnerships. Studies in the UK have found that some industries have a higher propensity to partner with R&D agencies than others and this may be related to senior management attitudes, awareness and prior contact with public research. Other problems relate to the changing priorities of managers. At the programme level, there is a risk of conflict between programme managers who are keener to develop their own relations rather than linking the programmes to other service providers. Public sector and non-profit partners may also be under pressure from their own priorities, so that limited attention and resources are available for the partnership. Partners must be able to anticipate from the outset what the objectives are, how and what each partner is expected to contribute, how performance will be monitored and under what conditions partnership will be institutionalised.

A problem in designing partnerships concerns the effect of R&D assistance on product market performance. In so far as partnership aims to achieve other goals beyond cost sharing, such as learning and skills enhancement, this may lead to more intense competition. In fields where technology is changing rapidly, however, partners may diverge in terms of their goals and expected outcomes, resulting in termination of the partnership or requiring adjustment to the project.

Yet another predominant factor relates to the potential limits to knowledge transfer and networking in R&D agency - industry partnership. There is also a debate on whether emphasis on such partnership with exclusive outputs (e.g. patents and licensing agreements) could restrict other forms of collaboration between R&D agency and industry (e.g. joint publishing), thereby limiting diffusion.

1.2.6 S&T Policy in Partnership

The existing S&T policy in any given country closely outlines and specifies the nature and contents of the R&D agency – industry partnership in that country. For example, science in China before 1990s was highly isolated from Industry and it was only after the Chinese economic reform that the R&D institutes got opportunity to commercialise their activities. In early period of the Republic of Korea, the development strategy followed the Japanese model, but later in 1980s there was a shift in industrial policy paradigm to innovation-based industries, and in 1990s, the policy changed to encourage SMEs and develop high-tech industry. In the UK, as will be elaborated later, the government policy is fundamentally important for R&D agency - industry partnerships with an array of relevant institutions such as the government and its agencies, higher education institutions, intermediaries and industrial sectors contributing to the development of a large number of initiatives intended to bolster the development of networks of collaboration.

In Indian context, it is evident from its Science and Technology Policy 2003 that the country is making sincere efforts to forge R&D agency - industry partnerships to take the science for socio-economic benefit [17]. This policy recognises the changing context of the scientific enterprise and the prerequisite to meet present national requirements in the new era of globalisation. It concedes that a strong base of science and engineering is a must for technology development, transfer and diffusion, stating that priority would be placed on the development of technologies, which address the basic needs of the population and make industries (small, medium or large) globally competitive; and special emphasis would be given not only to R&D and the technological factors of innovation, but also to the other equally important social institutional and market factors needed for adoption, diffusion and transfer of innovation to the productive sectors. This policy further adds that intensive efforts will be launched to develop innovative technologies of a breakthrough nature and to strengthen traditional industry so as to meet the new requirements of competition through the use of appropriate science and technologies. It stresses that every effort would be made to achieve synergy between industry and scientific research including creation of autonomous technology transfer organisations (TTOs) as associate organisations of universities and national laboratories to facilitate transfer of new knowledge / technology to the industry.

1.2.7 Accountability and Assessment

Evaluation of R&D agency - industry partnership is essential to improving programme design, assessing costs and benefits and generating vital feedback for improving policy. Partnership outcomes such as patents, commercial products, and even jobs may be easily measured in some industries. In others, such as the services sector, they may take on a more diffuse character yet still contribute to the local economy. Evaluations can shed light on the theoretical justification for government support, notably the extent to which market and systemic failures actually justify policy action.

1.2.8 Financing Mechanisms in R&D Agency - Industry Partnership

Studies have been conducted as to how public financing of partnerships should be designed and what form of finance (grants, loans, equity, etc) is most appropriate for which type of partnership. One of the ways of seeking answer is to view it from the angles of R&D agency and industry that require different types of funding arrangements at different stages in the partnership - from the R&D to the commercialisation stage. From an economic viewpoint, there are two main questions in financing partnerships. The first concerns the optimum amount of public support, whereas the second relates to the most effective type of support like grants, loans, equity and in-kind support. In theory, the answer to the first question would be the amount that lowers uncertainty, which is higher in the early phases of the technology life cycle, and the social returns are also comparatively insignificant because of the small public investment in the partnerships.

With regard to the most effective type of public support, the experience in OECD countries suggests some reasons for or against certain designs. Matching funding is often used in collaborative research programmes and consortia, although excessive bureaucratic procedures (e.g. accounting and reporting rules) may exert a heavy administrative burden on industry. At the same time, matching fund requirements as well as competition among programme participants reduce the risk that partnership projects attract only second-rate research projects and less qualified research teams. In the larger US partnership programmes that focus on generic technology, grants have tended to be favoured over contracts in some of the new government-sponsored collaborative research partnerships because they accelerate the selection and approval process. Similarly, while the provisions to recover in the event of success have been used, experience has shown that they may potentially undermine the government's basic intent of cost sharing. Loans at low interest rates are often used to fund partnerships in applied research, but it is important to reduce the risk of moral hazard and opportunistic behaviour by industry, which may use the public funds as a substitute for more expensive funds, taking benefit from a substantial reduction in interest rates.

While financial arrangements are of critical importance, the share and forms of delivery of public funding are usually the right incentives to make the best use of public money. In an auction-based financing system the industries bid for the opportunity to participate in a partnership. The rationale is that industries rather than government know better where to direct research. Under the bidding system, public funding for the R&D partnership is leveraged since the mechanism ensures that the best industries participate at the lowest cost to government. Special mechanisms concerning royalties and cost sharing are put into place to avoid opportunistic behaviour on part of the government and industries. It is important to stress that the financing mechanisms must be tied to the evaluation apparatus, which can signal when government support may no longer be necessary, or whether it should be maintained.

1.3 R&D Agency-Industry Partnership for Technology Development and Transfer

Partnership between R&D agencies and industry is one of the important subjects being discussed in the field of higher education, R&D, technology development, transfer and commercialisation. The Ministerial Level OECD Committee for S&T Policy on "Science, Technology and Innovation for the 21st Century" in its meeting on 29-30 January 2004 concluded **[18]** that changing innovation processes and the evolution of the relative contribution made by the private and public sectors have emphasised the need for strong industry-science linkages. A well-functioning interface between the innovation and science systems is more necessary than ever to reap the economic and social benefits from public and private investments in research, ensure the vitality and quality of the science system, and improve public understanding and acceptance of science and technology and the importance of innovation.

R&D agencies and industries have been working not only on standalone basis but also partnering for R&D, technology development and transfer since long. This interaction has been in place in one form or the other for more than a century, be it industrial extension service, equipment donation, consultancy, exchange of personnel, research programmes, etc. Research parks, innovation centres, interactive centres and faculty development bodies were established mainly in the West. However, the importance of such interaction was realised only in the later half of 20th Century **[19]**. The governments of most countries having realised its values are now encouraging and supporting various forms of partnerships between R&D agencies and the industry in order to improve the efficiency of the innovative base of the economy. Most policy makers today subscribe to the view that such collaboration increases the distributive power of innovation systems by allowing the smoother and faster flow of knowledge from R&D agencies to industry, the final user of this knowledge. With regard to human resources, partnership enhances the training possibilities and facilitates mobility of personnel between R&D agency and industry. The governments expect that a closer collaboration between the two will allow the former to compensate for reduced, or even lost, government funding. The partnership is also seen as a response to the requirements of the industry to bring the researches being carried out at the R&D agencies closer to market demands.

In developing countries, the public sector often needs to take the initiative since the private sector is not so developed and R&D activities largely take place in public sector. S&T system in India with its robust and graded organisational structure is now moving up to attain newer heights drawing advantages from strengths built up in front-ranking research in chemistry, biology, physics, engineering and so on. The R&D budget of the government departments in the current 5-year Plan is nearly twice of that what was in the last Plan (from Rs. 12,000 Cr. to Rs. 25,000 Cr.). Ever since the liberalisation process has started, the requirement for innovations and application of scientific knowledge has gone up and the Indian science and scientists are trying to rise to the occasion and compete globally. In India the NIS has changed in the recent past due to the exposure to market forces. A number of global players have established R&D centres in India. Large private industries have increased the spending on R&D. India has been reasonably successful in areas like biotechnology for health, agriculture, space technologies and discovering new molecules. India's conscious policies and well-orchestrated research support in life sciences has made it emerge as a vaccine superpower. The culture of patenting is being inculcated and the number of patents filed by India is growing at a substantial pace (15.5% in 2003). India today is emerging as a global R&D platform and manufacturing hub, a preferred low cost destination with better R&D infrastructure and quality consciousness in industry with new emerging areas such as biotechnology, drugs and pharmaceuticals, manufacturing, nanotechnology, etc.

Some of the newly industrialised countries have been successful in achieving technological advancement and economic growth by dovetailing technology imports with domestic R&D endeavours. In India, till recently, the two main players in the innovation chain, viz., the R&D system and industry enterprises lacked the sprit of partnership in achieving the common objective of national development **[20]**. Despite this, the domestic R&D system, which is mainly confined to publicly funded government owned institutions, has thus far done rather well in strategic and non-competitive areas of R&D and technological development, such as aerospace, atomic energy and agriculture, but its impact on the commercially-oriented industry and services sector has been minimal. However, the shift towards a networked knowledge economy has given rise to the necessity of collective effort by industry, R&D establishments, academia and the government through formal as well as informal cooperation among the constituents.

In recent period there has been an increased tendency in India towards interaction among scientists and industries to utilise R&D results for industrial application. Several factors contribute to the changing nature of partnerships between R&D agency and industry. Even the largest industries now depend on a nimble ability to combine resources and knowledge from different sources at all stages of product development. Complexity and rapid technological progress make it impossible for an industry to cover the waterfront by itself. The attitudes of the R&D agencies towards industry-sponsored research have changed, owing to cutbacks in government funding and to new opportunities to benefit from these ties through increased knowledge exchange (e.g. personnel flows) and commercial relationships, including patent licensing and fees from technology transfer. The establishment of TTO's or industry liaison offices at many R&D agencies such as the Indian Institutes of Technology (IIT's), Indian Space Research Organisation (ISRO), institutes of Council of Scientific and Industrial Research (CSIR) and the explicit inclusion of technology transfer obligations into the missions of R&D agencies are some of the indicators of changing attitudes within academia. R&D agencies no longer see public money as the only appropriate source of financing for their activities, even though it remains the main source of their funding. Such attitudes are encouraged and stimulated by the trend for governments to refocus their criteria for R&D funding towards performance and economic impacts **[13]**.

On the industry side, there is growing appreciation for the quality of research conducted by the R&D agencies. This is partly due to the emergence and expansion of science-based (high-technology) industries such as biotechnology and microelectronics, where industries need access to the skills and research input of R&D agencies. Faced with their own declining profit margins, many industries are also outsourcing a greater share of their basic research. A recent study on the growing trend to outsource R&D found that corporations take two sets of factors into account: i) *internal drivers,* which reflect corporate acceptance that they are not large or wealthy enough to know and develop everything and yet need to manage in an increasingly complex and demanding environment where innovation is the key to corporate survival and prosperity; and ii) *external drivers,* which are based on the increased opportunity to obtain knowledge available outside the corporation, particularly through partnerships with universities and research institutes **[21, 22]**.

Finally, to quote Dr. R.A. Mashelkar, Director General of CSIR **[23]** on the need for partnership between R&D institutions, academia and national laboratories with private sector, "National Laboratories, as repositories of knowledge and scientific aptitude, represent important sources of development as nuclei for growth clusters. The government has made and continues to make substantial investments in the laboratories, which have developed a significant store of technology and talent. National laboratories such as CSIR, Indian Council of Medical Research (ICMR), Indian Council of Agricultural Research (ICAR), R&D departments and institutes of Department of Atomic Energy (DAE), Department of Ocean Development (DOD), Department of Biotechnology (DBT) possess unique capabilities, facilities and equipments, thus constituting a valuable national resource. Just as the laboratories potential offer much to the private sector, the labs themselves recognise that they cannot fulfil their mission in isolation, especially given today's rapid pace of innovation. To remain effective all labs understand that they must stay abreast of rapid technological change taking place in the commercial arena. This means building and maintaining ties to the private sector. Science can make economic sense only when we wake up the scientist in an entrepreneur and also the entrepreneur in a scientist. Nations that occupy leading positions have successfully done this but in India we have not done it so successfully. Further, our science-business links have been traditionally very poor. The fundamental problem that we have today is that the research institutions and the business units in industry have different cultures. The fact that science has to make an economic sense has not dawned on our institutions. On the other hand, the fact that competitive advantage in business can only be reached by using cutting edge science alone has not been realised by our industry. There is a difference in the basic orientation between the institutions and the industry. The institutions work on the basis of scientific novelties and perceived needs, whereas the business units work on the basis of attractiveness in the market and potential for profit….. Indian industry should be prepared to assume the role of partners, who have the technical, financial and marketing strengths to take ideas to the market place. In the true spirit of partnership, the industry must integrate national R&D resources into their business strategy willingly. All this would be possible only when we can change the climate for an interaction between our institutions and the industry with an improved communication and understanding, faith in mutual growth and development of healthy working relationships."

1.4 Gaps and the Need for the Study

The above sections indicate the emerging importance and some key issues pertaining to partnerships. These include factors such as increasing globalisation and competition, funding of research, transition to knowledge based economy, IPR, changing nature of product life cycles, changing role of industry and its increasing dependence on R&D and technology. Theses developments have enhanced the role and importance of the initiatives by the governments in promoting partnerships. The broad features of these partnerships in India and abroad have been reviewed in detail and presented in subsequent chapters. This section describes some of the gaps and the needs to undertake the present investigation.

A large number of industries are today looking for new ideas and innovations for surviving the competition. It is thus necessary to create new effective mechanisms to enable generation, diffusion and utilisation of new knowledge for economic growth of the country, which would basically involve R&D agency – industry partnership. The conventional view of a 'linear model', in which new science creates new technology that in turn leads to new products and processes in the marketplace, has been replaced by a model of interdependence and continued feedback. Effective technology transfer is a key parameter determining the quality of this new model. This transfer is being underpinned by new ways of in-sourcing and out-sourcing technology throughout the process of interactions between R&D agencies and industry. The critical gap is to maintain a healthy relationship of interdependence between them. The role of intermediary agencies and their relationships with R&D agencies and industry is significant in defining this interdependence. However, there are gaps both in understanding and implementing various initiatives by intermediaries in building partnerships.

There is a widespread expectation that wealth creation in a knowledge economy depends on quality R&D, and a corresponding belief that public investment in research should lead more directly to commercial products. An emerging role of R&D agencies is to catalyse the creation of high technology start-up companies to lubricate the processes of technology transfer and exploitation. At the same time, the public is becoming more aware of the impact of technology and is increasingly critical of problems and ethical issues that seem to result from the use of technology. R&D partnerships between the public and private sectors offer a way to re-establish trust.

World over a number of studies have been conducted to study the R&D agency - industry partnerships, efficacy of existing mechanisms and impact of partnerships. The empirical studies **[24-27]** indicate that there is a gap between the industry needs and the aspirations of R&D institutions. These have been well coordinated in developed countries by studying the local needs, keeping the R&D at the cutting edge of technology, and making the industrial application and production globally competitive. Studies have shown that there are a variety of factors that act as barriers to such interaction, like lack of awareness about each other's needs, capabilities, strengths and weaknesses, absence of mutual trust and multiplicity of rules, regulations and procedural bottlenecks, that can inhibit closer ties between the constituents **[1, 28, 29]**. Even in the USA, where 'Public – Private' partnership is an integral part of their NIS, a strong need for revisiting the technology policy vis-à-vis partnerships has been reported [30]. The present study addresses such gaps in the Indian context.

There is an increased realisation that in view of globalisation and emerging competition the hitherto adopted models of building partnerships between R&D agencies, industry and the intermediaries may not help nations to benefit from S&T developments. Therefore, the need of new partnership models is being felt in different parts of the world including India. In the recent past, the Indian government has taken a number of initiatives to and continued feedback. Effective technology transfer is a key parameter determining the quality of this new model. This transfer is being underpinned by new ways of in-sourcing and out-sourcing technology throughout the process of interactions between R&D agencies and industry. The critical gap is to maintain a healthy relationship of interdependence between them. The role of intermediary agencies and their relationships with R&D agencies and industry is significant in defining this interdependence. However, there are gaps both in understanding and implementing various initiatives by intermediaries in building partnerships.

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1.5 The Problem and the Orientation of the Thesis

Any country that wants to face competition and become a global player has to address many problems. Like others, the Government of India (GOI) is also seized of these issues. One of the major ones being addressed with an ever-greater concern is on partnerships between R&D agencies and industry for technology development and transfer. The country has realised that there is a considerable scope to analyse and assess the gaps and missing linkages between the R&D agencies and industry for fruitful interaction for better, innovative and competitive technology development and their commercialisation. All the major R&D and technology organisations of the government such as the Department of Science and Technology (DST), Defence Research and Development Organisation (DRDO), DBT, CSIR and ICMR are studying this issue at length. Very recently DST through its National Science & Technology Management Information System (NSTMIS) Scheme for the period 2003-06 has decided to fund projects for conducting studies on themes such as 'Survey of industry and S&T Institution Linkages', 'Influence of Technological Innovations on the Growth of Manufacturing SMEs' and 'Linkages between S&T Institutions and Industry for Rapid Development' with an objective to generate information on success stories of R&D agency-industry partnerships and identify gap areas.

There exists a strong need to suitably address the concerns and perceptions of the R&D institutions and the industry on the issue of how technology development is to be achieved in India and accordingly evolve mechanisms or strategy. There appears to be an absence of a well-structured methodology or scheme that addresses the issue of bringing together of R&D agencies with industry providing an atmosphere for strong motivation and purpose. This has to be addressed in a systematic and scientific manner. Thus the main problem addressed in the thesis relates to the processes of building partnership, the roles of stakeholders and the associated problems of interfacing amongst them and the present thesis has endeavoured to make an assessment study on 'R&D Agency – Industry Partnership for Technology Development and Transfer in Indian Context'.

1.6 Value Addition and Knowledge Generation

The study has been undertaken in view of the increased realisation of the importance of R&D agencies and the need of their partnership with industry as the new mantra for growing and sustaining in the competitive era. In the Indian context, there has not been any detailed documented scientific study available so far in this regard and the topic has assumed such urgency that all the players including the policy makers, technology providers, technology takers and the intermediaries are regularly discussing this topic with an objective to bringing about the necessary improvements. The concerned stakeholders have expressed the need to study and analyse various features of partnerships for coming up with recommendations for strengthening the working mechanisms for partnership.

A critical appraisal of the experience in the partnership promoting efforts of select developed countries as well as some countries with emerging economies, including India, has been made in the present study giving a detailed understanding of the issues involved, important features of the partnership building process and the roles of the key stakeholders. The study compares these experiences with the Indian status to identify the gaps in Indian context. The investigations build an understanding of the perceptions of stakeholders, namely, R&D agencies, industry and intermediaries to explore the evolving interactions amongst them and understand the associated problems. Thus the findings of the present study provide an empirical data based on the practical experience of the key stakeholders, which is a baseline data to the Government and other stakeholders to proceed further in taking appropriate measures to facilitate these partnerships.

Specifically, the present work adds considerable knowledge by providing insights into the processes of building partnerships and redefining the roles of the key stakeholders as there is a very limited knowledge currently available on the perceptions of the stakeholders on building up of the partnerships.

1.7 Chapterisation

The thesis has been divided in eight chapters.

Chapter 1 is introductory and highlights various issues related to partnerships, genesis of the problem and necessity of the present investigation, orientation of the thesis and knowledge addition by the investigations.

Chapter 2 outlines the objectives of the study, research plan and methodology for data collection and analysis.

Chapters 3 and 4 respectively deal with the experience on policies, programmes and initiatives for promoting partnership between R&D agencies and industry of the developed countries, such as the USA, Japan, Germany and the UK, as well as of countries with the fast emerging economies, such as the Republic of Korea, China and Brazil, which have taken initiatives to leapfrog to technological advancements by adopting specific S&T innovation policies and generating novel structures of R&D agency - industry partnership. The chapters make a critical appraisal of specific features of these efforts.

Chapter 5 presents the Indian scenario on the linkages between R&D agencies and industry, which are mainly supported by the Government initiatives. The issues looked into pertain to the policies of the Government since independence, institutionalised mechanisms of its S&T departments and agencies promoting partnerships and the efforts of the S&T organisations for enhancing technology partnerships in order to analyse and attempt to arrive at a conclusion about the mechanism that may have an edge over the other. It compares the key features of the initiatives in select countries for enhancing development, transfer and commercialisation of innovation and technology through partnerships. The chapter also identifies salient aspects for making improvements in the existing initiatives on partnerships.

Chapters 3, 4 and 5 provide an update on related initiatives of the governments, their specific features and influence on partnerships. The understanding from this study was used in formulating the relevant questions for identifying the problems associated with building partnerships and their implementation.

Chapter 6 looks into initiation, formulation and implementation of partnerships in selected collaborative projects of R&D agencies with industry in India and draws lessons in strengthening such partnerships on the basis of micro level experience. The chapter provides an understanding of the key issues related to partnership building processes and problems associated with them in the Indian context for use in identifying the questions for designing the questionnaire.

Chapter 7 focuses on formulation of specific questions and design of questionnaires with respect to the role of stakeholders, the interface between them and the processes of building partnerships. The responses of the stakeholders to the questionnaires are scientifically analysed to propound relevant suggestions for enhancing the partnerships.

Chapter 8, the final chapter, based on the conclusions and findings of the analysis in previous chapters, makes appropriate recommendations to advance the partnership building processes, role of stakeholders and interface between them. It also includes some concluding remarks, specific contributions made by the author in the dissertation and future scope of the work.

Chapter 2

Objectives, Research Plan and Methodology

In the previous Chapter the salient features of the public and private partnerships have been spelt out particularly in the context of partnerships between R&D agencies and industry for technology development and transfer. The need to remodel the existing partnerships between R&D agencies and industry has also been emphasised. It has also been observed that there are gaps in systematically addressing the issues of bringing together R&D agencies and industry indicating a considerable scope in improving the interactions between them for better innovative and competitive technology development. The broad parameters of the issues and the problem orientation of the thesis have also been indicated in the first Chapter.

In order to systematically assess all the related issues, the following objectives, plan and methodology have been drawn out. While doing so, the study is considered as management related study and the broad approach suggested by Kotler **[31]** has been adopted that is defining the problem and the research objectives, developing the research plan, collecting the information, analysing the information, and presenting the findings, as elaborated below.

2.1 Research Objectives

As has been mentioned earlier, the main objective of the thesis is towards assessing the R&D agency – industry partnership for technology development and transfer in Indian context and making appropriate recommendations to advance the partnership building processes, role of stakeholders and interface between them. In order to accomplish this task, the following objectives have been identified:

(i) To understand R&D agency – industry partnership systems followed in other countries and in India and correlating them.

(ii) To investigate and analyse the success and failure in existing partnerships.

(iii) To suggest possible improvements towards enhancing sustainable R&D agency – industry partnerships in India for technology development and transfer.

It may be noted here that the scope of the present study is limited to the above objectives and does not attempt to investigate the financial aspects, except in an indirect manner.

2.2 Research Plan

For achieving the above laid out objectives, a research plan was evolved as below.

(i) To examine the efforts made in other countries in regard to enabling closer interactions between R&D agencies and industry. For this firstly a few developed countries, viz. USA, Japan, Germany and UK, which have been reasonably successful in this area, were selected. Additionally, the countries with fast emerging economies, viz. Korea, China and Brazil were chosen because of their similarities to India. The plan study was focused on policies, S&T structure and organisation, stakeholders and their role, technology transfer issues, partnership enabling programmes and socio-economic reasons for partnering in these countries.

(ii) To review the general status of linkages between R&D agencies and industry in India, particularly, the facilitating institutionalised mechanisms of the government S&T departments and agencies and R&D institutions. In this context the Indian government policies adopted since independence were considered and an update was provided.

(iii) To correlate the partnership experiences of India with those of the other countries for identifying the gaps and suggesting necessary measures for improvements.

(iv) To look into initiation, formulation and implementation of partnerships in selected collaborative projects between R&D agencies and industry in India.

(v) To obtain response of the working scientists and R&D manages in R&D agencies, industry and intermediaries (government S&T departments, agencies and R&D institutions) facilitating partnerships about their partnership related activities, their experience on building / facilitating partnership, and their perceptions on the changes required to re-model the existing partnerships.

(vi) To analyse the relevant aspects in building partnerships, specific to the respective stakeholders, namely, R&D agencies, industry and the intermediaries and the salient features of such interactions amongst them, based on the responses obtained as above.

(vii) To suggest necessary measures to encourage and enhance the R&D agency - industry partnerships in India for technology development and transfer.

The overall philosophy is the collection of primary as well as secondary data and correlating it.

2.3 Methodology and Data Collection

An extensive literature survey was undertaken by compiling both secondary as well as primary data.

The secondary data was collected on the work already carried out by other researchers on the topics related to the subject of the present investigation as well as on policies, S&T system, role of stakeholders in technology development, transfer and commercialisation, and the existing practices and efforts of the government and related agencies in India and in selected countries for enhancing partnerships between R&D agencies and industry. The data on the partnership promoting efforts of India and those of the selected countries was compared to understand the gaps and suggest necessary measures. The first objective was accomplished based on these inputs.

In order to investigate and analyse the success and failure in existing partnerships as required under the second objective, the use of primary data was made. This implied obtaining the general and specific experiences on partnerships of the researchers and managers in the R&D agencies, industry and partnership facilitating intermediary agencies in India. For this purpose, the methods of 'case study' and 'survey based on the questionnaires' were chosen. The method of case study focussed on the specific experience of the partners in initiating and implementing the collaborative projects between R&D agencies and industry and facilitated preliminary insights into the partnership formation and implementation process. One of the purposes of undertaking such case studies was to understand the complexity of the partnership process and also gain insights for formulating specific questions covering related aspects and issues of partnerships, experience and perceptions of involved stakeholders while formulating the questionnaires.

The stakeholders, namely, R&D agencies, industry and intermediaries, their roles and perceptions about the partnerships and experience are vital to evolve or re-model the existing relationships. Therefore a survey of the general experience of the stakeholders was felt necessary to understand and appreciate the underlying issues, studying the efficacy of the existing mechanisms, knowing the expectations of the partners from each other, and on their views for improving the present situation. For this purpose, the techniques of participation in relevant workshops, symposia and meets and the personal interviews were used. Further, the technique of survey based on written questionnaire was selected as an effective and low-cost means to collect data from a large sample.

Three sets of questionnaires were designed, respectively, one each for a) working scientists and R&D managers in the R&D agencies – the technology developers, b) industry – the technology takers, and c) intermediaries – interface agencies facilitating technology development / transfer. A copy of each of theses questionnaires is placed at **Appendix A, B** and **C**, respectively.

The third objective on suggesting possible improvements for enhancing sustainable R&D agency – industry partnerships in India for technology development and transfer was achieved from the analysis of secondary and primary data collected through literature survey of existing practices and programmes, case studies and the questionnaires. The analysis was undertaken of relevant aspects in building partnerships, specific to the respective stakeholders, namely, R&D agencies, industry and the intermediaries and the salient features of such interactions amongst them. The necessary measures were also suggested to encourage and enhance the R&D agency -industry partnership for technology development and transfer.

2.3.1 Secondary Data

The secondary data was collected from published sources such as books, journals, presentations made during workshops and symposia, minutes and recommendations of special committees and groups formulated by governments and related agencies. The data was also obtained from the appropriate sites on the Internet. **Fig. 2.1** presents a flowchart depicting the decision path that was followed while using secondary data for the present study. As may be seen, the flowchart divides into several steps. In the first step, an attempt was made to raise

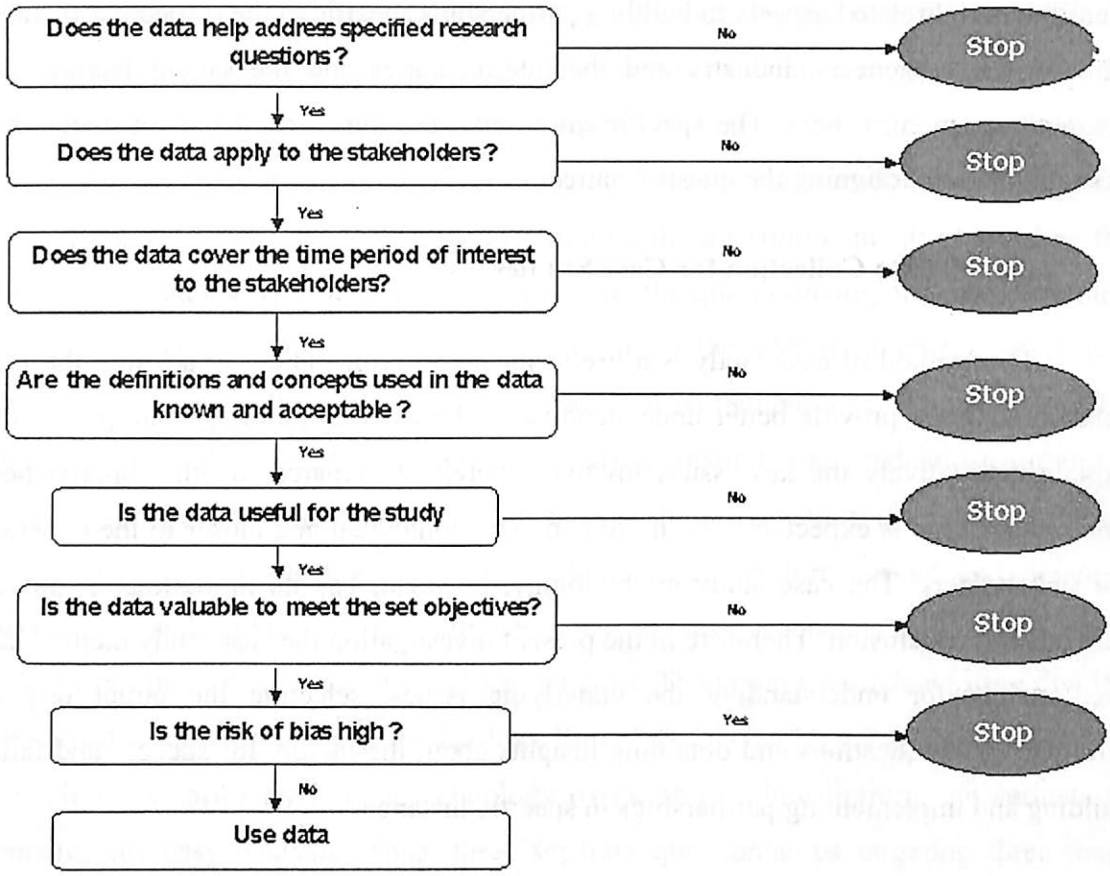

Fig. 2.1 Evaluating Secondary Data for Use in the Study

questions relating to the specified objectives. In the next steps, the relevance of the data and its time period of interest to the stakeholders were examined. The acceptability of the definitions and the concepts were looked into. This was followed by the assessment of the usability of data, its value to specific research objectives, and subjectivity. This path was followed to decide the usability of data in the present study.

2.3.2 Primary Data

The primary data was collected by participating in relevant workshops and meetings in India, which were periodically organised by government S&T departments and agencies as well as financial and industrial organisations to bring the knowledge generators and knowledge users together for faster and successful transfer and commercialisation of existing as well as new knowledge and technologies. The participation in seminars and short interactions with researchers, research managers, government administrators and officials belonging to financial and industrial organisations greatly facilitated the understanding of the problems and the issues. Based on this understanding, the insights were obtained to define and identify several related aspects in building partnerships specific to the respective stakeholders, namely, R&D agencies, industry and the intermediaries and the salient features of such interactions amongst them. The specific questions were thus formulated for undertaking the case studies and designing the questionnaires.

(i) Data Collection for Case Studies

The method of case study is a useful means to bring salient issues into the focus for detailed analysis, provide better understanding of the existing public private partnership and explain qualitatively the key issues involved therein. Compared to other approaches, case study knowledge is expected to be more concrete, contextual and closer to the experience of the stakeholders. The case study methodology, however, has its limitations in providing a generalising conclusion. Therefore in the present investigation the case study method has been used mainly for understanding the underlying issues, selecting the target respondents, formulating the questions and obtaining insights about the factors for success and failures in building and implementing partnerships in specific instances.

The partnership projects for undertaking the case study were selected in a manner that these reflected different facets of partnerships and experience of stakeholders. In all fifteen cases have been considered for detailed analysis. The selected partnership projects represented different S&T disciplines, involved the interface agencies and a number of partners to understand various nuances of partnership implementation. Some of these projects had influence of the government policies. The main focus was to understand building up of partnerships leading to successful development, transfer and commercialisation of technology. In part the study also looked into not so successful projects as well as those, which are in the process of building linkages aimed at commercialisation.

The method of personal interviews was used for discussing the individual case studies. The help was also taken of the published literature and deliberations of the workshops and official meetings relevant to the case studies. These discussions and inputs facilitated identification of a number of parameters for undertaking the case studies.

(ii) Data Collection through Questionnaire

Design of Questionnaire: A well-designed questionnaire is important to achieve the objectives and purposes of any survey. A good questionnaire provides complete and accurate information to achieve the research objectives; is easy for both interviewers and respondents to complete; and is so designed as to make sound analysis and interpretation possible. To design the basic framework of the questionnaire, several aspects were considered including i) decision on the information required; ii) defining the target respondents, iii) selecting the method(s) of reaching the respondents; iv) determining the question content; v) wording the questions; vi) sequencing the questions; vii) pre-testing the questionnaire; and ix) developing the final questionnaire. For the present study, to meet the identified objectives it was necessary to obtain data from all the stakeholders of partnerships viz., researchers and research managers in R&D agencies including research institutions, academic institutions, industry, policy makers and programme coordinators in the intermediary agencies promoting partnerships. In view of varying issues as evident from literature survey and personal interactions with stakeholders it was felt necessary to design separate questionnaires to receive data from the stakeholders of R&D partnerships. The target respondents were divided into three broad categories, namely, Technology Providers, Technology Takers and Interface Agencies / Intermediaries facilitating technology partnerships while limiting the variants of questionnaires for easy analysis. Thus, three separate questionnaires targeting three main stakeholders were formulated. **Fig. 2.2** shows how questionnaire design fits into the overall process of the research design.

The first step was to articulate the questions that research was intended to address. This meant broad understanding of the salient features of the public and private partnerships particularly in the context of partnerships between R&D agencies and industry for technology development and transfer, identifying the gaps and the need to re-model the existing partnerships. The exploratory interviews with experts, working scientists, senior R&D managers, officials in the partnership facilitating organisations like NRDC, TIFAC, DST, DSIR, etc as well as with officials from industry were conducted to discuss the problem itself as well as matters directly related to it. Simultaneously, the problem was discussed with the colleagues to benefit from their experience and a focussed view was developed based on personal experience. The iterative process as indicated in the flowchart facilitated sharpening of the understanding of several aspects related to the study. These steps led to finalisation of the research objectives, listing of specific issues to be investigated and articulation of specific questions for the questionnaire. These steps helped in defining the right type of questions. During the framing of each question it was ensured whether the question was really needed. The temptation to include questions without critically evaluating their contribution towards

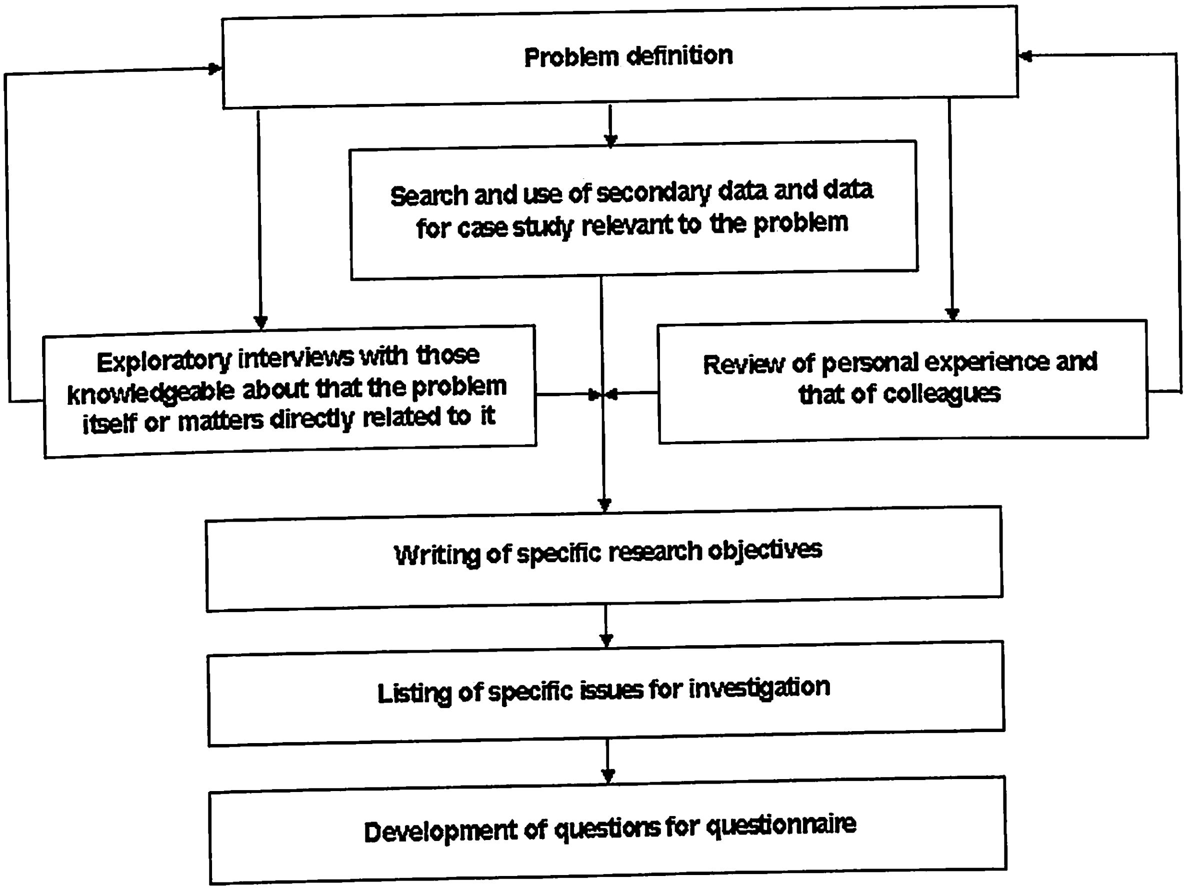

Fig. 2.2 Steps Preceding Questionnaire Design

the achievement of the research objectives, as they are specified in the research proposal, though surprisingly strong, was avoided. The expectations from the questionnaires were clearly defined. The questionnaire formulation required a range of item-writing skills. The questionnaires were structured to include the multiple-choice questions as well as open-ended questions. The multiple-choice questions that were easy to analyse were used to obtain more specific data on the considerably known topics such as parameters for success / failure. The respondents were asked to limit their options to a maximum of five in the order of priority. The open ended questions were asked for the topics / issues needing wider range of responses to get in-depth information relevant to expectations of the stakeholders or policy requirements. The focus of both the questions was made clear and specific. Questions related to respondents' direct experience and actions were included to ensure truthful and useful responses. Biased words and phrases were avoided as these could influence the responses. To avoid confusion each question addressed only one thought. The concept of participant confidentiality was given importance, avoiding their specific references or inferences. The questionnaires designed were very innovative and the selected questions facilitated the task of the participants in the survey to respond in a very easy to reply mode and at the same time eliciting from them all the requisite information. The questionnaire was pre-tested before the final survey form was circulated on selective basis. Thus, based on the feed-back the questionnaire was modified and finalised.

Dissemination of Questionnaire: Keeping in view the reality of the situation based on past experiences in similar surveys, wherein the respondents usually show reluctance to give their feedback, the final questionnaires were disseminated to a large number of scientists, experts and managers in a wide spectrum of R&D agencies including universities and institutions of academic importance, and industries representing small, medium and large scale firms in different S&T sectors. This ensured that even if the percentage responses were of the order of 15-20%, it provided the necessary data to meet the objective of the dissertation. In the present investigation, the target respondents were divided into three broad categories, namely, technology providers - R&D agencies including academia, technology takers - industries and intermediaries – interface agencies facilitating technology partnerships. The names of the targeted respondents in each of these categories, who were sent the questionnaires, are listed at **Appendices D, E and F**, respectively

In all, the questionnaires were sent to a total of 379 individuals, 172 in 73 R&D agencies and academic institutions, 190 in 159 industries and 17 intermediaries for sharing the individual and corporate experiences. The questionnaires were circulated through email and post as well as were handed over in person. Dissemination of questionnaires was rigorously followed up to ensure receiving timely and useful responses. The individuals were further contacted through telephone, emails and also personally to let them know the importance of their response, to ensure confidentiality, to bring clarity and to correct misunderstandings, if any. The individuals who have successfully implemented, or are coordinating the partnership projects, were requested to facilitate getting the responses from their colleagues and other partners in R&D agencies as well as industry having similar experiences. The method of personal sitting for getting the inputs for the questionnaire was very helpful in avoiding and correcting misunderstandings and probing inadequate responses. This method was also useful in getting a high rate of response, particularly in case of individuals needing greater motivation to provide the response and also from higher officials whose inputs were crucial and who did not otherwise have time to fill the questionnaire.

2.4 Data Analysis and Presentation of Findings

Analyses of the secondary as well as primary data was undertaken with a view to achieve the objectives stated above and draw conclusions and findings of the study. The analysis of the primary data was made based on a) the analysis of data from case studies, and b) analysis of questionnaire responses. The following sections describe the framework of analysis in respect of each of these data.

2.4.1 Analysis based on Secondary Data

The secondary data on the linkages between R&D agencies and industry and the facilitating institutionalised mechanisms in India and abroad (USA, Germany, Japan, UK, Korea, China and Brazil) were mainly of qualitative nature indicating the initiatives taken by these countries in promoting S&T through partnerships. A critical appraisal of the specific features of such efforts was made for developed as well as developing counties and presented in the respective Chapters 3 and 4. These data were conceptualised and classified to highlight their characteristic features such as policy objectives relating to development, transfer and commercialisation of technology through partnerships; means for affecting partnerships such as institutionalised S&T programmes, technology-specific initiatives like drugs and pharmaceuticals, establishment of joint centres of R&D agencies and industry and consortia; name of the programme/ mechanisms in the selected countries and their significant contributing features in impacting the partnerships. These aspects were tabulated to provide a comparative picture of the initiatives promoting partnerships between R&D agency and industry and the role of intermediaries in select countries for enhancing development, transfer and commercialisation of innovation and technology. Based on this information, analysis was made and presented in Chapter 5 to indicate good policy practices for promoting partnerships and draw lessons in the Indian context.

2.4.2 Analysis based on Case Studies

The review of the above practices enabled an understanding of their strengths and weaknesses in the context of Indian initiatives. An appraisal was also done of the general concepts and models of technology partnerships from the literature. Based on this understanding, an effort was made to look into initiation, formulation and implementation of partnerships in selected collaborative projects of R&D agencies and industry. Fifteen case studies of the partnership projects for development of technology representing multiplicity of

S&T disciplines, interface agencies and R&D agency / industry partners were presented. These included, respectively, technologies for Palm Oil, Zeolite 'A' Intermediate for Detergent, Rice Husk Particle Board, Clot Busters (TPA, UK, SK), Specialty Monomers, Drug (Amlodipine) Molecule and Leaf Cup Making Machine, all of which have been commercialised; Biodegradable Plastics technology, which has been licensed, but is yet to be commercialised; Catalytic Process for Butadiene Conversion and Sol-Gel Abrasives technology, which have also been licensed, but there is little further possibility of commercialisation due to various reasons; technologies for Flux Bonded Fly Ash Components and Cokeless Cupola for Foundries, in which technology transfer is in progress (there are some problems in the latter case); technology of Bioactive Molecules from Plant Extracts, which is being developed for transfer to industry partners; and FEM of Structures and Components and Satellite Imagery Digitisation, which are for knowledge generation and societal needs.

The salient features emerging from these case studies were analysed a) separately for each case study and b) in a consolidated form to draw conclusions and suggest recommendations about the significant dimensions of the partnerships and presented in Chapter 6.

2.4.3 Analysis based on Questionnaires

The analysis was mainly based on the inputs received from the mailed questionnaires. The responses to the questionnaires were received from forty-six researchers or research managers from R&D agencies, twenty-five stakeholders from industry and ten officials from the intermediary agencies. The responses from industry were limited, as anticipated, a large number of them expressing inability to participate in the survey due to confidentiality of the data. The respondents often answered to the queries based on their personal experience. The survey result was categorised in types of stakeholder and the scientific area of work for the purpose of analysis.

The questions posed were such that they were related to respondents' direct experience, were easy to respond, elicited specific data and were convenient for subsequent analysis. Besides background information on the respondent's organisation, the questions were focussed to probe into the specific partnership related issues of the organisation like the types of technologies developed, transferred and commercialised, motivations to enter into partnerships, or the reasons for not wanting to have partnerships for commercialisation of the developed product, factors for success and failure, expected from the partners and facilitating mechanisms. The analysis of the responses received through questionnaires included distribution, sample size and return rate of questionnaires and the general profile of the respondents from R&D agencies, industry and intermediaries. In depth analysis was undertaken of the responses specific to R&D agencies, industry and intermediaries. The analysis specific to R&D agencies included analysis of multiple choice questions related to the objectives, focus and sources of demand of R&D activities and their distribution according to scientific disciplines; analysis according to user agency focus, viz., national agencies, internationals agencies and / or both; and analysis of the methods in-place for approaching the user agencies and their distribution according to scientific disciplines. The other issues considered in this regard related to intellectual property and knowledge generation, internal regulations of R&D agencies vis-à-vis their employee scientists, and the feedback from the technology taker / industry on technologies developed and transferred.

The analysis of responses specific to industry included analysis of multiple-choice questions on the need for acquiring R&D inputs, awareness about the Indian sources for R&D inputs, funding from government and financial institutions, role of R&D in industry, and institutional and market disincentives to partnerships. The data with respect to the new technologies developed through partnerships with R&D agencies and of those technologies inducted from R&D agencies without partnerships by industry during last ten years was also compiled and analysed.

The analysis of responses specific to intermediaries included analysis of the salient features of their partnership promoting programmes and schemes (including name of the agency/schemes, purpose of support, stage at which support extended, type of funding provided, and return on funding). The analysis also covered mechanisms for monitoring of projects supported under these schemes and included aspects such as a) special features like relationship of the schemes with history of the organisation's support to industry, extent of leading role played by industry in these schemes, cost-sharing, emphasis on commercial feasibility of technology, flexibility, focus with respect to social or economic benefits, encouragement to formation of partnerships, selection process, evaluation of the management of scheme; b) driving forces of schemes like sharing of costs, expertise and risks, complimentarity, access to knowledge, increased competition, having end-user of technology, knowledge of industry on the market and the future needs, existing outlets of industry for products, and practical approach of industry to convert new knowledge developments into products; c) role of the schemes like sustaining economic growth, enhancing citizen welfare and / or achieving government mission; d) ownership of IPR; and e) mechanisms of monitoring of projects supported under these schemes like area specific review committees, periodic reviews and their frequency, visits to project sites, strong communication and legal agreements on annual milestones. Further analysis was made on the outcomes of the schemes since their inception in terms of knowledge / technology / product developed jointly by R&D agencies and industry, evaluation of the schemes and measures adopted for necessary reform, expectation of R&D agencies and industry from these schemes, impact of the schemes on technology development, diffusion and commercialisation and suggestions of respondents for improving the functioning of the schemes.

The assessment of the respondents for improving the functioning of their respective schemes included responses on achievement of legislative objectives, implementing the monitoring mechanisms, valuable achievements, serving as the potential model for other technology partnership programmes, and generating high social benefits in specific disciplines. The suggestions for improvement in the schemes related to adoption of a process involving round the year calling of the proposals, distribution of projects in various disciplines while retaining general competition, ensuring a quick decision on the basis of expert reviews and their early dissemination, assuring greater predictability and stability in funding, capitalising on core competencies in the schemes vis-a-vis the ability of managers to screen, select, monitor, and assess projects with technological and commercial promise, and using funds efficiently and effectively consistent with the goals of the schemes.

The questionnaires also addressed partnership related issues and included analysis on a) purpose of partnerships, b) response of partners to the partnership proposal, c) formulation of partnership with or without the help of external agency, d) reasons for failure and success, e) sharing of outcome of the partnership projects, f) success rate of commercialisation of the partnership projects, g) multiple-time partnership between the same R&D agency and industry, h) motives of the partners for partnership, I) factors limiting and affecting partnerships, j) views of stakeholders on partnerships, k) preference to partner with SME / LSI, l) effect of technological change on products, services, processes and organisations, m) technology development and advancements in India, n) impact of researches in R&D agencies on performance of industry, o) expectation of industry from the R&D agency, p) role of industry in India in technology development/transfer/diffusion, q) organisational structure, attitudes and objectives supporting innovations and diffusions, r) ingredients of technology development, marketing and transfer strategy, s) role of technology policy and policy instruments with references to technology management at enterprise level, t) policy measures and fiscal incentives for partnerships, u) views on government initiatives for enhancing partnerships and the need of reforms, and v) global practices vs. Indian preferences in technology partnership programmes.

Some of the above issues were further examined and analysed by defining their characteristic features. These included the query on the 'purpose of partnership' such as development of new technology for existing products, cost effectiveness, technology upgradation, increasing efficiency, acquiring new skills, sharing facilities / infrastructure, validation / clinical trials, diversification and scientific surveys. The query on 'reasons for success of partnerships' included features such as timely completion of targets, commitment towards work to be demonstrated and not just stated, managing expectation by agreeing to a firm plan of mutual benefit, setting priorities, sharing human, infrastructural and / or financial resources, partnership founded on faith, understanding and mutual respect, flexibility of approach, well-structured management and review, two-way communication and casual phone calls, focus on result rather than process, room for improvement by doing self-critic and improving performance, preparedness towards change over long-term length of the Partnership, working environment of the partner organizations, incentives through IPR, well recognized and accommodated differences in objectives, valuing the diverse inputs of the partners and fair/transparent/open selection of partners.

The query on 'motives of R&D Agencies and Industry in partnering with each other' included responses on motives of R&D agency as well as those of the industry. The motives of R&D agencies included features such as gaining insights into the research problems of interest to industry for sourcing ideas for projects and new areas for research and training, applying knowledge to solve real business problems and widen the customer base, harnessing private and public funding (Funding for ideas that is more applied in nature), fulfilling mission of the R&D agency (by adoption of user agency), establishing links with industry's national and international networks, building on excellence and reputation, complementing the physical, human and economic resource base (sharing of domain knowledge), sourcing job opportunities, sharing risk, learning new skills and techniques developed in industry like concept of process development, learning business processes / new approaches to managing projects, helping the industry to contribute to economic development of the country, broadening the experience of employees to increase their intellect and attracting skilled personnel for coordinating applied R&D programs. In contrast the motives of industry for partnering with R&D agencies included features such as benefiting from new ideas and past experiences of R&D agencies, using technologies developed in R&D agencies for renewal and expansion of their activities, harnessing public funds by bringing additional financial resources to bear on research, combating enhanced internal / international competition, establishing links with R&D agencies' national and international networks, smoothing fluctuating in-house demand, complementing physical and human resource base (accessing infrastructure, services, and multi-disciplinary expertise of R&D agency), identifying potential employees for industry and reducing risk and overall expenses by sharing costs, releasing staff time etc.

The query on the responses of R&D agencies, industries and intermediaries linked to the functioning of R&D agencies included aspects on part of R&D agencies as well as those on part of the industry. The aspects on part of R&D agencies included promotion / recognition - depends on peer reviews and papers published, nature of Research - not always industry oriented, objective - knowledge generation and expansion with valuation through publications, focus - long-term research with no emphasis on urgency, no incentive for partnership, non-profit status of R&D agency, and legal protection of IP. The aspects on the part of industry included promotion - depends on technologies developed / commercialised, nature of research - directed, strategic and applied research, objective - knowledge generation for development of product and process and restriction on publication and communication with valuation through patents or revenue generation, focus - short-term goals with high pressure of time, no incentive for partnership, profit oriented status of the Industry, and overstretched provisions of IP.

The views of stakeholders on partnerships were sought on 'preferences for types of partnerships' such as formal and informal; 'preference for modes of partnerships' such as sponsored research (sharply focussed in terms of objectives, time, money, IP sharing etc), mobility of experts, information exchange on new scientific and technological advances, sharing infrastructure, exchange of data, consortia (provides capability to handle large multi-disciplinary projects), informal involvement of R&D agency in the activities of Industry, sub-contracting; 'appropriate stage in innovation chain for of forging partnerships' such as lab or bench level feasibility, production prototype and pilot plant, engineering prototype and testing, commercial introduction or operation use, testing and modification, protecting IP, basic research / discovery of a principle, diffusion to other areas, widespread adoption and social and economic impact; 'preferred forms of financial support' such as grants, equity, loans or their combinations; and 'need for technological information and databases facilitating partnerships' such as information on indigenous and foreign technologies, patents, testing facilities / pilot plants available in the country, short term technology training programmes, technology development funding agencies and information on technical barriers to trade as well as databases on individual experts, certification / regulatory agencies for quality control and tests carried out by them.

The query on the 'impact of researches' provided options such as very large / large / medium / small / very small impact. The views on the expectations of industry from R&D agencies were sought through options such as giving solutions to technological problems through consultancy, developing new technologies, products and processes for the growth of industry and providing assistance in adaptation of new technologies.

The method of qualitative aggregation was used to extract the findings from the collected data, as the sample data was not very large. Three separate compilations of discipline-wise replies to each question by each of the three stakeholders were made. The observations were converted to numbers on the basis of the responses to specific questions in the questionnaires. The method such as tabulation and frequency distribution were used to make inter-comparison among the same stakeholders as well as among different stakeholders, particularly for the multiple-choice queries. Very few stakeholders indicated their options in the order of priority due to which the ranking could not be possible. However, the top priority options indicated by the respondents were specifically highlighted. Most of the open-ended questions related to qualitative responses and facilitated critical insights into the characteristic features of several issues addressed by them. The critical insights so obtained provided valuable inputs to examine, evaluate and analyse the partnerships in the Indian context and used to clarify the concepts contributing towards making conclusions and useful suggestions.

Thus the responses to the questionnaires have been scientifically analysed and logically presented in Chapter 7. By applying the qualitative aggregation method for analysis of the survey data, operating guidelines, which are flexible to cater to future requirements and demands of different stakeholders to further enhancing the R&D agency – industry partnerships, have been recommended.

Chapter 3

Partnerships in Developed Countries

The previous chapter has delved on the objectives, research plan, methodology for data collection, framework for analysis and presenting findings of the study. In this chapter, the focus is on providing an update on the partnership promoting programmes and initiatives of select developed countries. The chapter makes a critical appraisal of the trends in partnerships in such countries with a view to compare these developments with initiatives in India and identify relevant gaps for better definition of the objectives of the thesis.

3.1 Introduction

Governments are addressing different aspects of functioning of the innovation systems and are therefore increasingly assuming the role of honest brokers, along with some of their traditional functions in supporting education, training and R&D. Countries, which are behind the technological frontier, not only need to gain access to and master the technologies used by the leading countries, but also put in place the institutional structures inducing technological advancement. Most technologies are operated through appropriate institutional structures. Therefore, the approaches adopted in management also become an essential part of the catch up process. One of the roles of the governments is to formulate S&T policies that are generally designed by nations in light of their economic growth trajectories and different cultural and philosophical views about the role of S&T and promote economic growth through innovation.

The increasing complexity, costs and risks involved in innovation enhance the value of networking and collaboration, which in turn encourage generation of new forms of technology links involving two-way relationships aimed at sharing technological knowledge and partnering on R&D, training, manufacturing, information management and marketing. Such technology partnerships are knowledge links that give the industry access to other organisations' skills and capabilities. The growing need for partnerships between R&D agencies and industry has led to a systematic approach for the policy formulation for innovation [32].

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In order to give a lucid picture of how the government - R&D agency - industry partnership functions in various countries for promotion of technology development and transfer it is important to grasp specific nuances of the scientific management and structures and roles of these diverse entities in the countries. This chapter discusses different policy mechanisms and innovations systems in some developed countries with the objective of moving towards establishing benchmarks for the promotion of innovation. In order to study the experience of industrially developed countries we have selected the USA, Japan, Germany and the UK and have provided brief information on some of the programmes and initiatives currently operating in these countries. These overseas initiatives will later be compared to the Indian experience and support structure, including incentive and cooperative schemes with a view to draw lessons and inferences in defining objectives of the study.

3.2 United States of America

3.2.1 Introduction

With the end of the cold war the USA embarked on several major initiatives to reinforce its S&T base with the clear understanding that the economic success largely depends on the strength of the country's S&T infrastructure. Another objective of these new initiatives was to continue maintaining its hegemony in the world. The USA has always recognised that academic research with university involvement is vital to an economy built on new technology. Therefore it has been making efforts to promote the high technology economic development through close interaction of the government, industry, R&D institutes and academic sector. Another major initiative of the USA in the recent years has been to redirect the national laboratories under the federal government from their Cold War mission to conduct applied and basic research to provide the country an edge in global security and to encourage these labs to become partners with industry **[33]**.

3.2.2 Management of Scientific Research in the USA

The USA has a distinctive system of science management in which a) there is no single ministry dealing with research; b) the lead player for public research is higher education; and c) the majority of R&D activity takes place in industry sector. Research funding in the USA is through an intermediate level, such that there are organisations that are funded to fund others, rather than carrying out researches by themselves. The USA has a massive, dispersed and complex R&D system. It has always maintained a strong element of basic research within its overall federal research profile and therefore even though the huge R&D spending is dominantly on applied and industrial research, the considerable public investment in research plays a strategic role notably in supporting basic research and carrying out investigation in fields not high in commercial interest. In fact, even during the severe drop in the research budgets in 90s, there was a tendency to protect the basic and university research as compared to the applied research.

The structure of the research system and the Federal support for R&D in the USA have remained stable over the years **[33]**. The USA has had a continuing, large Federal research budget, which fostered the development of an important stratum of research-intensive universities, both public and private. During the 1990s, civilian research emerged more prominently and has remained so until very recently, with a mixed public-private economy of resourcing and delivery.

A defining feature of the USA system of science management is pluralism. It enables multiple sources of initiative and empowerment with respect to research activity and has proved to be the most successful research system. Another unique feature is that it is not a unified national system. It has multiple goals and priorities emanating from different sources. Each administration has its own priorities for research, as expressed in the President's Science and Technology Policy Agenda and achieving these is through a complex and negotiated process involving the committee system of the USA Congress, in which changes can be and are made at many points. Over the past decade the federal government has been giving enhanced emphasis on biomedical and related disciplines. This development in the very broadly defined field of Health is most significant among the various individual agencies and is an example of how goals and priorities emerge, not through a unified national process, but through the sectoral mobilisation of resources.

The White House Office of Science and Technology Policy (OSTP) in its secretariat role for the National Science and Technology Council has important policy coordination responsibilities. The executive branch of the US government has four offices or councils, which advise the President on science and research, namely, (a) National Science and Technology Council (NSTC), which coordinates policy and budgets for multi-agency S&T activities; (b) OSTP, which helps co-ordinate Federal science activities to meet presidential goals, and jointly with the Office of Management and Budget (OMB), issues an annual budget memorandum on R&D priorities besides providing the secretariat for the NSTC; (c)

President's Council of Advisors on Science and Technology (PCAST), which helps NSTC secure private sector involvement in its activities; and (d) OMB, which coordinates the overall budget process of the President. A number of bodies offer advice to the various research policy actors and have budgetary implications. It includes the National Science Board (NSB), the National Science Foundation (NSF), the National Academies (the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine), the National Research Council (NRC), and the American Association for the Advancement of Science (AAAS) and a wide variety of other professional bodies and special interest groups. In addition to these the USA has a strong philanthropic tradition wherein the major foundations provide significant funds for research institutions. Further the government seeks to stimulate private investment in research through measures such as tax preferences and the priorities and goals are influenced by the uptake of these credits.

The quest for patents and IPRs is another factor in setting the priorities and goals. In 1980 the introduction of Bayh-Dole Act **[34]** enabled the researchers to retain the patent for research that was funded federally and thus facilitated technology transfer.

The US research system has an in-built set of checks and balances in keeping with the style of the country's constitution and governance. It has remained relatively stable over a period of years and no major structural changes are presently envisioned. The research system maintains diversity, which is seen as strength in maintaining the risk taking behaviour, which by common consent has served the US system well in its effective performance in S&T.

3.2.3 Research in Government Laboratories and R&D Institutions of the USA

At the level of the Federal government, about 30 agencies have research budgets. The most significant ones among these in terms of the Federal S&T budget are the National Institutes of Health (NIH) comprising ~25 institutes and centres each focusing on health related areas; National Aeronautics and Space Administration (NASA), funding research in three major fields, viz. Space, Earth and Biological / Physical Sciences; National Science Foundation (NSF) having no R&D laboratories of its own, but functioning to promote and advance progress in science and engineering, fund programmes across the spectrum of research and support science and research education at all levels with about one fourth of the Federal funds for basic research in higher education; Department of Energy (DOE) focussing on energy, national nuclear security and environmental quality; and Department of Defense

(DOD) that has, in addition to defence, additional funds for R&D of technologies and systems addressing terrorist threats. Other agencies like the Department of Agriculture, Department of the Interior, Department of Commerce, Environmental Protection Agency, Department of Transportation, Department of Education and Department of Veterans Affairs also have considerable Federal S&T budgets.

There are over 720 government laboratories and institutes under various Federal departments and agencies listed above. The main goal of these agencies is to convert the research and technological assets and skills of the R&D institutes and laboratories to assist private industries, initiate programmes to transfer technology and create dual-use technologies that can be used by both the Federal government and industry. Essentially, the new mission of the Federal laboratories is to transfer ideas, scientific and technological innovations and people or organisational experiences from a Federal facility to the private sector with the primary aim of enhancing US industrial competitiveness.

3.2.4 Research in Higher Education System of the USA

The USA has a distinct higher education system comprising about 3000 institutions. In terms of the 2000 Carnegie Classification **[35, 36]** these include Doctoral / Research Universities (6.6%), Master's Colleges and Universities (15.5%), Baccalaureate Colleges (15.4%), Associate's Colleges (42.4%), Specialized Institutions, including theological seminaries, teaching colleges, military academies etc. (19.4%) and Tribal Colleges and Universities (0.7%). The bulk of research is undertaken in the Doctoral / Research Universities comprising 261 institutions offering a wide range of baccalaureate programmes and committed to graduate education through the doctorate. Of these, 166 are public, 93 private non-profit and 2 private for profit. Certain specialised institutions, such as medical schools and medical centres, may also undertake significant research. Although only a small proportion of higher education institutions are research intensive, because of the scale of the country, a significant number of institutions in numerical terms are involved in research. The higher education institutions are the dominant publicly funded research performers. While industry performs the largest proportion of R&D within the country, a sizeable number of research-intensive private universities also undertake research activities **[37]**.

3.2.5 R&D Partnerships between Key Stakeholders

The US Government, concerned with the erosion of its technological superiority, launched several partnership promoting programmes in the 1980s with an aim to enhance US competitiveness. In the USA the term 'Partnership' reflects the reorientation of publicly supported R&D. The R&D policy generally focuses on integration of research, education and commercialisation, IP arrangements and involvement of industry in the planning as well as in the evaluation of the programmes **[38]**. The partnership programmes involve all the stakeholders including national laboratories, universities, non-profit organisations and the industry. The Federal as well as the State Government agencies facilitate and use their influence and resources to encourage partnerships among various stakeholders, which are forged and implemented among all combinations of these key players.

A. University - Industry Research and Technology Partnerships

University – industry partnerships bring the knowledge generation together with the knowledge utilisation and are potential instrument for effective dissemination of knowledge among stakeholders. Most of these are bilateral having relationship of one university with one company, but sometime there are the consortia of several universities and several companies. Mobility of researchers from science to industry and vice-versa usually is very high **[39]**. Universities view basic research as their major role but value the incremental funding and the access that partnerships give faculty and students to new and interesting technical problems and employment opportunities for their graduates. On the other hand applied R&D is more common in industry. Moreover, university collaboration is a means of monitoring new developments in S&T and carrying out exploratory research in technical areas beyond the strategic core of the business. For technology licensing most universities have transparent and extensive policies, extensive and effective contractual procedures, and TLOs varying in size and competence and having professional staff. It is a requirement for researchers to disclose inventions, which may be commercialised through the TLOs that receive some percentage of the gross income and in addition take equity in new spin-offs based on university technology.

An assorted array of partnerships exists between the universities and industries, each with a different goal and offering diverse benefits to the partners as determined on a case specific basis. Six major mechanisms of the partnerships are discussed below.

- **Sponsored Research**: Direct sponsorship of university research by industry is the most frequent form of research partnership. The industry provides funding for a specific work during a limited period of time. The sponsor expects a license to use and exploit IP resulting from the funded research. The nature and scope of the license is generally defined in the research agreement.

- **Collaborative Research**: Certain federally funded partnership programmes such as the multiple agencies Small Business Technology Transfer Programme (STTR) and the NASA Centres for the Commercial Development of Space Programme require university-industry collaboration as a condition of obtaining the Federal funding. University-industry research centres, which may or may not have Federal funding, likewise are established on the premise of collaborative research **[40]**.

- **Consortia:** Consortia enable the members to leverage financial investments and provide cost-effective access to generic, precipitative research projects. In a university-based research consortium, participating companies join forces and contribute resources, often in the form of an annual fee, to support research in a technical area of common interest to the group. The consortium members normally have first right to negotiate a commercial license to the results of the research conducted by the consortium. SEMATECH is the world's premier university research management consortium providing competitive advantage to its member companies by delivering relevantly educated technical talent and early research results. It plans and manages a programme of basic and applied university research on behalf of its participating members. One of its major accomplishments is the generation of semiconductor manufacturing technology, which has brought the Government into the partnership as the third partner. Another example of the US Consortium is the Blue Laser Consortium established by Defence Advanced Research Projects Agency (DARPA) **[4, 41]**.

- **Technology Licensing**: As impetus to industrial growth the university technology licensing has been especially significant in knowledge-based industries such as Biotechnology. The licensee typically grants right to the company to manufacture, make use of and sell commercial products under the university's IPR's.

- **Start-up Companies**: The 'start-up' or 'spin-off' companies are established to high-risk opportunities to commercialise a university technology, rights to which are obtained through a license agreement. Most university spin-off companies include the entrepreneurs from the universities.

- **Exchange of Research Materials**: The exchange of research materials between university scientists and industry has become a common practice. To facilitate these exchanges, material transfer agreements are utilised. These agreements generally stipulate that the materials are provided for research purposes only, and not for commercialisation.

Two most successful outcomes of partnership efforts of the academic institutions of the USA are the 'Silicon Valley' and 'Route 128', which are the premiere technological concentrations not only in the USA, but also in the world **[42]**. These regions have been devoted since World War II to the creation of new IT following different strategies.

i) **Silicon Valley**: Dr. Termen at Stanford University in 1950 observed that, "Industry needs access to high quality research in order to be competitive in international market. Academicians ought to commercialise the results of their research for the overall good of humankind." The concept of 'Science Park' was born with this philosophical approach around 1950. To build the Park the university had plenty of land, which it started leasing out to the industry that found this long-term lease as attractive as outright ownership. Thus the Stanford Industrial Park was founded with an aim to create a centre of high technology close to a cooperative university **[43]**. The University decided to make leases limited to only high technology companies that might be beneficial to Stanford. The first company was Varian Associates that moved into the first building in the park in 1953 and Eastman Kodak, General Electric, Preformed Line Products, Admiral Corporation, Shockley Transistor Laboratory of Beckman Instruments, Lockheed, Hewlett-Packard, and others followed soon after. By the 1980s, the entire park was rented out to area firms.

The regional advantages such as presence of world-class academic institutions, namely University of California at Berkeley, brilliant scientists, military procurements of semiconductors and the pleasant climate of Northern California conspired to produce one of the greatest science parks in the world. The government greatly contributed to the success of the Park. The Science Park today is known as the North Carolina Research Triangle. Thus the

Stanford Research Park, through the efforts of a few influential professors and university administrators, became the nucleus of the budding Silicon Valley. In short, Silicon Valley has a regional-based industrial system, that is, it promotes collective learning and flexible adjustment among companies making specialty products within a broad range of related technologies. The region's dense social networks and relatively open labour markets encourage entrepreneurship and experimentation.

ii) **ROUTE 128**: Like Silicon Valley, academia, industry and government influenced the development of electronics-related companies on the 65-mile highway surrounding Boston and Cambridge in the area's major research universities. The Massachusetts Institute of Technology sought to provide the theoretical and practical foundations for its students to make major contributions to society. While doing so, it engaged in a seemingly endless number of advancements in world class R&D and decided to reach out to large companies such as DuPont, Kodak, Xerox in Massachusetts and outside the state. The Federal government supported the expansion of this region with great vigour. In 1970s and 80s the Department of Defence itself had accounted for over 60% of federal R&D spending in the State benefiting the industry the most in terms of contracts etc. Several smaller firms got created to solely fill government orders. Government agencies ranging from the NSF to the NASA to the DOE provided universities and industry millions of dollars for R&D, resulting in rise of whole new industries in sectors such as computers, biotechnology, artificial intelligence, etc. By 1990, the State contained over 3,000 high-technology firms that included some of the firms, which became the pillars of the 128 community: Digital Equipment Corporation, Raytheon, and Lotus Development.

In direct opposition to the Silicon Valley's reliance on risk-taking and partnerships the focus here had been on convention, decorum, and self-reliance. In short, Route 128 firms are much more staid and centralized affairs than the loose confederations of scientists and engineers in northern California. Their histories, attitudes and strategies have created technological societies similar in products manufactured but very different in their economic and social manifestations.

B. Industry - Industry Partnership

There are occasions when significant partnerships are forged within the diverse members of each type of institution, a typical form of which is the Research Association. The industry – industry partnerships is the linkage of the supply chains between large innovative industries and their most innovative suppliers. This is the emerging pattern through which US firms are seeking to accelerate the commercialisation of innovation. It gives rise to the need for more partnering between these smaller, specialised industries and the universities and national laboratories. Where the larger industries used to rely on their corporate research for the ideas to be used by their suppliers, they now outsource the innovation. The smaller, technically specialised industries are expected to be highly innovative, but they must look to the universities and national laboratories for those new ideas.

C. National Laboratory - Industry Partnership [44]

A mechanism that was established by the Congress for National Laboratory - Industry Partnership as a result of the Stevenson-Wydler Technology Innovation Act of 1980 (amended by the Federal Technology Transfer Act of 1986), is the Cooperative Research and Development Agreement (CRADA) **[45]**. CRADA is a written agreement between a private company and a government agency to work together on a project allowing the Federal and the non-federal partners to optimise their resources, share technical expertise in a protected environment, share intellectual property emerging from the collaborative effort, and speed the commercialisation of federally developed technology. In addition to industry CRADA encourages partnership of national laboratories with non-profit organisations and academia. The partners collaborate and share the results of a jointly conducted R&D project, where each partner pays for its own internal costs and receives benefits in proportion to its own investment. Government support for CRADA projects is mainly in kind including staff hours and access to federal laboratory facilities. While CRADA-initiated partnerships are mainly considered as promoting technology transfer rather than research, they nevertheless contribute to building the infrastructure for co-operative R&D. The skill base of R&D agencies is used for development of high-tech industry. Success under CRADA is evaluated not in terms of money generated but in terms of the number of CRADA signed and products commercialised.

Implementation of CRADA has faced a number of problems in the initial years mainly due to the administrative complexities and delays in negotiations by the federal agencies sponsoring the laboratories and by inflated and unrealistic expectations from Congress and the administration. Besides this, two conceptual problems were envisaged with CRADA. First of these related to an impression that the technical knowledge created by a national laboratory was fully paid for by the federal agency pursuing government mission, and this knowledge was now free to be shared with industry after having made its contribution to the mission. Paid for it might be, but the knowledge and skill still had value, and industry had to have concern about the fairness of the process through which the firms may be selected as the partner to share this knowledge, and other may be rejected. The second problem was that when single firms are selected as CRADA partners, there must be a public interest justification for the expenditure of additional Federal money to sustain the laboratories costs of participation. Here the problem was conceptually no different from the use of government agency funds directly to subsidize commercial research in a single firm. However, CRADA is now recognised as a useful mechanism that finds a benefiting role where the project serves government requirements as well as private interests and facilitates the commercialisation of government research, which has been undertaken for the purpose of accelerating private sector progress in a field of legitimate Federal concern **[46]**.

The other programme called 'New Generation of Vehicles (PNGV)' was created by the Clinton Administration in 1993 aiming at inventing a prototype 'super-efficient' car, bringing together the big three automakers (DaimlerChrysler, Ford and General Motors), Federal agencies and several government defence, energy and weapons laboratories. In this partnership several government agencies, coordinated by the Technology Administration of the Department of Commerce, apply the assets of national laboratories to an industry consortium, United States Council for Automotive Research (USCAR) of automobile manufacturers and their component suppliers with a clearly defined goal of an automobile technology that allows 80 miles per gallon with minimal pollution and reduced oil consumption early in the next decade **[47]**.

D. National Laboratory - University Partnerships

There are examples of national laboratory-university partnerships that predate CRADA by many years and appear to have none of the difficulties associated with them. This is a much more natural and effective diffusion mechanism than CRADA. For example, the Joint Institute for Laboratory Astrophysics (JILA) is a genuine partnership between NIST and the University of Colorado at Boulder for studying the radiating hot gases far from states of thermodynamic equilibrium. Here the institutional secret is that each party to the partnership funds 100% of its own internal costs yet can legitimately claim credit for the work of both partners jointly. Thus on paper at least JILA is twice as productive as another laboratory with the same skills and facilities. Incidentally, JILA is an institute in which the Bose (*Satyendra Nath Bose*) condensate, a new form of matter, was discovered a few years ago.

E. Universities - Industry – R&D Institutions Partnership with Federal Support

In early 80's the US Government initiated the Advanced Technology Programme (ATP) to creatively support and catalyse partnership between universities, research organisations, industry and State and local entities to develop innovative technologies by sharing the cost with industry and encouraging it to invest in longer-term, high risk research with payoffs far beyond private profit, and helping it to raise its competitive potential. Its merit-based, rigorous selection process ensures high quality, objectiveness and fairness. ATP accelerates development of early-stage, innovative technologies. To facilitate knowledge diffusion, ATP encourages industry to publish and share their results and pursue patents and licensing to give others a chance to benefit from new knowledge created in ATP projects. In these tripartite partnerships involving university, national laboratory and / or R&D institute, all of which are generally funded by the government, and industry, which is generally difficult to manage, the government gives the coordinating role to one of these partners. University is often a subcontracting partner, but the rules forbid it to be the lead partner in an ATP project, whereas in programmes coordinated by NSF, such as the Engineering Research Centers, a university is the lead partner expected to attract industry support and research involvement.

ATP projects focus on the technology needs of American industry, and not those of the government, and research priorities are set by industry based on its understanding of the marketplace and research opportunities. For profit companies conceive, propose, co-fund, and execute ATP projects in partnerships with academia, independent research organisations and federal labs. It follows strict cost-sharing rules, making the Joint Ventures (two or more companies working together) to pay at least half of the project costs, large companies participating as a single firm to pay at least 60% of the total project costs, and SMEs working on single firm ATP project to pay a minimum of all indirect costs associated with the project. The critical features of ATP set it apart from other government R&D programs **[48]**.

Manufacturing Extension Partnership (MEP), launched in mid 80's and coordinated by NIST, is a network of technology assistance and business service providers **[49, 50]**. It is a network of not-for-profit centres in nearly 350 locations nationwide, whose sole purpose is to provide small and medium sized manufacturers with the help they need to succeed. MEP is funded by federal, state, local and private resources to serve manufacturers. That makes it possible for even the smallest firms to tap into the expertise of knowledgeable manufacturing and business specialists all over the USA, who are the people with experience on manufacturing floors and in plant operations. MEP are decentralised, make their own strategies and services appropriate to the state and local conditions. They employ field personnel with industrial experience for interacting with industry to identify their need, broker resources and develop appropriate assistance projects. In addition they also provide information, technology demonstration, training and referrals. NIST provides matching funds and periodically reviews the quality of member centres. With the growth of MEP system almost 30,000 manufacturing firms, mostly SMEs are being assisted annually through assessments, technical assistance projects, workshops and other services.

Practically every Federal research agency has created and funded significant research programmes to promote and enhance national competitiveness through technology development. The government provides significant funding directly to universities to enhance national competitiveness through alliances with industry. The Industry University Cooperative Research Centers and Engineering Research Centers of the NSF and NASA's Centers for the Commercial Development of Space are examples of federally sponsored programmes mandating that the university centre collaborate with industry partners.

For a more flexible institutional arrangement, Federal agencies might look to States, or groups of States, to take the lead in assembling a consortium to move a regionally important industry into a world leading position. In this situation, the State-brokered consortium can come to the Federal government seeking support (either financial or through cooperation of federally supported laboratories and universities) for the most advanced research needs of the consortium. These State programmes include Ben Franklin Technology Partners of Southeastern Pennsylvania (BFTP/SEP), which are part of an economic development organisation with a mission to foster economic growth by building partnerships that develop and apply technology for competitive advantage [51]. These represent in the aggregate a larger investment in industrially relevant research than the Federal government's civilian technology programmes. The State programmes also enjoy, in most cases, bipartisan support within their congressional delegations and the State government.

The high technology economic development is promoted in a locality by government, industry and universities acting together to strengthen community foundations, viz. excellent schools, high workforce skills and sources of scientific and engineering knowledge. A pioneering effort of this type is the Research Triangle Park (RTP) of North Carolina, which began in the late 1950s to transform one of the poorest regions of the nation into what is today a world centre of technology, finance, education and research **[52]**. The centrepiece of the effort was the privately financed RTP that aimed at housing the companies attracted to the technology and trained people generated by the three major universities, University of North Carolina, North Carolina State University and Duke University. RTP today occupies nearly 7,000 acres, and the research organizations housed there employ about 50,000 people. Businesses in fifty or so additional satellite research parks within a 15-mile radius employ an additional 70,000 people. A primary lesson of this history is the need for sustained commitment. Establishing the conditions, in which high-tech growth can take off, requires attention to basic economic and institutional foundations, such as education, research, private investment, infrastructure, to serve a long-term economic strategy. A second lesson is the need for partnership. None of the three parties (State government, business and universities) could have achieved this success without the steady cooperation of the other two **[53]**.

3.2.6 Technology Transfer Issues

Federal involvement in technology transfer arises from its interest in promoting the economic growth that is vital to the nation's welfare and security. The movement of technology from the Federal laboratories to industry and to State and local governments is achieved through technology transfer. It is a mechanism to get federally generated technology and technical know-how to the business community where it can be developed, commercialised and made available for use by the public sector. Economic benefits of a technology or technique accrue when a product, process or service is brought to the marketplace where it can be sold or used to increase productivity.

In recent years however there has been an apprehension that the research from the Federal laboratories is not being transferred at an acceptable level to the market place. This lack of transfer has been the result of several factors, but one of the primary factors has been that federal research has been available to everyone. On the surface this seemed appropriate, but the end result has been that industry has not wanted to invest in technology in which it could not protect its investment. To resolve the problem, the U.S. Congress has taken several legal measures to promote technology transfer and protect private sector investment. **Table 3.1** shows the important pieces of legislation enacted since 1980.

Table 3.1 Legal Measures adopted by US Government to promote Transfer and Commercialisation of Technology

Initiative	Enactment Year	Important Features
Stevenson-Wydler Technology Innovation Act (PL-96-480)	1980	Established foundation for TT within the Federal government for enhanced info dissemination from the Federal labs to private industry; Required federal labs to play more active role in cooperation with potential users of federally developed technology; Provided means for others to access lab developments through CRADA
Bayh-Dole Act	1980	Enhanced transfer and commercialisation of technologies developed in universities under federally funded research; Enabled researchers to own the inventions made under federally funded research and get involved in commercialisation process which resulted in formulation of TLOs; Permitted exclusive licensing to industry, to manufacture resulting products in US contributing to the US economy.
Small Business Innovation Dev. Act (PL 97-219)	1982	Enforced federal agencies to set aside special funding for relevant small business R&D.
Cooperative Res. Act (Pl-98-462)	1984	Relieved companies and consortia of the threat of treble damages from antitrust suits when they participate in joint pre-competitive R&D
Trademark Classification Act (PL-98-620)	1984	Amended the Bayh-Dole Act making the terms and benefit to all stakeholder more attractive in terms that labs can decide about licensing, any private company can obtain exclusive licensing etc.
Federal Technology Transfer Act (PL-99-502	1986	Amended the Stevenson-Wydler Act by making a number of changes that impact on the technology transfer process so that e.g., inventor from government owned and operated labs receives minimum 15% share of royalties generated through patenting or licensing. The Act established Federal Laboratory Consortium for Technology Transfer.
Exclusive Order 12591 Facilitating Access to S&T	1987	Assured the government owned government operated labs to enter into cooperative R&D agreements with other Federal Labs, state and local governments, universities and private sector with Federal labs having to apprise these parties about their TT opportunities. Resulted in establishment of the "Technology Share Program" and "Basic Science and Technology Centers" with university partners.
National TT and Advancement Act	1995	Further amendment to the Stevenson-Wydler Technology Innovation Act regarding inventions made under cooperative R&D agreements, and for other purposes.

Despite government legislation and development of transfer support programmes, barriers to effective transfer and tangible economic results however still remain. In some cases transfer activity has been encouraging but considering the amount of government funding appropriated for technology cooperation and transfer programmes, not enough technologies have been developed or transferred. The main impediment to transfer activity is the R&D laboratory's inability to work effectively with industry and to use applied research to develop competitive technologies. Although communication has improved, industrial partners often accuse the R&D agencies of being unresponsive and insensitive to business needs. It is difficult for R&D agencies to match research to near-term commercial product development. Federal programmes for technology transfer are designed to reduce barriers to transfer and make Federal institutes accessible and useful to industry. The programmes' purposes vary from marketing technical assets and expertise to promoting and establishing technical assistance for businesses and to providing financial assistance for businesses that are unable to fund dual-use development projects.

3.2.7 Conclusion

A summary of the significant efforts being undertaken in the USA to promote the R&D agencies - industry partnerships is presented in **Table 3.2**. As may be seen, most of these efforts were initiated only in early '80s with an aim to internationally achieve the technology competence.In the USA most of the national laboratories concentrate on defence-oriented research, though the Government emphasises on dual use technologies necessitating the partnership between these labs and the industry. Academic research is however vital to an economy built on new technology. There are privately and Federal / State funded universities in the USA, in all of which it is common to get funding from industries within the country as well as from multinationals outside their geographical boundaries. In many universities there are research parks and research centres in specific areas, which act as conduit for the flow of S&T collaborations. Universities and industry have become increasingly comfortable with each other as partners, developing structured approaches to harmonising the independence of research with the transfer of technology. University - industry research partnership is the primary factor in the growth of the US S&T. It has contributed and will continue to contribute significantly to national competitiveness as well as the intellectual vitality of universities and the economic health of industry in the USA.

Technology transfers and defence conversion programmes in the USA have not been as successful as was expected. In fact, not enough transfer activity is occurring to justify the level of funds appropriated by the Congress for transfer and conversion programmes. Although every government institute and laboratory can point to instances where it has been successful at transferring technology, it is difficult to measure this success. The keys to improved technology transfer programmes are improving interaction between industry and federal agencies, allowing the process to be customer-driven rather than supplier-driven and attracting more small and medium-size businesses to transfer activities. The problem however is that small businesses do not have the money to form these partnerships.

Table 3.2 Major US Efforts to promote R&D Agencies - Industry Partnerships

Programme / Initiative	Purpose	Special Features	Partners
CRADA (Cooperative Research and Development Agreement) of NIST, 1980	Speeding up commercialisation of federally developed technologies through resource optimisation and sharing technical expertise and IP emerging from joint effort.	Written agreement between industry and govt agency to work together. Industry gets access to the expertise and facilities of the federal institutes. Success is evaluated not in terms of money earned but in terms of the number of CRADA signed / products commercialised.	Federal institutions and industry as well as academic and not for profit institutions
ATP (Advanced Technology Program) of NIST, Early 80's	Creatively support and catalyse partnerships to develop early-stage innovative technologies	Cost sharing with industry, encouraging it to invest in longer-term, high-risk res. with payoffs far beyond private profit; Helping it to raise competitive potential	Research and academic institutes, industry and state and local entities
STTR (Small Business Technology Transfer Program), 1982	Provide JV opportunities for SMEs and premier research insts and fosters the innovation necessary to meet the S&T challenges in the 21st century.	Federal funding to SMEs and res. insts for collaborative projects only. In addition government encourages SMEs to explore their technological potential / commercialise it by providing funding support under SBIR	Universities, research institutions and industry
Govt - Univ. - Industry Res. Roundtable, 1984	Incubate activities of on-going value to the universities, research institutes and industry	Identifying important themes for partnership; discussing the partnership related issues and resolving them jointly with all the stakeholders	Senior most reps from government, universities, and industry
MEP (Manufacturing Extension Partnership) of NIST, Mid 80's	Transforming manufacturers to compete globally	Networking of resources, supporting greater supply chain integration, and providing access to technology for improved productivity	Research /academic institutes, industry, non-profit agencies as well as federal / state governments
ERC (Engineering Research Centers) of NSF, 1985	Intellectual foundation for industry to partner with univ. on resolving generic, long-range challenges and producing knowledge base for steady advances in tech. and their speedy transition to marketplace.	Interdisciplinary centres wherein activity lies at the interface between the discovery-driven culture of science and the innovation-driven culture of engineering.	Universities and industry as well as research institutes
STC (S&T Centers) of NSF, 1987	Promote partnerships to ensure conversion of knowledge to technology	Fund important basic res. and education activities; Encourage TT and innovative approaches to interdisciplinary problems	Universities and industry as well as research institutes
SEMATECH (Consortium of Semiconductor Manufacturers), 1987	Accelerate commercialisation of technology innovations into manufacturing solutions	Create opportunities for flexible partnership and conduct strategic R&D to reduce time from innovation to manufacturing; delivers relevantly educated tech. talent and early res. results through planning / managing basic and applied univ research programmes.	Universities, industry and other consortia
Blue Laser Consortium of DARPA	Joint hunt for a blue solid-state laser for expanding electronic information storage capacity and reducing cost	Mechanism for sector specific partnership	Universities, research institutions and Industry

Space Research Partnership Centres of NASA	Extensive networking to benefit space exploration, other NASA missions, and life on Earth	Centres located at universities or non-profit institutions (12) contributing to space exploration by leveraging resources creating dual-use technologies	Research and academic and non-profit institutions, and industry
PNGV (Partnership for New Generation of Vehicles) of Commerce Dept. 1994	Plan and manage R&D activities for wide ranging leading-edge potential to dramatically improve fuel economy of and reduce emissions from cars and light duty vehicles	Partnership between Federal government and US Council for Automotive Research (USCAR) having DaimlerChrysler, Ford, and General Motors as its members aiming to Invent a prototype 'super-efficient' car by using the assets of national labs to an industry consortium.	Universities, national laboratories and industry

3.3 Germany

3.3.1 Introduction

Germany's public research infrastructure evolved in a complex environment characterised by the traditional Central European view of natural science as a value in itself and by the demand from industry, by the inertia of public institutions and tensions between federal and state responsibility for education and research.

After World War II, the distinction between basic and applied science emerged not only in the USA, but also in most other industrialised countries as a paradigm of public research. Basic research, which is performed without premature thought of practical use, became seen almost as the equivalent of the private under-investment in R&D. In Germany, the separation of pure and applied science was traditionally institutionalised in universities of technical and natural sciences. But it was not until the integration of the Fraunhofer, when the division between basic and applied research was officially carried out in the non-academic public research sector as well.

Germany possesses a diverse range of public research institutions, which are committed to different means and technology transfer channels. Publicly funded R&D infrastructure in Germany can be subdivided into three groups, namely, universities, polytechnics and non-university research. It has vastly varied institutions in the areas of Natural Sciences, Technology and Engineering, which include 81 universities, 90 technical universities (*Hochschule*), 81 Max-Planck institutes, 47 Fraunhofer institutes, 16 Helmholz centres, 51 "*Blaue-Liste*" institutes, 24 Federal research institutions and 47 local research institutions in the Federal States. In the 1990s, Federal and state governments spent about DM 25 billion per year for R&D, half of which went to universities and polytechnics and the remaining to public research laboratories. In addition, DM 5 billion was directly given to private businesses as project related subsidies for R&D. While tradition-bounded universities offered limited potential for ambitious research policy, the Federal or local governments established additional research laboratories to fill gaps in the wide spectrum of technology transfer to private business. In addition to such well-known organisations as the Fraunhofer, Max Planck or Helmholtz, there is a bunch of larger and smaller publicly financed research institutes and federal agencies. Although the main purpose does not always consist of technology transfer, they still have some effect on industrial innovation.

While Germany may boast in patenting of ranking third after USA and Japan, its major focus is on basic research as well as on long-term application oriented basic research. Because of the inherent complexity and resource limitations, comprehensive measures have been adopted by the Federal Ministries and the Ministries under the Federal States (Länder), research institutes and other elements of the S&T system for achieving excellence in science.

3.3.2 Management of Scientific Research in Germany [54, 55]

Germany has a distinctive science system, which is a federal system with shared responsibilities between Federal and state governments and institutionally divided within both the higher education and the public research institute sectors. The system is institutionally complex, serving a populous federated country with an advanced and diversified industrial economy. The large bulk of R&D in Germany is performed by industry, which is evident from the fact that in 1999 the share of R&D by industry was 63.3%, 15.5% by higher educational institutions and only 13.3% by the public research institutes (federal and private non-profit). Public funding for different aspects of research is organised in one of the three ways: i) from federal sources (e.g. project funding); ii) from state sources (e.g. institutional funding for higher education institutions, state R&D institutions); and iii) jointly from federal and state sources according to agreed formulae (e.g. institutional funding of public research institutes of national significance; project funding for universities; categories of research infrastructure).

The current German research system is highly versatile and multifaceted, broadly categorised in groups like higher education institutes (universities, Fachhochschulen etc.), Max-Planck, Helmholz Centres, Fraunhofer and *'Blue-list'* Institutes, Federal research institutions and local research institutions. All these features are abundantly intertwined and account for the largest share of research expenditure after industry. In addition, there is a horde of larger and smaller publicly financed research institutes and Federal agencies with specific research activities like material testing, pharmaceutical approval and defence technology assessment, whose main purpose does not necessarily belong to hardcore science or technology transfer, but also exhibits strong influence on German science. Basic research in natural sciences has a long tradition in Germany, and its success is inextricably linked with the use of excellent large-scale facilities at national and international research centres.

A. Research in Higher Education System of Germany

Universities in Germany have a long tradition of research in natural and medical science reaching back to the middle ages. Social and natural science universities are known mostly for teaching and basic research without aiming at commercialisation. Their main transfer channel seems to be the publication of research results. In contrast, technical universities usually carry out industry-related research, which, like in the USA, have been formed since the last century to enforce inventions and technical applications of scientific findings but have subsequently focused on basic research. They receive up to 40% of external research funds from industry although it is less than 10% of all their research spending. As the public law imposes some restrictions on technology transfer, universities have established legally independent external institutes in order to gain administrative flexibility. In 1993, these institutes made up about 4% of all researches at universities and this share was rapidly increasing in the 1990s.

Polytechnics (*Fachhochschulen*) are widespread within Germany with a specific role of often being specialised in the same technical fields as local businesses and supporting SMEs through consultancy and supply of graduates. They emerged from engineering schools and have gained reputation for down to earth research and applicable engineering know-how, compensating the shortcomings of universities that are oriented towards basic research. They mainly focus on education, but also conduct research albeit on a much smaller scale than universities.

It is noteworthy that university patenting in Germany appears to be quite prolific. The share of patent applications listing university professors as inventors has been rising steadily and represented 4% of total applications by the mid-1990s **[56]**.

B. Research in Non-Academic Publicly Funded Research Centres

The history of publicly funded research centres in Germany set up in addition to universities goes back to the last century. Their main mission typically was to support the national economy. Subject to few exceptions, the justification for their establishment was to either maintain the international competitiveness of private companies or to close a German technological gap to other nations, mainly to the USA. The first public research agency, the Physikalisch Technische Reichsanstalt, was founded in 1887 under the initiation of Werner von Siemens, one of the first German industrialists. In 1911, the Kaiser-Wilhelm Society was set up with the strong financial and ideological support of the German chemical and heavy industries. Some of its institutes were reunited in the Max-Planck Society (MPG) and became quite independent from industry, from where they now receive less than 1% of their total budget as research grants. MPG comprise ~60 institutes, that together with the institutes of the Fraunhofer Society (FhG), are designed to complement research at universities and are often located within their proximity, even being headed by university professors. The latest external evaluation of MPG proposed the instrument to set up research groups as temporary institutes in order to strengthen the networking of research activities between universities and MPG. In the meantime 3 research groups of MPG have been devised and agreed at universities.

(i) German Research Foundation

The mandate of German Research Foundation (DFG) according to its statutes is to serve science and the arts in all fields by supporting research projects carried out in universities and public research institutions in Germany, promote cooperation between scientists, and forge and support links between German academic science and industry and with partners in foreign countries **[57]**. It performs this task as a self-governing organisation of German science. Even though the Federal Government predominantly funds it, the choice of research themes is done without any interference of the Government. Thus autonomy is a special feature in its functioning. DFG is comparable to Research Council in British and western European terminology or (National) Research Foundation in American terminology. It has Collaborative Research Centres and Transfer Centers in Humanities, Biology and Medicine, Natural Sciences and Engineering Sciences. It also offers particularly outstanding Collaborative Research Centres the opportunity to set up a career development group. Transfer Centres aim at the rapid transfer of ideas and findings of scientific research into the realm of application. They take the form of collaborative projects between research institutes and industrial enterprises or other interested parties.

(ii) Fraunhofer Society (FhG)

The Fraunhofer Society (FhG) was founded in 1049 in Bavaria as a geological institute, but was soon transformed into an organisation of institutes for industry like applied research **[58]**. FhG was fully integrated in the research-funding programme of the Federal Research Ministry in 1968. Over time, the Fraunhofer institutes established themselves as the leading contract research institutions for industrial innovations in Germany. Its 47 institutes are comparatively small and regionally dispersed and altogether employ only 3300 scientists and engineers. Whereas the MPG and big science laboratories receive full public funding, most of the Fraunhofer institutes receive a small share of about 40% of their budgets as non-project-related public funds. That is why they are keen to acquire research funds from industry and through public research programmes FhG institutes pool their expertise in cooperative 'Alliances', like Microelectronics Alliance, Materials and Components Alliance, Production Alliance, Surface Technology and Photonics Alliance, and Polymer Surfaces Alliance to offer their customers a broad range of services.

(iii) Helmholtz Association

15 national research centres involved in scientific-technical and biological-medical research together form the Hermann von Helmholtz Association of National Research Centres (HGF) constituting by far the largest non-university research organisation in Germany **[59]**. Their budgets account for about 20% of the Federal Ministry of Education and Research (BMBF) research budget. The Federal and state authorities share the total budget of the Helmholtz centres in a ratio of 90:10.

The centres were earlier funded as institutions because they were originally founded for a specific purpose, but in autumn 2001 all the stakeholders decided to review the centres to bring necessary reforms of the Helmholtz Association. The first round of evaluation of all research fields involving >200 internationally renowned scientists, more than half of them from abroad, was finished in 2004. The reform suggested several changes including introduction of new budgetary provisions, most important one being carry-over of funds to the subsequent year and abolition of binding staffing schedules. As a prerequisite for these changes, controlling procedure that is suited to scientific activities have been adopted and modern business management methods have been applied to monitor the research centres. The core element of this reform is the programme-based funding of the Association, meaning that since the scientific work of the centres is focussed on research programmes, the distribution of the funds should be based on programmes instead of the centres as such. The experience gained so far reveals that it is a major step forward towards strengthening the flexibility, competitiveness and achievement-orientation of the Helmholtz Association, allowing priority setting for the Association as a whole and stimulating competition and cooperation between the individual centres while not affecting their legal independence.

(iv) Leibniz Association

The Leibniz Association of German Research Institutes (WGL) comprises ~80 institutes employing about 5000 scientists and engineers in the natural, engineering and medical sciences, out of which 16 perform service functions for research (information centres, specialist libraries, research museums) **[60]**. The first public research institution, the Physikalisch Technische Reichsanstalt, is now one of the several Federal agencies with R&D activities. WGL works predominantly as a partner to universities, business and policy makers in an area of research between basic science and applications on an international level. Leibniz Association is not a funding agency. The so-called 'blue list' institutes are financed equally through funds of the Federal and host state governments, but research grants from industry are scarce. The donors have taken fundamental decisions on the further development of joint funding in resolutions passed by the Bund-Länder Commission for Educational Planning and Research Promotion. A comprehensive quality management system with the elements evaluation, cost-performance accounting and programme budgets has been introduced at the institutes of the Leibniz Association in order to further improve R&D.

(v) Steinbeis and Other Foundations

The German foundation sector, although still small, has been growing in recent years. The Steinbeis Foundation for Economic Promotion, founded in 1971, acts as an interface between academic researchers and businesses **[61]**. It is a globally active service organisation for the transfer of technology and knowledge, pursuing innovation, providing impulse and putting ideas to work. Closely interconnected with science and economy, the Foundation has created an internationally unique transfer network, which bundles special competencies of all branches of technology and management. For nearly 25 years the Foundation has provided a bridge between academia, research bodies, politics and industrial companies with great success. The successful transfer of technology and knowledge is guaranteed by direct access to the latest scientific research results, by long years of experience in implementing scientific research into the economy and by constructive co-operation of all partners in the Steinbeis network.

The Steinbeis Foundation, which is autonomous, flexible, decentralised and customer-oriented, encompasses >450 Transfer Centres and subsidiaries as well as cooperation and project partners in 42 countries. These transfer centres are mostly located at research institutes, universities, technical universities and professional academies and specialise in different fields providing services like the development of individual products, processes and systems; fine-tuning of key processes; re-engineering and optimisation of existing processes; procedures design; development of new marketable products and processes from prototype development via testing; patent applications right down to series production / implementation of product or user-specific pilot projects; arrangement of contacts and cooperation with partners from other R&D fields, academia and / or industry. Many university professors direct these transfer centres and through the immediate involvement of crucial carriers of knowledge, accelerate the development of research results into competitive products, procedures and processes. ~4000 experts of all fields are part of the Steinbeis network, working towards securing the information lead for businesses and their competitiveness in the growth markets. Steinbeis Transfer Centers have immediate access to a pool of these professors, engineers, natural scientists, experts on industrial management and designers, covering an enormous range of specialisations. Thus it can engage the right specialists to work on each project and can concentrate on particular needs on the spot, no matter how specific. In 2001 the network completed >20,000 projects with turnover of >EUR 80 millions.

The *Stifterverband fur die Deutsche Wissenschaft* is another charitable institution active nationally in promoting science, humanities, research and education, including endowed chairs, academic prizes, and supporting new types of research co-operation between universities, business and public research institutes. Established in 1920, it works exclusively with private funds, including company and individual endowments, and manages a number of foundations.

3.3.3 German Innovation Centres

German Innovation system has been very successful, as it involves an excellent combination of corporate financing system, system of R&D institute – industry partnership, educational and vocational training system jointly operated by the Government and industry, system of inter-company relations and innovation policy. German industry not only supports, but also helps in smooth functioning of all the above systems. The concept of German Innovation Centres was conceived in 1983 to focus at technology development **[62, 63]**. These were established with the objectives of providing technical support to technology oriented start-ups and infrastructure to be used by the companies; promoting co-operation between science and economy and regional development potentials for technology oriented enterprises and start-ups; initiating technology park projects and technological cooperation; supporting regional economic development; providing information on innovative technology; and improving regional innovation framework. **Fig. 3.1** shows their growth since 1983 **[62]**.

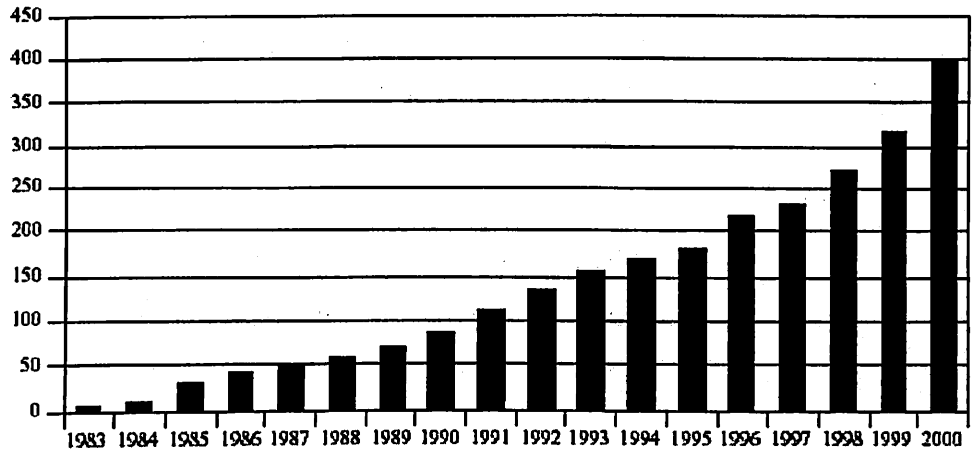

Fig. 3.1 Growth of Innovation Centres in Germany

As may be seen, the number of these centres has now exponentially grown to 400, thanks to their success stories. Catalytic factors for their success are i) their policy, which creates an atmosphere; ii) financing; iii) cooperation amongst the members (external experts) of the centre; and iv) cooperation with foreign agencies for technology transfer directly through their intermediates. They are located all over the country, 45% near the scientific and research institutions and universities, 28% in the rural areas and 27% near the industry.

Furthermore, the reform of public sector employment law has provided important impulses for increased orientation to their performance, and this has meanwhile been extended to non-university research centres. As a result of the reform of public sector employment law, important impulses have not only been provided for performance-based pay, but also for a considerably earlier commencement of independent teaching and research by young researchers. The performance-based elements are successively being extended to the HGF and the MPG. The Employee Inventions Act was amended in 2002 to ensure rapid translation of ideas from higher educational institutes into new products and giving right to these institutions to claim the inventions of all their employees and get them patented and commercialised through their patent and commercialisation agencies.

3.3.4 Federal Ministry of Education and Research

The Federal Ministry of Education and Research (BMBF) occupies a central position in the German S&T system. It is instrumental in implementing the federal policy aiming at increasing investments in education and research for restoring and consolidating Germany's business efficiency and international competitiveness; developing the research system to reduce isolation, increase flexibility and create a sharper profile and stronger focus; increasing project funding for bringing more flexibility, competition and quality into research; and increasing joint activities between research centres, academia and industry for improving innovation and developing a clearer and more efficient competition oriented profile **[64]**. Thus its major role is to act as an interface between science, industrial research and general state S&T policy. It does not direct, nor control S&T policy and strategy, but rather acts as a formative moderator, albeit as a partisan of its own institutional interests. All BMBF research, ultimately, is aimed at societal improvement. BMBF is currently focusing research funding under its programmes on those fields, which have great leverage for growth and employment. One of the important issues being addressed by BMBF is on the promotion of the commercialisation of research results. The Commercialisation Campaign of the BMBF is promoting a professional infrastructure in order to facilitate the patenting of research results and their economic exploitation on the part of universities. The EXIST campaign supports university-based researchers who are willing to start their own spin-off companies by providing them with the necessary training and advice.

BMBF is composed of Referats (Working Units), which cover different application areas (biotechnology, genomics, microsystems, electronics, health, traffic, environment). Each Referat has its own criteria for programme definition, derived from their specific remit and research fields. Whilst they have similar general goals, the precise criteria differ. Recently, a research gap has been identified in the area of clinical research and attempts are being made to link basic research to clinical practice. Genome research is also an expanding area and a new Department has been set up in this area.

Germany has a very high dependence on established industries, which rely greatly on production technology, e.g. automotives, electrical goods, machine tools. In general, BMBF programmes are defined through consultative studies performed by industry and research institutes. The selection of "Production technology" as a BMBF programme area was made at the political level, but based on input from a range of expert advisory sources.

Last year the Federal Government gave a new strong impetus for international scientific research with large-scale facilities. It is planned to make long-term investments available to an amount of more than €1 billion for new research facilities in Germany to secure a top position for basic scientific research.

3.3.5 Government Support for Private Sector R&D and Innovation

Germany depends on the innovative capacity of young industries, which not only create new products and services, but also new internationally competitive jobs. The Federal Government has therefore set up an integrated concept, known as Innovation and Future Technologies in the SME Sector – High-Tech Master Plan, to remove the obstacles to the establishment and growth of young innovative industries and to ensure financing conditions, which promote their growth. The purpose of these measures is to help and develop the great potentials of young innovative industries. Changes in the design of specific instruments are explained in more detail below.

(a) Venture Capital

On the venture capital market, VC providers are currently demonstrating strong reservations with respect to new investments. There are hardly any new VC funds, and fund managers are reluctant to invest in young technology industries. VC market for the very early R&D-based phase of start-ups has almost entirely dried out in Germany. In this phase a new architecture of promotion is required that provides the VC market with additional liquidity and opens up new financing sources to R&D-based start-ups. For this reason, the Federal Government has adapted the instruments of venture capital promotion to the new situation by establishing a new joint VC fund consisting of the funds of the ERP Special Fund and the

European Investment Fund (EIF) to invest in German VC funds for early-stage and growth companies together with private investors.

A KfW VC Programme, started in 1995 and continuing till date, offers re-financing of VC invested by private banks in SMEs and provides VC investors with long-term financing at favourable conditions. The programme on Venture Capital for Small Technology-Oriented Firms (BTU programme) that was also started in 1995 but was over in 2002 addressed a perceived shortage in private VC for technology-based start-ups and small, fast-growing technology oriented firms **[65]**. Further, the Federal Government at the national and EU levels has committed considerable public resources to promoting VC in the hope of stimulating start-up firms and innovation **[66]**.

The Federal Government has also launched a seed fund for R&D-based start-ups. It would be designed to ensure sufficient financing opportunities in the early stages of a start-up in which private investors (VC funds, etc.) have not yet made any commitments. It will also be necessary to provide more VC than before for innovative, well-established SMEs **[67]**.

(b) Tax Treatment

Since the removal of an R&D investment allowance and faster write-offs for R&D investment (physical capital) in 1989, no special tax incentives for R&D were introduced in Germany. However, tax policy has always been regarded as an important instrument for improving overall profitability of enterprises, thereby giving industry more leeway to finance investments and innovations. German government has now adopted the tax relief measures for 2004 and 2005 that will offer additional financing opportunities to industry as well as relieve the tax burden on citizens and companies. The tax relieve measures include reduction in maximum tax rate by 42%, which is the lowest rate ever applicable in the Federal Republic of Germany; reduction in the corporation income tax rate by a standard 25%, etc. In the scope of its tax policy, the Federal Government is pursuing the goal of an internationally competitive taxation of VC in Germany in order to provide efficient incentives for the provision of private capital. Realising the importance of creating a reliable planning basis for the industry in the tax policy, the Federal Government in co-ordination with the federal states, has improved legal certainty concerning a number of previously undefined tax scenarios.

(c) Direct Public Funding of Business R&D for SMEs

The Federal Government increased the sums made available for R&D promotion for SMEs by 32% from 1998 to 2002. It can be assumed that the total support provided by the Federal and state authorities will reach 5,000 industries and thus a major part of the businesses engaged in R&D activities. Evaluations of the BMBF's specialised programmes confirm the enormous leverage of the measures. Accordingly, the industries use each Euro from R&D promotion as an incentive to increase their own R&D budget by another Euro. Nevertheless, the proportionate share of small and medium-sized enterprises has been declining both in the R&D budget of the German economy and in overall innovative activities since the mid-1990s. Although the number of industries engaged in continuous research increased according to surveys of the Centre for European Economic Research (ZEW), many SMEs, which conducted research sporadically, have withdrawn from the process of innovation. The Federal Government intends to use the measures listed to efficiently strengthen the involvement of small and medium-sized enterprises in innovative activities.

(d) Programme Innovation Competence for SMEs

Programme Innovation Competence for SMEs (PRO INNO) is the scheme under the technology policy of the Federal Ministry of Economics and Technology (BMWi), which is managed by Association of Joint Industrial Research (AiF) **[68]**. The programme has three main elements: (a) development of an innovation-friendly environment, (b) international research cooperation, and (c) promotion lines, the last of which addresses innovation financing, technological consultation or cooperation. PRO INNO scheme promotes national and international research partnerships between SMEs and other SMEs or research institutions through grants and exchange of national and international staff. The Programme is very close to the market aiming at strengthening the activities of German SMEs by supporting their activities in R&D. The participation is open to foreign partners so as to encourage know-how transfer and access to new markets. 124 out of 1117 projects are trans-national with partners in 33 countries, the majority in Eastern Europe. At present the dominant partnership is contract research, with 10% of research in universities being industry funded **[69]**. This does not fully exploit the comparative advantages of universities.

The PRO INNO programme, which is aimed at creating a network between SMEs and research institutions, has a very widespread impact. Since 1999 PRO INNO has initiated R&D expenditures in 4,850 industries. In the year 2003, as in 2002, ~1,000 SMEs took advantage of the programme for the first time. The 2^{nd} phase of the programme 'PRO INNO II' was initiated in 2004 to introduce significant modifications to this successful promotion campaign. In order to improve the utilisation of PRO INNO by SMEs in the former West German states, the access limitation for these enterprises is cancelled. In order to also support trans-national partnerships in the scope of national programmes with a widespread impact, PRO INNO II provides for a specific promotion bonus for projects involving European partners, also within the framework of the Europe-wide Network for Market-oriented R&D (EUREKA).

(e) Promotion of Industrial Co-operative Research and Development

The programme for the "Promotion of Industrial Co-operative Research and Development" (IGF) supports sectoral innovation networks between industry and science through >100 research groups of AiF in a project-specific approach. Additional elements of competition, such as openly awarding research jobs, will be introduced in order to create incentives for more competition among research institutions and to include research establishments not previously participating in IGF. The relevance of the projects for the SME sector will be preserved or enhanced by an even stronger inclusion of SMEs in project development and accompanying committees. Finally, in cooperation with AiF, the usability of the research results will be evaluated more profoundly and refined through random inspections of the research associations.

(f) Innovation in Former East German States

In order to compensate existing location-related disadvantages of the research and innovation activities in the former East German states, the Federal Government is providing additional assistance to enterprises and research institutions there. ~3,200 research projects were promoted under the R&D special programme from 1999 until late 2003. Under the InnoRegio programmes **[70]**, more than 700 R&D and educational projects received support in 36 regional innovation alliances in the East German states. These were designed to implement regional innovation concepts and to build up industrial 'clusters' in the respective regions. ~70% of the promotional funds granted up to 2006 are expected to go to the SMEs. The BMBF's 'InnoRegio' and 'Innovative Regional Growth Cores' programmes have successfully implemented the region-oriented innovation policy approach in the East German states over the past three years. By promoting joint projects between SMEs and research institutions, research competencies and innovation potentials are strengthened through innovation-focused self-organisation. The initiative 'Interregional Alliances for the Markets of Tomorrow' supports 33 regional networks, which are at the very beginning of their development and are experiencing a strong momentum for an innovative, regional alliance through the organisation of so-called innovation forums.

On 1 January 2004, the new 'Programme to Support Research, Development and Innovation for Sources of Economic Growth in Disadvantaged Areas' (INNO-WATT) came into force. Compared with its predecessor, 'R&D Special Programme for the East German States', this programme concentrates more on the engines of growth. Applicants have to prove that they have complied with their obligations to use the results of the previously promoted R&D projects and have efficiently marketed these results or transferred them to other companies.

The new promotional competition 'Network Management – East' (NEMO) launched in 2002 is continuing with the 4th round of competitions in 2004. The formation of innovative, market-oriented networks between small companies in the former East German states is supported by proportionate subsidies for external management, which will be reduced over time. This will result in concentrated technological competence, the development of joint market strategies, and the opening up of new employment opportunities.

3.3.6 Promotion of Federal Research and Technology Programmes for SME Sector

It has been realised that the transparency concerning the existing promotional programmes, non-bureaucratic application procedures and targeted programmes are of key importance, especially for the SME sector. For this reason, the Federal Government is further simplifying the conditions of using its research promotion as well as its customer friendliness by improving the systems for electronic application for easy application procedure and further improving project management. The time span between the idea for a project and the decision about its promotion is being shortened by additional simplification of the processes. At the same time, the efficiency of the promotion granted is closely monitored and improved, if necessary, by enhanced regular evaluations of the specific promotional measures. All SME-oriented technology programmes within the portfolio of the Federal Ministry of Economics and Labour (BMWA) are subjected to harmonised terms and uniform calculation methods in the future. The wide range of specialisation of SMEs is specifically accounted for by thematic opening clauses for the SMEs in the new specialised programmes. Furthermore, in suitable cases, SMEs have the opportunity to apply for inclusion at any time, regardless of deadlines.

Where this is not possible, the largest number of deadlines are offered, thus keeping the waiting time between the project application and the granting of promotion as short as possible. An increasing number of transfer and diffusion schemes within the specialised programmes allow the SMEs easier and faster access to potential innovations, especially if developed by scientific institutions.

The Federal Government aims to improve the German share in the 6th EU framework programme concerning research with a total volume of approximately €20,000 billion (2002-2006). The EU is planning an SME share of 15% of the thematic priorities. Accordingly, two important SME-specific programmes, namely, 'Co-operative Research' (CRAFT) and 'Collective Research', were launched. The SME advisory network was regionalized in co-operation with the Innovation Relay Centres (IRC), which exist in all federal states. A success-related remuneration for the advisory services of the IRC helped Germany to attain a top position in terms of successful applications for SME-specific subsidies. The 'Network for International Technology Cooperation' promoted by the Federal Government maintains 15 offices in 13 countries that support German SMEs seeking technological co-operation schemes with foreign companies and industry-related research institutions. They provide assistance in the search for suitable cooperation partners and accompany the cooperation schemes locally. Placed under the uniform leadership of AiF, the network concentrates on the Central and East European countries, the European successors of the CIS states, and on the dynamically growing and technologically interesting Asian states, namely China and India.

A diversified mosaic of promotion, loan and investment programmes, co-operative and network initiatives as well as research and advisory infrastructures has emerged in research and innovation promotion in favour of SMEs in Germany. It is designed to account specifically for the special investment opportunities and obstacles of different groups of SMEs. However, the efficiency of these measures also depends on their transparent presentation and conveyance. The Federal Government has ensured that each enterprise receives a complete overview of the investment promotion opportunities available to it by a simple phone call or on a web page. With the newly established SME advisory service programme, the BMBF has created an attractive service for SMEs in search of suitable innovation subsidies and possible partners for cooperation. This programme mainly consists of information services tailored to the needs of SMEs, counselling concerning all promotion opportunities at the Federal, State and EU level, and practical guidance for filing applications.

3.3.7 Conclusion

Partnerships in Germany are characterised by industry collaboration with university as well as research institutions. There has been a shift in partnership policies away from institution-based collaboration towards project-based partnerships that involves multiple actors in the innovation system. The education and research system in Germany is in the process of being reformed. This reform is part of the planned reorganisation of the overall Federal structure, the aim being to improve the Federal and state governments' ability to act, assign political responsibilities more clearly and increase appropriateness and efficiency in the discharge of responsibilities. BMBF is focusing research funding under its programmes on those fields, which have great leverage for growth and employment. This means strengthening information and communications technology as the basic technology and driver of growth in many branches, as well as its linkage with other technologies and its integration into applications (motor vehicles, machinery, services), micro-systems engineering, optical technologies, materials research (through WING - Materials innovation for industry and society programme), and clean processes and production technologies with a view to expanding existing markets, biotechnology, nanotechnology, genome research (through Integrated General Concept for Life Sciences), laser technology, etc. **Table 3.3** summarises the important initiatives of Germany in regard to R&D agency – industry partnerships.

The largest share of R&D in Germany is performed by industry, largely in the area of applied research and experimental development. Relatively little long-term application-oriented research is performed, which is mostly limited to the chemical and electrical engineering sectors. Individual research institutes, such as the National Research Centres and the Government research institutions, outsource the research projects. However, the research activities of the National Research Centres are not limited to specific Government requirements. Neither is the performance of Government oriented research limited to these institutes alone. Innovation is strengthened through appropriate research funding, increasing the efficiency of the research system, supporting a pro-innovation climate and improving the environment for education and research. The funding for R&D is linked with longer-term technological, economic and social trends, also in terms of a national sustainability strategy.

New developments are successful where people are provided with customised solutions. The broad-based innovation campaign of the Federal Government aims at strengthening the German innovation system at all levels. With its initiative entitled

Table 3.3 Major Efforts to promote R&D Agency - Industry Partnerships in Germany

Programme / Initiative	Purpose	Special Features	Partners
Steinbeis Foundation, 1971	Provide interface between academic researchers and businesses by bridging between academia, research bodies, politics and industry.	Globally active, autonomous, flexible and customer-oriented organisation for transfer of tech. / knowledge and pursuing innovation. Has created unique transfer network involving <450 Transfer Centres, mostly at R&D / academic institutes / professional academies and partners in 42 countries.	Academic institutions, R&D institutions, industry.
Innovation Centers, 1983	Provide technical support to tech-oriented start-ups and infrastructure for industry; Promote regional dev, potentials for tech-oriented enterprises and start-ups; Start technology park projects and partnerships.	Independent entity, supports economic development, combines corporate financing system, system of R&D institute – industry partnership, educational and vocational training system jointly operated by Govt and industry, system of inter-company relations and innovation policy.	Academic, research & vocational training institutes, and industry
Legally independent external institutes by univ. for TT	Gain administrative flexibility, as the public law imposes some restrictions on TT from universities.	400 centres were established upto year 2000 leading to enhanced partnerships between universities and industry	---
EXIST campaign of BMBF, 1998	Support university-based researchers willing to start their own spin-off companies	Provide necessary training and advice	University researchers
PRO INNO (Prog Innovation Competence for SMEs), 1999	Support SMEs' R&D activities, Promote national / international SMEs – SMEs / res institutes partnerships	Provides grants and exchange of national and international staff. Succeeded in initiating R&D expenditures in 4850 industries by 2003.	Academic and research institutes, and industry
FUTUR / German Research Dialogue, 2001	Identifying future-related topics of societal relevance needing solution through research; Developing lead visions for research policy	Interaction organised on two levels: a) through new Innovations Committee and b) via the newly launched German research dialogue.	Expert Committees/ participation of all stakeholder
IGF(Programme for the Promotion of Industrial Co-operative R&D)	Promote R&D activities of industries	Support industrial cooperative R&D through sectoral innovation networks between industry and science in a project-specific approach.	Academic & research institutes & industry
High-Tech Master Plan: Innovation and Future Tech-nologies in SMEs of BMBF, 2005	Help young innovative industries to remove obstacles to their establishment and growth; Ensure financing	Establishing new joint VC fund to invest for early-stage and growth companies together with private investors; Tax Incentive; Direct public funding of business R&D	
InnoRegio and Innovative Regional Growth Cores programme of BMBF	Promote innovation in east German states	Supporting joint projects between SMEs and research institutions to strengthen research competencies and innovation potentials	Research / academic institutes and industry

'Innovation and Future Technologies for Medium-Sized Companies - High-Tech Master Plan', which is part of the innovation campaign, it continues to develop its SME policy in important fields of action.

With the aid of the German research dialogue 'FUTUR', societal issues are being identified, and it is being analysed how research might contribute to their solution **[71]**. FUTUR intends to identify future-related topics and develop lead visions for research policy. Interaction is being organised on two levels: first, by means of a new Innovations Committee and second, via the newly launched German Research Dialogue, which is based on broad participation. The initiatives of the German government have increased industry's willingness to pursue innovation. Industrial research in Germany is increasingly geared to cutting-edge research and technologies, which offer the best prospects for growth.

3.4 Japan

3.4.1 Historical Perspective

Japan began its industrialisation in 1867 during the Meiji Restoration that based on indigenous technology as well as imported technology, and continued with the same well up to 1941. Education was given due importance in this process. The merger of Tokyo Denki and Shibaura Mfg. led to the establishment in 1939 of Toshiba, a world brand even today. The country was lagging in technological progress in general during the World War II (1941 to 1945) and industrial development was biased to war-related 'heavy' industries, viz. shipbuilding, aircraft, arms, steel and chemicals. While Japan was isolated during this period, new industries were emerging in the West in the areas of petrochemicals, appliances, pharmaceuticals etc. More than 60% of the plants and equipment survived the war. The government made sincere efforts to seek new technologies through foreign engineers coming to Japan, Japanese engineers going abroad, purchase of machinery, equipment and technologies, reverse engineering, academic and trade journals, exhibitions, trade shows and foreign direct investment. The main factors for the post-War growth were emergent markets, intense competition, high absorptive capacity, government policy, inward foreign direct investment (FDI) and threat of dominant foreign firms **[72, 73]**.

With the rapid economic growth, income was expanding. One could expect high returns on investment in imported technology and in plants and equipment. There was intense competition among existing firms. The fringe industries like Kawasaki Steel went into innovation to face the challenge. New companies such as Sony, Sharp, Honda, Tsuzuki (Textile) were entering and the existing ones like Suzuki, Toray and Mitsui Petrochemical were diversifying. The government often tried to discourage further entry to reduce 'duplicate investment' and 'excessive competition' and to achieve 'economies of scale', but with little success. Domestic R&D and technology importation grew together. The R&D-GNP ratio was continuously increasing, from 0.84% in 1955, to 1.73% in 1961, to 2.14% in 1980, to 3.26% in 1998. In the later stage, the sellers of technology started to acquire technology in return. The Japanese industry was willing to invest in assimilating and applying imported technology and often imported technologies at a commercially untested stage. The Japanese government made policy concerning technology import. It enforced control on commercial technology imports with an aim to save precious dollars. This probably increased the bargaining power of Japanese licensees and led to liberalisation in 1961, 1968, 1972 and 1980. Preferential tax measures were undertaken resulting in reduction of tax withholdings on payments made to foreign corporations in exchange for imported technology and tariff exemptions on designated advanced machines. Tax breaks and low interest rates were given as financial incentives for investment in plant and equipment. Restrictions were put on trade and foreign investment. Foreign companies were no more free, neither to export their products to Japan, nor to invest in Japan to produce domestic products. They therefore could exploit their technological superiority only by selling their technologies. Japanese industry remained under constant threat of dominant foreign firms, as it was aware of the inevitability of capital liberalisation. Industry had strong motivation to introduce new technologies and improve competitiveness.

3.4.2 Current Policies and Budget

As Japan's industries achieved first-rate status in the 1980s, government policy began to shift towards a focus on the earlier phases of R&D to increase basic scientific research and thereby provide an internal science base that could make contributions to Japanese industrial technology research, help achieve social objectives requiring technology development, and support the global scientific community. This change towards objectives similar to the U.S. and European programmes resulted from the realisation that Japanese companies needed to prepare for subsequent technology life cycles in advance rather than continually rely on the 'catch-up' strategy of the 1970s. Moreover, Japanese companies that had attained the world status were no longer interested in sharing their now considerable applied R&D capabilities by participating in government-led consortia. The Next Generation Project and more focused programmes such as the Fifth Generation Computer Project of the Ministry of International Trade and Industry (MITI) are examples of early attempts to shift government research programmes toward the early (generic) phases of technology research **[73]**.

The Japanese government realised that its R&D systems tended to lack flexibility and competitiveness. Thus the 'Law for the Orientation of Science and Technology' was enacted in 1996 to achieve higher standard of S&T under which the government was required to draw up Basic Plans for S&T for periods of five years at a time **[74]**. The first one covered the period 1996-2000 and contained a programme for systemic changes in the Japanese R&D-system, primarily those parts influenced by the government. The Plan included major themes, such as strengthened cooperation between industry, universities and government research organisations; promotion of the establishment of new ventures based on technological seeds or ideas from universities or research institutes; increased support for young researchers by drastically increasing the number of post-doctoral fellowships; increased mobility of researchers; more competition for research funds and higher degree of concentration of research funds; and increase in government resources to R&D.

The Cabinet adopted the Second S&T Basic Plan in 2001 for FY2001-2005 to further develop the systemic reform agenda and raise the goal for government R&D-spending. Four priority fields, viz. Life science, Information and Telecommunications, Environment and Nano-technology and Materials, were designated for concentrated government R&D spending. In this Plan, the policies considered necessary for the establishment of a nation based on the creativity of S&T were priority setting for strategic promotion of S&T, and S&T system reforms to achieve excellent results and utilise them. It was also attempted to retain the percentage of the governmental R&D expenditure as a portion of the GDP at least in the same level as the ones in leading European countries and the US **[75, 76]**. The Plan is currently steadily advancing. Structural reforms including incorporation of national universities into corporations and transformation of R&D-related public corporations into incorporated administrative agencies, etc., are proceeding **[77]**.

The Japanese government brought reforms in its law in 2000 aiming to strengthen the industrial technology base. This effort established a system for transparent consulting between university researchers and industry and permitted the university researchers to be the directors and managers in industrial companies, provided their aim was to commercialise the university research. This effort yielded in sparked rise in university start-ups as shown in **Fig. 3.2.**

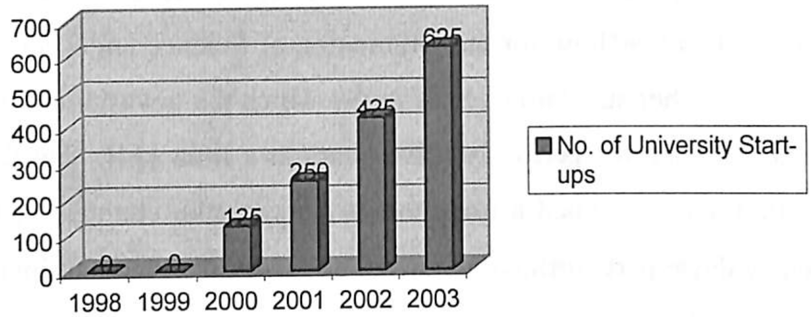

Fig.3.2 Growth of University Start-ups in Japan as a Result of Legal Reforms [77]

In April 2001 when MITI became the Ministry of Economy, Trade and Industry (METI), an independent administrative institution called the National Institute of Advanced Industrial Science and Technology (AIST) was inaugurated as an Incorporated Administrative Agency unifying 16 existing research institutions under MITI. These institutes were otherwise unable to take up co-operative research with industry and academia. AIST can accept funds from private parties to conduct commissioned or collaborative research. An Incorporated Administrative Agency refers to a governmental institution that has been turned into a legal entity, which does not have governmental status. This reform aimed at replacing advance interventions and controls from government to the entity with after-the-fact checks as far as possible, as well as to assure flexible, effective and highly transparent administration in order to supply effective and prompt public services that meet citizens' needs.

In Japan today METI is the second largest ministry in terms of S&T controlling 17% of the S&T budget after having increased from 12% a decade ago. Besides AIST, METI has one large R&D-funding agency, the New Energy and Industrial Development Organization (NEDO). In 2002 AIST and NEDO had budget of ~US$110 million and ~US$220 million per year, respectively, covering very diverse fields of S&T. Almost two thirds of the government budget for S&T is channelled through the Ministry of Education, Culture, Sports, and S&T (MEXT), which was created in 2001 through the merger of the former Ministry of Education (Monbusho) and the Science and Technology Agency (STA). Monbusho, which made up 43% of government S&T spending in 2000, was solely concerned with universities and certain institutes considered part of the university system. STA made up 24% of government S&T spending in 2000 and operated its own research institutes and other R&D agencies spending resources mainly on areas like nuclear energy and exploration of space and oceans.

From 2002 to 2003, AIST continued to urge organisational reform internally in line with its purpose as an Incorporated Administrative Agency. As a result, consciousness that their research results should be commercialised and practically applied to social needs has been raised among individual researchers. In addition, quantitative indicators regarding research performance such as external research funding, the number of papers published, the Impact Factor, the number of patent applications and income from patents are rising, compared to the situation before the inauguration of the AIST an independent legal entity.

Japan maintained its efforts to bring reforms. In April 2004 the national universities, which were previously branches of the Ministry of Education (MOE), were made national university corporations. Under Japanese Patent Law§35, these can now acquire ownership of all work related employee inventions. The 1999 Japanese "Bayh Dole" Law authorised government agencies to let R&D contractors patent government-funded inventions. This law has been modified since April 2004 and now the Japanese national universities can own all inventions by their faculty and students and are permitted to patent many government-funded inventions. However, the licensees are obligated to manufacture in Japan. MOE established the 'Intellectual Property Headquarters and Centres to Promote University-Industry Collaboration' (IPHQs) in 34 universities with an objective to solve the problem of Technology Licensing Organizations (TLOs) being outside many universities. The MOE provides annual funding of ~US$650,000 to ~US$650,000 each IPHQ for a period of 5 years, which is enough for about 4 full time staff. IPHQs were expected to play the leading role in technology development. The responsibility of TLOs is limited to licensing and is sort of subordinates to IPHQs. While this initiative of government encouraged the university technology generation, this system has potential drawbacks. The IPHQs tend to be more bureaucratic and have no financial incentives to be entrepreneurial as TLOs control royalties and financial incentives for universities and industry to make the system work. The authority has been divided between IPHQs and TLOs that causes poor coordination and rivalry. Moreover, insufficient staffing results in excessive workload.

National Institute of Science and Technology Policy (NISTEP) seeks opinion of experts on likely breakthrough in various areas of S&T from among a thousand identified for the purpose. NISTEP claims that while two-thirds of the developments predicted 20 years ago have actually been realised in time, the predicted breakthrough include fuel cell powered commercial vehicles (2013), treatment of some cancers (2015), clinical use of organs from stem cell (2019), room temp superconductor (2022) and forecasting earthquakes with a magnitude of >7 (2024).

In the IT area, Telecommunications Advancement Organization of Japan (TAO) had operated Japan Gigabit Network from FY 1999 to FY 2003 as a research infrastructure for both of public, academic and business researchers. It was a nationwide network consisting of ultra high-speed fibre-optic circuits and institutes for R&D and contributed to R&D more than 600 organisations. TAO, which supported private R&D, and Communications Research Laboratory, the public R&D organisation for IT, were unified in 2004 to form National Institute of Information Technology, which is an Incorporated Administrative Agency under the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT). It implements R&D by itself and comprehensively supports R&D in the private sector. This research infrastructure has resulted in the developments of various applications and it is expected to achieve the creation of new industries and new markets and the fosterage of human resources, etc.

Today Japan is highly R&D intensive. The government only provides limited funds for R&D whereas the Japanese industries play a large role. Japan has increased patenting activity and improved technology trade. Various ministries such as METI, MEXT, Agriculture and Fisheries, Health and Labour, Construction and Communication have their own allocations. The current annual budget of MEXT is ~$1.9 billion. It has reserved additional amounts of $91 million for a human genome analysis project and $29 million for comprehensive support for nanotechnology. An amount of $12.3 billion would be spent in next 5 years to renovate and rebuild university facilities and improve the environment for academic research there.

3.4.3 University – R&D Institute – Industry Partnership

The Japanese government enacted the Law for Promoting University-Industry Technology Transfer in 1998, in pursuance whereof METI and MEXT approved 36 Technology Licensing / Management Offices (TLOs) for national and private universities as of Dec. 2003 and established a variety of policies to support the approved TLOs. These included, for example, grants for technology transfer activities, technology transfer-related information services, alleviation of annual patent fee by half, measures to offer free use of national universities, etc. However, the ownership system was not changed and therefore uncertainty over inventors' ownership still remained. There was no legal provision for an internal university office to handle royalty payments or to have freedom to hire capable technology managers. Most TLOs were established as independent for-profit companies and could manage inventor-owned inventions, only when inventors were willing to assign to them. Nevertheless, there was real, though uneven, progress by TLOs. These have already been opened in at least 28 universities. Their function is to mastermind joint research projects, monitor IPR and incubate start-ups. But lack of entrepreneurs and management sharpshooters in Japan reflects the anaemic number of start-ups born from the licenses handled by TLOs.

Industries in Japan have often followed the tradition of in-house R&D. The asset-inflated economic bubble collapsed almost ten years ago, after which these companies cut back especially on basic research and got geared to receive a compliment from universities and research institutions including those abroad. Such participation of R&D agencies is now considered crucial to industrial success, as private firms are finding it increasingly difficult to keep up with rapidly advancing technologies on their own. Closer ties between industry and academia ensure an ever-fresh supply of innovative ideas, entrepreneurs to start businesses and corporations to encourage new products. Due to the incompatibility of infrastructure for relevant research, Japanese universities have often been handicapped in executing R&D for companies on an equal basis. However, poor infrastructure has led to a lack of interest in universities for putting researches to practical use. Having learnt their lesson the hard way, the companies are now eager to change this dynamics hoping that new research capabilities and technological breakthroughs could help strengthen the Japanese economy. Universities were corporatised in April 2004 with MOE granting the national universities a control over IP resulting from the work of their research staffs. The government also allowed the professors of national universities to take corporate postings on the side.

In 2004, the number of joint research projects between industry and universities has grown by 28.8% to 4,029 and those sponsored by companies by 8% to 6,368. Research grants are being given preferably to joint research projects with industries instead of to those implemented by the universities alone. This has propelled the universities to set up TLOs and intensely search for external research funds. The government is encouraging the universities to set up 1,000 start-up companies in three years. Some universities have created close alliances and consortia of professors and companies, which aim to put research results to practical use. For instance, the Kyoto University has recently started a 5-year project on nanotechnology, advanced organic materials and next-generation devices with a contribution of $0.4 million each from Mitsubishi Chemical Corporation, Hitachi Limited and Rohm as well some contribution from the Government. The project is expected to give innovative products in three years time. A bio-industrial information-oriented consortium (JBIC) with participation of universities, Nara Advanced Institute of Science & Technology and several industries including Mitsubishi, Omron and the local governments of Kyoto, Nara and Osaka was established in November 1998 with the funding from MEXT. It gave rise to thirty new start-ups in areas like medical care, education and the environment. Twenty-five companies from medical industry are doing individual R&D in partnership with professors at Keio Integral Medical Research Centre. Some of these are on regenerative medicine or antibodies in haematology to treat blood cancer. With financial support from MEXT and sometimes also from industries, several Japanese universities like Tohoku and Nagoya have established one or more Venture Business Laboratory (VBL) or the Centre for Interdisciplinary Research with most modern tools and facilities. Specific products, their technology and processes are developed and analysed here, often jointly with personnel from the industry and the specifications are directly implemented into commercial products.

In order to secure the world-class educational research results, a 5-Year Programme for Emergent Improvement of the Facilities of National Universities was adopted in April 2001. It had a planned improvement area of approximately 600 million square meters and target project cost of about 1,600 billion yen including the facilities at universities, etc. for development within the next 5 years. By the FY 2004, initial budget of ~1260 billion yen was provided and approximately 373 million square meters was developed. It is pertinent to note that the government provides much larger institutional funds to national universities than to private universities, in spite of the fact that there are almost four times as many students in private universities as in national universities. As a result students at private universities pay much larger tuition fees than students at national universities. Some observers question whether national universities will be able to maintain their privileged position in terms of institutional funds from the government over the longer run.

Besides the university system, Japan has various groups of research laboratories supported by specific ministries. Five ministries, covering Health, Agriculture, Telecommunications, Environment and Transportation & Construction, plus the Defence Agency and the Cabinet Secretariat, each make up between one and four percent of the S&T budget. While they control a small share of the total government resources for S&T, they all play an important role in their respective fields. The smallest among them, the Ministry of Environment, has an annual S&T budget of more than US$26 million. It is also noteworthy that several of the smaller ministries in S&T terms have increased their share of total government S&T spending significantly during the last decade. This is true for Health, Telecommunications, Construction and Environment, while the share for Agriculture has remained stable and that for Transportation decreased.

New incentives have recently been offered to research personnel to encourage research output that could be adopted by the industries and promote entrepreneurship among the researchers. They can pay up to 50% of the fee while filing their innovation for patent. The researcher's institutions pay the remaining portion of the fee. Money earned through royalty on the IP is shared between the researcher and the institute in the same proportion. Researchers are encouraged to take up industrial projects, take dual positions at their own start-ups and be on the board of companies. New measures to encourage entrepreneurship are on the anvil. More incentive and encouragement for product-oriented research are expected to enhance involvement and boost economy. Teams of personnel from industry, academia and government define the goals of theme-based research and fix its duration. Companies fund research to turn research done here into commercial products. Other forms of industrial linkage include licensing work where collaborative entities take the results of research done here to a practical stage such as in the New Sunshine projects of NEDO for developing new kinds of fuel cells. Veteran scientists now find commercial applications of previous research and suggest technologies that are needed to prepare new research themes.

3.4.4 Initiatives on Direct Funding

In May 2001, the METI launched an initiative, known as the Plan for the Creation of New Market and New Jobs. MEXT also promotes partnership between industry-academia-government. Japanese Government provides seed funding to private companies seeking commercialisation of technologies based upon their basic researches in specific areas of biological sciences like Regenerative Medicine and Genome-based Drug Development. Companies working on selected themes get grants of up to ~$4 million per year for a period between 3-8 years and have to pay it back along with the profit only if the funded effort succeeds. Another scheme of commissioned development projects with annual grants up to about $3 million for a period of 2-3 years is for highly competitive areas. This is similar to the system for tapping basic research results from academia, research institutes and bio-ventures in the USA. The proposed scheme is aimed at nurturing new business from domestic companies, which are often unable to sustain their research efforts, especially the clinical testing owing to high costs.

The rate of tax subsidies of R&D is extremely low in Japan in international comparison. Japanese government has recently amended its R&D tax incentive system to overcome the depressed economic situation. The previous tax incentive system was designed for incremental R&D expenditure. The highest 3 yearly expenditures in past 5 years were averaged, and the increased amount from the average could be available for deduction. This plan was successful when the Japanese economy was growing continuously with high rate. However, after the economic downturn it lost its effectiveness and the total value of the tax deduction in Japan decreased from more than 100 billion yen to 20 or 30 billion yen. Therefore Japanese government modified this tax incentive system in 2003 to allow 10-12% of total R&D expenditure to be deducted. In order to keep an incentive to companies for increasing their R&D expenditure, it is prescribed in the new tax incentive system that the deduction rate is raised from 10% to 12% with the rate of R&D expenditure in total sales volume of the company.

As for an innovative cluster base, there is a Yokosuka Research Park (YRP) an R&D cluster base supported by MPHPT specialised for radio communications technologies. More than 60 organisations site their laboratories there. The next-generation radio communications systems, such as 4th Generation Mobile Phones, are being developed in YRP through joint R&D among publics, academics and private firms.

3.4.5 Japanese Technology Transfer System and Intellectual Property Issues

Broadly speaking the strength of Japan's technology transfer system has been to tolerate informal passages around bureaucratic bottlenecks. This manifests itself in the distinction between *tatemae* (the way things should appear) vs. *honne* (the way things really are). As per old *tatemae* principles taxpayer funded inventions were freely available to all. The university faculty was treated as civil servants who should have no interest in business matters. The funding determined the ownership of technology in Japan up to around 2004. The nation owned the inventions arising under MEXT grants-in-aid and the government sponsored or collaborative research contracts. Japan Science and Technology Agency, a government bureaucracy, coordinated all the patenting and licensing, which was only on non-exclusively basis until April 2002. The country was the owner or co-owner of the inventions arising out of industry sponsored / joint research programmes. No transfers were allowed to third parties. The Inventor could be the owner of his/her inventions arising under the inventor's standard research allowance (kouhi) and corporate donations only **[78, 79]**.

Implementation of the system had specific characteristics. Great incentives were given to avoid national ownership. Reporting requirements were very weak. It was very easy to classify / misclassify inventions as arising from 'donation' funding. As a rule the proportion of various funding sources =>~50% of inventions belonged to the nation. Inventors had no encouragement and they simply transferred the technology without receiving any incentives. This resulted in low commercial value of transferred technologies. While nation owned most of the inventions this system had several negative effects. Most inventions were either not commercialised or passed informally to large companies with no development obligations, including many publicly funded inventions. Small companies were left out of invention flow and hence could neither give many donations nor offer attractive jobs to the students. Venture companies were also hurt by uncertainty over inventors' ownership rights. Hence the system could not make any positive impact on Japan's economy and university research.

There is a negligible share of the universities in total patents in Japan, less than 0.1% compared to about 3% for US universities. Recently the Japanese government has added the escape routes, increasing chance that inventors themselves will own and manage some inventions. Nevertheless too much bending of the rules can result in uncertainty over patent ownership, which may hurt the ability of venture companies to raise capital. US universities struggled hard for their rights under Bayh-Dole. In contrast, Japanese universities are passive with the Government driving the change. Civil servant administrators of universities have had few incentives to manage technology well. However, it is still hard to mobilize university researchers for cutting-edge research or research that is of importance to industry **[80, 81]**.

A topic, which has received high-level political attention in recent years, is that of intellectual property (IP). In February 2002, Strategic Council on Intellectual Property was set up because IP was considered an issue crossing the boundaries of many ministries. Based on the strategy proposed by the Council in July 2002 a new Basic Law on IP was enacted in March 2003 and the cabinet adopted a promotion programme in July 2003 for 'creating, protecting and utilising intellectual property'. Proposed measures for strengthening the protection of IP include areas like regenerative medicine, new plant varieties, computer software, design models, and brand names. Greater involvement in international standardisation is one of the measures proposed to improve the practical utilization of IP.

Recently both MEXT and METI have launched cluster programmes. METI promotes Industrial Cluster Projects in order to encourage the development of new businesses by making use of networks of people in business, academic and public sectors. 19 such projects were implemented in 2002 and 2003. Financed by MEXT, the 'Intellectual Clusters' programme has made awards to each of 13 regions for carrying out R&D-projects in cooperation between industry, academia and other research organizations. The clusters selected through an open competition focus on IT, life sciences, and nanotechnology.

Table 3.4 illustrates the advances made in contract research and patenting as observed in the pre- and post- S&T reform period.

Table 3.4 Advances made in Contract Research and Patenting as observed in the Pre- and Post- Science and Technology Reform Period*

	FY 2000 (Pre Reform)	FY 2001 (Post reform)	FY 2002 (Post Reform)
Joint research	972 cases	1131 cases	1577 cases
Contract Research from private sectors	5 cases (18 million yen)	78 cases (370 million yen)	131 cases (920 million yen)
Japan patent applications	1022 cases	1017 cases	1401 cases
Venture Companies originating from AIST	2 cases	13 cases	24 cases
Licensing contracts	149 cases	187 cases	296 cases
Patent Execution fee	48 million yen	144 million yen	310 million yen

*(*Source: AIST Annual Report 2004)*

3.4.6 Conclusion

Promotion of cooperation between industry, universities and government R&D agencies is one of the elements in Japanese S&T policy. Thus a significant part of the R&D funded by the government at universities and research institutes is performed in cooperation with industry. In 2001, industry contributed ~US $800 million for research in universities, which was ~2.7% of total R&D expenditure. Japanese research and innovation is presently undergoing more radical changes than probably anytime since its establishment as a modern society well over a century ago. Japanese society is passing through deep structural changes. Values and economic, social and political institutions that came to be taken for granted are being questioned and alternatives are being explored. This also includes many institutions and practices in the fields of education, research and innovation. A majority of impetus for change derives from the poor performance of the Japanese economy since the beginning of the early 1990s. Some of the root causes of these problems, such as the weak balance sheets of financial institutions and the high propensity of Japanese households to save rather than consume, have little connection with S&T. Nevertheless, investments in S&T and effective utilisation of their results are generally considered to be a key prerequisite for returning the economy to a stable growth path in the long run. Important targets of systemic reform in Japanese S&T policy are to increase mobility of researchers, opportunities for young researchers, cooperation across sector boundaries, competition for funding, concentration of resources, internationalisation, etc.

Japan has a dual system of large enterprises and a large number of SMEs. About 74% of all employees are working in SME's, which constitute 99% of all enterprises. Science-research-industry relationships are traditionally strong and based on informal networks that usually involve only larger enterprises. Until recently, formal networks were discouraged by legislation. The Japanese economic crisis since the 1990s challenged this system and in order to revive the Japanese economy, new models had to be found. As a general trend, the policies of the two main actors, METI and MEXT, encourage formal networking, include SMEs in science-research-industry networks, develop and strengthen regions by means of networking and increase mobility of employees. **Table 3.5** shows a number of initiatives taken by Japan to promote industrial research activities through R&D agency – industry partnerships. **Table 3.6** lists the legal measures in Japan for enhancing R&D agency–industry Partnerships.

Japanese technology and R&D levels are high, but Japanese society lacks technology managers prompting to establish technology management courses in universities, entrepreneurship promotion programmes etc. Recent international and domestic surveys find that Japanese have low interest in S&T, but the Japanese government considers that public understanding of S&T plays a key role to build an advanced S&T-oriented nation, to secure innovative technology and to boost industrial competitiveness. While there is strong support for the need to further increase the R&D investments, there is also a strong opinion favouring radical changes in the system for financing and performing research and innovation. Japan has been looking towards the USA as the model. The large apparent difference in economic performance between the USA and Japan during the last decade has been seen as evidence that the American innovation system today is more effective than the Japanese one, especially the creation of new high tech venture companies in such fields as IT and biotechnology, of which there has been very little in Japan, and the internationally leading position of the US research universities and their seemingly effective system for transfer of technology and knowledge to industry.

Table 3.5 Major Initiatives to promote R&D Agency – Industry Partnerships of Japan

Programme / Initiative	Purpose	Special Features	Partners
Scheme of Commissioned Development Projects	Tap basic research results from R&D agencies and industry for nurturing new business from domestic companies	Annual grants up to about $3 million for a period of two to three years for highly competitive areas such as biotechnology.	R&D agencies and industry
ERATO, JST, 1981	Bringing together researchers from science, industry and from abroad.	A nation-wide prog. Annually funds 4 new res. teams for undertaking exchanges for a 5-year period.	Researchers in universities and industries
Yokosuka Research Park (YRP) by MPHPT, 1996 and other research and technology parks	Promote joint R&D among R&D agencies and industry in technologies for radio communications .	Innovative R&D cluster base. YRP houses over 60 organizations working on next-generation radio communications systems such as 4th Generation Mobile Phones.	R&D agencies and industry
CREATE (Network-Structured Centre of Excellence in Each Region) of JST, 1996	Builds on local strengths by networking key players to contribute to the total strength of the nation	Enables smooth cooperation among centres of strength in the region and promotes joint research, new technologies, leading edge companies, new industries.	Univ., public and national laboratories and companies, government
Knowledge Cluster Initiative of MEXT, 2002	Create internationally competitive knowledge concentrated system for technology innovations.	National-wide programme.18 sector-specific knowledge clusters set up.	Universities, public /national labs, companies
Industrial Cluster Programmes by MEXT and METI	Encourage development of new businesses by making use of networks of people in the business, academic and public sectors.	Launched specialised cluster progs viz, 'Intellectual Clusters' granting awards to 13 regions for carrying out collaborative R&D projects. Clusters are selected through open competition with focus on IT, life sciences, and nanotechnology.	Universities, public /national labs, companies
Joint Research Centres	Progress towards innovation through strengthening Japan's industrial competitiveness through partnership.	Joint research centres in 61 (of 99) national universities were set up as of FY'01/'02. A number of joint projects are being implemented in these centres.	

Table 3.6 Legal Measures adopted by Japanese Government to promote Transfer and Commercialisation of Technology

Initiative	Enactment Year	Special Features
Law for the Orientation of Science and Technology	1996	5-year Basic Plans for S&T to achieve higher standard of S&T by brining flexibility and competitiveness in the R&D system. 1st plan (1996-2000) sought for systemic changes in the R&D-system; strengthening the univ. - govt R&D agencies - industry partnership; promoting setting up of new ventures based on tech. ideas from univ. / research institutes.
Law of Technology Licensing / Management Office (TLO) (28 TLOs established by univ.	1998	Promote transfer of technologies from university to industry by masterminding joint research projects, monitoring IPR and incubating start-ups. Independent for-profit companies mostly established outside universities. government provided annual funding support to approved TLOs but did not change the ownership system (no rights to inventor)
Japanese Patent Law§35,		Gives universities the right to acquire ownership of all work related employee inventions.

Japanese "Bayh Dole"	1999	Authorised government agencies to let R&D contractors patent government-funded inventions.
Law to Strengthen Industrial Technical Ability – (Japanese Bayh-Dole amended)	Apr. 2000	After acceleration of the process, creation of "Intellectual Clusters", "City area program", "Industrial Clusters" etc initiated,
Law for Administrative reform	2001	Creation of MEXT and Council for S&T Policy (CSTP), 2nd S&T Basic Plan (2001-2006), Center of Excellence Prog. for 21st century.
Basic Law on Intellectual Property	Mar. 2003	Facilitate creation, protection and utilization of IP. Launched Prog. for 'Creating, Protecting and Utilizing IP in S&T including areas such as regenerative medicine, new plant varieties, computer software, design models, and brand names. Promoted greater involvement in international standardization to improve the practical utilization of IP.
National University reform Bills	Jul. 2003	Transform in April 2004 all "national universities" into independent administrative organizations.
Japanese "Bayh Dole" further amended	Apr. 2004	Grant control to the national universities over IP resulting from the work of their research staffs. Universities can own all inventions by their faculty and students and patent government-funded inventions. However, the licensees are obligated to manufacture in Japan.
Setting new business targets for universities and industry,	2004	Encourages universities to set up 1000 start-up companies in 3 yrs. As a result universities jointly with industry set us Venture Business Lab. (VBL) or Centre for Interdisciplinary Research for creating close alliances / consortia of professors and companies, aiming to put research results to practical use and more intense university - industry partnership to set up business centres
S&T Structure Reform	2004	Enhance R&D output and its impact and boost economy by a) converting national universities into national university corporations and making R&D institutions independent legal entity to replace the government interventions and controls, assure flexible, effective and transparent administration enabling them to accept funds from industry for collaborative research; and b) providing higher incentive to researchers for product-oriented research to encourage research output and promote entrepreneurship among the researchers, which are expected to enhance involvement and boost economy;

3.5 United Kingdom

3.5.1 Introduction

The United Kingdom is committed to the development of a knowledge-driven economy where knowledge and know-how form the key foundations of economic success and performance in the global industrial economy. Within the knowledge-based economies, the contribution of the science base is vital in the supply of both knowledge and trained people. A third role has been emerging in which the science and engineering base acts as an initiator of entrepreneurial ventures which after a suitable period of incubation pass into full industrial ownership in return for financial gain to the institution. However, this last aspect is still rather small compared with the other two.

The UK's science and innovation policy has been preoccupied with the relationship between science and economic success for more than a century **[82]**. In recent period the desire to improve industry-science partnerships has become the central organising principle for science-funding initiatives, encompassing issues such as prioritisation and network-building through foresight; 'customer-focus' for research funding bodies; and initiatives aiming to foster entrepreneurship among faculty and graduates. Many of the initiatives were inspired or at least updated by the experiences of other countries, for instance, that of Japan in technology foresight and of the USA in technology commercialisation.

In the UK, the policy context is of fundamental importance for R&D agency - industry partnerships. A whole range of relevant institutions, viz. the government, its agencies, higher education institutions, intermediaries and industrial sectors contribute to the development of a large number of initiatives intended to bolster the development of networks of collaboration. A wide variety of initiatives in innovation and technology policy, education and labour policy and fiscal and competition policy affect these partnerships. In innovation policy, the emphasis has been to promote the partnerships themselves as a means to achieve innovation, technological development and economic growth. The UK Government White Paper on Science and Technology **[83]** evidences the significant emphasis upon the creation of R&D agency - industry partnerships as a cornerstone of innovation and technology policy, stating that: "the Government, with others, has a clear role in the funding of basic curiosity-driven research; the value of basic research can rarely be captured by the private sector. In addition, scientific knowledge is often produced through collaboration. Society benefits from basic knowledge being shared as widely as possible. The private sector will rarely invest in research when it cannot be confident of making a return." In addition there are often market failures in the networks and partnerships, which bring the public and private researchers and industries together. Although all parties would benefit from these partnerships being stronger, it is in no one party's interest to take on the cost and responsibility for forming these networks **[84]**.

Due to the role of the Research Councils and of the research assessment exercise, the governance of the publicly funded research system in the UK is less decentralised than one might think. The universities and Research Councils respond to signals from the government, when it uses clear criteria for allocating public money to them. In fact, these institutions balance the various signals, including those coming from the research community. Since industrial funding is the only category of funds, which until recently could increase significantly, universities have tended to become more receptive to industrial needs. In the same line, the 'teaching quality reviews' of the universities include criteria about the jobs held by students. This provides a clear incentive for universities to enhance their industrial relations.

Since 1994, the UK has been engaged in two rounds of a national Foresight Programme **[85]**. The goals of the exercise are to develop visions of the future, that is looking at possible future needs, opportunities and threats and deciding what should be done to make sure the UK is ready for these challenges; build bridges between business, science and government, and bring together the knowledge and expertise of many people across all areas and activities in order to Increase national wealth and quality of life. The programme has operated through ten sectoral and three thematic panels. The latter have engaged problem-centred areas, dealing with the consequences of the ageing population, crime prevention and the future of manufacturing. Through an infrastructure of task forces and implementation activities, the programme is seeking to affect a cultural shift through the creation of new future-oriented networks. Among the follow-up measures to the first round of Foresight was a dedicated scheme, the Foresight Challenge Competition. This was launched at the end of 1995 with the explicit aim of increasing interaction between industry and academia. Consortia of business and the science base were able to apply for matching funds for projects addressing Foresight priorities. In this round awards were made to 24 projects costing a total of £92 million, of which £62 million came from industry and £30 million from the Office of Science and Technology. In the second round (1999 –2002) of the initiative, renamed Foresight LINK Awards, 65 Task Forces were established and 160 seminars were held. The current phase that began in 2002 is a rolling programme of issue-based projects. Foresight and LINK activities have been the most effective government mechanisms in the promotion of industry-science relations **[86]**. One of the explicit aims of the UK foresight exercise is to bridge the gap between the research community and senior management in industries, seen as a barrier to better R&D-industry partnerships.

3.5.2 Research in Higher Education Sector

Universities are the main performers of basic research in the UK. Although principally funded by government, they are independent institutions with charitable status. Their employees are not civil servants. There were 143 university institutions in the UK, counting separately the colleges of the Federal universities of London and Wales; 45 institutions which are not universities but run a substantial number of degree courses usually in conjunction with a local university; 4 foreign institutions with campuses in the UK; and 5 profession and post-graduate institutions [87]. Older universities in a few cases are centuries old, with civic universities founded in the late 19th and early 20th centuries and most of the rest in the 1950s and 1960s. Former polytechnics were given the status of universities in 1992 and are often referred to as 'new' universities. Despite the presence of priorities and strategic programmes, the majority of research carried out in universities is funded in 'responsive mode', in which the topic and approach are identified and proposed by the researcher and there is no restriction on publication other than the normal governance of peer review. Within the higher education sector, research is carried out in the vast majority of institutions, although a strong concentration of research activities in stream is now being terminated with the introduction of new incentive funding for industrial collaboration.

Universities are funded for research through a dual support system. Higher Education Funding Councils (separate bodies for England, Scotland, Wales and Northern Ireland, with funds derived from ministries responsible for education) provide general funding, used mainly for academic salaries and research infrastructure, while Research Councils with funds derived from the Office of Science and Technology (OST) in the Department of Trade and Industry (DTI) provide funding for projects (including salaries of contract researchers), research training and centres on a competitive peer-reviewed basis. Some of the Research Councils also operate own institutes. The other principal funding source for research is the charitable, non-profit sector, notably the Wellcome Trust, which is the largest single supporter of medical research. Universities and Research Council institutes collectively form what is generally referred to as the 'science base'.

Funding Councils for each of the countries that comprise the UK have existed for some years. As the devolution of political power to the new national assemblies of Scotland, Northern Ireland and Wales gathers pace, national policies for research have already begun to vary as Funding Councils react to local needs and priorities. In Scotland, for example, while a significant proportion of Funding Council support for research still comes through the Research Assessment Exercise (85% in 1999), the new Research Development Grant scheme (RDG) allocates around 10% of Funding Council grants with the aim of bringing about a realignment of the research base with perceived economic and social priorities.

The six Research Councils, which are non-departmental public bodies, are Biotechnology and Biological Sciences Research Council (BBSRC), Economic and Social

Research Council (ESRC), Engineering and Physical Sciences Research Council (EPSRC), Medical Research Council (MRC), Natural Environment Research Council (NERC) and Particle Physics and Astronomy Research Council (PPARC). In addition, the Council for the Central Laboratory of the Research Councils operates large central facilities. MRC, NERC and BBSRC operate institutes or research units of their own as well as support university research through grant funding. PPARC also handles UK contributions to international facilities in particle physics and astronomy.

Each of the Research Councils in the UK system establishes its own research priorities within the context of overall priorities set by its Director General and informed by the Foresight Programme. The Director General himself is part of the process of priority setting through links with the government's Chief Scientific Adviser, the Council for Science and Technology, which is chaired by the Secretary of State for Trade and Industry, and the Chief Scientific Advisers in each government department. An informal ministerial committee, the Ministerial Science Group, also contributes to the setting of priorities, although its main purpose is to co-ordinate science policy across government.

3.5.3 Academia – Industry Partnerships and Commercialisation of Academic Research

In order to find a niche in the competition for funds the universities tend to specialise in certain types of R&D-industry partnership. Smaller universities are tempted to transform part of their research departments into business support units and contract research organisations, especially because the UK has imposed tough competition for core funding. Since the universities traditionally maintain close contacts with industry where the majority of their students end up working, and since employment of post-docs and interns is a flexible process, it is easy to understand why emerging science-based industries like the biotechnology and information & communication technology (ICT) sectors see the universities as a favourable pool for human resources. Hence in these sectors UK industry is particularly innovative and competitive, while the more traditional activities suffer from a lack of technological vision and engineering skills.

The production of human capital in the UK has been strongly influenced over many years by the need to ensure that graduates receive both the theoretical and the practical knowledge required by industry and the professions. Industrial needs are taken into account in the development of curricula for undergraduate and postgraduate courses. Industrial links to undergraduate teaching take a wide variety of forms. At a general level, advisory committees to faculties with courses of vocational relevance typically contain industrial representatives. Active involvement by industry in courses includes provision of visiting speakers, and occasionally lecture series, validation of courses, membership of examination boards, carrying out of student projects in collaboration with industries, and sponsorship of student prizes. Also widespread is a trend towards seeking to develop students' transferable skills relevant to the industrial environment, including for example computer literacy and working in teams. Training for entrepreneurial skills is supported by the Enterprise in Higher Education initiative. Undergraduate degree courses designed to meet the needs of a specific industry or group of industries are offered, out of which almost two-thirds are part-time. Sandwich courses, in which the student typically spends a year working for an industry during the course, are very important for some institutions. The University of Ulster, for example, has some form of sandwich arrangement for 50% of its full-time first-degree students, usually for one year. Shell, in conjunction with DTI, established a technology enterprise programme in which 1500 students were placed in industries around the UK. This was an 8-week placement, which was effectively a mini-sandwich course with each student trying to devise a solution to a pressing problem faced by the host business

Further, the UK government has taken steps to better align educational provision in the country with the needs of industry through creation of a new degree format, the Foundation Degree. Such prototype degrees reflect the growth of the new service economy with 16 degrees in the new media and technologies, and 16 in the areas of health, supporting public services and tourism. The number of engineering and chemical industry related courses is low, with only three indicated in the initial group of around 40 prototype courses.

An important evolution is taking place regarding the incentives for university-industry partnerships. A type of funding in addition to teaching and research was started as the 'Higher Education Reach Out to Business and the Community (HEROBC)', although this initiative has now been subsumed within the Higher Education Innovation Fund (HEIF), which was launched after the government's spending review in 2000. HEIF is a platform for core funding designed to enable the universities to pursue the partnership in favourable conditions (the 'third leg' of funding, after core and contract funding). It provides the partnership not only with greater funding but also with a stronger political and institutional status. HEIF receives funding from across government, from the DTI's Office of Science and Technology, from the Higher Education Funding Council for England, and from the Department for Education and

Employment (renamed as the Department for Education and Skills in 2001). HEIF also fulfils the function of consolidating and simplifying what might be seen as a confusing array of third-mission support initiatives. It aims to develop the capability of universities to respond to the needs of business and to contribute to economic growth and competitiveness by enabling them to put into practice organisational and structural arrangements to achieve their strategic aims in this area. This scheme has at its core the belief that all universities should be engaged with business in different ways. The fund is intended to enable them develop links across the full range of academic endeavours, and develop closer working relations with industry, which could also influence the way in which they prepare their students for employment.

The Teaching Company Scheme (TCS) dating from 1975 is operated by the DTI. Under TCS a graduate student (associate) originally with a science or engineering background is employed to spend 90% of time working in an industry on specific projects, and the balance time in used for training in the higher education institution. The purpose of the TCS is to strengthen the competitiveness and wealth creation of the UK by stimulation of innovation in industry through collaborative partnerships between the science, engineering and technology base and industry. TCS has a number of precise objectives that ensure close working and collaboration between industry and academia to facilitate the transfer of technology and the spread of technical and management skills; encourage industrial investment in training and R&D; provide industry-based training supervised jointly by personnel in the science, engineering and technology base and in business for high-calibre graduates intending to pursue careers in industry; and enhance the levels of research and training in the science, engineering and technology base that is relevant to industry by stimulating collaborative R&D projects and forging lasting partnerships between the science, engineering and technology base and business. Programmes have ranged in size from a single associate employed over a 2-year period to a group of 14 associates employed over 3-year period on contract, which is renewed. Mostly the industries themselves provide up to 60% of the cost of the programmes and at least 50% of the cost of renewed projects, but SMEs pay less, usually 30%.

DTI announced in September 1997 the establishment of four pilot Faraday Partnerships which would each receive £50000 in start-up funds and then up to £1 million over four years. The main objectives of the Faraday Partnerships are to encourage greater interaction between university and industry, especially SMEs. The establishment of Faraday centres has had a long and difficult 'birth'. Inspired by Germany's network of Fraunhofer Institutes, the Centre for the Exploitation of Science and Technology (CEST) proposed the current 20 centres as far back as 1992 as a means of bridging academia and SMEs. The aim is to expand information flows and links, thereby improving awareness in academia of industry requirements and increasing exploitation of research results. Of the four initial Faraday centres, three involve Partnerships between universities and independent research and technology organisations. The centres are in the domains of enhanced packaging technology, 3D multimedia applications and technology integration, interdependent mechanical and electronic parts, and intelligent sensors for control technologies. Faraday is believed to be the most effective of all government programmes to promote R&D-industry partnerships.

The University Challenge Fund competition assists winning universities or consortia of universities in setting up local seed funds to support the early stages of commercialisation of academic research, which is managed by a board, normally with VC expertise present. The funds may finance further research in support of commercialisation and the patenting cost, building prototypes, market research and the preparation of business plans to attract next-stage capital. The DTI, the Wellcome Trust and the Gatsby Charitable Foundation initially supported the fund. In the first round, 15 awards to a value of £25 million were made which, with matching funding from universities and other sources, created funds of £60 million.

In educational policy, the emphasis has also been on the promotion of science and engineering to young people. The creation of a new system of foundation degrees and a 'University for Industry', or 'Learndirect', within the education policy indicate a desire to involve the educational system in a closer relationship with industry. Learndirect is a government-sponsored initiative in flexible learning, intended to make learning new skills accessible to everyone through 178 centres operated by locally based associations of colleges, universities, local authorities, trades unions, companies and business organisations [89]. In the Collaborative Awards in Science & Engineering (CASE) scheme [90] the student at graduate level receives a grant from the Research Council in addition to a contribution from an industrial partner. The doctoral research addresses an industrial or commercial problem. Academic and industry representatives provide joint supervision.

3.5.4 Science Parks, Incubators and Spin-Off Industries

Universities, and public laboratories to some extent, have been closely linked with the emergence and development of science parks in the UK [91]. Policy initiatives have largely centred on property-led schemes around science parks and related research and technology parks. Goals for science parks include earning revenue; capturing more satisfactorily IPR leaking out of the university; attracting companies who may then become customers for the universities' research; and fulfilling a wider economic regeneration role within the local economy. However, other science parks have few or no ties with universities. The growth in the number of industries on university science parks within the UK suggests that a period of rapid growth in the number of businesses operating in UK science parks has come to an end. Whereas the number of tenant companies on UK science parks rose from 301 industries to 1020 in the period 1985-91 representing a rate of increase of 240% over the period, in 1991-97, it increased from 1020 to 1414, an increase of just 40%. While the latter half of the period still shows a high rate of growth, the trend is certainly very much reduced **[92]**. It should also be noted that many of the industries established on science parks are not formally connected to the local university or indeed to any university.

Recently, the science park concept has itself given birth to so-called 'incubators', which are a supporting environment usually consisting of office premises, rather than whole buildings as in a science park. These are provided within existing or new buildings in close association with a university. Incubators also include some on-site management expertise and are normally focused upon a particular technology or subject area, such as biotechnology. Incubators are therefore smaller in scale than science parks but they are intended to provide much of the infrastructure in which academic-industry interactions can occur.

The UK has a long history of joint R&D projects and establishments. These joint establishments were set up to allow researchers working in basic and applied research to work on common problems and thereby to share tacit knowledge and develop novel techniques. This format is also favoured by overseas multinationals, which have established laboratories in or close to UK universities (for example, the Hitachi Research Laboratory at Cambridge University). In the pharmaceutical area, some of the larger industries are very strongly involved with large numbers of universities from the UK and abroad. Glaxo Wellcome (pre-merger) had a number of links, which it terms 'strategic partnerships' with universities around the world. There are currently four major joint developments in which the industry is linking with specialist academic expertise in the UK and Wales.

Further, the UK has a growing number of spin-off businesses that have been set up by universities to commercialise a particular research potential **[93]**. In 1998 around half of the surveyed universities had set up wholly or partially owned companies to exploit research. A total of 223 companies were identified, including holding companies for other spin-offs and IP. Four of the responding institutions reported that companies owned by them had gone into liquidation during the period 1995-97, confirming the impression that spin-off businesses are usually open to considerable business risk. Of the industries operating in science parks that are university-owned, the majority are working in the biotechnology, life sciences and medicine, with engineering in second place. Spin-offs are important, since they create a direct link between research and markets. However, they require public support during their infancy.

3.5.5 Intellectual Property Rights in University Research

For the university sector until 1985 a public body known as the National Research and Development Corporation (NRDC) had a monopoly in the exploitation of publicly funded research. This was ended by the then Conservative government with the intention that universities should take ownership of IP generated as an incentive to engage with commercialisation, which is a similar logic to the US Bayh-Dole changes. The NRDC itself was restructured under the new name of the British Technology Group (BTG) and subsequently privatised as an IP management company. Universities formally had to satisfy the BTG that they had proper mechanisms in place for identifying, protecting and exploiting their intellectual property, and in particular for properly rewarding individuals. Since the mid-1980s, many higher education institutes in the UK developed far more sophisticated strategies for protecting and making use of innovations coming out of academic research. Many of them started to set up specialised IP management and administrative centres, commonly known as technology licensing offices either within, or parallel to, the existing industrial liaison offices.

IPR are potentially a problem in any R&D agency - industry partnership. In the UK, there are various sets of rules, although there is a move to shift title to the institution, in particular in the new polytechnics. The BBSRC grants title to IPRs to the individual institutes, while the Medical Research Council retains IPRs ownership itself. Each of the BBSRC institutes is permitted to retain exploitation income equivalent to up to 10% of its annual recurrent income from BBSRC. If revenues exceed the 10%, the institute may make a proposal for reinvestment. At Warwick University academics can receive 75% of royalties up to a certain threshold, after which the share drops to 50% for the researcher and 50% for the university.

The production of IP, which ultimately finds industrial application, can take a number of forms. At one extreme, IP may be given free to industrial users with the proviso that there is a right to publish the findings of the research. At the other extreme, research can be carried out by the university but patented by the industrial partner. A combination of these types involves some collaboration in the carrying out of the work and/or sharing of the resulting IP between the university and the funding industry **[88]**. In order to encourage patenting, the Patent Office has undertaken to reduce charges for patenting or, in some cases, to remove them altogether. To increase general awareness of patents and new technologies, a new database based on the work of the Association of University Research and Innovation Links (AURIL) has been set up on the Patent Office Web site.

3.5.6 Public Sector Research Establishments

The government laboratories sector, which is now termed the public sector research establishments (PSREs), has been considerably reduced in recent years through the privatisation of government laboratories **[94, 95]**. R&D spending by government departments has declined, but remains substantial. It is now disbursed primarily on a competitive basis, with former government laboratories remaining major performers. The remaining PSREs exist to assist in the pursuit of government objectives, including improving quality of life (e.g. medical research); economic development through advance in basic science (e.g. agricultural research); informing government policy making (e.g. advice on genetically modified crops); and statutory scientific testing and regulatory functions (e.g. testing animals for disease). These organisations fall into two main groups, which are the departmental bodies, responsible to central government departments, either as an executive agency or as part of the department, and Research Council institutes, accountable to the Council concerned. A vast majority of scientists working in the PSREs are engineers and scientists, although a very small number of researchers are qualified in either social science or the humanities (4.4%). Reduction in numbers due to budget cuts and privatisation is evident, for example, from the number of researchers employed by the Department of Environment, Transport and the Regions, which has fallen to 15% of the number in the predecessor ministries such as the Department of Environment because of the privatisation of the Building Research Establishment and the Transport and Road Research Laboratory. However, the scientists who continue to work in these establishments are still primarily engaged in providing services to government, in some cases in pursuit of an R&D-industry partnership mission.

It was recommended for the public sector science research establishments that responsibility for commercialisation and use of research outputs should be local and decentralised. [96]. This would require a fundamental change in the culture of organisations with openness to the challenge presented by commercialisation. To this end, commercialisation of IP would become a core goal of the laboratory. Further, the research organisations should be put at arms' length from the government, taking the form of the Scottish Office's agricultural research stations, which have the status of non-department public bodies but are accountable to a Secretary of State. Also in order to ensure effective commercialisation, new skills and new capabilities would be needed within the laboratories.

3.5.7 R&D Agency-Industry Partnership

For scientific institutions, the major incentives for collaboration and the formation of academic-industry links are firstly, and most importantly, access to funding. Collaboration and creation of links with industry is a strategic goal that many institutions have readily embraced. A number of other incentives are also present for creating and maintaining industry links. The need to find a way to exploit existing research capabilities is an incentive. Stewart [97] in his study on "The Partnership Between Science and Industry" has identified barriers to such partnerships and motivation of the industry to collaborate with R&D agencies and has observed that the individual industries were active in R&D partnerships as long as they received the benefits from collaboration greater than the costs of participation. Motivations for industries to enter into such partnerships are broadly to secure a supply of recruits, access to scarce scientific expertise, access to exploitable intellectual property, enhancing the scope and testing of in-house corporate activities, and cost saving through outsourcing. At the same time the barriers, which industries believe prevent them from entering into effective and productive partnerships with science institutions, are lack of a professional approach by the institution, divergence of objectives between the partners, misunderstandings and lack of precise aims, apparently low priorities given to the work by researchers which downgrades the role of partnerships, maintaining contacts with the inevitable turnover of employees within the industry, and high perceived costs of locating partners and participation.

Research in industry takes place within a broad range of industries in all sectors, but expenditure and activity are concentrated in just a few areas. Industrial R&D is heavily concentrated in pharmaceutical companies, with the top three financiers of R&D being pharmaceutical companies, two of which have recently merged to form Glaxo. Expenditure on R&D by SMEs is generally low but those in high-technology sectors may have very high R&D-to-sales ratios. Industries in UK tend to have an insufficient capability to absorb science, reflecting the rather low level of R&D carried out in most companies. Innovation surveys show that while almost half of manufacturing industries consider R&D agencies to be an important source of innovation, only 10% have developed formal relationships with them **[98]**. This is not to deny the importance of formalised linkages, especially contract research, and the fact that the most spectacular ongoing change in R&D agency-industry partnerships is the accelerating development of some of these formal relationships, especially spin-offs and patents.

Private subsidiaries of universities are becoming central actors in R&D agency-industry partnerships though the consequences of this trend remain uncertain. Nevertheless, a key feature of the handling of such partnerships at the local level is its diversity. The management of partnership in some universities is left to the individuals concerned, whereas in others, all aspects of the partnership are centralised in a specialised office or in a subsidiary; in yet others, an intermediate situation exists, mixing aspects of the above. It is noteworthy that a number of universities have hired industrialists as vice-chancellors, with a view to facilitating the creation and development of partnerships.

The number of intermediaries in the area of R&D agency-industry partnership links has grown significantly over recent years. Intermediaries and/or consortia often provide an essential mechanism in cases where if they did not exist, R&D agency-industry links would not occur. There are two major rationales for their existence, that is, in scientific or technological fields one industry often cannot afford to fund, or risk funding, the research, and sometimes a single R&D agency cannot supply all the scientific and technical capabilities of the required research. There are situations where an intermediary provides a link between the industry/industries and suitable R&D agencies, which otherwise would not occur through lack of information, or the high costs of information scanning for the industry. There are more complex areas where a single industry on its own would not fund the research and needs an impartial arbiter and 'animator' to set up a project. This would occur in situations such as research on aspects of industry standards or use of shared facilities or networks. Many of these intermediaries are local or regional in character. In the UK the pharmaceutical and biotechnology industries have strong intermediary organisations, namely, the Association of the British Pharmaceutical Industry (ABPI) and the Bio-Industry Association (BIA). The latter in particular is concerned with support for SMEs, which have been adversely affected by the decision of larger pharmaceutical industries to base manufacturing processes outside the UK to reduce costs.

3.5.8 Technology Transfer in Partnerships

The notion of technology transfer cannot any more be understood as a transmission of knowledge from the R&D agency to the receiver easily and usually with almost none follow up. Instead it is no longer like a relay race, in which the baton is passed cleanly and quickly from one runner to the next. Technology transfer looks more like a soccer game in which the R&D agency is a member of a team. To score it needs the aid of all the team members. The ball is passed back and forth among the players who may include businesspeople, venture capitalists, patent attorneys, production engineers, and many others in addition to the university faculty. This is why it has been even suggested that technology 'interchange' is a more appropriate phrase than technology transfer **[99]**.

The LINK Collaborative Award scheme **[100]** is the government's principal mechanism for promoting partnership in pre-competitive research between industry and the research base. It aims to stimulate innovation and wealth creation, and improve the quality of life. The scheme offers an opportunity to engage with some of the best and most creative minds in the country, to tackle new scientific and technological challenges so that industry can go on to develop innovative and commercially successful products, processes and services. LINK focuses on areas of strategic importance for the future of the national economy. All new programmes address priorities under the government's Foresight Programme. Companies and research organisations throughout the UK can participate in LINK projects. SMEs are particularly encouraged to get involved. Multinationals can also participate, provided they have a significant manufacturing and research operation in the UK, and the benefits of research are exploited in the UK or European Economic Area. LINK covers a wide range of technology and product areas from food and biosciences, through engineering to electronics and communications. Each LINK programme focuses on a particular technology or market area. Overall the sponsors i.e., the Government departments and Research Councils in consultation with industry and the research base define programme goals. Each programme supports a number of collaborative research projects. A typical project lasts between two and three years and brings together research base and industrial partners within a well-defined project management framework. Each project must contain at least one industry and one science-base partner. A collaboration agreement drawn up by the partners specifies how the fruits of the research will be shared. LINK stimulates interdisciplinary research in areas such as sensors, medical engineering, advanced food science, new communication systems, future vehicles, surface engineering and catalysis. Networking is strongly encouraged so that participants can share in the programme's achievements, supported by newsletters, seminars, technology transfer clubs and the LINK Web site.

3.5.9 Conclusions

In the UK, framework conditions are becoming increasingly favourable to R&D agency - industry partnership. A change of culture is occurring in response to shifting incentives and there is a growing alignment between framework conditions and industry-science interaction. Some major initiatives in the UK to promote R&D agency – industry partnerships are shown in **Table 3.7**.

There is evidence to suggest that partnerships are sector and field specific, for example, with links in biotechnology being of a quite different nature to links in the service sector. Accordingly, extrapolation of policies from one sector to another is dangerous. Government can facilitate such links to help turn scientific ideas into innovation. This means examining new public-private partnerships to bring industries and R&D agencies (including academia), ideas and finance closer together, as well as initiatives to create regional clusters. Government cannot and should not attempt to manage these networks but can play a critical role in facilitating their creation. It must also provide the best framework for scientists and industries to make international links.

Commercialisation by spin-offs and licensing of technology has received central attention in research and innovation policy. A relatively large infrastructure of intermediary organisations has developed in response to successive initiatives. These may be part of the main players in the partnership or may exist independently with a mandate for regional development being a common mission. The issue at stake is whether excessive emphasis on specialised transfer agencies could monopolise knowledge flows and act as a barrier to the creation of a positive knowledge culture diffused throughout the industry-science nexus. Globalisation has also caused some traditional links to be cut as industries rationalise their R&D activities. On the positive side, the science base is also a major attractor of mobile R&D investment. This is an increasingly important rationale for public support **[101]**.

Table 3.7 Major Initiatives to promote R&D Agency – Industry Partnerships of UK

Programme / Initiative	Purpose	Special Features	Partners
TCS (Teaching Company Scheme) of DTI, 1975	Facilitate TT; Encourage industrial investment in training and R&D; Provide industry-based training jointly by personnel in S,T and engineering base and in business; Collaborative R&D projects	Industry employs a graduate or a group of students with a science or engineering background, to spend 90% of his time working in the industry on specific projects. The balance time is spent in the higher education institution to undergo training.	Universities (science, engineering and technology base) and industry
Foresight Programme of OST, 1993	Build bridges between business, science and government, and bring together the knowledge and expertise of many people across all areas and activities to Increase national wealth and quality of life.	Sectoral approach, Discussion forums, questionnaire surveys, consultation documents and events for producing reports for developing vision by considering possible future needs, opportunities and threats and deciding the future actions	Government, Scientists, technologists, businesses an consumers
LINK scheme of DTI	Promoting partnership in pre-competitive research between industry and the research base for stimulating innovation and wealth creation, and improving quality of life.	Government's main mechanism to support R&D agency / industry participation in Strategic Programmes identified by Foresight in consultation with industry and academia experts. Each Programme has several projects helping industry to develop innovative and commercially successful products.	University, research institutes and industry
Foresight LINK Awards, 1995	Increase interaction between industry and academia.	Matching funds to consortia of business and the science base for projects under Foresight priorities.	Univ. research institutes and industry
Faraday Partnerships of DTI, 1997	Encourage interaction between univ, and industry, especially SMEs to expand information flows and links; improving awareness in academia of ind. requirements and increasing exploitation of research results.	Four pilot Faraday Partnership Centres have been established focussing in different areas that involve partnerships between universities, research institutes and industry	University, research institutes and industry
HEIF (Higher Education Innovation Fund), 2000	Encourage universities for partnering with industry	Platform for core funding to enable the universities to pursue partnership with industry	
'University for Industry', or 'Learndirect',	Involve the educational system in a closer relationship with industry.	Create new system of foundation degrees to provide course material to industry through 178 centres operated by locally based college / university associations, local authorities, trade unions and business organisations.	Local college / university associations, authorities, indistry, etc.
CASE (Collaborative Awards in Science & Engineering	Bring Industry relevance to education	Student receives grant from SERC and also from industry partner. The doctoral research addresses industrial or commercial problem. Academic and industry reps provide joint supervision.	Graduate students, academic faculty and industry
University Challenge Fund Competition	Support the early stages of commercialisation of academic research	Setting up of local seed fund to universities or consortia of universities, managed by a board having expertise for furthering the research/ patenting/prototyping etc.	University and consortia of universities

Industry-science relations are of fundamental importance in the UK policy. A whole range of relevant institutions, viz. governments, their agencies, industrial sectors, higher education institutions and intermediaries have all contributed to the development of a large number of initiatives intended to further the development of networks of collaboration. Other innovation policies relevant to the industry-science interactions have originated from the Patent Office and concern aspects of the patenting process, although they do not involve specific legal changes. The changes proposed to the operation of the Patent Office concern the costs of patenting, and the provision of information about existing patents.

3.6 Critical Appraisal: Inputs Towards Research Objectives and Investigation

The R&D policy of the USA generally focuses on integration of research, education and commercialisation, IP arrangements and involvement of industry in the planning as well as in the evaluation of the programmes. The USA has created good framework conditions for closer cooperation between research and industry by providing flexible infrastructure for R&D, close connections between education and research, and long term funding for fundamental research unconstrained by the type of organisation (university or industry). Legal measures adopted by the government to promote transfer and commercialisation of technology provide significant impetus to the processes of building partnerships. Several institutionalised programmes initiated for this purpose illustrate the importance of written agreements between partners, new knowledge and technology, and cost considerations.

In the USA, the universities, federal research institutes and industry partner with each other on their own for sharing, generating and commercialising new knowledge and innovative technologies even without any formal mechanism instituted by the government. Mobility of researchers from science to industry and vice-versa usually is very high. USA has a long history of catalysing university-industry cooperation and cluster development with strong respect to industry needs. Various examples for clusters, that are the regional hubs of innovation for producing high-value products and services supporting high-wage jobs, can be found across the USA, the most popular examples being the Silicon Valley and Route 128.

In case of Germany the federal government aims at Increasing investments in education and research for restoring and consolidating Germany's business efficiency and international competitiveness; developing the research system to reduce isolation, increase flexibility and create a sharper profile and stronger focus; increasing project funding for bringing more flexibility, competition and quality into research; and increasing joint activities between research centres, academia and industry for improving innovation and developing a clearer and more efficient competition oriented profile. The key research players in Germany are universities, polytechnics, and research institutes. The nation has a long tradition of partnerships between universities and research institutes. The institutes are generally located in the proximity of the universities, some of which are even headed by the university professors. The industry is technologically matured and shares 60-70% of the total R&D expenditure whereas the universities and R&D institutes have a share of only 10-15% and 15-20%, respectively. The industry is ever ready to cooperate with the research institutions. The main focus of the government remains on long-term basic research. State governments are very active in supporting the S&T promoting efforts.

The German government has not instituted any specialised programmes or schemes for promoting partnership. However, there are several partnership promoting efforts, the special features of which are flexible and customer-orientated organisation for transfer of technology, providing necessary training and advice, encouragement to industry for R&D by financial incentives, programme specific funding, enabling competition, enhanced government support for private R&D and special technology programmes particularly for SMEs, regional innovation development through innovation centres, and developing a science dialogue recognising the importance of public support to the continued public finance for increasingly costly research activities.

In Japan, the S&T policies encourage formal networking, include SMEs in science-research-industry networks, develop and strengthen regions by means of networking using cluster approach and increase mobility of employees through specialised programmes as the Japanese by nature usually are averse to move. The Japanese systems had evolved by enacting special laws for the orientation of S&T and building partnerships. Some of the Japanese initiatives included strategic R&D programmes in the priority areas, reforms aimed at strengthening industrial technology base, joint research projects between universities and industry facilitating mobility of researchers and industry personnel to each others institutions, encouraging research personnel to produce industry-oriented output and promoting entrepreneurships among researchers, and IPR issues.

In the UK, the aim of innovation policy is to maximise the contribution of S&T to the UK's economic development and stimulate stronger university-business links to turn its science and engineering excellence into successful and innovative products and services. Industry-science relations are of fundamental importance in the UK policy. A whole range of relevant institutions, including government and its agencies, academia, intermediaries and industry, have contributed to the development of a large number of initiatives intended to further the development of networks of collaboration. Government's strategy increasingly aims at strengthening innovation through cluster development in the regions. The key features of the UK's partnership promoting initiatives include emphasis on science and industry partnerships, role of intermediaries, prioritisation and network building through foresight, customer-focus for research funding bodies, bridging gap between research community and senior management in industry, IPR in university research creating new systems of foundation degrees and student grants, and setting up local seed funds for early stage of commercialisation of academic research.

The review of the programmes and initiatives of developed countries discussed above indicates that the partnerships evolve in each country in its respective context around the organisation and management of S&T and the policies for its promotion and growth, its institutional framework, structure of industrial organisations and the market, role of financial institutions and the approaches adopted by the government in networking. There are, of course, several common features in these countries that include increased R&D spending, establishing Technology Transfer Offices in universities, creating partnerships at sub-national, regional, sectoral and local levels by setting up innovation centres, and encouraging setting up of start-ups and spin-off industries.

The review further points out that the focus of the present assessment study on 'R&D agency – industry partnership for technology development and transfer' in case of India has to be in its own context related to initiatives pertaining to promotion of S&T, building partnerships, specific roles and perceptions of key players in R&D and industry, and those promoting partnerships.

Chapter 4

Partnerships in Countries with Fast Emerging Economies

Chapter 3 discussed the role of government - R&D agency - industry partnerships in development and transfer of technology in some countries in the category of superpowers, namely, the USA, Germany, Japan and UK, and provided a critical appraisal of the specific features of their efforts. These are technologically well-advanced countries and have capability to not only improving upon the existing technologies but also creating new ones. Countries lagging behind the technological frontier need to gain access to and master the technologies used by these leading countries of an era, as well as put in place the institutional structures inducing technological advancement since most of the technologies are operated through specific systems of governance. The present chapter discusses the organisational structures and modes of management of scientific & technological developments, mechanisms of technology transfer / commercialisation and technology partnerships in some of the countries with fast emerging economies, namely, South Korea, China and Brazil.

4.1 Introduction

A country with emerging economy often starts with so called 'Imitation' stage of technology development in which it acquires a technology and begins to assimilate it. Later it improves upon the acquired technology in the internalisation technology stage. At the same time it continues to acquire new technologies, assimilate and improve upon them and the time taken between acquisition, assimilation and improvement gets shorter **[102]**. In a knowledge economy, science is exerting a more important and direct influence on innovation, especially in fast-growing newly industrialising countries. The intensity and quality of R&D agency - industry partnership thus play an increasing role in determining returns on investment in research in terms of competitiveness, growth, job creation and quality of life. They also determine the ability of countries to attract or retain increasingly mobile qualified labour. Such partnerships are undergoing fundamental changes prompted by globalisation and other factors as part of an overall trend towards accelerated development of a market for knowledge. The most visible transformations are the emergence of broad alliances between universities and industries, and growing activity in the realm of commercialisation of results through licensing of IP and spin-off industries.

The interactions between the public research sector and industry in different developing countries take various institutional shapes and differ in their nature and intensity, reflecting national specificities in institutional set-ups, regulatory frameworks, research financing, IPR and status and mobility of researchers. The roles of the two main types of publicly funded organisations, viz. the universities and research institutes, in R&D performance may vary even more, although the share of universities has been steadily increasing in most countries in the last decade.

Whereas the experiences of some countries, especially the USA, suggest that research and commercialisation goals are not only compatible but can reinforce one another, countries that are forging ahead in building new and more flexible models of R&D agency - industry partnerships, are experiencing novel challenges. Some of the developing countries with fast emerging economies besides India, which have taken initiatives to leapfrog to technological advancements by adopting specific S&T innovation policies and generating novel structures of R&D agency - industry partnership are the Republic of Korea, China and Brazil, among others. The following paragraphs provide a brief on the S&T programmes and policies and modes of R&D agency - industry partnership in these countries, which are aimed at facilitating and fostering the technology development and technology transfer.

4.2 Republic of Korea

4.2.1 Introduction

Korea achieved independence in 1945 with the end of the Japanese colonial rule after the Second World War. The perseverance of Korean people in turmoil and hardship inflicted by foreign invasions, the associated *'Han'* psyche that produces energy, disciplined work habit, the dense population and severe cold has forced Koreans to work competitively, and the memory of deprivation has bred the hardworking trait into the country's workers. Since 1990s Korea has emerged as a major S&T power of the world, the evolutionary process that began around 1960s. Korean science, technology and industry policy has distinctly changed thrice in this period and these well-identified phases may be broadly termed as (a) Mature Industry-Based Growth Phase from 1960 to 1980; (b) Consolidation Stage between 1980 and 1990; and (c) Emergence Stage from 1990 onwards. During each of these phases, Korea developed a systematic and integrated strategy that harnessed the strength of its private sector, academia and government, and resulted in a strong National System of Innovation **[103]**.

In the initial phase of the growth process, the government shaped the development strategy on the Japanese model, but during the 1980s Korea witnessed a shift in policy paradigm when the focus of industrial policy shifted from the light and mature industries to innovation-based industries. In order to build and develop comparative advantages in priority industries, technology acquisition was liberalised and at the same time, domestic R&D was aggressively promoted. Carefully crafted policy measures ensured that imported technologies were assimilated, absorbed, mastered and upgraded through domestic R&D efforts. Limited R&D resources were directed at promoting R&D in the priority industries. In recent years, however, the Korean government has further strengthened the system by adopting policy measures to develop innovation clusters in which industry and the related supporting institutes closely network to share knowledge and information.

4.2.2 Historical Perspective and Current Policies for Technology Development in Korea

In the earlier period in Korea there was nearly a total absence of demand for formal local R&D. The government took initiatives in indigenous R&D efforts by creating public institutes. In 1966, the government established the Korea Institute of Science and Technology (KIST) as an attempt to draw back Korean scientists and engineers overseas by offering very attractive salaries to reverse brain drain. It also carried out a number of studies on Korea's technology development potential, which served as a basis for the formulation of national policies in later years. In 1967, a separate full-fledged Ministry of Science and Technology (MOST) was created. In the 1970s, a number of other specialised research institutes were set up. Thus by end-1970s, there were 16 R&D institutes staffed with overseas trained academicians and scientists. In 1973, the 'Daeduk Science Park' was established to serve as a linkage between research institutes, universities and industries. However, since the industry tackled mature technology and the *chaebols* aggressively performed imitative reverse engineering, there was little demand for institutional R&D and the contribution of the R&D infrastructure in technology generation was negligible. As a result, these institutes took upon a consultative role in identifying technology and facilitating technology acquisition by Korean industries. They also provided services in solving simple problems of technology transfers and absorption. They attracted the best talents and served as a think tank for the government in assessing the needs and potentials of the country.

To promote in-house R&D in the private sector, the government offered various tax incentives and preferential financing schemes including loans and subsidies for R&D activities to entrepreneurs, but given the relatively easy means of acquiring embodied foreign technology and assimilating it through shop floor R&D, they faltered. As a result, formal R&D expenditures accounted for only 0.39% of GNP in 1970 and the government share in total R&D expenditure remained nearly 70%. Thus the continuous inflow of foreign technologies through capital goods imports together with the shop floor R&D helped in learning, mastering and accumulating technological capabilities, which determined the process of technological development and high growth rate in Korea. Between 1960-77, the average annual growth in GNP was over 9%. Production in the manufacturing sectors and exports of goods and services increased at the rate of 18% and 28%, respectively. The share of manufacturing in GDP increased from 11.5% during the period 1950-60 to over 23% by 1970-77 and that of exports increased 30 times from 3% to 30% over the same period.

By the 1980s, the industrial base of Korea had broadened. But a rise in wages and the entry of low-waged countries in the export markets eroded its price competitiveness in mature industries. Besides, there was an increasing international pressure on the Government to discourage reverse engineering. This led to gearing the industrial policy towards transforming the industrial structure into the one based on comparative advantage and expanding technology-intensive industries like machinery and electronics. Capital goods sector, which had been subjected to low protection till the late 1970s, also came under import substitution. Thus the focus shifted from light industries with generic technologies to high-tech industries.

Several Institutions such as Korea Productivity Centre, Small and Medium Industry Promotion Corporation, Korea Academy of Industrial Technology, National Technology Institute, Regional Industrial Technology Institute, Industry-Specific R&D Institutes, Korea Institute of Industrial Design and Packaging, Inspection and Testing Institutes, Korea Standards Association, Industrial Technology Information Centre and Industry Associations were established for dealing with technology diffusion. Daeduck Science Park was established to disperse people from the over-populated Seoul Metropolitan area and encourage mutual cooperation among the government research institutes. The Park had modern buildings and facilities but also drawbacks such as being isolated from industry and having little synergy from agglomeration, it was difficult to hire qualified scientists and engineers in a place away from the centre and it did not result in much cooperation amongst the government research institutions.

With change in the industrial policy, a need was felt to reorient the technology policy approach as well. The two major changes introduced in this policy were: (a) Reversal of the government policy on foreign technology licensing; and (b) Rigorous promotion of domestic R&D. The foreign licensing policy was completely relaxed for all industries and for all terms and conditions, marking a shift in the preference from the acquisition of embodied technology to disembodied technologies that reflected the need for progressively more sophisticated technologies. The government established a technology transfer centre, which provided industries with information regarding alternative technologies available abroad and their suppliers. It assisted industry in preparing contractual documents as well. Besides, three technical information centres were set up to collect and disseminate technical information. Public institutes helped the private industries in identifying foreign technologies and in negotiating technology transfers by undertaking joint research with them. Technology payments that were $96.5 million during the period 1972-76 rose to $2130.3 million by 1987-89. The policy towards FDI, another important source of foreign technologies, was also relaxed comparatively during this period but on a selective basis to provide protection to the domestic industry. FDI was channelled into industries supplying critical intermediate inputs or complex technologies and was prohibited for consumer durables. Besides, joint ventures were encouraged under local majority ownership to facilitate technology transfers and the development of managerial skills. To maximise spill over from FDI, the government enforced local content requirements and showed direct preference for the desired kind of technology.

While technology licensing was liberalised, the government undertook massive efforts to promote domestic R&D efforts. The objective was to strengthen the absorptive, learning and technology generating capacity of industries. In 1982, the 'National R&D Programme (NRP), was initiated under which a series of national R&D projects were launched that covered high-risk activities, such as semiconductors, computers, machinery and fine chemicals. It began with two categories of research projects, namely, the 'government-initiated and government-funded projects' and the 'industry-initiated and government-industry co-funded projects'. Later, the scope of the programme was widened and more categories, such as basic research projects, venture technology projects etc. were also added. The objective was to develop core technologies in those fields where Korea had potential advantages. The total expenditure on these projects during 1982-91 was $1205 million. Of this, the government spent 59.4% and the remaining investment was incurred by industry. Thus in line with the industrial policy of creating comparative advantages in selected high-tech industries, the R&D policy focussed on directing the limited R&D resources to industries through NRP. To pursue the policy rigorously, the government abolished all industry-specific promotion acts and legislated a new 'Industrial Promotion Act' that tied all incentives with specific industrial activities, such as the promotion of R&D and development of human resources. Various programmes including tax incentives, preferential financing and exemption from compulsory military service were offered to the industry to increase R&D activities. Some of the policy measures adopted by the government were:

(a) Reorientation of the administrative infrastructure, in which the President's Science and Technology Advisory Council was instituted to provide coordination between various ministries involved in science and technology on a regular basis;

(b) Extension of tax privileges and financial supports to in-house R&D units of private industry under the Industrial Technology Development Law: SMEs that were not able to set up R&D centres were encouraged to form *research unions* with other industries. As a result, the number of such institutes and unions substantially increased in the 1980s. In 1989, there were 749 research institutes and 50 research unions (with 1102 firms).

(c) Massive financial support package to industries undertaking research in core areas, in which the government funded up to half of R&D costs of large industries and up to 80% for SMEs: Under the Industrial Technology Development Programme, up to two-thirds of the R&D costs of joint projects between private industries and research institutes was subsidised. Several tax incentive programmes were also offered to the industry. To provide loan and investment services for new technology, several VC corporations were established. A highly systematic approach was evolved in providing these supports and is currently in practice. This is quite analogous to the programmes undertaken by the Technology Development Board (TDB) of India. At the earliest stages of the R&D process, the Korean government usually supports the private sector activities with direct subsidies while in the subsequent production and marketing stages the main supports are preferential taxes, VC funds and government procurement. Since basic research is highly risky with very low probability of success, the objective of the policy of subsidising these processes at the earliest stages is to cover the maximum risk and encourage industries to undertake research. Another important feature of these government support measures in Korea since the beginning has been that these incentives are performance linked and are monitored effectively through mandatory and legal mechanisms.

(d). Promotion of high-quality higher education: In order to increase scientists and engineers, the government established new institutions such as science high schools, Korea Institute of Technology (KIT) and company training colleges. Various ministries also started supporting university research. As a result, enrolment ratios in higher education increased by over 70% in six years between 1980 and 1986. University grants were, however, tied with their research performance. Besides, Korea Science and Engineering Foundation started its overseas programme to support Korean scientists and engineers for overseas study.

(e) Tightening of patent laws: In order to protect IPR, patent protection was provided not only to foreign technologies but also to indigenously developed technology from local imitation for the period from one year to four years.

(f) Restructuring of existing public research institutes and rationalisation of their operation: Science Research Centres (SRCs), Engineering Research Centres (ERCs) and Regional Research Centres (RRCs) were set up at universities to support R&D. These institutes played an important role both in innovative and adaptive R&D. With the government launching the NRP and *chaebols* undertaking aggressive R&D, the public institutes started forging closer ties with the industry. For every joint research project, public institutes served the role of nucleus because of their diverse experience in technological development and project management.

(g). Introduction of the Fair Trade Act for gearing the industrial policies to maintain competitive pressures within the economy and to counter the increasing economic power of chaebols and the resulting monopolistic practices;

(h). Promotion of SMEs, in particular, technology-based industries to sustain the competitive structure of the economy;

(i) Reorientation of public procurement policy: Through such reorientation the public agencies became able to procure capital goods and other items from local producers. The selection criteria were based not only on price but also on a quality index. This induced quality-based competition among bidders and encouraged R&D efforts among them.

Launch of the NRP in 1982 facilitated research in core technologies and helped in building close links between industries, academia and public institutes. Legal mandatory mechanisms were devised to monitor the use of tax incentives and other fiscal supports.

Grants to universities and public institutes were linked with their research performance to ensure the optimal use of R&D resources. Competitive pressures were maintained on industries to force them improve their competitiveness. The Government continued an aggressive export drive and at the same time encouraged SMEs to ensure the competitive structure of the markets. This strategy paid off and in the highly motivated and competitive environment, industries intensely pursued R&D activities. The well-developed human resources and the presence of large industries were some of the factors that helped in the transformation of the economy.

Korea emerged as a highly industrialised nation with massive technological capabilities during the 1990s. The ratio of R&D expenditure to GDP increased to around 2.8% and became higher than that in many developed countries including the USA. The number of in-house R&D units increased from 966 in 1990 to 2270 by 1995 with the number of researchers going up from around 27,000 to over 63,000. The research unions formed by SMEs increased from 54 (with 1181 industries) to 63 (covering 1346 industries) over the same period. The number of US patents granted to Korea was 5970 during 1990-96 as compared with 580 during 1983-89. However, the neglect of scientific education and scientific base came up as a serious bottleneck in sustaining growth. To overcome the bottleneck, the government focused its attention during this phase on expanding the scientific base and used a multi-pronged policy with especial emphasis on international cooperation.

The Korean government adopted a highly focused industrial policy during each phase of growth and evolved S&T policies within an overall framework of industrial policy. This resulted in a well-balanced S&T approach during each phase. On the demand side, competitive pressures were maintained by aggressively pushing exports and by maintaining the competitive structure of the domestic industries through well-crafted industrial policies. On the supply side, technology accumulation was encouraged using an appropriate mix of technology acquisition and technology generation. While during the first phase, technology capabilities were accumulated through reverse engineering of imported machinery at the production level, in the second phase, technology licensing was combined with a rigorous promotion of domestic R&D. Specific technologies were identified and the National R&D Programme was launched to develop them. This helped in evolving close links between universities, research institutes and industry. A systematic approach was adopted in designing support measures and a legal mechanism was evolved to monitor their use.

In the final stage, recognising the importance of international cooperation in S&T in expanding the scientific base, Korea commenced aggressive promotion of such cooperation. The Government established formal cooperative relationships in S&T with foreign countries in the form of agreements and other arrangements. Such arrangements facilitated the exchange of scientists, exchange of information, joint research, direct and joint investment and other cooperative activities. Thus starting from reverse engineering during the initial phase of growth Korea moved to technology generation in high-tech industries by the 1990.

A summary of the three stages of evolution of Government initiatives in Korea for technology advancements is presented in **Table 4.1.**

Table 4.1 Three Stages in the Evolution of Government Policies of Korea

Major Planning Objectives	Trade Regime	Industrial Regime	R&D Policies	Technology Acquisition Policies
Mature Industry Based Growth Stage (1960-1980)	- Outward Oriented for Mature Industries - Import Substituting for New Industries	-Competition Promoting -Biased in Favour of Efficient Large Firms	- Emphasis on Diffusion at the Production End	- Restrictive for FDI and Licensing and Liberal for Capital Goods Import
Consolidation Stage (1980-1990)	- Import Substituting for Major Import Items - Outward Oriented for Others	-Liberal with Curbs on Monopolistic Powers of Large Firms	- Emphasis on Technology and Technology Generation	- Greater Emphasis on Licensing
Emergence Stage (1990 Onwards)	- Outward Oriented	-Encouragement to SMEs	- Expanding Scientific Base with Emphasis on International cooperation - Developing Innovation Clusters	- Liberal for Inward and Outward FDI

4.2.3 Korean National Innovation System and Policies

Korea has developed a strong National Innovation System **[104]**. It has adopted a highly focused approach by identifying specific industries and specific core technologies that can be evolved and by directing the limited R&D resources to the promotion of these technologies through a well-formulated NRP. Four conditions need to be satisfied for building a strong innovation system: (a) strong competitive pressure on domestic industries, be it from other domestic industries, importers or export markets; (b) the presence of high-quality human capital; (c) well-developed links between R&D agencies and industry; and (d) access to foreign technologies. Korea tailored the country's innovation system in each stage to accommodate these conditions, as is illustrated in **Table 4.2.**

Table 4.2 Stages of Evolution in Innovation System of Korea

Year	Industrial Development	Technology Development	Highlight
1980's	- Transform industrial structure to one of comparative advantage - Expand technology-intensive industry - Encourage manpower development and improve productivity of industries	- Develop and acquire top-level scientists and engineers - Perform national R&D projects efficiently - Promote industrial technology development	$1,655 per Capita Capital and Technology in 1980
1990's	- Promote industrial restructuring and technical innovation - Promote efficient use of human and other resources - Improve information networks	- Reinforce national R&D projects - Strengthen demand-oriented technology development system - Institutional reforms	$5,890 per Capita Technology and Innovation in 1990
2000-2003	- Move towards High tech and high value-added industries - Develop IT industry - Search the next generation	- Strengthen national and regional innovation systems - Internationalise R&D systems and information networks - R&D increase in IT, BT, MT	$9,823 per Capita Innovation and KBE in 2000

Under the new framework of national S&T planning, Korean S&T system comprises the National Science and Technology Council (NSTC) and Presidential Advisory Council on S&T. Ministry of Science & Technology (MOST) serves NSTC as its secretariat. President is the Chairperson of NSTC and its members include 15 S&T-related Ministers in MOST, Ministries of Commerce, Industry & Energy (MOCIE), Information & Communication (MIC), etc. and 9 selected civilian experts. The main function of NSTC is short-term and long-term policy coordination. Korea Institute of Science & Technology Evaluation & Planning (KISTEP) is the supporting agency to NSTC for Technology Forecast, Assessment, Roadmap, Administrative support for Evaluation and Pre-budget Review etc. Some of the features of the current science, technology and industry policies in Korea are as follows:

(i) Support to Scientific Education: For the promotion of basic science, R&D investment in universities and colleges was increased to ~12% of the total R&D by the year 2001 to ~$4490 million from ~US $581 million in 1993. Government promotes basic science and places special emphasis on the training of the creative scientists and high-calibre technological manpower. SRCs, ERCs and RRCs are being expanded to advance basic scientific research. In parallel, the Government is heavily investing on the up-gradation of the quality of education and research facilities in the university system. The Ministry has set up two new institutions, namely, Korea Institute for Advanced Study and Asia-Pacific Center for Theoretical Physics, as Centres of Excellence for attracting first-rate scientists from advanced countries. Korean students and researchers are being sent abroad to acquire advanced degrees or study specific fields of knowledge.

(ii) Encouragement to International Cooperation for Basic Research: The Government is supporting international R&D cooperation. The Science and Technology Policy Institute (STEPI), a public research institute, is planning to create joint institutes with 10 developed countries; MOST provides subsidies for joint international research programmes; and public institutes have been signing research contracts with foreign industries and universities. The public sector 'Electronic and Telecommunications Research Institute', for instance, has teamed up with Stanford University for the joint development of an operating system for an indigenous multimedia workstation. Technologies will be transferred to LG, Samsung and Daewoo for commercialisation. The *cheabols* have also formed international industry-academic cooperative associations with foreign universities to undertake joint research in advanced technology. LG electronics, for instance, has put together a $10 million joint research cooperative structure involving 32 foreign universities. Samsung is carrying out a number of joint international R&D projects in semiconductors and LCDs with foreign universities. Besides, the *chaebols* are forging direct cooperative agreements with foreign companies to develop new technologies. A number of such agreements have been forged by LG. These involve giants like Motorola, Phillips and Xerox. The Korean firms have also been directly purchasing patents. They have been acquiring low-cost patents from Russia, on the one hand, and patent portfolio from the US patent brokers, on the other.

(iii) Employment of Foreign Nationals: Hiring foreign experts for an indirect technology transfer is widely practised by Korean companies. It is recommended and facilitated by the government. The government and the industry operate systems to identify and recruit qualified employees who they believe may transfer new technologies. Highly attractive salary packages are offered to them. Besides, Korean companies regularly send employees abroad for on-site training at overseas companies. The practice exposes Korean technicians to the technology, operations and practices of a foreign company.

(iv) Liberalisation of FDI Policies: To attract the complex and advanced technologies and infuse competitive pressures, Korea has substantially liberalised the economy for FDI since the 1990s. FDI in Korea increased from an annual average of $863 million during 1986-

1991 to $2341 million in 1997. Now most manufacturing and service sectors are open to 100 per cent foreign ownership on the basis of a simple notification.

(v) Encouragement to Outward FDI for Acquiring Local Knowledge Base: A number of incentives have been offered to *chaebols* to invest in overseas activities to claim markets and take advantage of local expertise. For starting production facilities in developed countries, *cheabols* are pursuing the policy of acquisition and mergers. The objective is to acquire latest science, technology and know how of the acquired companies. LG Electronics secured patented High Definition TV technology by acquiring Zenith and dominated the huge High Definition TV markets; Samsung acquired Harris Microwave Conductor to secure world class technological capability in non memory semi-conductor; Hyundai purchased controlling stakes in the US firm Maxtor to obtain patents on HDD components and ASIC technology; Hyundai also acquired NCR's Microelectronic Product division and secured rights to 690 patents and trademarks.

(vi) Locating Research Centres Abroad: The Korean government and the *chaebols* are locating research centres in advanced countries to acquire and generate new technologies using the local expertise. The major US-based research facilities that are owned by the Korean industries include San Jose Research Institute and Image Quest Technology in Silicon Valley by Samsung Electronics; San Jose Institute and LG North American Operations in Chicago by LG Electronics; and SEMR Research Institute in San Jose by Hyundai Electronics. Besides, Daewoo Electronics is setting up a worldwide research network that includes 12 R&D centres in eight foreign countries.

(vii) Launching of Highly Advanced National (HAN) R&D Projects: In 1992, the Korean government launched the HAN project called G-7 with the aim to turning Korea into one of the top seven technologically advanced countries. After the first phase (1992-94), its performance was evaluated to decide whether to continue the programme further. It revealed that in the first phase 2500 patents were applied and 550 patents were granted, and 2100 papers were presented in seminars of which 1900 were published in journals. It was therefore decided to continue the projects. HAN project is currently a large-scale project with the estimated cost of $5069 million and covers 17 strategic fields that are essential for advancing the economy in high-tech sectors. Various R&D organisations such as universities, industries and public institutes are participating in this project. International cooperation is also being pursued for the projects.

(viii) Creation of Innovation Clusters: In an important development during the 1990s, the Government started pursuing the policy of creating innovation clusters with R&D labs, technology parks and government regional research centres where industries are vertically and horizontally integrated from R&D to production through networks. In that context, the government is planning to construct five more science parks in Kwangju, Pusan, Taegu, Chunju, and Kangleung along the lines of the Daeduk Science Park. In addition, RRCs, which are the research consortia to undertake research associated with regional development involving local industries, universities and research institutes, are being set up to establish a regional research network among research agents.

(ix) Establishment of S&T Forums and Techno-Marts: The government is supporting the establishment of S&T forums and organisations of techno-marts for acquiring technologies from foreign industries. A nationwide data network has also created that is periodically upgraded for providing on-line access to information on advanced industrial technology in foreign and domestic database.

The Science and Technology Framework Law, enacted in 2001, is the most influential and comprehensive law, as indicated by its title. It provides an institutional framework to govern all the rules and regulations on science, technology and innovation. Other laws can be grouped into five areas, viz. technology development support; promotion of R&D institutes; nuclear and energy; improving manpower, and others. There is a complicated set of laws and regulations for science, technology and innovation. This fact may reflect the government's active role and leadership, but at the same time it may indicate duplications and authoritative intervention. Indeed, excessive regulations and duplications of R&D programs are problematic.

The strong leadership or intervention of the government and the relative weak position of the private sector characterises Korea's governance of its S&T policy. The share of R&D budget of the total government budget has steadily increased. Moreover R&D investment by the private sector has increased more rapidly even though the government has tried to allocate a larger portion of its budget to R&D activities.

4.2.4 Conclusion

As stated, the growth process in Korea was primarily adopted from the development strategy of the Japanese. Along the process from basic research to the manufacturing of tangible products, Japan and Korea focus more on the research end of the spectrum. For example, both countries put emphasis on basic and applied research in their effort to develop science parks. Also, science parks in both countries are more domestically oriented and there is no deliberate effort to attract foreign companies to settle in these parks. Korea actively supports the development of networks and clusters in strategic fields of innovation. Their development is supported through a bundle of measures ranging from the establishment of free economic zones over the financial support of R&D projects to tax incentives. It is the one outstanding aim of the Korean government to attract foreign investment to these clusters.

The Korean innovation policy system in the past and present is hardly regarded as the one based on the concept of horizontal innovation policy. It is rather characterised by a strong hierarchical structure in decision-making. The private sector in general is still concentrating on the rapid commercialisation of outside technologies and imitating global front-runners. The private sector's R&D share of the national total was 74% in 2002. The share of the private business sector has steadily increased whereas that of research institutes has decreased. The fundamental problem of the Korean NIS and S&T governance is that the system was designed for the imitation era, which is inefficient and a bottleneck for the innovation era. Although the system was relatively successful in mobilising resources in the past, it has recently been severely criticised to be inefficient for the new era of knowledge-based economy, where innovation is the most important factor. Thus Korea is facing a serious challenge for creating a new governance scheme for more efficient and democratic science, technology and innovation policy. The system needs substantial reforms towards a horizontal innovation policy system in which genuine cooperation and coordination among branches of the government and the general public's participation in the policy formulation are incorporated **[105]**. Benchmarking of many leading countries has contributed to the discussion on the problem and new designing **[106]**. The new administration known as 'Participatory Government' has started since 2003, which operates on a catch phrase of 'creative destruction of the '*ancient regime*''. It has been formulating a grand strategy for reforming the Korean NIS in terms of structure, resource allocation, and balanced regional development, for which the main framework has been formulated.

Table 4.3 presents major initiatives taken up by the Korean government to promote R&D agency - industry partnerships. It may be seen that there are not many initiatives, but at the same time there are a number of laws promulgated in Korea **(Table 4.4)** that promote the sectoral development of technology and its commercialisation.

Table 4.3 Major Initiatives to promote R&D Agency – Industry Partnerships of Korea

Programme / Initiative	Purpose	Special Features	Partners
NRP: National R&D Programme (1982)	Support to basic research / venture tech projects; develop core technologies in S&T fields of potential advantages, viz. computers, machinery, fine chemicals, semiconductors by covering high-risk activities	Supported two categories of research projects, namely, 'government-initiated and government-funded projects' and the 'industry-initiated and government-industry co-funded projects'. Later started supporting basic research, venture technology projects etc.	Universities research institutes and industry
Industrial Technology Development Programme	Encourage industries to undertake research by offering support package to industries undertaking research in core areas to cover the maximum risk	Subsidizing upto 2/3rd of R&D costs of joint projects in the earlier phase. Tax incentive, VC funds to provide loan and investment services to industry for new technology for production / marketing.	Universities research institutes and industry
Innovation clusters, 1990s	Regional research network between R&D agencies and industry to promote vertical and horizontal integration from basic research to production	Established science parks as S&T Centres along the lines of the Daeduk Science Park as well as RRCs. RRC is research consortium for research associated with regional development.	Universities research institutes and industry
HAN (G-7): Highly Advanced National R&D Projects, 1992	To turn Korea into one of the top seven technologically advanced countries.	A large-scale project covering 17 strategic fields essential to advance the economy in high-tech sectors. International coop. also being pursued.	Universities research institutes and industry

It takes much long time to recognise problems of a national innovation system and even longer to reach a consensus on the direction and measures for reform. The recognition is a result of combined and accumulated efforts of various actors in the system. A kind of crisis consciousness is a crucial factor. In the case of Korea, the challenge of the rapidly rising Chinese economy is contributing a lot to this. Managing conflicts and vested interests and consensus building is the most difficult part in the process of reforms. Korea is still in the process of the management of conflicts.

Table 4.4 Important Laws promulgated to promote R&D Agency – Industry Partnerships in Korea

Initiative	Enactment Year	Purpose
Machinery Industry Law	1956	Promote experimental research, initial production and industrial rationalisation of machine tools
Electronics Industry Law	1957	Promote experimental research, initial production and industrial rationalisation of electronic technologies
Industrial Technology Development Law	1967	Encourage SMEs to set up in house R&D Units through tax privileges and financial supports resuling in increase in Number of such institutes and unions substantially increased in the 1980s. In1989, there were 749 research institutes and 50 research unions (with 1102 firms).
S&T Framework Law	2001	Provide an institutional framework to govern all rules and regulations on science, technology and innovation

4.3 Peoples Republic of China

4.3.1 Introduction

China is the sixth largest and fastest growing economy in the world and prides itself on rich research brains and low operation costs. It is the third largest spender on R&D in terms of Purchase Power Parity and is fifth by way of the number of Science Citation Index papers. Among the scientific accomplishments of Ancient China were the four 'Great' Inventions, namely, Compass, Gunpowder, Papermaking and Printing. Chinese astronomers were also among the first to record observations of a supernovae. Regretfully, however, China's technological base was devastated during the Cultural Revolution (1966-1976) and since the early 1980's the country confronted many serious problems in rebuilding and achieving its technology development goals. These led to the formulation of new industrial and economic reform policies that became an integral part of China's 5-year economic plans. The latest technology programmes in China have been extended to the year 2010 **[107]**.

Prior to economic reform, research and technology development projects were determined according to government plans and implemented by government-funded institutes. However, recognising the existence of a huge technological gap between the Chinese economy, its industries and the other industrialised nations, Chinese policymakers emphasised the acquisition of foreign technology to achieve rapid technological development in the belief that the imported technology would replace obsolete technology within the industrial sector and would allow China to "leap frog" over several generations of technology to move into the modern phase of high-tech industry. The government sought to increase China's technological development and industrialisation by creating and funding major research and technological development projects in order to achieve both mid-term and long-term development goals for developing and enhancing the industrialisation and commercialisation of scientific research and technology. The areas targeted were the traditional industrial sectors, high-tech industries, infrastructure and scientific research institutions. Foreign technology was to be monitored, imported and absorbed, thereby increasing China's industrial and technological capacity as well as economic growth.

The "Spark" Program (1985) promoted economic development through S&T development and propagating R&D discoveries to rural areas. The "863" Programme (1986) was responsible for monitoring emerging foreign technologies with widespread interest in commercialising high technologies (5-10 year period) and keeping abreast of the world's latest scientific achievements in biological engineering, space, information storage and retrieval, laser technology, automation, energy and new technology. The Torch Program (1988) initiated by the State Commission for Science and Technology (SCST) accelerated the application of technology in business enterprises and helped in the commercialisation of new technologies and promotion of economic growth with high-tech products competitive on local and world markets. These efforts along with the creation of high-tech zones and technology parks led to the advancement of Chinese industry and more competitive enterprises.

At present the role of government is still important but is diminishing with market guided research and technological development becoming more prevalent. An important element of China's technological development is the technical renovation of industry and enterprises. Key industries are selected and specific areas are targeted for technical renovation. In the early periods of reform the technical renovation focussed on light industry and machine-manufacturing facilities, but currently the emphasis is clearly on enterprises with leading profits, upgrading of facilities in targeted industries, new technology applied towards production, manufacturing machinery, automated systems, and the replacement of obsolete technologies **[108, 109]**.

4.3.2 S&T Management in China

MOST, a central government agency under the State Council is responsible for the nation's S&T activities. At the same time, the S&T departments of various ministries and administrative agencies or bureaus in the local governments control the S&T activities under their respective charge. Chinese Academy of Sciences, R&D institutions under various ministries and administrative agencies, universities and colleges, local R&D institutions and R&D institutions affiliated to defence and industrial enterprises, are the core scientific technological research bodies in China. Additionally, there are over 160 national scientific and technological academic organisations under the jurisdiction of the Chinese Science and Technology Association and their branches in large and medium-sized cities. The Academic Council Members' General Meeting in China is the supreme state consultative organ on S&T.

The Chinese Academy of Engineering, founded in June 1994 and having 96 council members is the highest advisory academic institution in China's engineering community. The Chinese Academy of Sciences with its headquarters in Beijing is the supreme academic organ and comprehensive research centre in the natural sciences. It has academic departments including mathematics and physics, chemistry, earth sciences, biology, technology and agricultural research, 123 research institutes located throughout the country, and branch academies established in provinces, autonomous regions and municipalities where research organs are concentrated. Before the 1990s, the Chinese Academy of Sciences, modelled on the Soviet system, placed much of the country's greatest scientific talent in a huge under-funded apparatus that was largely isolated from industry. However, pursuant to Chinese economic reform, most of its scientific institutions were encouraged to commercialise their activities and Chinese scientists increasingly began to 'Xiahai' (enter the sea) or go into business.

A National Steering Group on Science, Technology and Education was set up in 1998 with its major terms of reference being the study and review of national development strategy and major policies of science, technology and education; review of significant S&T and education tasks and programmes and coordination of important relationships related to S&T and education between different governmental departments and between central government and local governments.

It may be noted that Chinese institutions are vertically integrated and the lack of internal and external disciplinary or programmatic integration can lead a lot to duplication of effort, and problems communicating data across institutional structures often limit the effectiveness of research.

4.3.3 S&T Policy in China

In order to effectively promote the development and practical application of new and advanced technology the Chinese Government in March 1992 promulgated the National Compendium on Intermediate- and Long-Term Scientific and Technological Development that set out a grand blueprint highlighting the essential loci of China's plan to develop new and advanced technologies, key technologies and the nation's strategic objectives for the coming 30 years.

On May 6, 1995 the Chinese Communist Party Central Committee and the State Council issued the 'Decision on the Acceleration of Progress in Science and Technology' that set the overall goal (both public and private) to attain Chinese R&D spending equivalent to 1.5% of GDP by the year 2000. It urged scientific academies and institutes of higher education to set up high-tech industries and noted that S&T are the chief forces of social and economic development. It focussed on S&T issues like population control, feeding people, environment (including pollution control technologies) and public health (such as pharmaceuticals development) and called for a reform of the Chinese S&T structure to meet the needs of the socialist market economy in order that science moved out of the institutes into private enterprises and government research institutes entered into cooperative ventures with Chinese and foreign companies, deciding the direction of their research by themselves and becoming responsible for whatever profits or losses they incur. This policy expected the flow of personnel, information and capital to become faster and smoother so that industries as well as government research institutes and universities which have created their own high tech companies, could orient their research programmes according to market needs, and consequently to what the market was willing to fund.

The key features of the current S&T policy of China are:

- Encouragement to citizens and entities to engage in scientific research, technology development, inventions and other creative activities and advocate and support effective and timely application of S&T achievements to production;
- Achieving major advances in industrial and agricultural research and technological development, basic research and high-tech R&D to markedly increase the contribution of scientific and technological progress to economic growth;
- Guaranteed funding earmarked by the State for key research areas and projects while encouraging greater public input in S&T by creating an S&T investment pool absorbing government appropriations, funds raised by enterprises and the public, loans from financial institutions as well as foreign funds;
- Significantly greater level of international S&T cooperation and exchange through official, non-governmental, bilateral and multilateral channels on the basis of equality and mutual benefit;
- Attention to the acquisition and assimilation of foreign technology while developing S&T capabilities primarily on indigenous efforts;

- Putting together a comprehensive legal system by strengthening legislation and enhancing the public awareness of legal work with respect to S&T and protecting IPRs, so that inventors' lawful rights and interests are not infringed upon;

As a part of the reform of Chinese S&T structure 1,185 R&D institutes were supposed to be converted to business entity. By the end of 2002, 946 had completed their conversion. **Table 4.5** presents the converted R&D institutes of which 273 were originally attached to the central government and the remaining to the local government.

Table 4.5 - Converted R&D Institutes in China (2002) [108]

Number of Institutes	Central	Local	Total
Became industrial businesses (groups)	160	180	340
Became large S&T businesses attached to the central or local government	33	4	37
Became industrial technical innovation diffusion centres	5	11	16
Became S&T industrial businesses	63	448	511
Became industrial businesses as the result of the parent organization's industrial conversion	9	17	26
Became intermediary agencies		8	8
Became a part of universities	3	4	7
Became non-independent S&T activity unit attached to other departments		1	1
Total	**273**	**673**	**946**

Table 4.6 Categorised Reform of Public Good Institutes (2002) [108]

Number of Institutes	Central	Local	Total
Became S&T industrial businesses	4	28	32
Became intermediary agencies	7	6	13
Became a part of universities	6	10	16
Became non-profit public institutes	32	29	61
Became non-independent S&T activity units attached to other departments	0	4	4
Became other forms of existence	32	20	52
Total	**81**	**97**	**178**

Table 4.6 above shows the categorised reform of public good institutes, which achieved substantive progress. As of the end of 2002, 178 public institutes got reformed, of which 81 were subordinated to the central government and 97 to the local government. The reform converted 61 of them into non-profit public institutes, 32 turned into S&T businesses, 13 became intermediary agencies, 16 became part of universities and 4 became non-independent S&T activity units attached to other departments.

The continuously deepened reform and industrial conversion has produced notable progress in industrialisation process by further enhancing the technical innovation capacity and superior technology diffusion capacity. The strategic objectives of China towards the year 2010 are to reinforce and perfect the newly established S&T system and realise an organic integration of S&T with the economy; train and turn out a highly qualified scientific and technological contingent and markedly improve the nation's S&T and cultural quality; bring its S&T capacity in important disciplines and high-tech fields to or near the world advanced levels; drastically increase the ability to engage in independent innovation and come to grips with critical technologies and systems design technology in major industries; enable production technologies in major areas to reach or approach the level of the developed countries in early next century; and lay a solid foundation for building the country into a modern, power socialist state.

4.3.4 Intellectual Property Rights

China's recognition of IPRs has been a very recent occurrence when the Chinese Communist Party came into power. The Marxist-Leninist system of law did not consider scientific, literary and other intellectual works as personal property **[107]**. **Table 4.7** lists out various laws and regulations on IPR along with the date of their enactment. **Table 4.8** shows the international conventions for the protection of IPRs that China has acceded to indicating the date of accession. To increase China's intellectual properties, accelerate S&T conversion and protect the legitimate rights of state, units and individuals, MOST and the Ministry of Finance on 5th March 2002 jointly published "The Regulations on the Management of National S&T Programmes' and Projects' Intellectual Properties". It is clearly stipulated in these Regulations that the state entitles implementing institutions the right to the findings resulted from research projects, and to the associated intellectual properties, except for those involving national security, national interests and major public interests. The implementing institutions can decide on their own to implement, license and transfer it, or make it an equity investment and obtain corresponding benefits. Meanwhile, the State may, under special circumstances, retain the right to freely using, developing and exploiting it, or making profit from it.

Table 4.7 Enactment of IPR Laws and Regulations [107]

IPR Laws and Regulations	Date of Enactment
The Trademark Law of China	Mar. 1, 1983 (Amendment) July 1, 1993
The Patent Law of China	Apr. 1, 1985 (Amendment) Jan. 1, 1993
The Technology Contract Law of China	Nov. 1, 1987
The Copyright Law of the People's Republic of China	June 1, 1991
The Regulations of the People's Republic of China for the Protection of Computer Software	Oct. 1, 1991
The Regulations Regarding the Implementation of International Treaty on Copyright	Sept. 30,1992
The Regulations for the Administrative Protection of Agricultural Chemical Products	Jan. 1, 1993
The Regulations for the Administrative Protection of Pharmaceuticals	Jan. 1, 1993
Supplementary Provisions of the Standing Committee of the National People's Congress for the Punishment of Crimes of Counterfeiting Registered Trademarks	July 1, 1993
Law of China on S&T Progress	Oct. 1, 1993
The Law of the People's Republic of China for Countering Unfair Competitions	Dec. 1, 1993
Decision made by the Standing Committee of the National People's Congress on Punishing the Copyright Infringement Crimes	July 5, 1994
Regulations for the Administration of Audio and Video Products	Oct. 1, 1994
Regulations for the Customs Protection of IPR	Oct. 1, 1995
Law of China on Accelerating the Commercialisation of S&T Research Results	Oct. 1, 1996

Table 4.8 Accession of International Conventions for IPR in China [107]

International Conventions for IPR Protection	Joining Date
The Paris Convention for the Protection of Industrial Property	1984
The Madrid Convention for International Trademark Registration	1989
The Treaty on Integrated Circuits Related IP	1989
The Berne Convention on the Protection of Literary and Artistic Works	1992
The Universal Copyright Convention	1992
The Convention on the Protection of Phonograms	1993
Patent Collaboration Treaty	1993

4.3.5 S&T Industrial Parks and Service Centres

Development of science and technology industrial parks (STIPs) is an important content of China's strategy of revitalising the nation with science and education. In May 1988 the State Council approved the establishment of the Beijing Experimental Zone for the development of new technology industries, which became the first STIP in China. After that as a major part of the "Torch" Programme that was aimed at promoting the commercialisation, industrialisation and internationalisation of China's hi-tech achievements, STIPs vigorously multiplied in the country. Since 1991, 53 national STIPs have been established, which in 2000 altogether housed 20,796 small and medium sized new and high-tech enterprises with high flexibility, market adaptability and strong technological innovation capability are growing up at a fast pace **[110]**. The location of theses STIPS depends upon the favourable conditions of the areas and meeting the needs of a particular area e.g., to renovate traditional industries and speed up the development of local economy.

Inspired by the success of the business incubators abroad China established the high and new technology innovation centres, the S&T service institutions of public interest, with an objective to stimulate transfer of S&T achievements into products and services and to cultivate high and new technology enterprises and entrepreneurs by extending all necessary help and services to S&T start-up companies in their early stage of development. These service centres as a base to commercialise high and new technology achievements, provide a bond between entrepreneurs and universities or colleges, R&D institutions as well as SMEs. More than 70 service centres have been established by now.

Centring around theses service centres, STIPs continue to make efforts to built and improve relevant infrastructure and institutions, and provide services to S&T start-ups in such area as R&D, information, financing, trade, legal protection, loan guarantee, technology evaluation, human resources, international exchange and training, IP protection and technology transaction, thus establishing initially and incubation system of China's characteristics for technological innovation.

4.3.6 Major Programmes in China for Development / Transfer of Technology

In pursuance of the S&T policies promulgated by China from time to time several national programmes as described below have been taken up, which have, besides others, influenced the technology development and transfer activities in the country **[108]**.

➢ **National Programme for Key S&T Projects:** This programme first launched in 1982 is a critical component of the 5-year plans for the national economic and social development. It is updated every five years and is submitted for approval by the National People's Congress (Chinese Parliament). Its objective is to find solutions to the scientific and technological bottlenecks in the national economic and social development. It is funded by both the central and local governments and is supplemented by financial inputs from different industrial sectors and institutions. The government investment is in three types: completely free support, partially free support, and loans. The government investment on the Programme during the Eighth 5-year Plan period (1991-1995) was about 3.5 billion yuan (~US$423 million).

➢ **Spark Programme**: Approved by the Chinese Government in 1986, Spark is the nation's first guided development programme designed to develop the rural economy through S&T. The objectives are to bring advanced and appropriate scientific and technological achievements to the rural areas; guide the farmers onto the path of modern S&T-driven agricultural production; lead scientific and technological progress in township enterprises; improve productivity; and ensure a sustainable, fast and healthy development of the rural economy. Its financial resources are mainly raised from the public with some seed money from the State. The approved projects are entitled to favourable bank loans and preferential taxation policies. The future focus of the Spark programme is to develop regional pillar industries in rural areas and establish Spark-intensive areas in conjunction with the construction of small cities and towns.

➢ **National High Technology R&D Programme (863 Programme)**: In March 1986 four eminent Chinese scientists urged the initiation of a new national high technology programme, also referred to as 863 Programme, which was launched by the Chinese Government after its thorough assessment by experts. While the guiding principles of 863 programme are limited target clearly-defined priorities, vigorous monitoring of global technological advances, striving for breakthroughs wherever possible, and combining the military with the civilian while focusing attention on the civilian, its objectives are to pool the best technological resources in China for the purpose of keeping up with the world's high technology advances in certain fields, close the gap between China and other countries in several critical areas and to strive for breakthroughs wherever possible. 863 Programme also devotes attention to providing technological backup for the nation's economic development, national defence and the commercialisation of high technology. The financial support required for the Programme comes from special government appropriations.

➢ **Torch Programme:** The Chinese Government approved the High and Emerging Technology Industry Development Programme (widely known as Torch Programme) in 1988 with the objectives of promoting the commercialisation, industrialization and globalisation of the results of key high technology projects, including those from the 863 Programme, through market mechanisms and facilitating the development of new and advanced technology industries. The financial resources are mainly raised from the public with support of start-up funds from the state. New product projects listed in the Programme are entitled to priority in getting bank loans and to preferential taxation policies over a specified period of time. The creation of the High and Emerging Technology Industry Development Zones represents a major thrust of the Torch Programme. The central government has thus far approved 52 such zones at the national level resulting in clusters of burgeoning high and new technology industries in the coastal, frontier, boarder and inland cities all over the country. Preferential policies have been put into effect in these zones.

- **National S&T Achievement Dissemination Programme:** This programme, initiated in 1990, is aimed at injecting advanced and mature S&T achievements into the nation's economic and social development in a well organised and planned fashion; mobilising large numbers of scientists and engineers for the implementation of massive popularisation efforts in the rural areas, enterprises and a wide range of economic and social activities so as to enhance the overall performance level of the national economy. The significant features of the programme are meeting the technological requirements of enterprises, the countryside and the traditional industries, and aiming at higher economic returns with less investment, short investment cycle, good demonstration role and spin-off effect. While the loans, investments and funds are raised for this programme by enterprises and the public; the government provides the start-up money. The projects listed in the programme are entitled to preferential treatment during implementation.

- **National Programme for Key Basic Research Projects**: the National Programme for Key Basic Research Projects (also known as 'Scaling the Height' Programme) was initiated in 1991 and is designed to conduct high quality research on major scientific problems that have important bearing on the nation's S&T as well as economic and social development, vigorously train young talents for basic research, and strengthen the build-up of a high quality research contingent. The government provides the funding required for the 'Scaling the Height' Programme. This Programme covers seven branches of basic research and eight branches of applied basic research fields, viz. mathematics, physics, chemistry, mechanics, astronomy, geography, biology; energy, materials, information and computer, basic agronomy, basic medical sciences, resource and environment science, space science, and engineering science, but most of the research projects so far undertaken are in basic sciences.

➢ **National Programme for Science and Technology for Sustainable Development:** This Programme is aimed at improving the quality of living of the people, coordinating the relationship between man and nature, and encouraging S&T progress in social undertakings and related industries.

➢ **Soft Science Research:** Soft science is a complete scientific and technological knowledge system encompassing natural sciences, social sciences and engineering technologies under the charge of the State S&T Commission (SSTC). By 1992, some 960 soft science research organisations were established nationwide affiliating about 29,000 researchers. Over 16,000 research topics of soft science were completed with 4,341 having won national, ministerial or provincial level awards for S&T progress. The main mission of Soft Science Research in the New Era is to strengthen research on soft science theories and methodologies; conduct research on important and critical issues in reform and development; provide services to a democratic and scientific decision- making process; foster commercialisation and industrialisation of soft science research results; and cultivate and develop a consultancy industry. The central government agencies and local governments provide the funding.

➢ **International S&T Cooperation Programme for Priority Projects:** The International S&T Cooperation Programme for Priority Projects was created in the 10^{th} five-year S&T plan of China to support and organise international S&T cooperation projects having strategic importance to enhancing the nation's S&T innovation capacity, spurring high-tech industrialisation process and accelerating S&T cooperation. Working on international scientific cutting edges, the Programme also strives to make China's S&T innovation activities in line with international norms. It encourages research institutes and universities to be an active part of international S&T activities, including basic research, high tech development, large science and major international programmes and gives priority support to the institutes and universities having a solid research capacity and strong international cooperation endeavour, and make them national bases for international S&T cooperation.

➢ **National Science Foundation of China (NNSFC):** The NNSFC promotes basic research in all S&T sectors and carries out the plans of SSTC for basic research. Grants awarded by the National Natural Science Foundation of China fall within areas, which are designated as scientific priorities by the current Five Year Plan **[111]**. Thus funding decisions are based on a judgment on how research opportunities and interests of researcher match national science goals enunciated in the 5-year Plan. Within these designated areas, the peer review panels make awards. NNSFC grants often serve as seed money attesting to the quality of a project. Local government money often follows thereafter. Shielded from government-wide funding costs, the budget of NNSFC is becoming an increasingly large part of China's basic research spending. Grants include neither overhead nor salary but are dedicated to direct research costs. The NNSFC funds 60 major projects at 5 million Yuan (~US$0.6m) per year and 500 - 600 other projects at 1 million Yuan per year as well as a large number of smaller grants at 150,000 Yuan (~US$18,000) per year.

4.3.7 Regional Innovation System and Industry – Industry Partnership

To promote innovation system construction at the national level and S&T innovation capacity building at the local level and to further strengthen local S&T activities, China in 2003 launched an experiment for establishing the regional innovation system. The experiment selected a number of areas, including the Yangtze River Delta, Pan Pearl River Delta, Jiangxi Jingdezheng Township and Urban Areas of Shandong Peninsular to be the target sites. An experiment to establish the regional innovation system for old industrial bases in northeast China was also kicked off. In November 2003 the authorities of Shanghai, Jiangsu and Zhejiang jointly signed an agreement to establish a regional innovation system in the delta area. Further, in December 2003 Hong Kong and Macao and 9 inland provinces including Guangdong jointly signed an agreement to establish a Pan Pearl River Regional Innovation System. Based on these experiments the Chinese Ministry of Science and Technology provides guidance in promoting local authorities to work out their work plans for constructing the regional innovation system, and in establishing corresponding systems and policy framework for an effective operation. Through these experiments MOST continues to support joint actions to establish interregional innovation systems and is now working on system and policy issues concerning the national S&T innovation system.

4.3.8 Technology Transfer Issues in China

In order to further strengthen the coalition between universities, research institutes and industries and to promote the combination of both universities' and industries' S&T resources and the transfer of advanced proven technologies to industries, a number of technology transfer entities created by the universities possessing strong S&T expertise and rich S&T findings have been selected to be the national technology transfer centres. These centres play a positive role in accelerating the establishment of technology innovation system with industries as the core, optimising industrial structures and upgrading production techniques. The terms of reference of a national technology transfer centre as infrastructure to organise and consolidate universities' S&T resources include promoting and improving the creation of industrial technology centre, promoting the conversion of universities' research findings and technology transfer, strengthening international technical innovation cooperation, and providing comprehensive service for industries. Campus S&T parks, formally launched in 2000 at a junction of S&T, education and economy reforms, have also achieved notable progress under the support of authorities at different levels. They are becoming bases for converting universities' S&T findings, high tech industrial incubators and a new growth point of the economic development.

Notwithstanding the above, many enterprises in China still remain large, bureaucratic entities lacking production efficiency and innovation incentives. In addition to encouraging collaboration and information sharing between research institutions and high-tech enterprises, in creating innovation it is also necessary for enterprise managers to understand market principals, product quality and market demand. An appreciation of market principals would create incentive for enterprises to produce innovation. Information exchange between scientist and technicians in high-tech enterprises is vital to innovation.

The technological advance achieved in Chinese industries is a direct manifestation of imported technology and technology promotion efforts **[112, 113]**. In the context of developing countries, considerable effort is required to adapt and learn from existing technologies in order to take full advantage of their embodied knowledge. Hi-tech industry is the focus of international economic and scientific competition and as such it gets priority on the development agenda of China also. Technological advancement in industry has also led to the growth in the export of manufacturing products, which has occurred through increased productivity, more competitive industries and lower production cost. This element of a stronger export market has also increased the overall economic growth.

The use of imported technology has played a substantial role in China's industrial production dating back to the beginning of the People's Republic of China. During this period, Russia was the major technology provider and served as the ideal industrial model. After reform, technology imports were considered even more essential in order for China to close the technology gap and production levels with the rest of the industrial countries and to develop a high-tech economy. The benefits of importing large-scale technology have continued to enhance the technological development of Chinese industries and improve productive capacity. These improvements in China's industrial structure that have resulted from imported technology have enabled more industries to become further competitive. Technology transfer and imports have also led to the creation of new emerging industries in China and a vibrant consumer electronics industry in which its exports are considered one of the most competitive worldwide.

Much of the technology exported to China since the late 1980's have been through FDI. The main focus of FDI has been through technology transfer though it enters China in many different forms such as Chinese-foreign joint ventures, wholly owned foreign enterprises and cooperative operations. FDI brings large amounts of capital into China, as well as advanced management skills, technology and equipment and is used to develop China's technological base and industrial/physical infrastructure. In addition to FDI bringing in new technologies and management knowledge, foreign enterprises are considered an important source in the rapid growth of Chinese exports, which have created many new employment opportunities **[114]**.

The acquisition of new technology has served as a method to enhance China's technological development. There have been in the past and present, government efforts to encourage industry innovation and for enterprises to develop their own technological plans. In addition to efforts to renovate obsolete technologies and facilities of enterprises, the Chinese government provides incentives and preferential treatment, such as profit and tax incentives to key enterprises or within target industries. Private enterprises in China are benefiting from technology transfer and provide the Chinese economy with growing technology industries and the best prospect for further technological development and innovation.

Many Chinese scientific and technological results in some high-tech industries such as electronics, space technology, advanced machinery and instrumentation have achieved world standards [115]. The electronics industry has been one of the fastest growing industries in China since reform policies. China has become a major manufacturer of consumer electronics primarily due to the importing of foreign technology. China's national system of innovation and its globalisation process in the electronics industry has been established based on China's successful absorption of foreign technology, high export competitiveness and import substitution policy for a huge domestic market. The computer and semiconductor industries are also emerging as a result of successful private industries such as Legend (Lianxiang) and Stone (Sitong). Telecommunications is another rapidly growing industry in China with the growing presence of companies such as Motorola and Ericsson in the Chinese electronics and telecommunications market. Motorola is also a huge presence in the semiconductor market in China [116].

While China's transition from a planned to a market economy moves forward, a substantial industrial base has already been established. The traditional industries have made considerable progress in China, while new industries have only made minor progress, with much more development and improvement needed within the technology-intensive industries.

4.3.9 Conclusion

To summarise, China's S&T institutions and universities experienced large-scale shake-up and received unprecedented investment from the government pursuant to the reform. There was a gradual transition since 1985; and radical one began in 1999. Reverse inflow of overseas Chinese increased to a large extent. It is noteworthy that 7.5% Ph.D. degrees in the USA in S&T are conferred to Chinese-born scientists. China entered WTO in 2001. Foreign companies started to establish local R&D centres in China and more than 100 multi-national companies were already operating their R&D centres in China in the year 2004. Domestic industries are already sourcing know-how directly in US, Europe and Japan, or have created their own powerhouse of innovation, aiming to compete in the global market. HuaWei and Zhongxing in Telecommunication, TCL and Haier in Consumer Eletronics, are examples of such industries. In March 2004 China amended its constitution to protect the private property right. If China's state of technological development is compared to other advanced industrialised countries, China may seem as if it is an underdeveloped country. However, if its present state of technological development is compared to its condition prior to reform, it has made major progress.

Table 4.9 shows the national programmes taken up by China to facilitate S&T development and technology transfer activities in the country.

While there are national technology transfer centres and research parks to facilitate technology development and its transfer, there do not seem to be any specific programmes and schemes in China to promote R&D agency – industry partnerships for technology transfer and commercialisation though the role of technology transfer has been critical in achieving technological advances in China, ultimately reaching the goal of its becoming an advanced industrialised country. The primary way in this has been the import of technology through FDI. FDI, on the one hand, compensates the China's shortage of capital and the foreign capital through FDI is used to construct facilities and develop high-tech industries, technology transfer through FDI increases competitiveness of Chinese industries, creates new industries, as well as improves its infrastructure that has been severely underdeveloped prior to economic reform. Technology transfer also plays a key role in assisting the development of China's S&T base. It appears that technology transfer in China has had a greater affect on industrial production than it has on overall economic growth.

China faces a number of problems concerning its technological development ranging from the rapidly changing technological development production process itself to the shortage of capital for high-tech industrial production, decentralization of investments, lack of a strong scientific and R&D system, restrictions of local foreign technology imports, lack of innovation and inability to commercialise S&T results, and violations of IPR's. The organisational structure of R&D in China fails to bring together the research of S&T research institutions and industrial or commercial enterprises. China has not been successful at transferring domestic R&D results and applying it to industrial production. Further, the shortage in the S&T knowledge base is creating a crisis for China's high-tech industrialisation. The majority of the current scientist, engineers and management specialist had graduated prior to the Cultural Revolution during the period between 1996-1976. This tumultuous period created a void in which virtually no highly educated graduates were being produced. Since the reform era many younger scientist and engineers have been educated, however many of the promising graduates choose to work and study abroad. This has led to brain drain for China in

Table 4.9 Major S&T R&D Programmes in China

Programme / Initiative	Purpose	Special Features
Spark Program, 1985	Enhance S&T development and propagate R&D discoveries to rural areas.	Promoted economic development
National High Technology programme (Also known as "863" Programme, 1986	Monitor emerging foreign technologies with interest in commercialising high technologies and outside S&T achievements. Areas covered are biotechnology, engineering, space, IT, laser technology, automation, energy and new technology.	Focus on strategic, forefront and foresighted high technology to benefit China's long and medium-term development and security needed, promoting development of high technologies; Fostering new high-tech industry.
Torch Program (High and Emerging Technology Industry Development Prog) of SCST, 1988	Accelerate application of technology in industry and help in commercialisation of new technologies and promotion of economic growth with high-tech products competitive on local and world markets.	Creates favourable environment. 52 High & Emerging Technology Industry Development Zones created.
National Steering Group on Science, Technology and Education, 1988	Study and review national development strategy and major policies of S&T and education; review significant S&T and education tasks and programmes; coordinate important relationships on S&T and education between different governmental departments, central government and local governments.	
National S&T Achievement Dissemination Programme, 1990	Enhance the overall performance level of the national economy by injecting advanced S&T achievements into the nation's economic and social development in a well planned fashion; mobilising large numbers of scientists and engineers for the implementation of massive popularisation efforts in the rural areas, meeting the technological requirements of enterprises.	Aims at achieving higher economic returns with less investment, short investment cycle, good demonstration role and spin-off effect. Loans, investments and funds are raised by enterprises and public and Government provides start-up money. Approved projects entitled to preferential treatment during implementation.
National Programme for Key Basic Research Project, 1991	Conduct high quality research on major scientific problems having important bearing on nation's S&T, economic and social development, train young talents for basic research, and strengthen the build-up of high quality research contingent.	Funding by Govt.

the science and engineering fields in which the next generation of graduates are needed for high-tech development and industrialisation.

While there has been a major transformation of certain Chinese industries and substantial improvements in technological development, there still remains little incentive for innovation within state enterprises. Much of Chinese economic growth has been attributed to productivity improvements attained through structural reforms. Foreign technology has been thought to play an important, yet secondary role in these changes. At the same time China is in need of new technologies from developed countries to modernise its economy [117].

In today's new era of technology revolution, China continues its efforts to close the technology gap existing between it and other advanced nations. Special emphasis is placed on developing S&T and the future development results are expected to contribute to China's continuous economic growth and advanced industrialisation. The high-tech development programmes such as "863" and Torch have applied the research and technical development towards industrial production. However, the new high-tech enterprises have presently become the foundation for further development of high-tech industries. Looking at the present technological development and production process, high-tech industries are very dynamic and experience rapid change. Huge cost are associated with technology product development and the technology product life cycle is very rapid. The market also plays a key role as R&D and the production of new technology products depend more and more on market demands. As a result competition is intense and personnel and organisational structures are required to be flexible alongside quality management. The entire technology production process requires a complete and sophisticated infrastructure. China's ability to meet these set of challenges are very limited given its current state of technological development.

4.4 Brazil

4.4.1 Introduction

In the last 35 years Brazil developed the largest system of S&T in Latin America, one of the most significant among semi-industrialised nations **[118]**. S&T in Western Europe, and more recently in the USA, developed as part of a broader scientific culture linked to education, development of existing professions and a growing and prestigious scientific community and also as part of the increasingly effective industrial and military establishments. On the other hand many of the Asian countries introduced modern technology but little of modern science in their universities and other similar institutions. Most of their investments in technology were made in industry, rather than in large, isolated governmental agencies, including the military sector. Brazil, by contrast, developed most of its scientific capabilities in universities, while investments in technology went to a few large-scale government projects under the military and to a handful of state-owned corporations. The assumption in Brazil was that S&T would eventually spill over from higher education and sophisticated technological projects into society as a whole. In practice, the introduction of scientific research and graduate education in universities happened at a time of rapid expansion of higher education enrolment, leading to declining quality in scholastic standards.

As a result, while a handful of universities and departments reached levels of quality similar to those in the developed countries, most higher education establishments, private and public, lagged behind. In technology the large military-based projects in atomic energy, aeronautics and space research helped in the development of a few highly qualified networks of local suppliers and partners, but they did not enhance the quality and competence of the industrial system as a whole.

There are other features found in the Asian countries that did not exist in Brazil and that help to explain the different outcomes of their development drives. These traits include an emphasis on basic and secondary education leading to a competent and well-educated manpower base; lower levels of social inequality, thereby strengthening the internal market for local products; a sustained effort towards international competitiveness requiring high levels of industrial efficiency and quality control; and competent and powerful public bureaucracies working in tandem with a few large and well-endowed private industries.

Brazil has a national system of institutions rather than a national system of innovation. Due to the institutional framework of import substitution it was perfectly rational for Brazilian industries and researchers not to strive for the construction of innovation networks. In developing countries and developed ones alike one can locate the innovative industries not only in the so-called high tech sectors, but also within traditional ones, such as agriculture (soybean, coffee, poultry and meat) and resource-based sectors (mining, steel and pulp & paper). What seems peculiar to developing countries is that the level of innovation in traditional sectors may be much more embedded in the local sectoral dynamics and their correspondent competition patterns than those observed in high tech sectors, such as pharmaceutical, semiconductors and electronics. Having lost the main battles of the eighties and nineties to promote the transition from the traditional industrial structure based on the old metal-mechanics and chemical sectors to the new industries based on electronics and science-based activities, the Brazilian industry was able to gain in terms of efficiency and productivity. Some high-tech sectors like electronics had been ruined and almost disappeared; and some others such as pharmaceuticals were decidedly shrunk. Nevertheless the remaining industries under pressure for several years were able to restructure and gain competitiveness. In the early nineties, their first move was directed mainly towards static efficiency, something that other countries also underwent. In recent years, these industries have redirected their efforts towards dynamic efficiency, pursuing strategies that increasingly encompass efforts on technology and innovation.

4.4.2 S&T Management in Brazil [119, 120]

The institutional consolidation of the S&T sector in Brazil dates from the fifties with the setting up of the National Research Council, presently called the National Council for Scientific and Technological Development (CNPq), and the Committee for Post-Graduate Courses in Higher Education (CAPES). This support structure to R&D transformed an economy that had previously been predominantly agrarian. The establishment of CNPq was linked to the overall goals of promoting Brazilian industrialisation by both absorbing the new technologies introduced into the country and developing and consolidating the strategic sectors. The National Bank for Economic Development (the name was later expanded to include 'Economic and Social Development') was created in 1964 to support technological research through the Fund for Technical and Scientific Development (FUNTEC). The Studies and Projects Funding Body (FINEP) was created in 1967 under the purview of the Presidency's Planning Secretariat. Its role was complementary to that of CNPq, focusing on creating new ways to support Brazilian industries. The National Science and Technology Development Fund (FNDCT) got established in 1969, and its present administration is by FINEP. Together with the Ministry of Science and Technology (MCT), these are the pillars of the National Science and Technology Development System (SNDCT), which was formed in 1974 for the development and management of S&T in the Federal Government by the set of bodies having interface with the generation of knowledge from basic science to the application of this knowledge in industrial production. Universities, R&D centres, development agencies and industries, many of which have tax incentives for this purpose, further integrate SNDCT. The main instrument of the policies conceived within the scope of the SNDCT providing incentives for postgraduate studies and research is contract funding granted by specialist government agencies through direct negotiation with the beneficiary institutions in specific areas.

MCT was established in 1985. MCT is the principal agency for S&T policy, advising the Government on the broad allocation of funding and activities of other agencies. It administers the Programme for the Support for Development of Science and Technology (PADCT). Priorities areas for support include chemistry, biotechnology, materials science, instrumentation, S&T information and industrial technology. MCT also manages a Human Resources Development Plan, aimed at promoting creativity in industrial research through joint university-industry funding, primarily supporting engineering and technology Ph.D.s. It may be pointed here that Mercosur S & T activities are coordinated through the Secretariat for Technological Development (SETEC).

In 1997, Brazil invested 1.24% of its GDP in S&T, amounting to US$9.18 billion, and 0.7% of GDP (US$ 5.48 billion) on R&D. Of S&T allocation, ~37%, 48% and 6% respectively went to industry, higher education and government research institutions. The federal agencies for the development of research define their functional specialisation by using their budget as a lever for their activities. Thus most of the CNPq resources are used to provide study grants and various types of support for researchers. FINEP specialises in granting loans for technology projects in the private sector and in institutional support for teaching and research bodies.

Today Brazil has around 60,000 active scientists and technologists. Although this is still a small number compared to the population of Brazil, it represents significant progress compared to previous decades and third world nations. Brazil is also among the twenty countries, ahead of countries like Austria, Poland, Korea or Taiwan, with the greatest number of scientific articles published in specialised indexed journals corresponding to 1% of the published production worldwide. From 1981 to 1998 the Brazilian scientific production increased by 365%, much above the world's average. However, other indicators show the need for better performance, as the rates of scientific production per capita do not correspond to the dimensions of the Brazilian economy or the size and diversity of the country.

The main research centres in the country are in public universities, which predominantly generate Brazilian scientific production. Public bodies are far more proficient than private educational and research institutions. Within the pattern of public universities, the state universities of São Paulo play a leading role, contributing almost two-thirds of the Country's scientific production and training of researchers with doctorates. Other R&D institutes operating at national level and aiming at sectors or areas of specific knowledge are the Brazilian Company of Farming Research (EMBRAPA), which specialises in agriculture and animal husbandry research; FIOCRUZ, which specialises in pharmaceutical and tropical diseases; National Space Research Institute (INPE) in the area of space research and the Cristiano Otoni Foundation, specialising in administration.

At the state level, several R&D institutes were created in the seventies like Cetec in Minas Gerais, Ceped in Bahia, Cientec in Rio Grande do Sul and Itep in Pernambuco and these joined the traditional Technology Research Institute (IPT) and the Butantã Institute in São Paulo, IAC in Campinas, the National Technology Institute (INT) and the Oswaldo Cruz Foundation (Fiocruz) in Rio de Janeiro. Their operation concentrates on technology problems with a state or regional scope and covers technological areas aimed at reducing the gap between the supply of academic research and the demand for knowledge by industrial sectors.

In Brazil, the government agencies dispense funds to local industries in order to foster industrial growth and technological development **[121]**. The major national S&T research and funding institutions include:

- **National Council for Scientific and Technological Development (CNPq),** the largest and most important S&T agency with 10 national institutes and 2 directorates, has an annual budget of ~US$600 million, of which $US420 million is spent on human resources and $US180 million on direct R&D costs **[122]**.

- **Studies and Projects Funding Body (FINEP)** provides financial support to industries and institutions that invest in the development of new products and processes **[123]**.

- **Committee for Post-Graduate Courses in Higher Education (CAPES)** with an annual budget of US$400 million seeks to stimulate the development of human resources for teaching and research through the scholarships and grants awards and other mechanisms **[124]**.

- **National Institute of Research of Amazonia (INPA)** is responsible for national research in the Amazon, with funding of US$ 25 million annually **[125]**.

- **National Institute of Space Research (INPE)** is funded at US$100 million annually and encompasses space research, weather forecasting stations and climate change research **[126]**.

- **National Institute for Industrial Property (INPI)** has been established in the framework of the Technical Cooperation Agreement signed between the Government of Brazil and WIPO **[127]**.

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- Other government agencies also maintain a research arm, for example, the Brazilian Agricultural Research Corporation (EMBRAPA), which conducts research on biotechnology and forestry **[128]**.

The Science and Research Division of the Ministry of Foreign Relations administer a range of agreements from formal bilateral agreements to MOUs between the countries and also bilateral inter-agency agreements. Informal partnerships are also established through MCT or CNPq.

Research funding is also provided by the state level funding agencies such as the Foundation of Support to the Research of the State of São Paulo (FAPESP), which provides scholarships in Brazil and abroad and offers research support and undertakes activities related to scientific research; Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG); Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ); Fundação de Amparo à Pesquisa do Estado do Piauí (FAPEPI); Fundação de Amparo e Desenvolvimento da Pesquisa (FADESP); and Fundação de Amparo à Pesquisa do Estado de Alagoas (FAPEAL).

4.4.3 S&T Policy in Brazil [118, 120, 129]

The challenges of globalisation imposed an in-depth policy change in Brazil in order to underscore the strategic nature of technology for social and economic development and national competitiveness. Today S&T accounts for 1.5% of the Brazilian GDP, out of which 80% come from the public sector. The challenge is to increase this percentage up to 2%, while maintaining the public spending and increasing the participation of the private sector. The policy that was recently approved is designed to better integrate R&D to the industrial sector, thus allowing for the scientific upgrading of Brazilian industry, and to create an innovative environment in all parties concerned through broader universities / institutes / research centres partnership with the corporate world.

The improvement of Brazilian capability depends on ensuring stable allocation of funds in R&D to the Brazilian Centres of Excellence beyond the budgetary sources. The allocation of resources is now based on Sectoral Funds for the scientific development, covering the areas of energy, water resources, academia-enterprises interaction, mining, space, transportation, infrastructure, oil, IT and telecommunications. State-owned industries that have been or are being privatised deal with most of these sectors. As state-owned corporations, a number of them have advanced research centres under their institutional structure that must remain active and improve their capabilities.

Each Sectoral Fund is controlled by a Board of Managers organised by the MCT and the Ministry or regulatory agency of the area concerned together with representatives of the scientific community and the industrial sector. The composition of the Board ensures objectivity, transparency in the use of funds and the obligation of accountability. The Board identifies technological bottlenecks in the specific sector, bids for projects to solve them and selects the most appropriate one that receives the resources needed for its implementation. The Sectoral Funds are formed by a contribution for the exploitation of natural resources or a percentage of the revenues of recently privatised industries. In most cases, these resources are already being transferred to the Treasury in the form of levies, so they do not represent any additional financial burden to the privatised industries.

4.4.4 Industrial Policy in Brazil [130 - 132]

Cooperative and dynamic relationships between science and industry in Brazil are still at somewhat formative stage due to the process of industrialisation based on a massive importation of technology and protection of local industry through customs tariffs and market protections due to which there had been no need to invest in R&D [133]. Thus to protect the local industry, the government has introduced mechanisms to prohibit the transfer of technologies that are similar to ones being developed or that the Brazilian industries have already developed. Although this process took place at the time when the national S&T system was created, it resulted in a sort of a rupture in the relationships with Industry, which implicitly imported technology and did not feel the need to develop complex systems, as well as with the research and educational system which dedicated itself to the development of human resources for industry and basic research, since there was no demand for technological research. Even with limited investments in S&T, an enormous growth in GDP of 1,260% during 1947 to 1995 took place due to cheap labour, strong market protection mechanisms and an international environment favouring sizable foreign investments in the country.

In the industrial sector, the MCT is stimulating investment by private enterprises in R&D by offering them support in the areas of infrastructure, financing, human resources development and tax benefits. The government is trying to reduce the R&D costs of the enterprises through fiscal incentives.

In 1990, the government radically changed the framework conditions for industrial development. Taking cognisance of the fact that the import substitution model had run into a dead end, it opted for a policy of gradually opening the market to foreign competitors, thus creating an environment that requires international competitiveness and thereby forces industries to attain international levels of quality and efficiency. This was accompanied by a number of technology and industrial policy programmes [134]. However, they were either not implemented, or only after long delays, or have had little impact so far because the recession inhibited private sector investments. Even the Quality and Productivity Programme that has pursued an innovative approach mainly towards building a consciousness for quality issues inside industries did not much succeed [135].

With the end of import substitution one of the most important obstacles to the emergence of the NIS was removed. Another important obstacle was addressed with the macro-economic stabilisation policy that was launched at the end of 1993 [136]. The first measure increased the pressure on industries to become more competitive and thus extinguished the possibility of idiosyncratic technological behaviour, the second set out to create the conditions for industries to adopt a longer-term view in terms of corporate strategy, including the strengthening of technological capability at the firm level [137].

A law was passed in 1993 that introduced fiscal incentives for industrial R&D [131]. From a strictly economic point of view, the justification for fiscal incentives for R&D is much more linked to 'R' than to 'D'. In Brazilian industries, the larger part of R&D outlays is in development. It reflects the specific characteristics of the Brazilian industrialisation experience that policy makers consider to stimulate 'normal' behaviour, i.e. systematic product development efforts, with fiscal incentives. Moreover because of the existence of various semi-legal means of tax evasion and a general habit to exploit them, Brazilian industries do not actually consider fiscal incentives as a stimulus for any kind of activity, let alone innovation. Fiscal incentives for R&D only add more complexity to an already overly complicated tax system so that industries perceive them more as part of a more general nuisance rather than as a stimulus.

The Federal government launched its Policy for Industry, Technology, and Foreign Trade in May 2004, to be implemented by various agencies in the Federal public sector (Ministries, National Economic and Social Development Bank, FINEP, and others), defining health inputs (specifically medicines) as a priority for both industrial development and spawning innovations through partnerships between research institutions and industries **[138]**.

4.4.5 Science and Research Parks in Brazil

Science and research parks are the favourites of modern technology. Every university seems to want one and the industry, large or small, would like to be the part of one park or more. It is not surprising to find them being replicated in developing countries, but without adequate IP protection. There is no difficulty in building facilities, which duplicate those in the developed countries and various subsidies can be arranged. Consideration of whether such parks produce comparable results in developing countries has centred more on whether private financing is available and whether sufficient laboratory apparatus can be obtained to equip the facility, the latter issue often being a function of foreign exchange availability.

The failure of a number of research parks in Brazil to perform up to the expected international standard has caused some dismay **[139]**. This has applied to both the public and private parks and to those of mixed sponsorship. This below average performance has been attributed to several causes like poor availability of modern laboratory equipment and supplies as a result of import restrictions, lack of appropriate training of local students as compared to their counterparts abroad and non-protection of results.

4.4.6 Private Sector R&D and Partnership with Academia

R&D in the private sector in Brazil takes place among industries that participate in the international market and among those working in areas where the government has required or supported the development of local technology. While the 'required' areas include telecommunications and computers, 'supported' areas comprise agriculture and military equipment. In addition, industries have adopted medium- and long-term strategies based on technological innovation. An estimated 200 industries have significant R&D investment.

About 10% of public investments in R&D in Brazil are made by a small group of state-owned corporations in the fields of telecommunications, oil, electric energy, mining, metallurgy and aeronautics. Several of these corporations have created their own R&D centres, the best known being Petrobrás R&D Centre, Telebrás R&D Centre, Eletrobrás Electric Power Research Centre, Technology Centre of the Rio Dôce Valley Company and the Aerospace Technical Centre associated with the Brazilian Aeronautics Company. These centres are linked with the industries' suppliers and are responsible for establishing standards of quality and providing technical know-how. They also communicate with other R&D groups in government and universities in order to exchange ideas and information and bolster professional competence. The oldest and largest of these is Petrobrás R&D Centre, the most significant achievement of which has been the development of the state-of-the-art technologies for deep-sea oil drilling in association with Coppe at the Rio de Janeiro Federal University and several other Brazilian universities. It is located on the UFRJ campus, maintains links with research institutions in the USA, UK and other countries and provides research services for other clients. Nonetheless, the proportion of resources spent by Petrobrás on R&D is significantly lower than the international average for large oil industries. Telebrás' research centre, CPqD, with a budget of around US$50 million has played an important role in setting the standards for Brazil's telecommunication systems. Foreign industries in Brazil are requested to adopt these standards, local industries receive support to train personnel and to develop technological competence, and the government guarantees the purchase of products that meet Telebrás' standards. The consequence has been the creation of several dozen industries linked to the Telebrás system and protected from competition. These research centres usually are much better endowed with equipment, staff and resources than research groups in universities and academic institutes. However, because they are shielded from outside review and from financial constraints, it is uncertain whether their performance is commensurate with their costs. They have had to stay much closer to the direct operational needs of their institutions and forsake long-term and technologically more ambitious projects. Also they have had to look for independent sources of support, whether by selling their services or by establishing associations with the private sector and other R&D institutions. Privatisation has led to the shutdown of some of these research groups, as happened in some steel industries.

In order to guide negotiations with the private industrial sector and carry out research work in industry, a number of university foundations have appeared on the institutional scene with powers to sign contracts and agreements without the bureaucratic restrictions on public bodies. Examples of this are the José Bonifácio Foundation and the Coppetec Foundation, both linked with the Rio de Janeiro Federal University (UFRJ); Funcamp linked with the Campinas State University (Unicamp); Fundep linked with the Minas Gerais Federal University (UFMG); and FUB linked with the University of Brasília. Brazilian policy makers are pinning great hopes on initiatives to stimulate stronger links between universities and industries. Unfortunately, the prospects for this kind of venture remain limited even under the new economic framework conditions. On the supply side, the quality and capability of the universities vary widely. Because of the limited number of high quality universities and comparatively poor quality of staff they are not able to give substantial support to private businesses. Moreover, university researchers apparently show a tendency to direct their research along the lines of research in developed countries and thus their researches are not compatible with the industrial attitudes because competing at the leading edge of technology is something that only very few Brazilian industries do. In so far as the incentives for universities, especially for leading universities or scholars, to enter into cooperative ventures with private industries are concerned, the financial situation of the universities has never been too bad and is rather improving, not the least due to foreign funding especially from the World Bank. Paradoxically, foreign aid and funding agencies, which are keen to support the Brazilian science system, may have to inhibit stronger university-industry partnerships. Foreign donors will predominantly turn towards leading Brazilian scholars with an international reputation and international contacts. These scholars may even find themselves in the comfortable situation of being able to choose between different offers of foreign funds. This certainly will not stimulate their efforts to find funding from domestic industries.

On the demand side, it is now well documented that the traditional waterfall-model of the diffusion of innovation, from basic research to product development, does not at all match the reality. Rather, there is an interactive process of innovation, which means that in many cases the waterfall flows bottom-up, i.e. technical problems in product development stimulate applied research and bottlenecks in applied research stimulate basic research. For instance, research in solid-state physics has been stimulated by technical problems of microelectronics industries **[140, 141]**. Moreover, there are some industries that are much more inclined to maintain close contacts with research institutions than others, for example, the science-based industries like electronics and chemicals. In the case of Brazil, both these situations are not very helpful in catalysing the linkages of university research and industries' product development.

There are few high-tech, science-based industries in Brazil. The electronics industry has transformed itself into a final assembly industry after the removal of high import barriers; the pharmaceuticals industry is largely based on reverse engineering, and biotechnology and genetic engineering are in early phases of development. Therefore most Brazilian industries do not expect to encounter problems that can only be resolved by scientific research. They are facing problems for which solutions are available in other industries and countries. In order to adapt these solutions to their particular circumstances, Brazilian industries will have to put more effort into technological learning and capacity building. There is little reason to believe that universities are of much help in this process. Only in special cases universities are good in scanning the application-oriented technological know- how that is available worldwide, and there is little reason to believe that a university researcher should be better in adapting transferred technology than an industrial engineer. Thus as a rule the stimulus for industries to enter into joint activities with universities is very low. Looking at things in this way, it is not at all surprising that university-company-links are weak in Brazil.

In so far as the agribusiness sector is concerned, METAS project illustrates a successful R&D institute – university – industry partnership involving the federal government (Agriculture Research Corporation, EMBRAPA), university (Pelotas Federal University), State of Rio Grande do Sul extension service EMATER-RS, private farm supply industries such as *Monsanto do Brasil Ltda, Semeato S.A. Indústria e Comércio, Máquinas Agrícolas Jacto S.A., Sementes Agroceres S.A.*, and *Adubos Trevo S.A.*, several farmers' cooperatives, and several private extension agents **[142]**. This project led to achieving modern technologies, products and services at lower costs and also contributing to reduce the impact of agriculture on the environment when public and private efforts are complemented by each other by using the system's approach in R&D, i.e. identification of users and farm production system's demands and needs – R&D approach of solution technologies – validation tests – training extension agents and farmers - introduction of changes by users. The aim of the METAS project was to conduct research on the main constraints of the system and train the extension agents on the available no-tillage technologies. The main benefits for public organisations were the fulfilment of their missions and duties. For the private industries the main advantage was the direct investment in R&D approach, instead of having their own structure and hiring their own personnel, thereby reducing the risk of low returns. In addition, they were successful in developing the market for their products and consequently increased the market size and acquired the trust of users by working jointly with research and extension organisations. The mutual trust between public organisations and private industries was recognised by farmers and broke the resistance at the critical factor of moving from soil tillage to no-tillage using burn down herbicides. For farmers and the overall society the benefits derived from the project came from the technical support supplied and consequently, lower risks involved by no-tillage adoption. Such lower risks are a result of timely seeding, less labour, less fuel consumption, less equipment and personnel involved, less replacement parts, lower soil erosion and nutrients losses, lower variable costs, more stable yields and higher income due to crop diversification and enhancement of milk production. All these benefits are indicators of sustainability and competitiveness.

4.4.7 Venture Capital

The existence of private VC industries in Brazil indicates that there is willingness to mobilise capital for investment in start-up industries based on new technology. This is the classic instinct of VC. Yet the lack of IP protection inhibits disclosure of the very information, which is most critical to the investment decision. The spin-off or start-up industry is reluctant to divulge its newfound technology for fear that in the process it will fall into unfriendly hands. Although this risk is always present, it becomes unacceptable in a country without adequate IP protection. There is another reason why start-up industries may be unwilling to disclose their technology to a VC supplier. Without a disclosure, the VC industries cannot know whether bogus technology is involved. During the early stages of a small, technology-based industry's growth, the need for outside financing is usually crucial. It is not far fetched to suggest that the reluctance of the small entrepreneur to risk disclosure of his secrets in pursuit of needed capital has a chilling effect on the formation of new industries. The loss to the country is difficult to measure since it would amount to taking a measurement of that which does not happen. Certainly, the technical and industrial base of the country is not strengthened.

4.4.8 Conclusion

Brazil has developed a significant infrastructure for R&D and innovation. Most Brazilian researchers and research projects are in the universities, but they are not necessarily involved with professional, technical and general education. Areas in need of improvement include establishing closer links between S&T and the industrial sectors and stimulating the private sector to increase its share of the country's R&D efforts. Both cases require moving from a vertical approach, concerned with graduate education, leading-edge technology and large science projects, to a more horizontal one, aimed at increasing the general level of competence of the population and the productive system as a whole. This change in emphasis requires that the institutions providing support and incentives to science also be changed. R&D groups and institutions need to increase their autonomy and flexibility. They should be strongly encouraged to link to the industrial sector and engage in applied work, while maintaining a high level of academic and basic research activities. The resources for applied work should not come from the budget for basic activities but from specific sources in government agencies, special programmes, private industries and independent foundations. Applied projects need to be evaluated in terms of their academic quality, as well as their economic viability and social and economic significance.

2002, Even if the universities can only play a limited role in the technological modernisation of Brazilian industry, any existing potential should be used. Such potential may exist in fields like ad-hoc consultancy that is in helping industries solve one limited problem at a time, or in areas like metrology and quality assurance where the existing institutional structure apparently leaves much to be desired. Increasing the involvement of the universities may require a change in their incentive structure, especially in terms of financing.

4.5 Critical Appraisal: Inputs Towards Research Objectives and Investigation

The review in case of the countries with fast emerging economies indicates that most of them have adopted measures depending on their specific milieu and existing framework.

In Korea, the emphasis has been on assimilation of imported technology, generation of new products and innovations in manufacturing sectors, and creation of its own innovations in knowledge based industries. Industry leads the developments in technology as it had its own R&D base. The percentage share of R&D expenditure of industry, research institutes and universities is respectively about 75%, 15% and 10%. However, the Government spending on R&D vis-à-vis GDP has been increased from 0.25% 1963 to about 3% in 2001. The focus of building partnership is thus more in terms of instituting policies to bring the industry, the stronger partner, together with the R&D agencies to leverage its international competitiveness. The key feature of Korea's partnership promoting initiatives is development of networks and clusters in strategic fields being supported through measures such as establishment of free economic zones, financial support of R&D projects and tax incentives. The Korean government is taking measures to attract foreign investment to these clusters and provide equal opportunities for funding of R&D projects to foreign R&D centres as given to those of domestic R&D centres.

In China, the current policy pays attention to the acquisition and assimilation of foreign technology while developing S&T capabilities primarily on indigenous efforts and strong IPR protection through legal measures. An important element of China's technological development is the technical renovation of industry and enterprises. Key industries are selected and specific areas are targeted for technical renovation. In the early periods of reform the technical renovation focussed on light industry and machine-manufacturing facilities, but currently the emphasis is clearly on enterprises with leading profits, upgrading of facilities in targeted industries, new technology applied towards production, manufacturing machinery, automated systems, and the replacement of obsolete technologies. The Chinese S&T structure has been reformed to meet the needs of the socialist market economy in order that science moved out of the institutes into private enterprises and government research institutes entered into cooperative ventures with Chinese and foreign companies, deciding the direction of their research by themselves and becoming responsible for whatever profits or losses they incur. The policies are liberalised and give autonomy to the industries as well as government research institutes and universities that create their own high tech companies, to orient their research programmes according to market needs, and consequently to what the market is willing to fund. The R&D institutions have been converted to business entity that has produced notable progress in industrialisation process by further enhancing the technical innovation capacity and superior technology diffusion capacity.

A number of technology transfer entities in China created by the universities possessing strong S&T expertise and rich S&T findings have been converted to the national technology transfer centres with an objective to strengthen the partnerships with university, R&D institutes and industry. They organise and consolidate universities' S&T resources include promoting and improving the creation of industrial technology centre, promoting the conversion of universities' research findings and technology transfer, strengthening international technical innovation cooperation, and providing comprehensive service for industries.

The Chinese are interested in particular in scientific and high tech developments and its economy is booming. But what they are short of is information technology and modern processing, manufacturing and design skills.

In Brazil, most of the scientific capabilities are developed in universities, while investments in technology goes to a few large-scale government projects under the military and the state-owned corporations. Majority of funds are allocated for education and research in universities towards study grants and other support for researchers. The financial support to

S&T institutions involved in areas of specific knowledge is usually meagre. The universities have set up the university foundations for negotiating with industry for signing the research contract and carrying out research work in the industry. However, this initiative also contributes towards stimulating stronger linkages mainly because of a) lack of quality research and academic institutions, b) universities have no need to earn money on their own; c) the high tech Brazilian industries, which are very few, do not depend on scientific research, and d) incompatibility of interest of the two partners. University researchers want to pursue research on the lines of developed countries and the industry in Brazil is not technology conscious, with few exceptions.

The industry in Brazil is not very knowledge intensive and is not exposed to competition; as a result it is not quality conscious. The government agencies dispense funds to local industries in order to foster industrial growth and technological development. Although presence of VC industries in Brazil indicates that there is willingness to mobilise capital for investment in start-up industries based on new technology, but the lack of IP protection inhibits disclosure of the very information, which is most critical to the investment decision. However, the MCT is stimulating investment by private enterprises in R&D by offering them support for infrastructure, financing, human resources development and tax benefits. The government is trying to reduce the R&D costs of the enterprises through fiscal incentives.

The recent S&T policies in Brazil have been designed to better integrate R&D to the industrial sector to achieve scientific updating of the Brazilian industry and create an innovative environment in all parties concerned. A major initiative for building partnerships had been through science and research parks, which have shown mixed success.

The review of the initiatives of the countries with fast emerging economies indicates that there are not many focussed programmes like in developed countries for promoting partnerships. The emphasis in Korea is more on policies while in case of China and Brazil preliminary linkages exist but there is a considerable scope for improvement. Drawing from this experience, it is perceived that the promotion of partnership is to be viewed in terms of the policies, the maturity of the specific stakeholders and the nature of problems associated with building of their networks.

Chapter 5

R&D Agency – Industry Partnerships in India

Chapters 3 and 4 reviewed the partnership promoting efforts of selected developed counties and countries with fast emerging economies and made critical appraisal of the specific features of their programmes and trends in partnerships with a view to compare these developments with initiatives in India. This chapter aims to review the general status of linkages between R&D agencies and industry in India, particularly through the facilitating institutionalised mechanisms of the government S&T departments and agencies as well as select academic institutions, provide update of government policies since independence, and identify salient aspects to improve the existing partnership initiatives. The chapter compares the partnership promoting efforts and experiences of India with those of the selected countries with an aim to identify the gaps in the Indian context and focus the efforts in the investigation and makes appropriate recommendations to further promote partnerships in India.

5.1 Introduction

In India the policy makers have recognised the role of S&T in gaining self-reliance in the indigenous economic development. They have placed due emphasis on S&T growth in the socio-economic development through the 5-Year Plans that spell out the national concerns and priorities in detail, which are reflected in budget allocation to different socio-economic sectors. The concerted efforts of the GOI resulted in establishment of a strong S&T base, which was very small at the time of independence. This involved establishing a chain of national laboratories under the aegis of several central organizations, such as CSIR, ICMR, DRDO, DAE, Departments of Space (DoS) and Electronics (DoE), etc., as well as many other specialised R&D centres, universities, IITs and other academic institutions to continuously provide expertise, technically trained manpower and technological support to industry. It may be noted that the academic institutions in India are mostly involved in their conventional role of teaching and providing skilled manpower for absorption by industry. The linkages between academic and research institutions are not too popular.

Until 1990, however, the Government policies and support were mostly focused on basic research or initial phases of applied research and provided / supported interaction, between the R&D agencies and the industry only in limited way.

With the beginning of the liberalisation process in 1991, the Indian government took several steps to open the Indian economy to market forces. Some of these included delicensing of many industrial sectors, reduction of duties on import of machines, lowering of interest rates and removal of controls on capital markets. This compelled the Indian Industry to partner with R&D agencies for technology solutions, new ideas and innovations to be able to sustain the competition. The GOI launched several programmes, discussed in this chapter, to enable generation, diffusion and utilisation of new knowledge for economic growth of the country.

India must develop technological strength to be counted in the comity of nations. According to Rajan **[143]**, "India is at a cross road after nearly a decade of initiation of liberalisation and of being a part of global integration. The process of such an integration can get 'locked in' to a shallow, low value integration if policies including S&T policies and more importantly the implementation capabilities are not geared up to meet the new global, and technological and business realities". In view of Mashelkar **[23]**, India has reached a stage when it should not be merely defensive to protect the domestic market, but should also aim at international markets with a medium and long-term strategy through partnership between R&D agencies and industry. New paradigms in the IPR generation and protection are posing novel challenges. Urgent attention should be paid to substantially enhance the levels of innovation and creativity **[144]**. A major change in the offing is due to India's accession to WTO. Generation of IP, its capture, documentation, protection, evaluation and exploitation assumes a crucial importance in the new context. Thus the globalisation has posed several challenges as well as given opportunities to India in the area of S&T. India today has extensive S&T infrastructure, one of the largest pools of scientists and technologists in the world and deep scientific talent across a wide range of S&T sectors. The challenge is to commercialise R&D from the R&D agencies, light up the entrepreneurial spirit among the innovators and establish a facilitative framework of linkage between innovators, industry, venture capitalists and Government bodies for combining the research, finance and commercialisation platforms.

5.2 Policy Statements and Resolutions for Development of S&T

Science and Technology has always been recognised in India as a powerful tool of growth and development of the country. Pandit Jawaharlal Nehru at the Indian Science Congress Association on 26th December 1937 had said that, "The future belongs to those who make friends with science...", and "...I hope that in the days to come India will again become the home of science, not only as a form of intellectual activity, but also as a means of furthering the progress of her peoples..." **[143]**. In words of Dr. Shanti Swaroop Bhatnagar, the Founder Director of CSIR and one of the outstanding personalities in Indian science: "We can see today the dim lights of a new dawn in the distant horizon of Indian progress. These faint radiations are not the vanishing streaks of our glorious past; they are the sure signs of a new birth full of promise and glory for the future. This dawn represents the birth of the industrial movement in India".

India was amongst the first few countries to have a formal scientific policy. India has recognised importance of developing S&T in a major way since independence. After India became independent the need of a permanent policy framework as a commitment of the government to S&T was felt. Over the years the Government of India has adopted various legal measures for providing policy backing for the growth of technology sector in India. Some of these are listed below:

a) Scientific Policy Resolution, adopted by the Indian Parliament on 4th March 1958 **[145]**.

b) Technology Policy Statement, enunciated in 1983 **[146]**.

c) R&D Cess Act, adopted by the Indian Parliament in 1986 **[147]**.

d) Industrial Policy Resolution, adopted by the Indian Parliament in 1991 **[148]**.

e) Technology Development Board Act, enacted in 1995 by amending the R&D Cess Act of 1986 **[149]**.

f) Patents Amendment Act, passed by the Indian Parliament in 2002 **[150]**.

g) Science and Technology Policy 2003 **[17]**.

The above documents have been providing the basis for supporting S&T activities in the country at different times, vision for the future of India and aspiration for a rightful place for the country and its people. Ever since independence, as almost parallel effort the Government of India has been heavily investing in all the fronts, including industry, S&T and infrastructure. The Scientific Policy Resolution, adopted in 1958 with an aim to enhance

India's S&T capabilities led to creation of a sizable institutional infrastructure base for education, science, technology and industry.

The Technology Policy Statement of the GOI enunciated in January 1983 had stated that: "In-house R&D units in industry provide a desirable and essential interface between efforts within national laboratories and the educational sector as production in industry. Appropriate incentives will be given to the setting up of R&D units in industry and for industry including those on a co-operative basis. Enterprises will be encouraged to set up R&D units of approximate size to permit the accomplishments of major technology tasks". In line with this Statement the GOI took several measures aiming to encourage R&D by industry and also to establish workable linkages between R&D agencies and industry.

The changing global and national scenario as a consequence of global economy imposed greater demands on S&T. As a result the Indian government felt the need to revisit its S&T policies and in 1991 adopted the Industrial Policy Resolution. Among its objectives the Industrial Policy Resolution included 'injecting the desired level of technological dynamism in Indian industry' and 'the development of indigenous competence for the efficient absorption of foreign technology', and expressed the hope that 'greater competitive pressure will also induce our industry to invest much more in R&D than they have been doing in the past' with an intention to create a NIS that was in sharp contrast to that prevailing prior to 1991. The policies were made with a focus to encompass major strategies towards industrial development to take into account the overall objectives of the new industrial and trade policies, besides the changing international situation. The government took several steps to open the Indian economy to market forces which included de-licensing of many industrial sectors, reduction of duties on import of machines, lowering of interest rates and removal of controls on capital markets.

The Government policy framework continued to encompass encouragement of entrepreneurship, development of indigenous technology through investment in R&D, bringing in new technology etc. Liberalisation in technology transfer and trade were further intensified. Studies showed that R&D activities were paying high returns, and that an industrial company that significantly decreased its R&D was clearly reducing the chances of its future viability as a profitable organisation. The national priorities including quality improvement in our products and related efforts increased the demand for S&T, not only in concepts and design but right through production, testing, packaging, transportation of goods and post-sale activities, which in turn, created greater employment opportunities. Thus S&T activities no longer remained peripheral to Indian economic planning.

The S&T Policy 2003 of the GOI was scientifically designed to achieve synergy between industrial and scientific research and envisaged creation of TTO's as associate organisations of universities and national laboratories to facilitate transfer of the generated know-how. The policy further sought to encourage the transfer to industry of the know-how generated by scientists and technologists through flexible mechanisms for financial returns. In addition, the policy looked out to encourage through innovative mechanisms the investments by industry in education, research and R&D, either in house or through outsourcing.

The 5-year Plans have played a major role in transforming the S&T policies into actionable programmes for promoting and supporting S&T in the country. **Table 5.1** gives the anticipated expenditure in the 9th 5-Year Plan (1997-2002) and the outlay for the 10th 5-Year Plan (2002-2007), which shows that the budget allocations have more than doubled in the last decade.

Table 5.1 Plan Allocations of GOI (Rs. Cr.) for 9th and 10th Plan Period

S. No.	S&T Department / Agency	9th Plan (1997-2002) Anticipated Expenditure	10th Plan (2002-2007) Outlay
1.	DAE (R&D)	1525	3443
2.	DOD	453	1125
3.	DST	1515	3400
4.	DBT	622	1450
5.	DSIR	1369	2575
6.	DOS	6623	13250
	TOTAL	**12107**	**25243**

The whole-hearted government support to S&T has resulted in many accomplishments in a wide variety of disciplines. With outstanding achievements to its credit, Indian S&T has dazzled the world in many areas. India has achieved great success in mission-oriented sectors like space, agriculture and atomic energy. There has been a significant growth in the capabilities and achievements in several high technology areas, namely nuclear and space sciences, electronics, defence etc. In addition to the growth in these and other strategic vital sectors, determined by sectoral needs, there have been spin-offs and technology transfers to other sectors, especially the broader production sectors having large societal implications. Efforts have been mounted for developing the newly emerging areas, viz. microelectronics, informatics and telematics, biotechnology, new materials, renewable energy sources, ocean sciences and several areas of basic research. However, it is a fact that technology development in India is yet at low levels, which is not due to the lack of skills, but owes itself to the lack of competition **[20]**.

5.3 R&D Agency – Industry Partnerships in India

In India, like in most developing countries, the government budgetary allocation has been the main funding source for carrying out R&D in basic and applied sciences, which is evident from the statistics of the percentage share of various funding players on R&D in any given year. For example, in the year 1998-99 the percentage share of national expenditure on R&D of the Central Government was 62.5%: State Government was 8.0%; public sector industries was 5.0%; and the private sector industries was 21.6%. 83% of the R&D expenditure incurred by the Central Government sources came from 12 major scientific agencies, namely, the DST, CSIR, DOS, DBT, DRDO, DAE, ICAR, ICMR, Ministry of Information Technology (MIT), Ministry of Non-Conventional Energy Sources (MNES), Ministry of Environment and Forests (MoEF) and the rest from the other central ministries / departments / public sector industries. Amongst the major scientific agencies, DRDO accounted for 31.8 % of the expenditure **[151]**.

Notwithstanding the figures given in Table 3.1, the investments in S&T in India have so far been highly inadequate. Against a global annual expenditure on R&D of $500600 billion, India spends a mere $2.5 billion, which is slightly above what Merck, a U.S. based pharmaceutical firm, spent ($2.1 billion) in 1999. Compared to this the U.S. Federal outlay on S&T was $85 billion **[152]**. Further, it may be noted that the share of industry towards the organised research in India is much less than the norm in most other countries and is almost insignificant.

According to Tyabji **[153]**, India's NIS prior to 1991 had emerged as a result of the official Indian perception of technology capability creation. This perception was closely linked to the dominant philosophy of economic development based on the Nehruvian paradigm. The main characteristics of this system were public ownership of specific industries, import-substituting industrialisation, and encouragement to reverse engineering, copying and improvisation. The protected industrial environment created by the strict control of the GOI in licensing new industry was also, to some extent, responsible for lack of interest of industry to upgrade their technologies [1]. This resulted in a wide gap between the activities of the two key players, i.e., R&D agencies and the industry, for the development and prosperity of the nation and led to the growth of industrial sector, which mostly depended on imported technologies and equipment.

As in the earlier days, the Indian economic policy was more inward looking and innovation was not a priority with the R&D funding limited to the public domain. While the Government provided the funding, it never really cared to make the scientists and the managers accountable and transparent in their approach to technology transfer. R&D work was carried out predominantly in the public funded institutions and was generally not user driven. As the indigenous industry was well protected and it was easy to import proven technologies, it had no incentive to innovate or invest in R&D. Hence the aspect of design and development of new products remained a weakness.

According to others, there has been an absence of strategic and relevant R&D areas, lack of proper thrust and pace of R&D. Another principal reason for the lack of enthusiasm from the industry side was that the contributions / results of R&D were not available to the industry in a packaged or readily acceptable form. The entire R&D effort remained unutilised without commercial viability. These were the key factors that created gap and the linkages were found missing between R&D work centres and the industry **[154]**. This arose from a situation felt by the R&D institutions that the Indian industry does not come forward to invest in R&D. On the other hand, the industry was of the opinion that the scientists live in their ivory towers. Thus the Indian industry on its part played a role of appearing to be keen to promote research but lacked patience and belief in the Indian R&D delivery systems and in the scientists. The Indian industry always seemed to be in a hurry to import technologies and happy to be subservient to its principals abroad. The industry appeared to accept even outdated technologies at times, but did not look at the Indian R&D institutions **[155]**. Thus the mismatch in the incentives for cooperation among the various actors in the innovation system, including R&D agencies and the industry, impeded collaboration in R&D and technology, and led to lower social returns from public research **[156]**.

Opening up of economy and the global liberalisation policies of the Government causing severe competition in the global R&D base, particularly in strategic areas, awakened the industry to a great extent and it started looking outward. In view of the competitive environment in which the Indian industries had to compete even in the domestic market with imported products, it was expedient to focus the R&D efforts towards economic benefit of the country through better utilisation of research developments and capabilities available. The operation of market forces induced growth of forces supporting innovation. The Industry exhorted to graduate from the re-engineering culture to R&D culture to face the new challenges.

In order to obviate the highly independent identities of R&D agencies and industry and with a view to achieve techno-economic development India adopted a two pronged approach, one which relates to creating a climate for indigenous development of technology in the country and the other for the transfer and adaptation of technology imported from the advanced countries. The industrial development model pursued by India till the late eighties did not effectively encourage original R&D endeavour by industry. As a result, practically not a single globally competitive technology could emerge from India. The shift in the perception towards R&D began to change with the economic reforms of 1991 and a paradigm shift took place with India's accession to World Trade Organisation (WTO) in 1995. However, accessing globally competitive industrial technology became difficult due to the integration of the global trade / economy. Indian industry thus had no option but in order to survive, it had to indigenously develop such technology.

The liberalised economy had given Indian industry valuable opportunity to develop new ideas and technologies, which could be sold globally. The process of globalisation compelled both the publicly funded R&D agencies and the industry to enter into a dialogue and work together to mutual advantage. However, despite the fact that in India the need for interaction between the industry and the R&D institutions was fairly well recognised, and that all the stakeholders in this interaction know that they are expected to benefit by collaborating with one another, the progress achieved so far has not been adequate.

The task of finding an appropriate scientific - engineering liaison is critical to the success of any new university - R&D agency – industry interaction **[41, 157-159]**. In India this required government assistance in terms of healthy policy formulation, permitting knowledge transfer, adoption and implementation across institutions without procedural and bureaucratic barriers **[155]**. The Indian Industry that worked for four decades under the protected economy and license/quota regime initially required hand holding from the Government and R&D agencies to be able to excel in the new business environment.

Thus the Indian Government instituted several initiatives with focused endeavours to provide better opportunities for R&D agencies and the industries to work together and progress. The government support towards public sponsorship of R&D partnerships was the policy response to various market failures, which are not resolved by market mechanisms alone [5]. It established partnership-facilitating agencies and launched programmes to specifically address the issues of generation and diffusion of new knowledge and technology through partnership at various stages of technology development cycle indicated in **Fig. 5.1**.

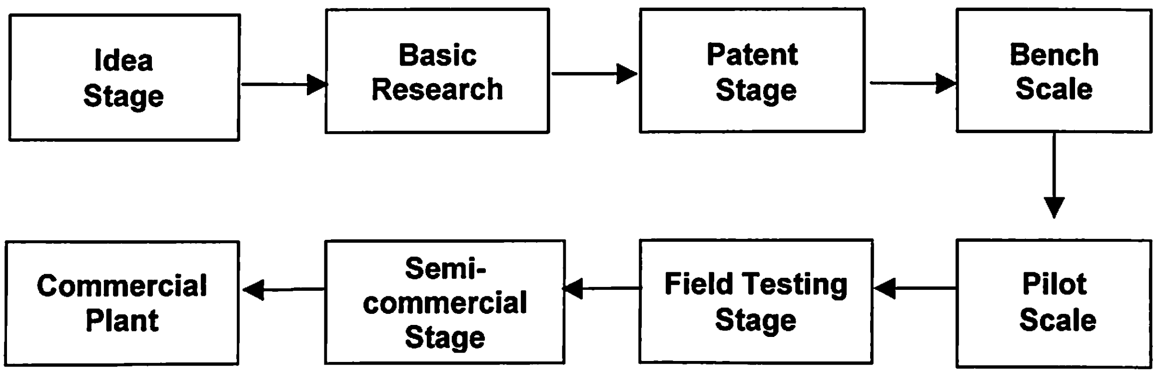

Fig. 5.1 Technology Development Cycle or Chain

The government has traditionally been supporting the idea stage as part of its basic research efforts. Once the idea is generated it needs to be protected by securing the necessary patenting. For example, NRDC provides funding support for this purpose. The government departments fund the R&D agencies for conducting basic research, which could be inquisitiveness driven or demand based. Then the knowledge generated needs to be up-scaled to a bench level. Once the innovation has reached the bench level there is a need to prove the technology at the pilot scale, which is followed by field-testing. Schemes such as Programme aimed at Technological Self Reliance (PATSER) and Home Grown Technology (HGT) were instituted to support the R&D agencies / industries for prototype development, pilot plant establishment, test and evaluation of products, user trials etc with or without collaboration with each other. This is the stage where intense interaction between the R&D and industry is required.

Once a technology qualifies the techno-commercial requirements, it needs to be taken for commercialisation. But the most important step at this stage is packaging the technology or a product into a saleable commodity, which requires specialised skills in design and engineering, not only for the product as such but the whole manufacturing system with economic viability. Many a time, the scientists say, we have an idea and it is up to the industry to use it. The industry says, they need the whole technology as a package and they alone cannot visualize the utility of the inventions. So there is a clear need of a special breed of technologists that could address this issue of realizing the full potential of new scientific inventions through their engineering skills and market knowledge.

After establishing the concrete evidence of techno-economic feasibility of a technology or a product, there is still an element of uncertainty of the success of a technological venture. In order to take care of this risk element, the Government established TDB in September 1996.

5.4 Government Initiatives to Promote R&D Agency-Industry Partnerships

5.4.1 Partnership Promoting Initiatives in All Sectors

Various mechanisms / programmes / fiscal incentives instituted by the GOI in the pre- and post-globalisation period are discussed below in chronological order.

(i) **The National Research Development Corporation [160]**: National Research Development Corporation (NRDC) was set up as early as in 1953 to address the issues related to exploiting indigenous know-how, to act as a link between national research laboratories and entrepreneurs by transferring technologies developed by mostly public R&D agencies, and to financially support the entrepreneurs for putting up pilot plant, prototype development and establishment of demonstration units and thus facilitating commercialisation of indigenous technologies. Current promotional activities of NRDC are being carried out under the Invention Promotion Programme (Proving Prize Award & Award of the World Intellectual Property Organisation (WIPO) to Meritorious Inventions; Protecting Inventions through IPR; IPR Consultancy; Incentive to Scientists and publications etc.) and the Technology Promotion Programme (Promotion of Rural and Household Technology; Export of Technology; Informatics for Technology Transfer and Technology Development Programme for Priority Projects). Its commercial activities include the licensing of technologies to industry; providing conditional grants for development of technologies to R&D laboratories and industries for setting up pilot plants to prove/scale up laboratory processes prior to commercialisation; providing IPR consultancy services to R&D institutes and industries; exporting Indigenous technologies and know-how; participating in equity to facilitate formation of new ventures using indigenous technologies; and executing turnkey projects abroad based on indigenous technologies

A large number of Indian technologies have been commercialised by industry under licence from NRDC in the areas of agro-food processing, biomedical devices, biotechnology, drugs and pharmaceuticals, chemical industries, eco-friendly chemicals, electronics, building materials, rural industries etc. NRDC has forged strong links with various R&D organisations in the country as well as from abroad during the past five decades of its operations. It is now recognised as a large repository of wide range of technologies spread over almost all areas of industries. It is not widely known that many of the products commonly used in India and even abroad use Indian technology in their manufacture. NRDC has developed these technologies and several new technologies are available with NRDC for commercialisation in India and abroad. NRDC has been exporting proven technologies and services to entrepreneurs / industries both in the developed as well as the developing countries that include USA, Germany, Malaysia, Burma, Nepal, Senegal, Indonesia, Madagascar, Philippine, Vietnam, Sri Lanka, Kenya, Brazil and Bangladesh.

(ii) **In-house R&D Centres Recognition Scheme [161]**: The GOI launched an 'In-house R&D Centres Recognition Scheme' in 1973 for granting recognition to in-house R&D units in industry, which was initially being coordinated by DST, but was subsequently taken over by DSIR. At the time of launch one of the objectives of the scheme was to provide liberal import facilities to recognised In-house R&D units under Open General License, which was later absorbed in the liberalised trade policies announced by the GOI in 1991. Recognising the need to establish their own R&D units and taking advantage of the incentives and support measures available, a number of industries set up their own in-house R&D units to meet the technical and technological needs of their production centres. The number of in-house units recognised by DSIR has increased steadily from about 100 in 1973 to around 275 in 1975; around 700 by 1980; around 925 by 1985; and to around 1190 by November 2004 **[162]**.

(iii) **National Science and Technology Entrepreneurship Development Board [163, 164]**: In 1982 the GOI set up a National Science & Technology Entrepreneurship Development Board (NSTEDB) under the aegis of DST with an aim to (a) promote knowledge based and innovation driven enterprises; (b) facilitate generation of entrepreneurship and self-employment opportunities for S&T persons; (c) facilitate information dissemination; (d) network various Central & State Government agencies for

S&T based entrepreneurship development; and (e) act as a policy advisory body to the Government agencies for S&T based entrepreneurship development. The Board has representation from socio-economic and scientific Departments / Ministries, premier entrepreneurship development institutions and all India Financial Institutions.

The Board has since initiated a number of programmes, which have been successfully operating to meet the above objectives. These have created awareness among S&T persons to take to entrepreneurship as a career. The academics and researchers have started taking a keen interest in such socially relevant roles and have engaged themselves in several programmes. About 100 organisations, most of which are academic institutions and voluntary agencies, were drafted in the task of entrepreneurship development and employment generation. The Board has also initiated programmes jointly with International organizations such as like United Nations Development Programme (UNDP) on vocational training.

One of its major initiatives is Science and Technology Entrepreneurship Parks (STEPs). The concept of 'Technology Parks' existed since long in the developed world. However, the GOI launched the STEPs scheme in 1984-85 through NSTEDB in collaboration with the Indian financial institutions, namely, Industrial Development Bank of India (IDBI), Industrial Finance Corporation of India (IFCI) and Industrial Credit and Investment Corporation of India Ltd (ICICI) for promotion of innovation and entrepreneurship among scientific and technical persons. Under this scheme STEPs are established in and around academic and R&D institutions of excellence. The STEP has a focus to facilitate establishment of closer linkages on continuing basis between R&D agencies and industry and permit theory to influence practice for its continued up-gradation. Other objectives promoting S&T development include a) providing a mechanism effective for transfer of technology from R&D agency to industry to reduce the lead-time between invention, product development and its commercial application to improve competitiveness of industry; b) providing a platform to the entrepreneurs for 'starting' enterprises, so as to economise their time to be invested in inventions, product development and its commercial application; c) creating an environment in which highly skilled scientists and technologists feel happy to work and make significant contributions; d) making higher education relevant, purposeful, up to date and cost effective; e) providing safety to clients from exploitation and cheating by unscrupulous consultants, which is a common phenomenon in developing countries; f) facilitating development of in-house technology to reduce dependence on foreign technology; g) stepping up capacity utilisation of scarce facilities installed in laboratories, and of human capital in technological institutes; and h) providing experience and parental care to young knowledgeable enthusiastic entrepreneurs and nursing them to use latest technologies. So far 17 STEPs, have been established near the educational and research infrastructure spread over the country **[165]**.

The Government increasingly realised that two distinct features, i.e. high growth and high risk, characterise the technology-based and knowledge-driven enterprises, coupled with time to market necessitate development of special mechanisms to nurture innovation and entrepreneurship. NSTEDB made a beginning to establish Technology Business Incubator (TBI) **[166]** by organising the first international workshop on TBIs in Bangalore jointly with the Asian and Pacific Centre for Transfer of Technology (APCTT) and the Directorate of Industries and Commerce, Government of Karnataka during 29-31 January 2001. It concluded that TBIs are the tool for catalysing the development and growth of technology based small enterprises and the initiative. Thus the initiative of the Government got formalised with a focus on integration of higher educational institutions, the seedbeds of new ideas and technologies, with business enterprises, which can yield good results. The setting up of TBIs was taken up as a major initiative in the 10^{th} five-year plan. During the last few years 16 TBIs have been set up in various higher learning institutions to leverage their strengths in a particular technological area. For example, the Advanced Research Centre for Powder Metallurgy and New Materials (ARC-I) m Hyderabad is involved not only in developing, upgrading and transferring the technologies for commercialisation, but also runs a TBI on Advanced Materials. According to Menon **[165]**, the main factors for the growth of TBIs include access to skills and competencies, access to financing, access to marketing and environment for innovation.

While the S&T parks provide an encouraging environment for technology development and commercialisation, the new concept of Business Incubators additionally provides hand holding, mentoring, specialised support services and networking during the start-up phase. TBIs are a perfect example of the kind of Government – Private Sector – Local Institutions – University – R&D Institutions partnership that not only materialise new technologies and products but also meet the requirement of faculty and human resource development in the processes of technology development and commercialisation. Bigger companies also source new technologies or sponsor new technology development from these outfits. Other indirect advantages are the increase in entrepreneurship base and employment. The year-wise growth of STEPs and TBIs is shown in **Fig. 5.2**. **Fig. 5.3** shows the types of institutions hosting the STEPs and TBIs.

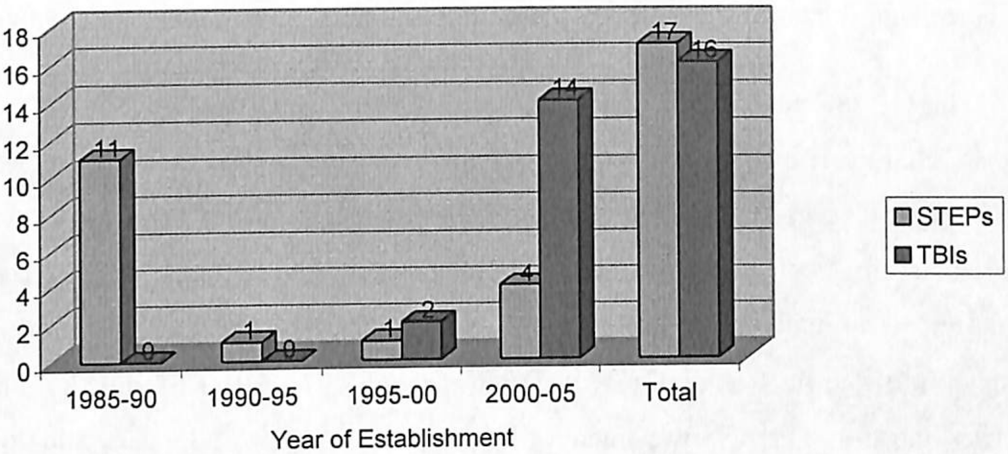

Fig. 5.2 Year-wise Establishment of STEPs and TBIs

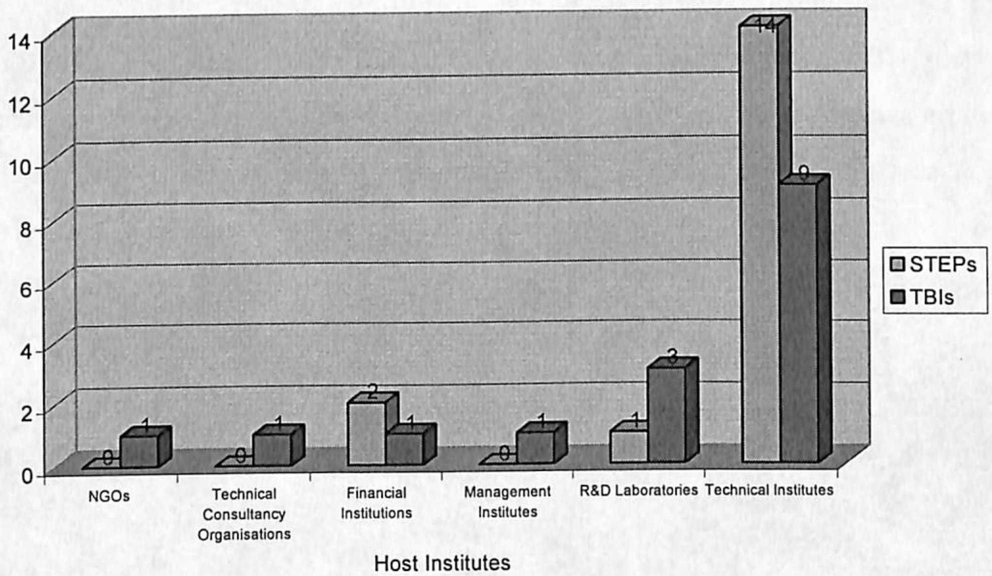

Fig. 5.3 Types of Institutes Hosting TBIs and STEPs

Entrepreneurship Development Cell (EDC) is the other major scheme of NSTEDB instituted with a mission to develop an institutional mechanism for providing various services including information to budding S&T entrepreneurs; creating entrepreneurial culture, fostering better linkages between the parent institution, industries and R&D agencies in the region and other related organisations engaged in promoting SMEs including Non-Government Organisations (NGOs); catalysing and promoting development of S&T based enterprises and promoting employment opportunities; and responding effectively to the emerging challenges and opportunities both at national and international level relating to SMEs and micro enterprises. The EDCs are established in academic institutions with requisite expertise and infrastructure. EDCs have already been set up in 55 academic institutions **[163]**. **Fig. 5.4** shows the entire Entrepreneurship Development Network in the country.

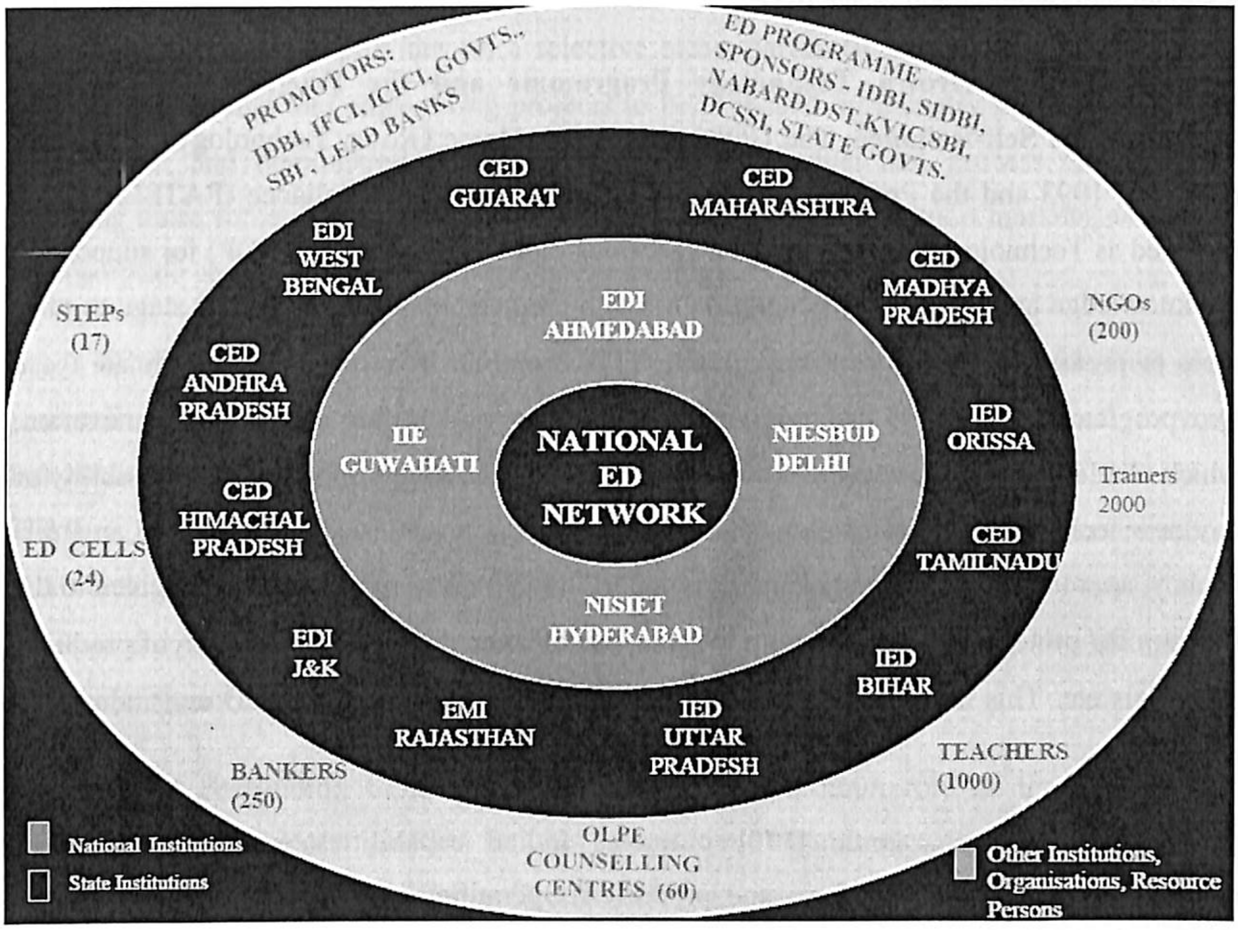

Fig 5.4 Entrepreneurship Development Network [165]

NSTEDB in partnership with Federation for Indian Chambers of Commerce and Industry (FICCI) has launched a Technology Innovation Management and Entrepreneurship Service (TIME IS), which is a website providing all information required by the industry to promote technology development and commercialisation with / without partnership with R&D agencies i.e., information on industrial promotion policies; incentive schemes; industrial infrastructure facilities; new technologies; technology / equipment sources; funding options; open learning programmes on entrepreneurship; technology trends and ST Entrepreneur magazine **[167]** .

iv) **Industrial R&D Promotion Programme [168]**: In order to promote the R&D activities in the industry and non-profit organisations several measures were evolved. A scheme was launched by DSIR to grant recognition to non-commercial voluntary Scientific & Industrial Organisations (SIROs) to enable them to be eligible for customs and excise duties on capital equipment, spares and consumables required for scientific research. Presently there are 552 SIROs recognised by DSIR that are engaged in R&D in the areas of agriculture, medical, natural and applied sciences.

(v) / (vi) **Home Grown Technology Programme and the Programme Aimed at Technological Self-Reliance**: The GOI instituted the Home Grown Technology Programme (HGT) in 1993 and the Programme Aimed at Technological Self-Reliance (PATSER) (now renamed as Technology Development and Demonstration Programme - TDDP) for supporting the knowledge and technology generation through partnerships from laboratory stage to pilot scale or prototype development stage **[169]**. TIFAC and DSIR respectively coordinate these two programmes. In both the programmes the industry identifies a particular innovation, which would be useful for up-gradation of an existing technology or explore the possibility of any new technology. Industry along with the technology provider, which could be an R&D agency, approach the government and the support in the form of grants or loans is given to the industry for prototype development, pilot plant establishment, test and evaluation of products, user trials etc. This is the stage where intense interaction between the R&D and industry is required.

The HGT programme **[170]** promotes Indian capabilities for development of contemporary and novel products and processes. Operating in a project mode it catalyses R&D efforts and fosters closer linkages between the R&D agencies and the industry. Financial support under HGT is available on soft terms and the repayment is spread over a period of 5 years after successful completion of the project. The unique feature of HGT is the techno-managerial support mechanism of TIFAC for which purpose a separate group of experts is set up by TIFAC to guide each project. These experts undertake travel to the project site every quarter of the year, resulting in close interactions with the industry and problem solving at the company site itself. HGT programme has proved to be a successful experience. More than 50 projects supported so far have resulted in development of 30 technologies out of which 10 have been commercialised, the important once include pick and place robotic arm, HFC134-A standardised eco-friendly natural dyes, plasma incinerator for hospital wastes, eco-friendly kerosene substitute for printing industry, etc. to reach the market.

The PATSER **[171]** aims to promote industry's efforts in development and demonstration of indigenous technologies, development of capital goods and absorption of imported technologies. The Government uses PATSER to catalyse the design, development, prototyping and commercialisation of innovations in and by the industry by means of financial support and institutional networking. NRDC manages the IP generated from the PATSER projects and also licenses the know-how so generated to other industries in India and abroad. The DSIR provides on a selective basis, partial financial support to research, development, design and engineering projects to be proposed by industry in the areas of the development and demonstration of new or improved product and process technologies, including those for specialised capital goods, for both domestic and export markets, as well as for absorption and up-gradation of imported technology.

Since its inception 165 R&D projects of industrial units of important industries such as metallurgy, electrical, electronics, instrumentation, mechanical engineering, earth moving and industrial machinery, chemicals and explosives, were supported under PATSER up to February 2005. Out of these 65 projects have been completed resulting in commercialisation of 30 technologies / prototypes. Currently 31 companies are paying royalty / lump sum to DSIR as per the terms of the agreement. The programme has strengthened the linkages of industry with more than 30 research institutes / laboratories **[172]**.

(vii) Patent Facilitating Centre **[173]**: Realising the important role of IP protection in gaining an advantageous position in the competitive technological game for achieving economic growth a Patent Facilitating Centre (PFC) was set up by DST under TIFAC in 1995 for (a) introducing patent information as a vital input in the process of promotion of R&D programmes; (b) providing patent facilities to scientists and technologists in the country for Indian and Foreign patents on a sustained basis; (c) keeping a watch on developments in the area of IPR and acquainting the policy makers, scientists, industry etc. with important issues; and (d) creating awareness and understanding relating to patents and the challenges and opportunities in this area including arranging workshops, seminars, conferences, etc. While major Indian scientific agencies have in-house facilities to provide patent support to their scientists, such facilities are not available to most of academic sector and smaller scientific institutions whether in the Central or the State sector. Thus PFC was created as a single window facility to serve these institutions with a friendly approach and has been successfully reaching out to remote universities and R&D centres.

(viii) **Technology Development Board [174]**: Once a technology qualifies the techno-commercial requirements, it needs to be taken for commercialisation. Realising this, in September 1996, for the purpose of the development and application of indigenous technology in a dynamic economic environment, GOI enabled the placing of the proceeds of an existent cess @5% on all payments made by the industry towards the import of a technology into a fund called "Fund for Technology Development and Application" and to administer this fund the government constituted the Technology Development Board (TDB). TDB is a unique organization of its kind within the Government framework with the sole objective of translating the fruits of indigenous research into commercial products or services. It plays a pro-active role by encouraging commercial enterprises to take up technology-oriented projects of future importance in all sectors. The Board encourages industry to enter into hi-tech hi-risk areas and motivates industry to have firmer linkages with the R&D. The board facilitates proactive dialogues between industry, scientists, technocrats and specialists and work in close association with industry bodies such as FICCI and Confederation of Indian Industry (CII).

TDB provides equity capital or soft loans at interest rate of 5% per annum to the industry and financial assistance to R&D agencies wanting to commercialise an indigenous development or imported technology for wider usage. The repayment of the loan together with interest thereon commences one year after the project is successfully completed or before the end of the fourth year from the date of disbursement of the loan, whichever is earlier. The loan amount along with the interest due thereon becomes recoverable in five annual instalments.

The TDB programme has made its mark in the technology development scene. More than 131 of 107 industries have been supported in the last few years and many products such as Hepatitis-B Vaccine, Lithium Ion Batteries, High Strength Alloys etc, have been successfully commercialised. The fund is supporting the ambitious project of commercialising indigenously designed multi-role aircraft. Many other venture capitalists also are coming to India, catalysed by the growth of Information Technology (IT). The present investment of the Board is about Rs 500 Cr., which is on the initial investment of Rs 30 Cr. Besides this its tie-ups with the Unit Trust of India (UTI) have also yielded us a 30% rate of return. The Board has not been running into losses. Each product is considered as a return to the programme.

The Board is taking several new initiatives to further its cause. It plans to tie up with other financial institutions for providing loans, while it already has a MoU with UTI Venture Fund. It also has a plan to tie up with the NSTEDB to encourage research and technological innovations at the academic institutions and shall target intuitions such as IITs to begging with.

(ix) **Technopreneur Promotion Programme [175]**: In its endeavour to tap the vast innovative potential of the individual innovators having original ideas the Government in August 1998 launched a novel programme known as Technopreneur Promotion Programme (TePP). Jointly operated by DSIR and TIFAC, this programme aims to promote and support untapped creativity of individual innovators; to assist the individual innovators to become technology based entrepreneurs and to assist the technopreneur in networking and forge linkages with other constituents of the innovation chain for commercialisation of their developments. The selected & screened individual innovators having original ideas are provided financial support for converting them into working models, prototypes etc.

(x) **New Millennium Indian Technology Leadership Initiative [176]**: The Government continued its efforts to promote S&T through R&D agency - industry partnership. Another landmark programme focusing on R&D agency – industry partnership, known as the New Millennium Indian Technology Leadership Initiative (NMITLI) was initiated by the Government in FY 2000-01 with the noble aim of helping India attain the global technology leadership position in select niche areas in a 'Team India' partnership, that fulfil national objectives. NMITLI therefore looks beyond present day technologies and seeks to build, capture and retain for India a leadership position based on technology by synergising the best competencies of publicly funded R&D institutions, academia and industry. The CSIR was given the responsibility to launch and coordinating this massive programme.

NMITLI scheme provides funds in the form of grant-in-aid to R&D agencies, SIROs, Public Sector Units (PSUs) as well as NGOs and soft loan with 3% interest to industries for the joint project of 3-4 years duration. The quantum of funding depends on the nature of the projects, their attractiveness and feasibility criteria, risk factors and ability to capture the global leadership position. The funds are released to the individual partners only after the involved partners enter into a legal agreement with CSIR. The repayment of the loan component as well as interest by the industry partners is in 10 equal yearly instalments, which commences within six months of the completion of the project.

NMITLI has proved to be a pioneering, path setting and proactive initiative with no parallels. The programme has distinctive features such as i) its objective: to capture global technology leadership position; ii) participation by a number of R&D institutes and industries in one project; iii) project evolution through national churning of best brains from all constituents; iv) project participation: by invitation, and not by application; v) the project implementation: disassembling of technology into constituents and parcelling constituent development to the best player; vi) project monitoring: being high level and stringent with foreclosure if leadership cannot be secured or progress is not upto the desired level.

With over 167 public R&D institutes / laboratories and 55 private industries networked together to implement 33 projects with an outlay of Rs. 220 Cr., NMITLI is the largest partnership facilitating programme in India today. According to Rao **[177]**, NMITLI for India as a whole has become a truly national movement that could propel it to global technology leadership.

(xi) **Relevance and Excellence in Achieving New Heights in Educational Institutions [178]**: On 24th July 2003, recognising the importance of supply of suitable human resource for accomplishing the technology development and commercialisation, for example, joint designing by academia-industry of the curricula in line with the business and market requirements, providing training and exposure, TIFAC launched a Technology Vision 2020 Mission Project called Relevance and Excellence in Achieving New Heights in Educational Institutions (REACH). The scheme aims to create a constellation of world class Centres Of Relevance and Excellence (COREs) in diverse disciplines across the length and breadth of the country. Mission REACH intends to create 80-100 such COREs, which together will emerge as a network of mini IITs across the country, integrally connected physically and electronically through a mix of landline and V-SAT networking. Mandated to turn out top quality human resource in the area of targeted excellence, which shall be intensely relevant to the Indian industries and society, these COREs will have flair of mini IITs. Each CORE is the outcome of the funding, infrastructure, expertise, knowledge and commitment brought together by the user industry, educational institute and government. Every one of them being a shrine of excellence with the best of teachers, students, researchers, entrepreneurs and industries, this network of COREs is expected to become a powerful and important resource to realise the dream of a developed India by 2020.

5.4.2 Sector Specific Partnership Enabling Programmes

The above paragraphs discuss the initiatives of the Government that served all the areas of scientific and industrial development. However with an objective to attain excellence and be the path-setter and not a follower in the global technology scene, the GOI has been promoting the R&D agency - industry partnership mechanisms in specific sectors as below.

(i) **Automotive Sector**: The government has recognised the importance of automotive sector in India that has significant backward and forward linkages, applies engineering skills intensively and essentially requires R&D agency – industry partnership to identify competency areas to focus efforts; establish supporting infrastructure (like test tracks, wind tunnel and crash-testing facilities) for validating vehicle developments; develop international R&D collaborations; encourage Indian Original Equipment Manufacturers (OEMs) to set up houses abroad to derive the location efficiencies; develop the component industry also to provide full system solutions to OEMs. Thus a Core Group on Automotive R&D was set up in 2003 / 2004 under DST involving the government, R&D agencies and industry **[179]**. The Core Group aims at identifying frontier technologies. Based on the interactions and strengths available in the country, embedded control systems, telematics, hydrogen-powered vehicles, advanced materials and road safety are identified as focus areas. The uniqueness of this initiative is that the driver is the industry, which wants access to the latent technological capabilities in the public funded institutions.

(ii) **Drugs & Pharmaceuticals**: Another innovation enabling partnership has been in the upcoming field of biotechnology, particularly, drugs and pharmaceuticals. On the advice of the Planning Commission DST initiated the Drugs & Pharma Research Programme (DPRD) in the FY 1994-05 with an aim to synergies strengths of publicly funded R&D agencies and Indian pharmaceutical Industry **[180]**. Under DPRD DST provides grants to the R&D agencies, 100% for equipment and 70% for the total recurring expenditure, to prove the bench scale feasibility of the research. The remaining 30% recurring expenses are met by the participating industry. Since its inception 70 research projects have been supported resulting in filing of 6 product patents and 13 process patents. One drug is in the 2nd phase of human trials.

In FY 2004-05 DST has established a Pharmaceuticals Research and Development Support Fund (PRDSF) to support the Drugs & Pharma Research Programme in the country by extending soft loans @ 3% to the industry at the bench level feasibility stage of the research projects. Five projects have already been supported under this programme. The programme has been successful in establishing alliances of R&D agencies with 50 Indian industries resulting in new development of new chemical entities, vaccines, assay systems and drug delivery systems. DST has so far spent Rs. 9 Cr. towards support of the above projects.

(iii) **Biotechnology:** One of the main objectives of the Department of Biotechnology (DBT) is to promote development of technologies, processes and products through the sustainable use of biotechnologies for larger societal benefits in the country. Special mechanisms have been established by DBT for enabling technology transfer to industry for commercialisation and large - scale use. These are, for example, the Micropropagation Technology Parks (MTP) based on the existing expertise and infrastructure of the two tissue culture pilot plant facilities at NCL, Pune and TERI, New Delhi **[181]**. These serve as (i) platform for effective transfer of proven technologies to the entrepreneurs by providing the infrastructure, know how, training etc. required for large-scale production; (ii) technology resource centre to the upcoming / established tissue culture units; (iii) training centre for large-scale production of plant species; (iv) training centre for new entrepreneurs as well as technical manpower; and (v) demonstration centre for production and performance of elite forest tree species through tissue culture, including development / refinement of tissue culture protocols for economically important species, which are either difficult to propagate by conventional methods or show marked variability. As the experience has been rewarding DBT is promoting the concept of MTP to provide an interface between the R&D agencies and industry. It is important to cite the example of a technology for teak that has already been transferred to an international laboratory of UK.

For promotion, transfer and commercialisation of biotechnologies DBT established Biotech Consortium India Ltd. (BCIL) as a public limited company in 1990 under the Indian Companies Act 1956. BCIL is promoted by the financial institutions including IDBI, ICICI, UTI, IFCI and IFCI Venture Capital (VC) Funds Limited and the corporate sector including Ranbaxy Laboratories, Glaxo India, Cadila Laboratories, Lupin Laboratories, etc. which have since contributed Rs. 5.37 Cr. towards its core capital. It works in close association with them for syndication of funds for eligible biotech projects in addition to facilitating technology transfer. Over 9 technologies such as Biopesticides, ELISA, HIV-1/2, Hepititis A and reproductive hormones diagnostics etc. have been transferred to industry through BCIL from academic institutions like Jawaharlal Nehru University, New Delhi and various R&D agencies [182].

(iv) **Space:** Indian space programme over the past three decades has set a fine example for the development of the sate-of-the-art technologies related to outer space and their applications in a variety of fields like telecommunications, TV broadcasting, satellite-aided search and rescue, meteorology and remote sensing of natural resources. The Department of Space (DOS) has established a capability to design, develop and build space infrastructure like the INSAT and IRS satellite systems, launch vehicles like Polar Satellite Launch Vehicle (PSLV) and Geostationary Satellite Launch Vehicle (GSLV) as well as associated ground systems. There has been a substantial growth in the use of space infrastructure making it necessary to produce space systems and establish associated ground facilities in an industrial environment.

Having graduated to the level of providing operational services through space systems, the Indian space programme has established a symbiotic partnership with Indian industries. Guided by the objective of achieving self-reliance in space technology, this partnership has been carefully nurtured through various initiatives. As a result of its conscious policy and initiatives, DOS has established linkages with more than 500 industries in the small, medium and large-scale sectors, either through procurement contracts, know-how transfers or provision of technical consultancy. Through its association with the space programme, the space industry has been meeting the growing challenges for advancing technology and handling complex manufacturing jobs.

A Group on Technology Transfer and Industrial Consultancy was set up at the ISRO Headquarters to deal with all matters concerning transfer of technology developed by various laboratories of DOS [183]. The Technology Transfer (TT) activities at ISRO conduct careful assessment of readiness of technologies, judicious selection of recipient agencies, technical consultancy backup to licensee after know-how transfer, quality surveillance by ISRO personnel during production at licensee's premises etc. which ensured successful commercialisation of its technologies. 261 technologies have so far been transferred by DOS to industries for commercialisation and more than 260 technical consultancies have been undertaken in various areas relevant to space technology in the broad areas of electro-mechanical, chemical and optics hardware to specialised software in representing a range of applications for industrial and societal purposes including several spin-offs. Considering the potential that exists for application of space in India and other markets as well, the role of Indian industries is poised to grow further.

DOS has formulated an Industry Participation Policy. The component of the policy include setting up of the modalities for identification of industries, commitment from DOS to these industries, utilisation of human resources and facilities available within the DOS, incentives for industries to promote space technology, etc.

Sponsored Research Programme (RESPOND) of DOS has the main objective to strengthen the academic interaction through collaborative research, educational and scientific activities at the academic institutions. The major activities supported under RESPOND are: (a) research and developmental projects (b) Space Technology Cells (c) institution of ISRO Chairs and (d) educational programmes, conferences, symposiums and promotional activities. RESPOND helps generate human resources to support the Indian space programmes. DoS has been regularly utilising the services of students from reputed management institutions for carrying out specific assignments concerned with market survey and system studies, economic analysis for technologies that have apparently good prospects, etc. This information is significant in terms of providing an understanding of the market needs of certain indigenous technologies.

DOS operates a 'Technology Utilisation / Vendor Development' programme to establish closer partnership with the Indian industries for maximal utilisation of the industrial capability. Over the years, the industry involvement has been steadily increasing, with industries being associated in the fabrication of hardware for satellites, launch vehicles and in the building of ground infrastructure, as well as the system level fabrication and integration activities, either independently or through a consortium. One of the important projects being executed by a consortium of industries is the second launch pad at SHAR Centre, which is an example of industries pooling in their resources together to execute a complex job.

In 1992 DOS established a company named 'Antrix Corporation Limited' at Bangalore, which is the apex marketing agency with access to resources of DOS as well as Indian space industries. Antrix markets subsystems and components for satellites, undertakes order for satellites to user specifications, provides launch services and tracking facilities and also organises training of manpower and software development. Antrix devotes its efforts and energies to sharing this rich bank of space expertise with the world. In its pursuit of marketing the space products and services, Antrix has been making rapid strides in the export market. Various initiatives taken by Antrix have resulted in the steady growth and increasing export turnover of the company.

(v) **Cooperative Research Associations**: The Government has encouraged setting up of cooperative research associations in select areas, viz., textile, building materials, rubber, tea, automobiles and electricals with active involvement of the industry. The government and the member industries jointly finance these cooperative associations. As per the experience of DSIR, the cooperative research concept has not grown adequately and that further encouragement is needed to enable this concept to flourish to the advantage of industry **[184]**.

5.4.3 Summary of GOI Initiatives

The Government has been reviewing all its initiatives as mentioned above. In order to improve implementation of partnerships enabling mechanisms and under the zero based budgeting exercise DSIR has formulated the Technology Promotion, Development and Utilization (TPDU) programme by merging several existing government schemes, viz. RDI; PATSER; Scheme to Enhance the Efficacy of Transfer of Technology (SEETOT) and the related activity of APCTT **[185]**. The activities of this programme are centred on promoting industrial R&D, development and commercialisation of technologies, acquisition, management and export of technologies, promotion of consultancy capabilities, etc. The specific components of the scheme include Industrial R&D Promotion Programme; Technology Development and Innovation Programme; Technology Management Programme; International Technology Transfer Programme; Consultancy Promotion Programme; and Industrial R&D and Technology Information Facilitation Programme.

Table 5.2 lists out the GOI initiatives that support the partnership between R&D agencies and industry. **Fig. 5.5** depicts the placement of such partnerships vis-à-vis their coverage of market and technology certainty levels **[186]**.

5.5 Partnership Enabling Initiatives of Council of Scientific and Industrial Research

The Council of Scientific and Industrial Research (CSIR) was established in 1942 as an autonomous society with wide charter of functions including development, promotion, guidance and coordination of scientific and industrial research, collection and dissemination

Table 5.2 Major Government Initiatives promoting R&D Agency – Industry Partnership

S. No.	Name of Agency /Programme	Name of Programme/ Purpose	Launch Year	Accomplishments
1.	NRDC	Transfer of Technologies	1953	Forged strong links with Indian / foreign R&D agencies; has large repository of wide range of technologies in almost all industrial R&D sector; has successfully exported technologies to Brazil, Burma, Bangladesh, Germany, Indonesia, Kenya, Madagascar, Malaysia, Nepal, Philippine, Senegal, Sri Lanka, Vietnam and USA
2.	NSTDEB of DST	S&T Entrepreneurship Programme (STEP)	1984-85	17 STEP's established near educational and research infrastructure to facilitate continued closer ties between R&D agencies and industry
3.	NSTEDB of DST	Entrepreneurship Development Cell (EDC)	1986	EDC set up in 55 academic institutions to provide info to budding technopreneurs; creating entrepreneurial culture, fostering better parent institute – industries - R&D agencies linkages.
4.	DOS	Technology Transfer and Industrial Consultancy Group	~1990	~ 268 technologies of ISRO have been transferred to industries for commercialisation and more than 265 consultancy assignments have been undertaken by ISRO for small, medium and large-scale industries
5.	DBT	Biotech Consortium India Ltd. (BCIL)	1990	Provides linkages amongst res. institutions, industry, government and funding institutions to facilitate accelerated commercialisation of biotechnology. ~9 technologies transferred to industry and ~ 300 trainees trained for industry during last 5 years.
6.	TIFAC	Home Grown Technology (HGT)	1993	>50 projects supported resulting in development of 30 technologies (10 commercialised)
7.	DSIR	Programme Aimed at Technological Self-Reliance (PATSER) (now called Tech. Development and Demonstration Prog.)		165 projects supported. 65 projects completed resulting in commercialisation of 30 technologies / prototypes; strengthening linkages of industry with over 30 research institutes.
8.	DST	Drugs & Pharma Research Programme (DPRD)	1995	70 projects supported resulting in development of 6 products and filing of 13 process patents
9.	TDB	Converting the fruits of indigenous res. into commercial products or services	1996	131 projects of 107 industries resulting in development of many industries, rise of new industry
10.	DBT	Micropropagation Technology Parks (MTP)	1997	2 MTPs at TERI and NCL; State-of-the-art tissue culture production facility with an annual production capacity of 2 million plants at TERI
11.	CSIR	New Millennium Indian Technology Leadership Initiative (NMITLI)	2001	33 projects supported resulting in 3 major technologies developed, 3 commercialised, many minor under development and networking of 167 R&D institutes with 55 industries
12.	NSTEDB of DST	Technology Business Incubator (TBI) Scheme	2001	16 TBIs established to provide hand holding, mentoring, specialised support services and networking during start-up phase of an enterprise
13.	DST	Pharmaceuticals R&D Support Fund (PRDSF)	2005	5 projects being supported

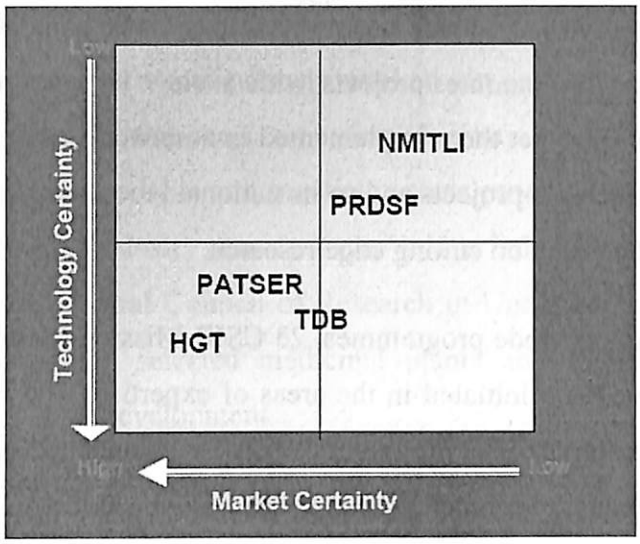

Fig. 5.5 Level of Market Certainty and Technology Certainty Supported Under GOI Programmes Supporting Partnerships [186]

of information on research and industry, funding of national institutes to further the research and exploitation of the research results for development of industry. Today CSIR is the largest publicly funded scientific industrial research organisation in the world serving a vide range of industrial sectors through its 38 research institutes and 38 field stations. CSIR institutes are equipped with the state-of-the-art infrastructure and trained manpower (total >1900, out of which the scientific & technological are ~5400; research fellows and research associates are ~4000). Its Annual Budget is around Rs. 1500 Cr.

The activities of CSIR are now much more focused and provide scientific industrial R&D that maximises the economic, environmental and social benefits for the people of India, providing technology for economic growth (industrial competitiveness, endogenous resources value enhancement), technology for strategic needs (S&T base for strategic sectors), technology for human welfare (societal welfare, Improving quality of environment) and science for technology (Advancement of knowledge, Nurturing extramural R&D). CSIR is being regarded as a powerhouse in some select areas and has proven competitiveness in the fields of Aerospace Engineering, Biotechnology, Chemicals, Drugs & Pharmaceuticals, High Performance Materials, Petroleum & Petrochemicals, and Environmental Technology.

As CSIR has been continuously striving to maximize the outcome of its R&D activities, it has been revisiting its policies from time to time with an aim to meet the current requirements such as it has laid its IPR policy in 1996 and Human Resource Development Policy in 2002. Furthermore in the 10th five-year Plan (2002-07) CSIR, for the first time in

India, has created innovative knowledge networks across and beyond CSIR laboratories by formulating well focused programmes/projects with a view to synergise the competencies developed in its institutes and get them implemented in a network mode. CSIR lays emphasis on industry oriented partnership projects and so its national laboratories tend to focus more on the contract research rather than on cutting edge research.

10 Strategic Mission Mode programmes, 23 CSIR Mission Mode Programmes and 22 CORE Programmes have been initiated in the areas of expertise. The Planning Commission has approved these programmes. The programmes have been launched in the networked mode so that they can deliver output by having strong linkages with industry linkages. Some of the representative programmes are SARAS of National Aerospace Laboratories (NAL), which directly involved Hindustan Aeronautics Limited (HAL) and has received funding from TDB for commercialisation; Bio-technology Programmes and Programmes in the area of Drugs and Pharmaceuticals.

CSIR has launched a number of programmes with an objective to have clear and close network between the Government, R&D agencies and industries:

(i) **New Drug Development Programme**: Based on the competencies, expertise and facilities available in eighteen of the CSIR institutes and to face the challenges raised by the changing trade and IPR scenario CSIR initiated a programme on New Drug Discovery in 1997 by pooling and networking existing resources of its institutes. This proactively initiated, coordinated drug development and commercialisation programme has been mounted with objectives to create an operational framework of integrated coordinated effort for new bioactive discovery based on plant sources and traditional preparation in CSIR; discover, optimise, protect and market new bioactive therapeutic agents based on plant sources, for tropical, metabolic and degenerative diseases; provide pharmaceutical industry new bioactives for further development and commercialisation; assist traditional system of medicine in improving their processes and products through modern scientific tools; help spread the knowledge and skills of contemporary new drug discovery in the country particularly to industrial enterprises; and build capacity for new sciences based techniques of new product discovery in order to remain a catalyst to the Indian industry. Apart from CSIR laboratories and the traditional knowledge based industry, 13 universities and 3 medical institutes are actively participating in this gigantic, devoted and very timely job.

The micro-level planning, management and execution of the widely dispersed and networked programme have been meticulously worked out and implemented. As a result of this programme CSIR has in the short time forged relations with organisations rich in traditional medicine knowledge base and practicing their products of traditional medicine a knowledge based Ayurvedic industry namely Arya Vaidya Sala (AVS), which is a non-profit making organisation, and Central Council of Research in Unani Medicine (CCRUM) of the Ministry of Health to screen selected medicinal plants and traditional preparations for deriving newer leads for drug development.

In order to enhance the effectiveness of this networked programme several measures have been taken to increase capacity building in terms of the state-of-the-art knowledge, expertise, equipment and facilities required for new drug discovery. The participating agencies upgraded / modernized their facilities for enhancing the new drug discovery capabilities **[76]**. The programme has helped to put in place modern expertise and facilities for new drug designs such as molecular modelling, computer graphics and analytical chemistry.

The viability of this networked system has been tried. The mammoth coordinated programme networking 20 CSIR institutes, 13 universities and 3 well known entities in the Traditional System of Medicine has provided many leads, which have the potential of development of products for the international market. The dedicated teams have discovered some new chemical entities and new herbal formulations for cancer, tuberculosis, filarial, malaria, ulcer, Parkinsonism and Alzheimer. Interesting leads have been obtained on hepato-protective cum immuno-modulation as well as memory enhancement. Two entirely new anticancer preparations in the area of women's' cancer are being developed by Indian firms. Also short-term toxicity of two entirely new anti-ulcer preparations have been completed and clinical trial protocols has been worked out.

(ii) Based on the experience of CSIR in managing and implementing the networked programmes, CSIR was given the responsibility to coordinate NMITLI (Details in 5.4.1.x).

(iii) The Institute of Genomics & Integrative Biology (IGIB) **[188]**, a constituent institute under CSIR, and a US based investment entity, through the Institute of Molecular Medicine have set up the Genomic Application Research Facility at New Delhi in May 2004 as a 50:50 financial participation. This is planned to be a world class Genomic & Proteomics facility that could be used as a shared resource for all the research centres in the country. The technical and research support will also be provided by CSIR and DST. This is a unique initiative of the GOI, R&D institutions and industry to offer world-class research facilities in the area of Genomics & Proteomics aimed at facilitating the industry to come out with competitive products.

The Facility will initially undertake genotyping and sequencing for medical genetics and population genetics. It will provide services like protein sequencing, fingerprinting, primer design & synthesis, expression profiling using micro-arrays, incubation laboratory for start ups in biotechnology etc. This Facility has already started providing service to large pharmaceutical and biotechnology companies and research institutions in the country and fulfils the critical need of research infrastructure, which otherwise is difficult for individual small companies and entrepreneur to afford. It will be cost effective due to its centralised operations and will serve as a single-stop shop to outsource their research requirements. By drastically reducing the cost of research and making leading edge capabilities widely available, it will allow Indian science to excel globally and enhance the pace of drug discovery.

CSIR has been taking a number of initiatives to enthuse the laboratories and scientists to become self-sustaining through technology development and transfers. In this context CSIR has put in place a reasonably well-defined system for developing and sustaining interaction with industry, especially in the form of contract research and consultancy services. It has been reviewing its policy from time to time in order to perform and deliver in the global scenario of economic, IP and technological changes. It has brought several changes in the organisational structure that is quick in response to the external changes and responsive to internal and external customer expectations and aspirations. Some of the initiatives / mechanisms initiated by CSIR towards enthusing the scientists and institutes to contribute to economic growth are discussed below **[189]**:

- The appraisal of performance of each CSIR institute once in three years has been made mandatory. The performance of the institutes is judged on the basis of their R&D deliverables that contribute to the industrial application.

- Encouragement is given to outward orientation to forge alliances and consortia for more comprehensive technology / service package.

- Publicity and marketing are being realised as essential components of R&D management.

- CSIR institutes now prepare "Business Plan' besides the usual R&D plans, commit to targets of external business generation which is monitored. Business Development Group/Cells have been set up in each institute to monitor the implementation of the business plan and interface between the institute and industry.

- CSIR has designed guidelines for sharing a portion of the monies realised from licensing of IP and the fees from sponsored research projects / schemes with the staff.

- CSIR was the first in India to announce a corporate 'Intellectual Property Management' policy in 1996, resulting in mass awareness of IP in CSIR and most of CSIR scientists are now patent literate and savvy. The IP Cells have been set up in every institute to capture the potential IP generated within CSIR at an early enough stage.

- CSIR was amongst the first publicly funded R&D organizations in the world to set up Customer Satisfaction Evaluation Cell in 1997 that evaluates the customer's satisfaction in all the externally funded projects of CSIR **[190]**. This reform has enabled CSIR to improve on its outputs and the process of delivering outputs. It has also enhanced the reputation and standing of CSIR in the corporate world enabling it to partner and forge alliances with some of the best known technology companies world over such as General Electric, Pfizer, Smith Kline Beecham and Mobil Oil Corp. in USA, and Reliance, Ranbaxy, Nicholas Piramal, Biological Evans, Godrej and Satyam in India.

- A Technology Advisory Cell (TAC) has been set up which is functioning with a two-tier mechanism viz. at central level and at laboratory level to assist industries to realize optimal returns from their assets and achieve technological self-reliance.

- CSIR and DBT have jointly set-up a Unit for Research and Development of Information Products (URDIP) at Pune with an objective to synthesise information for knowledge management which means to develop and distribute science, technology and industry related information products in electronic, online and web based formats [191]. URDIP is leveraging the information resources of the CSIR institutes and knowledgebase in specific sectors viz. Leather, Food, Drugs and Pharmaceuticals, Chemicals, Natural Products, Oceanography, Coal, Petroleum etc., to develop Science, Technology, Industry and Institution specific portals with embedded e-commerce applications to provide value added services over the internet to help researchers, industry and the public at large.

- CSIR has also initiated the web-based science and technology information service named Technology Advisory Point as a gateway to scientific knowledge that usually remains within the 'head' of a scientist, a researcher or an expert and is expected to bring the knowledge of CSIR's 6000 highly qualified scientists to the desktop of the user. The service has been started with an objective to save time and money especially for small and medium enterprises. This service is presently in the pilot testing phase and covers chemicals, food and leather technology areas only [191].

5.6 Initiatives of Some Select Academic Institutions / Agencies in Promotion of R&D Agency-Industry Partnerships

5.6.1 Foundation for Innovation and Technology Transfer (IIT, Delhi)

In 1992 the Indian Institute of Technology (IIT), Delhi set up a TTO named 'Foundation for Innovation and Technology Transfer (FITT)', as an autonomous registered society and interface organisation, with a view to achieve a quantum jump in the level of interaction and collaboration with industry on programmes and projects of mutual interest [192]. Focus of FITT is to improve visibility of the Institute Capabilities with Industry; facilitate Technology transfer activities of the faculty and scientific community at the Institute and encourage the spirit of entrepreneurship in the faculty, graduating students and scientists at large. FITT is financially and administratively autonomous of the IIT. It has since been serving as a single window service to industry, drawing upon IIT Delhi as the primary resource.

Keeping in view that graduating students of IIT Delhi complete more than 700 industry projects every year and of these at least 5-10 could be potentially commercialisable ideas, IIT Delhi initiated the 'Students-Faculty Led Incubation Program for Initiating Technology Start-Ups' through FITT [193]. In the Incubation process FITT motivates students along with faculty supervisors to spend 6-24 months in IIT Delhi to upgrade/package technology ready for transfer to industry, that could be converted into "business", developing and marketing products and services or be acquired by an existing company. The graduate students, FITT, IIT and faculty members are the stakeholders in the incubation process. FITT encourages and facilitates the students and faculty it seeks and facilitates VC funds and provides all infrastructure and support services. IIT Delhi has established its own TBI. The first company 'KRITIKAL Solutions Ltd.' physically moved to in this TBI in Sept. 2002. Presently four companies are housed here. FITT also operates a scheme of 'Corporate Membership', which is open to industry, industry associations, R&D agencies and financial institutions willing to support the concept of R&D agency-Industry interaction and derive benefits resulting thereof. It may be noted that joint centres have been set up by the industries like IBM and Monsanto in academic institutions like IIT, Delhi as well as at IISc, Bangalore.

5.6.2 Society for Innovation and Development (IISc, Bangalore)

The Society for Innovation and Development (SID) was founded in 1991 in close collaboration with IISc to enable India's innovations in S&T by creating a purposeful and effective channel to help industries and business establishments to compete and prosper in the face of global competition, turbulent market conditions and fast moving technologies **[194]**. SID brings the leading intellectuals of IISc, India's premier research Institute that has contributed in a significant way towards the scientific and technological growth of the country as well as producing outstanding intellectuals to manage industries, business houses and institutions, and the fruits of their R&D efforts closer to industries and business establishments in a cordial atmosphere with prosperity of the Nation as the ultimate goal.

SID undertakes sponsored R&D projects based on individual or joint proposals from the IISc scientists in collaboration with industries, business houses, national and international organisations. To facilitate project implementation it has set up the programme units, which are work groups in identified areas to undertake activities on sustained basis. These units undertake multiple projects with varying degrees of flexibility to facilitate and expedite execution of projects. SID can also formulate new, innovative modes of interaction to suit the specific needs of any proposed collaborative activity.

Since its inception SID has successfully completed ~100 research projects and currently houses eight R&D Centres of Indian industries such as, Cadila Pharmaceutical Ltd;

Cookson Electrronics India Research Centre; Satyam Computer Services Limited; Cranes Software International Ltd., Himachal Futuristic Communication Limited, etc.

5.6.3 Innovation Centre of Entrepreneurship Development Institute

The Entrepreneurship Development Institute of India (EDI), an autonomous body, set up in 1983, sponsored by apex financial institutions, viz. IDBI, IFCI, ICICI and State Bank of India (SBI) and supported by Government of Gujarat is an acknowledged national resource institution committed to entrepreneurship education, training and research. EDI has been spearheading entrepreneurship movement throughout the nation with a belief that entrepreneurs need not necessarily be born, but can be developed through well-conceived and well-directed activities. To achieve its objectives EDI with sponsorship of NSTEDB of DST has set up an Innovation Centre, which is a national facility for innovations and prepares and maintains `Data Bank' on innovative projects and new and advanced technologies, facilitates transfer of technologies from Indian R&D agencies to industry as well handles technology upgradation projects, provides personal counselling to the entrepreneurs and organises sector specific workshops thereby encouraging evolution of technology-driven enterprises **[195]**.

5.6.4 Confederation of Indian Industries

Confederation of Indian Industries (CII) is operating an innovative scheme called 'CII TDB Technology Transfer Centres' Network (CII TDB T NET)' to bring industry closer to R&D agencies in order to develop a strong and effective interaction. CII TDB T NET is a network of technology transfer centres, located at various technical institutes and universities across the country. These Technology Transfer Centres are managed and led by senior professors from the selected institutes and universities to provide technology problem solving services and technology development services to industries. Currently, Presently 18 such Centres are operating at various technical universities across the country **[196]**.

5.7 Awards and Incentives

Almost all the Government scientific departments and agencies have instituted various award schemes to encourage industry to carry out innovative and competitive research and develop competitive technologies. Some of the representative schemes are listed below **[162]**.

(i) **DSIR National Awards for Outstanding R&D Achievements and Commercialisation of Public Funded R&D Results**: DSIR instituted the "National Awards for Outstanding In-House R&D Achievements in Industry" in 1987 with an aim to recognise the efforts of industry not only in developing their own technologies, but also in absorbing / up-scaling the technology developed by R&D agencies or in indigenising the imported technologies.

(ii) **National Awards for Successful Commercialisation of Indigenous Technology**: TDB has instituted two national awards for successful commercialisation of Indigenous technologies that are awarded every year on 11th May, the Technology Day. These are, respectively, Cash Award of Rs. 10 lakhs to be shared equally between the industrial partner that has successfully commercialised an indigenous technology and the R&D agency/in-house R&D unit of the industry, that has developed / provided the technologies; and Cash Award of Rs. 2 lakhs to a Small Scale Industry (SSI).

Further, the Government has been providing several fiscal incentives with an aim to (a) bring in-house R&D into sharper focus; (b) strengthen R&D infrastructure in industry and SIROs; (c) promote R&D initiatives of the industry and SIROs; and (d) ensure that the contributions made by the in-house R&D centres and SIROs dovetail adequately in the overall context of technological & industrial development. DSIR coordinates such activities. The GOI has been reviewing and enhancing such incentives to encourage industries to carry out in-house R&D activities **[185]**. Some of the incentives currently being extended are highlighted below.

- In-house R&D units recognised by DSIR in the area of pharma and biotech sectors are eligible for duty free import of specified goods for R&D, comprising analytical and specialty equipment for production; pharmaceutical reference standards

- In-house R&D units engaged in R&D activities in the area of chemical, drugs pharmaceuticals, (including clinical trials), bio-technology, electronic equipments, computers, telecommunication equipments, aircrafts and helicopters are eligible for weighted tax deduction of a sum of equal to one and one-half times of any expenditure incurred on scientific research (not being expenditure in the nature of cost of any land building)

- SIRO's in the area of Medical Agriculture, Natural and Applied Sciences and Social Sciences recognised by DSIR are eligible for availing Custom and Excise duty exemption.

- Public Funded R&D Institutions registered by DSIR are eligible for availing custom duty exemption on import of equipment, spares and accessories and consumables and also for availing Central Excise Duty Waiver on purchase of indigenously manufactured items for scientific research purposes.

- Commercial R&D companies approved by DSIR before 1st April 2004 are eligible for 10 years tax holidays.

- Write off of revenue and capital expenditure on R&D, weighted tax deduction on sponsored research programmes of industry with national laboratories / universities / IITs; accelerated depreciation allowance on plant and machinery set up indigenous technology, custom duty exemption on goods imported for use in Government funded R&D projects, excise duty waiver for 3 years on goods produced based on indigenous technologies and duly patented in any two of the countries out of India, European Union (one country), USA and Japan.

In addition to above the government provides fiscal incentives such as customs duty exemption on components, consumables, equipment etc. to be used by used by industries in R&D projects supported by the Government under PATSER and other scheme.

5.8 Initiatives of Financial Institutions for promoting R&D Agency-Industry Partnerships

Finance is a necessary early input to any substantial product development. Financial investment in the innovation process consists of three phases, namely, investment on R&D, design and development; on industrial production; and in marketing. The success of all the three phases depends upon the availability of financial back up. Investment capital is a crucial fuel of the innovation process.

5.8.1 Venture Capital

Chronologically, the GOI guidelines for venture capital funds (VCF) were first issued in 1988; the guidelines for overseas investors were issued in 1995; and the Securities and Exchange Board of India (SEBI) VCF regulations were issued in 1996. According to the former Finance Minister and harbinger of economic reform in the country, Manmohan Singh, the government had recognised the need for VC in only as early as 1988. That was the year in which the Technical Development and Information Corporation of India (TDICI, now ICICI

Ventures) was set up, soon followed by Gujarat Venture Finance Limited (GVFL). Thus the Indian VC industry is very young. The first origins of modern VC in India can be traced to the setting up of a Technology Development Fund (TDF) in the year 1987-88 by the Government through the levy of a cess on all technology import payments. Though young by international comparison, the Indian VC industry has matured fast as a result of the liberalisation processes initiated by the GOI in the early 1999's. Today there are about 40 VCFs out of which about 20 are members of the Indian Venture Capital Association. The VC activity in India is mainly concentrated in a few places like Bangalore, Chennai, Mumbai and Delhi and is restricted to the IT industry **[197]**.

VC funding is different from traditional sources of financing. Venture capitalists finance innovation and ideas, which have potential for high growth but with inherent uncertainties. This makes it a high-risk, high return investment. Apart from finance, venture capitalists provide networking, management and marketing support as well. This very blend of risk financing and hand holding of entrepreneurs by venture capitalists creates an environment particularly suitable for knowledge and technology based enterprises **[198]**.

In various developed and developing economies including US, Israel, Taiwan U.K., Australia and Hong Kong, VC has played a significant developmental role. Scientific, technology and knowledge based ideas properly supported by VC can be propelled into a powerful engine of economic growth and wealth creation in a sustainable manner. The VC funding in India generally comes at a later stage of technology development. The Indian Venture Capital Association (IVCA) is the nodal Centre for all venture activity in the country. The VC firms as a rule do not participate at the initial stage and generally concentrate on projects that have prospects of fast growth. VC firms use high discount.rates of around 40-50% in a period of 3-5 years while evaluating the projects. This restricts the VC firms to fund a number of R&D projects, that could be otherwise viable but do not meet their stringent criteria **[199]**. Certain VCF are industry specific in that they fund enterprises only in certain industries such as pharmaceuticals, IT or food processing, whereas the others may have a much wider spectrum. Again, certain funds may have a geographic focus like Uttar Pradesh, Maharashtra, Kerala, etc, whereas the others may fund across different territories.

Recent developments have shown that India is maturing into a more developed market place and unconventional investments in a gamut of industries have sprung up all over the country. India, along with Israel, Taiwan and the USA, is recognised for its globally competitive high technology and human capital. The success India has achieved particularly in software and IT against several odds such as inadequate infrastructure, expensive hardware, restricted access to foreign resources and limited domestic demand is a pointer to the hidden potential it has in the field of knowledge and technology based industry.

5.8.2 Industrial Credit and Investment Corporation of India Bank Limited

The Technology Group of Industrial Credit and Investment Corporation of India (ICICI) strives to assist innovative projects leading to development of new technologies, products and processes and to promote clean and efficient technologies. The projects identified for funding by ICICI have high risk factor and demonstrative effect so that these technologies can be replicated. The Group has been implementing projects in diverse sectors such as post-harvest agribusiness, collaborative R&D, energy research, child & reproductive health, pollution prevention & control and Indo-US joint R&D ventures. The focus is on the cooperation to be fostered between an individual industrial firm and autonomous technology institutions, since R&D efforts would be cost effective, especially for SMEs, as it would be a collaborative process rather than the industrial firm creating all the facilities in-house.

For the World Bank the ICICI is implementing the Sponsored Research and Development Programme (SPREAD), design of which was finalised after extensive discussions with the industry, CSIR and other R&D agencies. The main objectives of the SPREAD programme is to encourage industry to substantially increase their R&D activities; to foster closer links between industry and R&D agencies; to utilise the existing infrastructure in R&D agencies to the fullest extent possible; and to assist them in improving the cost effectiveness of R&D projects and shortening the R&D project cycle. SPREAD programme supports projects at all stages of the R&D cycle starting from laboratory and pre-feasibility studies to prototyping and pilot plant operations. Projects are eligible only if the proposed development period is under 2 years. The project scope apart from capital expenditure could also include materials and consumables, payments to consultants and experts, royalty / cess payments to technology institution, etc. Assistance under SPREAD is limited to 50% of the cost of project or Rs. 1.5 Cr. The programme provided for a concessional interest @ 6.0% per annum for the development period (under 2 years) and then at near market rate of 15% per annum during the commercialisation phase.

Under the SPREAD programme ICICI has so far assisted 101 projects with an aggregate assistance of about Rs. 70 Cr. Out of these, 48 have been commercialised indicating a high success rate for R&D funding. Three industrial sectors, namely pharma / biotechnology, electricals / electronics and chemicals / petrochem constituted ~65 % of the portfolio (depicted in **Fig. 5.6**), and the projects in these sectors got success rates of over 50%. **Table 5.3** lists the R&D agencies, which partnered more than one SPREAD project. It can be seen that CSIR laboratories and institutes of higher education (including IITs) played a major role in the success of the programme.

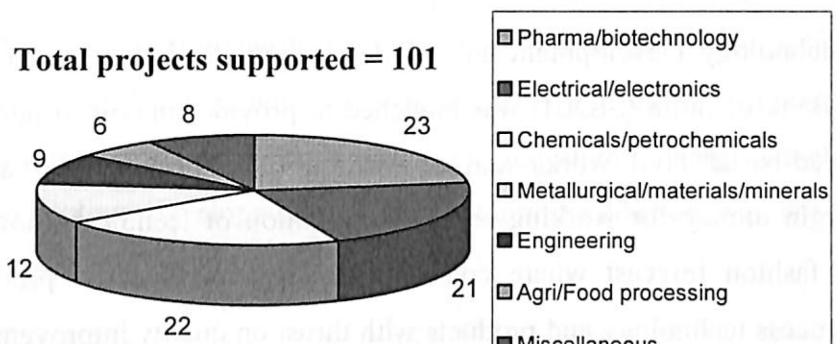

Fig 5.6 Industrial Sectors of Projects supported by ICICI under SPREAD

(Source: Technology Group of ICICI)

Table 5.3 R&D Agencies that partnered more than one SPREAD Project*

Name of the Project Implementing Institute	Number
Bhabha Atomic Research Centre	2
Electronics Research and Development Corporation	3
Indian Institute of Chemical Technology, Hyderabad	7
Indian Institute of Petroleum	4
Indian Institute of Science	8
IIT, Mumbai	8
IIT, Chennai	5
IIT, Delhi	3
National Chemical Laboratory, Pune	11
Regional Research Centres	4
University Institute of Chemical Technology, Mumbai	7

*(*Source: Technology Group of ICICI)*

5.8.3 Industrial Development Bank of India

Technology Financing Scheme of the Industrial Development Bank of India (IDBI) focuses on commercialisation of indigenous technology, adapting imported technology to wider domestic applications and projects envisaging higher than normal risk with potential for commensurate high returns. It prefers financing the technology development at the start-up level and provides the support in the form of equity, conditional and convertible loans (preference share). Its target return for 5-6 years has been 30% on equity investment. IDBI monitors the progress of its supported project by way of follow-up visits, quarterly progress reports, annual reports etc. and imposes legal enforcement like personal guarantee, first charge on assets, pledge of shareholdings of promoters, etc.

5.8.4 Small Industry Development Bank of India

The Technology Development and Modernisation Fund Scheme of Small Industry Development Bank of India (SIDBI) was launched to provide support in purchase of capital equipment, need-based civil works and acquisition of additional land and need based additional margin money for working capital; acquisition of technical know-how, designs, drawings and fashion forecast where considered relevant to specific product group; up-gradation of process technology and products with thrust on quality improvement comparable with acceptable domestic and international standards; improvement in packaging; and cost of Total Quality Management and acquisition of ISO 9000 Series Certification. The existing units in SSI sector which go in for modernisation / technology up-gradation are eligible to be considered under this scheme. They should have been in operation for at least three years. The units should not be in default to institutions / banks in payment of dues. Units graduating out of SSI are also eligible, within the overall ceiling of Rs. 37.5 million for investment in plant & machinery. Assistance under this scheme is given by way of term loan in rupee currency or foreign currency. In select cases SIDBI may consider participating in equity also depending upon the exit route available to SIDBI for disinvestments in due course.

5.9 Summary and Conclusion

The review indicates that since independence, the Government heavily invested on industry as well as S&T and infrastructure almost in parallel, resulting in a) the expansion of industrial sector that heavily depended on imported technologies and equipment, and b) rapid growth of R&D agencies that concentrated mostly on basic research or early parts of applied research. Because of mutual exclusiveness of their interests, the key players, namely, government, R&D agencies (including academia) and industry, worked without any coordination such that the interest of the Government in research was mainly of the strategic or directed type, influenced by premeditated requirements, public health, environmental issues and similar concerns; Industry's interest was mainly applied in nature; and R&D agencies channeled their efforts and resources in unidirectional and fundamental research. According to Rajan [143] the S&T and industry policies in India were not well integrated and resulted in a wide gap between the activities of the R&D agencies and the industries. Kathuria [152] opines that despite the aspiration of developing countries to leapfrog, their science policies often missed a most obvious link, namely the industry-university linkages. Thus the policies in India were not effective enough to bring these key players together. As innovation was not a priority, the R&D funding was limited to the public domain. The Indian industry was well protected, faced no competition and had no incentive to innovate or invest in R&D and this led to weak design and development of new products. But at the same time, India achieved great success in mission-oriented sectors like space and atomic energy which indicates that low levels of technology development and their commercialisation was not due to lack of skills, but due to lack of competition.

With the onset of economic liberalisation the national innovation system in India has changed [200]. The traditional framework of interaction between R&D agencies, industry and governments has undergone a significant change over the past two decades. In particular, knowledge flows from R&D agencies to industry no longer have to pass through the public domain. Similarly, resource flows from the private sector to the R&D agencies are no longer limited to grants, endowments, etc. At the level of national economy, these changes have been mostly dictated by three factors: a) increased speed of the transition to the knowledge-based economy; b) increased globalisation and competition; and c) budgetary constraints faced by governments and their impact on patterns of funding of research as well as the increased cost of research in general.

In July 1991, when India moved to integrate the Indian economy with the global economy, it was believed that integration started and ended with the capital T, as in trade. But unless the other T, as in technology, is emphasised and technology is also integrated, we cannot reach a competitive position [20]. There has been a misperception that with the opening up, there will be an enormous flow of foreign capital and technology. Such a flow of technology has not really taken place in important areas. Indian industry seeking technology is today looked at as a competitor [23]. The industrial sector in India will attain the full vigour of adulthood or will continue to require sustenance from public support systems will depend largely upon the extent, to which it internalises the responsibility for technological or directed type, influenced by premeditated requirements, public health, environmental issues and similar concerns; Industry's interest was mainly applied in nature; and R&D agencies channeled their efforts and resources in unidirectional and fundamental research. According to Rajan [143] the S&T and industry policies in India were not well integrated and resulted in a wide gap between the activities of the R&D agencies and the industries. Kathuria [152] opines that despite the aspiration of developing countries to leapfrog, their science policies often missed a most obvious link, namely the industry-university linkages. Thus the policies in India were not effective enough to bring these key players together. As innovation was not a priority, the R&D funding was limited to the public domain. The Indian industry was well protected, faced no competition and had no incentive to innovate or invest in R&D and this led to weak design and development of new products. But at the same time, India achieved great success in mission-oriented sectors like space and atomic energy which indicates that low levels of technology development and their commercialisation was not due to lack of skills, but due to lack of competition.

With the onset of economic liberalisation the national innovation system in India has changed [200]. The traditional framework of interaction between R&D agencies, industry and governments has undergone a significant change over the past two decades. In particular, knowledge flows from R&D agencies to industry no longer have to pass through the public domain. Similarly, resource flows from the private sector to the R&D agencies are no longer limited to grants, endowments, etc. At the level of national economy, these changes have been mostly dictated by three factors: a) increased speed of the transition to the knowledge-based economy; b) increased globalisation and competition; and c) budgetary constraints faced by governments and their impact on patterns of funding of research as well as the increased cost of research in general.

In July 1991, when India moved to integrate the Indian economy with the global economy, it was believed that integration started and ended with the capital T, as in trade. But unless the other T, as in technology, is emphasised and technology is also integrated, we cannot reach a competitive position [20]. There has been a misperception that with the opening up, there will be an enormous flow of foreign capital and technology. Such a flow of technology has not really taken place in important areas. Indian industry seeking technology is today looked at as a competitor [23]. The industrial sector in India will attain the full vigour of adulthood or will continue to require sustenance from public support systems will depend largely upon the extent, to which it internalises the responsibility for technological development **[201]**. There is an increased need to achieve technological self reliance which would be possible only by integrating all the key players in this area.

The GOI has realised that the S&T strategies need to be suitably moulded to integrate the R&D agency (including academia), the government and industry to meet the growing expectation from S&T to be in the forefront and not be a follower. The objective of raising investment in S&T to 2% of Gross Domestic Production (GDP) by 2007 as declared in the new Science Policy is a step in the right direction. From an all-time low R&D intensity of 0.71% in 1995-96, the increase to 0.87% in 1999-2000 is an indication of the growing importance being accorded to R&D. However, the real fruits of this investment will come only if R&D in India becomes close-ended with more linkages to the end-user. This could be achieved if the untapped potential of R&D agency – industry partnership were more actively harnessed.

Towards achieving this goal a number of initiatives were taken by the government S&T departments and agencies and financial institutions to foster the R&D agency – industry partnerships for transforming knowledge into saleable commodities. This chapter discussed in details such initiatives for promoting the partnerships and financing the R&D activities for their eventual commercialisation. The programmes institutionalised and operated by the government, public and financial institutions enable and support R&D agency – industry partnerships at different stages of technology development cycle, together facilitating the partnerships right from the conceptual stage to commercialisation of the innovation in all the areas of S&T. Some of the notable programmes are NMITLI of CSIR, PATSER of DSIR, HGT of TIFAC and TDB of DST. In addition to these there are the sector-specific programmes such as DPRD and PRDSF of DST that has been successful in establishing alliances of R&D agencies with Indian industries resulting in new development of novel chemical entities, vaccines, assay systems, drug delivery systems. Summary of these initiatives is presented in Table 5.2. At the institutional level the initiatives of IIT's and IISc for supporting partnerships for technology development and transfer are found to be working well and are good example of institutional level mechanisms. **Table 5.4** briefly compares the various mechanisms existing in India for funding technology development and partnerships.

Based on the above review the following observations are made:

Table 5.4 Technology Development Funding Mechanisms

S. No.	Name of Scheme	Stage of Tech. Development	Recipient Category	Quantum of Funding	Type of Funding Assistance
1.	Scientific Ministries/ Departments	-Basic research -Exploratory research -Capability Building	-Govt funded institutes -Institutes of higher learning –Major Universities	US$500-100,000 except for capacity building	100% grant
2.	-TePP, -NRDC's Patent Protection Scheme -Technology Innovation Board	-Idea stage -Patenting stage -Prototyping -Field demo	-Individuals -Start up SSIs -NGOs	Upto $12,000	90% grant 10% by recipient
3.	DPRD, DST	Bench scale	R&D agency jointly with industry partner		70% grant to R&D agency
4.	NMITLI, CSIR	-Basic research -Lab feasibility	R&D agency jointly with industry partner		Soft loan @ 3%
3.	-Scientific / Societal Promotion Ministries / Departments -Tech. Missions	Application oriented R&D for societal needs	-State S&T Councils -Extension Centres -NGO's	Up to $10,000	50% grant
4.	HGT of TIFAC, DST	After lab scale for Pilot Plant / Semi Commercial Plant (Science driven projects)	R&D Institute / University, but jointly with industry partner	$5000 - $350,000	Up to 75% grant to institution & upto 25% @6% interest to industry partner
5.	PATSER, DSIR	For pilot stage only	-Industry having in-house R&D -Industry jointly with institute / university	$10,000 - $1.5 million	Up to 50% grant but royalty to be paid to NRDC
6.	Industry Sponsored Research Programme	Any stage prior to commercialisation	R&D Institute / University	No limit (generally up to $200,000	100% grant but weightage Tax deduction and exclusive rights upto 5 yrs
7.	TDB, DST	Setting up first pilot plant for development and commercialising indigenous tech. or for adapting imported tech.	Any Industry / R&D Institution	No limit (generally $100,000 – 10 million)	Up to 50% of project cost as loan @5% interest, or up to 50% equity to industry and grants to R&D institutions
8.	NRDC Equity / Loan Scheme	For demo / commercial plant	NRDC's Licensee Company only	$20,000-$120,000	Upto 50% equity or equity loan combination
9.	VC Funds of Public Sector Banks	Commercial Plant	Any industry	No specified limit	Equity/loan at 9% interest
10.	Private Sector VCF's jointly by TDB, NRDC, Banks, etc.	Commercial Plant	Any industry	No specified limit	Equity/loan on case to case basis

- Most of the programmes taken up are need based and not out of future long-term strategy. These programmes are distributed across various government agencies, which are meeting a diversity of specific needs. What has been lacking to date is a coordinated effort to forge links between these disparate activities in ways that will deliver enhanced outcomes for innovation.

- A considerable scope still exists to improve the partnership promoting programmes by involving all stakeholders in decision making process and involving R&D agencies with industries more intensely through enhanced funding support mostly in terms of grants in aid, equity participation and zero interest loan.

- There are a number of areas in which barriers to interactions between R&D agencies and industry undermine our innovative capacity. These areas include the links into international S&T networks and investment in R&D; the scale, connectivity and focus of networks in areas of competitive advantage; research commercialisation; and cross-portfolio coordination of programmes. Barriers to research commercialisation are currently the subject of in-depth studies by the CSIR and many other departments under different ministries.

- In the context of the CSIR system the national laboratories, in general, have been found to be associated with the industry to solve their specific problems or provide solutions to fire-fighting situations and not on a long-term strategic relationship. There is a discernable trend towards self-sufficiency resulting from the decreasing government grants. Therefore, in general, the national laboratories are observed to give more emphasis on industry oriented partnership projects rather than the cutting edge research. However, from the Annual Reports of CSIR of last ten years, it is observed that while the total External Cash Flow (ECF) generated is on the rise, the ECF based on partnerships have not increased significantly in the last decade, increasing the gap between the two.

- If the research institutes of R&D agencies continue to focus only on industrial contract research for ECF generation and ignore the cutting edge science, they may have no breakthrough technology of their own in the future. It is a known fact that there can be no high technology without high science. S&T Policies of most of the countries around the globe and mechanisms adopted by the countries studied in this thesis lay emphasis on cutting edge science and increased R&D spending.

The following are the brief recommendations drawn from the above study:

- Awareness should be spread across the R&D agencies and industry as well as industry associations about various programmes being operated by the Government and public sectors supporting research-industry partnerships. These programmes should be linked to achieve enhanced outcomes for innovation.

- The existing partnership facilitating schemes such as HGT and PATSER should be revisited for evaluating their efficacy and introducing necessary modifications. For encouraging higher participation of the industry the schemes should cover the risk and provide equity support rather than loans which industry is required to return even if the technology fails. However, zero interest loans could be provided to industry for upgrading / commercialising the proven concepts / technologies. Grant in aid could also be extended for venturing into futuristic novel areas that could bring visibility to the country.

- Partnership facilitating programmes and VC should extend support to projects with low technology and low market certainty taking high risk. NMITLI is the model programme for this.

- Industry should be involved in technology development process right from the idea stage. NMITLI is one such programme that supports research-industry partnership for technology development right from the idea stage. The programme is industry driven with virtually no financial burden on the industry.

- TTOs as set up by some of the major academic institutions such as IITs and IISC for facilitating forging of alliances with industry for technology development and transfer should be established in every academic institution. The institutions and faculty members should be encouraged to participate in equity with industry.

- Some of the agencies like CSIR and ISRO have taken many initiatives to encourage its scientists and institutions to forge alliances with industry. Similar initiatives should be taken by all the R&D agencies.

- R&D agencies should make business plans in addition to R&D plans and should monitor and periodically review the plans and their implementation. The service rules and regulations of the R&D agencies should be further liberalised for scientists on giving sabbatical leave to work in industry in order to get industry exposure and also earning money from industry.

- Encouragement in the form of fiscal incentives, e.g. 5 year flat tax exemption on the profits generated from the partnership product, should be given to industry particularly to the new technology based spin offs.

5.10 Comparison of Efforts of Select Countries with India for Promoting S&T Particularly Through Partnerships

Table 5.5 presents the specific features of the major initiatives taken up in select developed countries and those with fast emerging economies, including India, for accelerating the innovation and development of technology and its transfer / commercialisation particularly through partnerships between R&D agencies and industry.

It may be noted that almost all the countries have diverse S&T collaborative programmes, whether general or sector-specific, networking the universities, research institutes and industry. As evident, India is quite at par with the developed countries in the variety of schemes / programmes through which the R&D agencies and industries / SMEs are funded by the government and its affiliated bodies at every stage of development. Indian partnership programmes do encourage participation of academic institutions, but with a few exceptions like IITs and IISc, they do not find these programmes relevant to their activities. Thus, there is an obvious serious lack of means in India to bring the academic institutions and industry together. In so far as the S&T Parks are concerned, India is in the right direction and is at par with the developed countries. Such parks have been established in premier institutes of India and many technologies have emerged as a result of the activities in these parks. However, India is relatively weak on clusters, regional technology development, TTOs and Discussion Forum for identifying future areas of importance.

Experiences of the selected countries show that the academic institutions besides their conventional role of capacity building and undertaking R&D activities of academic interest have also started playing significant role in contributing towards the national economic growth. Their new role of cultivating the spirit of entrepreneurship and creating the environment conducive for innovation and technological developments is being recognised and appreciated widely. These institutions have started functioning in entrepreneurial style and utilising their hitherto untapped resources, which include expertise, know how and facilities to the fullest potential. Universities have strong linkages with the corporate world.

The study further reveals that industries in most sectors in the developed countries, and in a few sectors in the developing countries, are matured and are able to take risks in partnership with R&D agencies, more specifically with the universities right from the conceptual stage and fund the entire research programme till its commercialisation, while protecting the IPR's involved. It is also observed that some of the countries such as Japan and China, where the initiative is taken by the government to support the R&D agency – industry partnerships, provide legal framework for enhanced autonomy. While most countries have laws and acts in place to help the researchers and inventors, relevant laws in India have also yet not been enacted that could motivate the researchers to develop commercialisable knowledge and products and at the same time encourage industry personnel and researchers to form linkages with each other to mutual advantage.

In India about 70% of R&D is performed by the central and state governments, an additional 27% by enterprises (both public and private sector industries), and less than 3% by universities and other higher educational institutions. In contrast, in most developed countries, the private sector usually finances at least half of R&D, because it increasingly has the finance, knowledge and personnel needed for technological innovation.

The review further indicates that the technology policies can be effective only when the three major aspects of the policy – technology acquisition, technology generation and technology diffusion are well balanced and are consistent with the industrial policies. Partnering towards keeping R&D costs down and decreasing implementation time frames on new and innovative products / technologies, transfer and utilisation of technology at the earliest should form the basis for adoption to survive competition which is global in nature **[202]**. The review of the experiences of partnership promoting programmes of the developed and devolving countries indicates that the 'best practice' and 'success stories' cannot be simply copied and expected to work. India has to find its own route to improve performance by learning from the experience of others, but being aware that the 'model' has to be adjusted to suit the national culture, conditions and objectives. The problems may be similar, but the solutions need reworking in coherence with the national context.

Table 5.5 Initiatives in Select Countries for enhancing Development, Transfer and Commercialisation of Innovation and Technology

Objective	Means	Country	Initiative	Salient Features
Development, transfer and commer-cialisation of innovation and technology through networking between universities, research institutes and industry	S&T collaborative programmes	USA	CRADA (Coop. R&D Agreement) of NIST, 1980	Speeding up commercialisation of federally developed technologies through resource optimisation, and sharing of technical expertise and IP emerging from the joint effort
			ATP (Advanced Tech. Prog.) of NIST, Early 80's	Cost sharing with industry; Encouraging industry to invest in longer-term, high-risk research with payoffs far beyond private profit; Helping industry to raise competitive potential
		Japan	ERATO, JST, 1981	Bringing together researchers from university, industry and from abroad. A nation-wide prog. Annually funds 4 new res. teams for undertaking exchanges for a 5-year period.
		UK	TCS (Teaching Company Scheme) of DTI, 1975	Facilitate technology transfer; Encourage industrial investment in training and R&D; Provide industry-based training supervised jointly by personnel in science, engineering and technology base and in business; Collaborative R&D projects
			Foresight LINK Awards, 1995	Increased interaction between industry and academia by providing matching funds to consortia of business and the science base for projects under Foresight priorities.
			LINK scheme of DTI	Promote partnership in pre-competitive research between industry and research base to stimulate innovation and wealth creation, develop innovative and commercially successful products, processes and services, and improve quality of life.
			HEIF (Higher Education Innovation Fund), 2000	Give core funding to university for partnering with industry
		Korea	NRP (National R&D Prog.), 1982	Support basic research and venture technology projects and development of core technologies in high-risk fields, such as semiconductors, computers, machinery and fine chemicals for implementation by universities, research institutes and industry
			Industrial Technology Development Prog.	Encourage industries to undertake research in core areas in partnership with R&D agencies by offering support package to cover maximum risk and tax incentive, VC funds in production / marketing stages
			HAN (Highly Adv. National R&D Projects), also 'G-7', 1992	Large-scale projects in 17 strategic fields aimed at turning Korea into one of the top seven technologically advanced countries in partnership of R&D agencies and industry.
		China	Torch (High and Emerging Tech. Industry Dev. Prog.), 1988	Accelerate application of technology in industry and help in commercialisation of new technologies and promotion of economic growth with high-tech products competitive on local and world markets.
			National Prog. for Key Basic Research, 1991.	Conduct high quality research on major scientific problems, train young talents for basic research, and strengthen the build-up of high quality research contingent.
		Brazil	FUNTEC (Fund for Tech. and Scientific Dev), 1964	Support to technological research by National Bank for Economic Development
			SNDCT (National S&T Development System), 1974	Development and management of S&T in the Federal Government by bodies having interface with the generation of knowledge from basic science to its application in industrial production; Tax incentives to R&D agencies and industries; Contract incentives for postgraduate studies and research.

			Prog. under Foundations, viz. José Bonifácio / Coppetec, UFRJ	Initiatives to stimulate stronger links between universities and industries.
		India	HGT (Home Grown Techn. Prog.) of TIFAC, 1993	Knowledge and technology generation through partnerships from laboratory stage to pilot scale or prototype development stage
			PATSER (Prog. Aimed at Technological Self-Reliance) of DSIR	Part financing of industrial technology development projects; Helping industry in developing state-of-the-art technological capabilities
			TDB (Tech. Dev. Board) of DST, 1996	Translating the fruits of indigenous research into commercial products or services by providing equity capital or soft loans
			TePP (Technopreneur Promotion Prog.) of TIFAC and DSIR, 1998-99	Tapping vast innovative potential of the citizens of India; Assistance and coordination required by innovators for commercialisation of products/processes.
			NMITLI (New Millennium Indian Tech. Leadership Initiative) of CSIR, 2000-01	Landmark programme aimed at helping India attain the global technology leadership position in select niche areas in a 'Team India' partnership by synergising the best competencies of publicly funded R&D institutions, academia and industry.
	Sector – specific S&T collaborative programmes	USA	Space Research Partnership Centres, NASA	Network of industry, government and academic partners located at universities or research institutions to benefit space exploration, other NASA missions, and life on Earth.
			PNGV (Partnership for New Generation of Vehicles), 1994	Inventing a prototype 'super-efficient' car by using the assets of national labs to an industry consortium
		Germany	IGF (Prog. for Promotion of Industrial Co-operative R&D)	Support industrial cooperative R&D through sectoral innovation networks between industry and science in a project-specific approach.
		China	National High Technology ("863") prog., 1986	Monitor emerging foreign technologies with interest in commercialising high technologies and outside S&T achievements in bio, engineering, space, IT, laser technology, automation, energy and new technology.
		Brazil	METAS project of EMBRAPA, 1993	Achieve modern technologies, products and services at lower costs and contributing to reduce the impact of agriculture on the environment by using systems approach in R&D
		India	New Drug Dev. Prog. of CSIR, 1997	Pooling and networking of existing resources of CSIR institutes to coordinate drug development and commercialisation.
			Core Group on Automotive R&D of DST, 2003 - 2004	Establish supporting infrastructure to validate vehicle developments; Encourage Indian Original Equipment Manufacturers (OEMs) to set up houses abroad to derive the location efficiencies; Develop component industry to provide full system solutions to OEMs.
			DPRP (Drugs & Pharma Res Prog.) of DST, 1994-95	Enhancing capabilities of institutions and the Indian drugs & pharmaceuticals Industry towards joint development of new drugs in all systems of medicine.

			PRDSF (Pharma R&D Support Fund), DST, 2004-05	Support drugs and pharmaceuticals research programme of industry by extending soft loans at bench level feasibility stage of the research projects.
	Centres to promote joint research activities	USA	ERC (Engineering Research Center) of NSF, 1985	Interdisciplinary centres providing intellectual foundation for industry to collaborate with universities on resolving generic, long-range challenges and producing knowledge base for steady advances in technology / speedy transition to marketplace; Interface between discovery-driven culture of science and innovation-driven culture of engineering.
			STC (S&T Centre) of NSF, 1987	Fund important basic research and education activities and encourage technology transfer and innovative approaches to interdisciplinary problems
		Japan	Joint Research Centres in Universities	Implement joint projects to achieve progress towards innovation through strengthening Japan's industrial competitiveness.
		UK	Faraday Partnerships of DTI, 1997	Establishment of Faraday Partnership Centres in specific areas to encourage greater interaction between university and industry, especially SMEs.
		India	ARCI (Int. Adv. Res. Ctr. for Powder Meta-llurgy & New Materials), 1989	Technology development and transfer centre for translating research to technology; joint development of technologies from CIS countries for bringing them to the levels of pilot plants/demonstration centres
	Thematic consortia	USA	SEMATECH Consortium of semiconductor manufacturers, 1987	Catalyst for accelerating the commercialisation of technology innovations into manufacturing solutions for creating opportunities for flexible collaboration and conducting strategic R&D to reduce the time from innovation to manufacturing
			Blue Laser Consortium of DARPA	Joint hunt for a blue solid-state laser for expanding electronic information storage capacity and reducing cost.
		India	BCIL (Biotech Consortium India Ltd.), 1990	Promoted by financial institutions for promotion, transfer and commercialisation of biotechnologies
	Science / Technology Parks and Business Incubators	All selected countries	S&T Parks, Innovation Centres etc	USA, Germany, Japan, US, Korea, China and Brazil have setup S&T parks, innovation centre, incubators etc. Details are given in **Table 5.6**
		India	STEP (S&T Entrepreneur-ship Parks), 1985	Established in and around academic and R&D institutions to provide mechanism for transfer of technology from R&D agency to industry to reduce the lead-time between invention, product development and its commercial application to improve competitiveness of industry
			Biotechnology Parks	In 8 such Parks the States attract entrepreneurs to set up their units and leverage on the vast talent pool and rich biodiversities in the respective states.
			Software parks	18 such Parks provide excellent Infrastructure and support aimed at furthering growth of Information Technology
			TBI (Technology Business Incubators)	16 TBIs nurture development of technology based and knowledge driven industries during the start up period by providing integrated package of workspace, office services, access to specialised equipment and value added services.
	Linking education with industrial	UK	Learndirect programme ('University for Industry')	New system of foundation degrees to provide course material to industry by local associations of colleges, universities, local authorities, trade unions, companies and business organisations for closer relationship of educational system with industry.

	needs		CASE (Collab. Awards in Sc. & Engg) of SERC	Joint projects by institutions and industry for carrying out industry relevant research by post-graduate / Ph.D. students with grants from SERC and also from an industrial partner
		India	REACH (Relevance and Excellence in Achieving New Heights in Educ. Insts) of TIFAC, 2003	Joint designing by academia-industry of the curricula in line with the business and market requirements; Providing training and exposure
	Encourage-ment for joint endeavours	India	Awards of DSIR / TDB, DST and fiscal incentives to R&D agencies and industry	Cash awards for developing technologies, absorbing / up-scaling technology developed by R&D agencies or indigenising imported technologies for commercialisation.
To promote technology development and transfer in specific regions	Setting up of thematic centres	USA	MEP (Manufac-turing Extension Partnership), Mid 80's	Network of resources transforming manufacturers to compete globally, supporting greater supply chain integration, and providing access to technology for improved productivity.
		Germany	Innovation Centres, 1983	Independent entity to provide technical support to tech-oriented start-ups and infrastructure for industry; Promote co-operation between science & economy; Promote regional development potentials for technology oriented enterprises and start-ups; Start technology park projects and technological cooperation; Support regional economic development
		Korea	RRC (Regional Res. Centres)	consortia for research associated with regional development involving local industries, universities and research institutes
	Collaborative Programmes	Germany	InnoRegio and Innovative Regional Growth Cores prog. of BMBF	Promote innovation in east German states by supporting joint projects between SMEs and research institutions
	Cluster Development	USA	Clusters-regional innovation hub of	Produce high-value products and services that support high-wage jobs. Popular examples are Silicon Valley and Route 128.
		Japan	'CREATE : Centre of Excel. in each region' of JST, 1996	Builds on local strengths by networking key players to contribute to the total strength of the nation
			Cluster Programmes of MEXT / METI	Clusters selected through open competition with focus on IT, life sciences, and nanotechnology to promote partnership among R&D agencies and industry;
			Technopolis Plan of MITI	Agglomeration with involvement of local / prefectural govts to support S&T in regional economic development policies
		UK	Cluster Programmes	Innovation thorugh cluster development in the regions to provide successful and innovative products and services.
		Korea	Innovation Clusters, 1990	Regional research network to promote vertical and horizontal integration of industry from R&D to production
	Rural Programme	China	Spark Prog., 1985	Enhance S&T development and propagate R&D discoveries to rural areas.
Mechanisms for promotion of transfer of technologies	Technology Transfer Agencies at national and agency levels	USA	TLO's in universities, 80's	Universities established TLO's after getting the ownership and the right to patent and commercialise the research output under federally funded research for liasing with industry
		Germany	Steinbeis Foundation, 1971	Provides interface between academic researchers and industry by bridging between academia, research bodies, politics and industry.

			Universities Independent legal external entity for TT	Established to gain administrative flexibility, as the public law imposes some restrictions on technology transfer from universities
		Japan	IPHQ and TLO	Licensing of technology developed in universities
		UK	TLO's in universities, 80's	Universities established TLO's as interface between academic researchers and industry for commercialising the res. output
		India	NRDC (National Res. Dev. Corpn), 1953	Exploit indigenous know-how; Act as a link between national research agencies and entrepreneurs for technology transfer; Financial for putting up pilot plant, prototype development and establishment of demonstration units
			Tech. Transfer and Industry Liaison Gps. of DOS, CSIR insts and some acad. insts like IITs, IISC	Liasing between organisation and industry; Facilitating technology transfer activities and encourage spirit of entrepreneurship of the faculty and graduating students; Negotiating and assisting in transfer agreements; Technical consultancy backup to licensee after know-how transfer, etc.;
	Human Resource Development for effective TT	India	SEETOT (Scheme to Enhance the Efficacy of TT) of DSIR	Supports training programmes involving technology developer, facilitator, users and others, aimed at developing human resource for an effective technology transfer process.
Major National Policy Initiatives bringing all stakeholders together	Discussion Forum	USA	Govt. – Univ.-Industry Res. Roundtable,1984	Incubate activities of on-going value to the universities, research institutes and industry
		Germany	FUTUR and German Res. Dialogue, 2001	Identifying future-related topics of societal relevance needing solution through research; Developing lead visions for research policy
		UK	Foresight Programme of OST, 1993	Build bridges between business, science and government; Bring together knowledge and expertise of people across all areas and activities to increase national wealth and life quality.
Promotion of entrepreneur-ship among scientists in research agencies		Germany	EXIST Campaign of BMBF, 1998	Support university-based researchers willing to start their own spin-off companies through training and advice
		India	EDP (Entrepreneurship Development Programme) of NSTEDB	Establishing Entrepreneurship Development Cells as an institutional mechanism to provide various services to budding S&T entrepreneurs; foster linkages between parent institution, industries and R&D agencies; promote development of S&T based enterprises and employment opportunities
Promotion of industry, including SMEs for technology development and transfer	Financial Incentives for partnership with R&D agencies	USA	STTR (Small Business TT Programme), 1982	Provides JV opportunities for SMEs and premier research institutions; Fosters innovation to meet the S&T challenges in the 21st century. Specific percentage of federal R&D funding is reserved for award to SMEs and research institution partners.
		Germany	PRO INNO (Programme Innovation Competence for SMEs), 1999	Supporting R&D activities of SMEs by promoting national and international research partnerships between SMEs and other SMEs / research institutions
	Encourage-ment though funding support	USA	SBIR (Small Business Innovation Res. Programme)	Encourages SMEs to explore their technological potential and commercialising it by providing funding support.

		Germany	High-Tech Master Plan for SMEs	Establishing new joint VC fund to invest for early-stage and growth companies together with private investors; Tax Incentive; Direct public funding of business R&D
		China	National S&T Achievement Dissemination Prog., 1990	Achieve higher economic returns with less investment, short investment cycle and spin-off effect. Government provides start-up money; enterprises and the public raise loans, investments and funds. Projects entitled to preferential treatment during implementation.
		Brazil	FNDCT (National S&T Dev. Fund) of FINEP, 1969	Creating new ways to support Brazilian industries
		India	In-house R&D Ctrs Recog. Scheme of DSIR, 1973	Recognition to in-house R&D units in industry which makes them avail tax incentives and other benefits
Significant legal measures for promoting Partnerships	Laws and Acts	USA	Stevenson-Wydler Technology Innovation Act (Public Law 96-480), 1980	Established the foundation for technology transfer within the Federal government for enhanced information dissemination from the Federal government to private industry. It made easier for labs to transfer their technologies and provided means for others to access lab developments.
			Bayh-Dole Act (Public Law 96-517), 1980	Enabled researchers to retain patent for federally funded research and facilitate technology transfer resulting in increased commercialisation
			Federal Technology Transfer Act (Public Law 99-502), 1986	Amendment of Stevenson-Wydler Act with changes having impact on TT process such as an inventor from government owned and operated labs receives minimum 15% share of royalties generated through patenting or licensing. The Act established Federal Laboratory Consortium for TT.
			Executive Order 12591 facilitating access to S&T, 1987	Assuring the government owned government operated labs to enter into cooperative R&D agreements with other Federal Labs, state and local governments, universities and private sector with Federal labs having to apprise these parties about their TT opportunities.
		Germany	Employee Inventions Act amended in 2002.	Ensures rapid translation of ideas from higher educational institutes into new products giving right to these institutions to claim the inventions of all their employees and get them patented and commercialized through their patent and commercialization agencies.
		Japan	Law for the Orientation of S&T, 1996	Making 5 year Basic Plans for S&T to achieve higher standard of S&T by bringing flexibility and competitiveness in the R&D system
			Law of Tech. Licensing / Management Office, 1998	Promote transfer of technologies from university to industry by masterminding joint research projects, monitoring IPR and incubating start-ups.
			Japanese "Bayh Dole", 1999	Authorise government agencies to let R&D contractors patent government-funded inventions.
			Basic Law on Intellectual Property, 2003	Launched programme for creating, protecting and utilising IP in S&T with areas such as regenerative medicine, new plant varieties, computer software, design models and brand names.
			Amended Japanese "Bayh Dole", 2004	Grant control to national universities over IP resulting from the work of faculty and students. Licensees are obligated to manufacture in Japan.

		Korea	Machinery Industry Law, 1956	Promote experimental research, initial production and industrial rationalisation of machine tools
			Electronics Industry Law, 1957	Promote experimental research, initial production and industrial rationalisation of electronic technologies
			Industrial Tech. Development Law, 1967	Encourage SMEs to set up in house R&D units through tax privileges and financial supports
			S&T Framework Law, 2001	Provide institutional framework to govern all rules and regulations on S, T and innovation
		Brazil	Macro-Economic Stabilisation Policy, end '93	Increased pressure on industries to become more competitive; extinguished possibility of idiosyncratic technological behaviour, and created conditions for industries to adopt a longer-term view on corporate strategy.
			Policy for Industry, Tech. and Foreign Trade, 2004	Defined health inputs (specifically medicines) as priority for both industrial development and spawning innovations through partnerships between research institutions and industries
	Patent facilitating body	India	PFC (Patent Facilitating Centre) of DST, 1995	Single window facility providing patent facilities to scientists and technologists for Indian and foreign patents on sustained basis

Table 5.6 Science, Technology, Industry and Entrepreneurship Parks, and Innovation Centres in Select Countries

Number of Science, Technology, Industry Parks and Innovation Centres								Affiliation
USA	Germany	Japan	UK	Korea	China	Brazil	India	
35	-	3	1	-	-	1	-	AURP
5	5	2	13	5	17	8	4	IASP
-	-	-	12	-	-	-	-	UKSPA
442	1	3	1	-	1	1	3	ASTC
-	-	-	-	-	-	-	17	STEP
-	BT Parks-9 Innov. Centres-400	-	-	Tech.Parks-15 Reg Tech Innov. Centers-39	S.T.Ind. Park -52 Innov. Centre-31 (ATIP Listing)	Software Parks Incubator Park (APROTEC)	BT Park - 8 S/W Tech Parks - 18	Others

*(*Different Sources)*

Chapter 6

Case Studies on Development, Transfer and Commercialisation of Technology through Partnerships

The review of partnerships in previous chapters has provided an understanding of the status, trends and general features of initiatives promoting partnerships in India, select developed countries and countries with growing economies. This chapter looks into initiation, formulation and implementation of partnerships in selected collaborative projects of R&D agencies with industry in India and draws lessons in strengthening such partnerships on the basis of micro level experience. The case studies have been selected mainly keeping in view the building of partnerships leading to successful development, transfer and commercialisation of technology or those, which have not been so successful or are in the process of building linkages aimed at commercialisation.

6.1 Introduction

The success of the technology development and its transfer aimed at eventual commercialisation depends on various factors including the roles of technology provider, technology taker, intermediary agency and the manner in which the partners join hands to build partnerships. There are various concepts in vogue that are practiced in implementation of partnership programmes. Some of these are a) lap race concept wherein equipment or technology (low end) development and transfer involves R&D agency, industry and intermediary / promotional agency; b) mother licensee concept wherein the promoter setting up the first project based on the invention becomes the mother licensee; c) high technology, multi-ownership concept; d) concept based on societal needs; e) concept driven through Government legislation; f) disruptive technology concept – which has very long gestation period, requires larger funds through VC and a very large number of partnerships. The partnerships my be formalised through formal or informal arrangements such as collaborative projects, contracting or sponsoring research, consultancy, turn-key projects, or exchange of information / personnel or sharing of facilities.

For the purpose of the present study, the partnership projects were selected in a manner that these reflected different facets of partnerships and experience of stakeholders. In all fifteen cases have been considered for detailed analysis. As the CSIR is a major government R&D agency with vast experience of collaborative projects with industry, twelve partnership projects were selected from CSIR institutions, Nine of these projects were implemented by one industry and one CSIR lab, one project involved partnership with German R&D institute and industry besides partnering with Indian industry, one involved partners from more than one CSIR lab, universities and industry; and one involved participation from institutions other than CSIR. Three projects of non-CSIR institutions viz, ISRO, IPRI, CTCRI, CPRI were selected. Out of the fifteen selected projects seven projects involved participation of intermediary agencies such as NRDC and TIFAC. The projects were so selected that they a) represented different S&T disciplines, b) involved the interface agencies to know the view of the partners on their schemes, c) involved a number of partners to understand various nuances of partnership implementation and d) had influence of the government policies. These case studies and their salient features are described below.

6.2 Case Study - 1: Commercialisation of Palm Oil Technology:

The agro-food processing area involves multiple partners for successful commercialisation of a technology. These partners generally have diverse backgrounds, for example, the farmers are mostly uneducated; the government is bureaucratic, rule and procedure oriented; industry is reluctant to locate itself in rural areas; NGOs are financially weak and often politician dominated; and scientists in R&D agencies lack knowledge of societal issues. Some other problems in commercialisation of technology include non-availability of raw materials on sustained basis throughout the year; long gestation period of several years for successful commercialisation; and many risk factors such as the crops or the raw material collection system can fail; the trained workers sent away in off-season may not return; mass anti-project movements may arise due to misconceptions, religious feelings, ignorance, etc.

The commercialisation of the palm oil technology is an example of a simple know-how involving the technology developers, technology takers and the intermediaries. It is well known that the yield of palm oil per hectare as compared to other oils such as groundnut, coconut, mustard etc. is the highest and this is more particularly so in the tropical-cum-coastal areas as may be seen from **Fig. 6.1**.

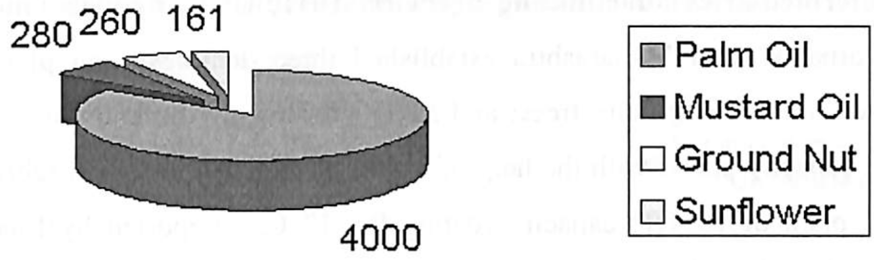

Fig. 6.1 Yield per Hectare of Various Oils

The Palm Oil was not grown in India till recently as the technology of extracting Palm Oil from the bunches of fresh fruits was complex, and was available only internationally. This technology needed minimum plantation size of capacity 50 T/H which required a 10,000 Hectares (approx.) palm tree plantation to feed the plant. Malaysia, the largest producer of Palm Oil in the world has many such large plantations. But due to the Indian social structure where the farm holdings are 0.5 to 5 Hectares, large plantations could not suddenly come up. Thus, on the one hand, the small farmers would not plant the tree unless they were assured that a palm oil processing plant nearby would buy the fruits. The oil in the fruit would become rancid if it was not processed within 24 hours, which necessitated the need of the processing plant near the plantation sites. On the other hand, the industry would not set up such plants until it was assured of adequate quantity of raw materials. It is to be observed that the first fruition of palm fruits takes place after 3-4 years. Realising these limitation, the government intervened in a very pro-active manner to make the palm oil production a commercial reality in the country. The significant step was taken by launching the National Oil Seeds Mission Programme that provided linkages amongst several players as listed below for successful development and commercialisation of the palm oil technology.

- **Technology developers:** Central Plantation Crops Research Institute, Palode, Kerala under the Indian Council for Agricultural Research for developing the crop variety; Regional Research Laboratory, Thiruvananthapuram (RRL-T) for process development; Central Mechanical Engineering Research Institute (CMERI), Durgapur for developing the Expeller; and Mechanical Engineering Research & Development Organisation (MERDO), Ludhiana for developing Twin Screw Press.

- **Technology takers:** Industry, namely, Andhra Pradesh Oil Federation, Pedavegi o **Intermediaries / facilitating agencies:** DBT, GOI in collaboration with Andhra Pradesh, Karnataka and Maharashtra established three demonstration plantations of 1000 hectares each for growing palm trees; and NRDC to upscale the know-how further to 5, 10 and 20 T/H capacity plants with the help of engineering consultants and fabricators. The first commercial plant of 10 T/H capacity costing Rs. 12 Cr. supported by financial assistance from TDB (Rs. 340 lakhs), Oil Missions (Rs. 100 lakhs) and National Cooperative Development Corporation (Rs. 820 lakhs), totalling Rs.1260 lakhs.

Building partnerships: The mission concept provided an apex level coordination between technology developers, technology takers and intermediaries. The mission brought together these key players to develop and set up a small sized plant of 2.5 T/H capacity as a demonstration unit. It is evident from this example that the success of this simple rural technology was the parallel partnership between the R&D institutions, promotional agency, manufacturing company. The linkages were developed based on the 'lap race concept' wherein the equipment or technology development and transfer involved R&D agencies, manufacturing company; promotional agency and marketing forces. Even with the involvement of all these agencies, the growth of palm tree plantations and the establishment of palm oil processing units has been a difficult task, which would take years to fructify to a stage of commercialisation where the market forces would play an important role.

6.3 Case Study – 2: Production and Commercialisation of Zeolite 'A' Intermediate for Detergent

This is an example of high-technology multi-ownership concept, in which a technology process for 'Zeolite 'A' - Intermediate for Environment friendly Detergent' was developed by Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar. The parameters of product quality of the detergent based on alumina developed by CSMCRI are indicated in **Table 6.1**. The product already existed in the Indian as well as foreign market which was being manufactured by large multi-national companies. The new technology process developed by CSMCRI required IPR protection, for which necessary process patents were obtained. The production based on this new process required project investment of the order of above US$10 million. There was a need to have an intermediate pilot plant and design and engineering consultants, which essentially meant a multi-partnership programme for successful commercialisation.

Table 6.1 Product Quality Parameters of Detergent

PARAMETERS	VALUE
Calcium binding capacity mg CaO / gm of dry Zeolite	Minimum 160
Particle size analysis	Not more than 4μ Average particle size d50
PH (5% Slurry)	11 ± 0.5
Mole composition (Based on chemical analysis)	1.0 ± 0.2 Na_2O 2.0 Al_2O_3 ± 0.5 SiO_2 6.0 (max.) H_2O
Bulk Density gm/cc	0.45 ± 0.1`
Crystallinity (X-Ray diffractions as compared with 4A BDH powder)	Minimum 90%
Whiteness Index	Minimum 95%

CSMCRI shook hand with NRDC for licensing the technology to an appropriate industry. The latter approached the alumina manufacturing companies in India. Although this was a unique technology but there were initially no takers. This was so because the process technology required a very long time for getting commercialised, popularised and required an investment of ~ Rs. 30 Cr. for setting up a 10,000 tonnes/annum plant. On pursuance of NRDC, the National Aluminium Company (NALCO) having good understanding with NRDC got convinced with the proposal but demanded that this technology should first be proven by setting the pilot plant of 500 kg capacity, conducting the feasibility report and validating the results. Accordingly, a pilot plant of 75 Kg/batch capacity was set up. Five trial runs, each running for seven days for producing 500 Kg/batch, were carried out to validate product quality parameters in CSMCRI and independent labs; five trial runs were carried out to study the boundary process conditions; and ten trial runs were carried out for use of Zeolite 'A' for production of detergent material in existing manufacturers plant. 2000 Kg. of Zeolite 'A' based detergent material was used for field trials on controlled group.

CSMCRI and NRDC involved a consultant from Engineers India Ltd (EIL) for setting up the pilot plant right from the beginning for preparing the feasibility report, conducting international survey etc. EIL, NRDC and CSMCRI jointly took up this project at a cost of ~Rs. 30-40 lakhs for running 20 trials. NALCO wanted to have a guarantee, so (a) the process guarantee was given by CSMCRI, (b) design guarantee by EIL, and (c) quality guarantee by NRDC. The comprehensive process and product quality performance guarantee was provided by EIL & NRDC. With this NALCO got satisfied and was ready to take this technology. The negotiation started for licensing of this technology to NALCO at a price of Rs. 1.35 Cr. The license fee was equally shared between CSMCRI, NRDC and EIL.

In order to transfer the technology abroad it was required to obtain the patent. The four parties, viz. CSMCRI, NRDC, EIL and NALCO, jointly shared the expenditure on equal basis for obtaining the patent. Two patents have since been filed in India. The international patent search was carried out and the patents were filed in all major Aluminium producing countries. The process licensing fees to future licensees both in India and abroad would be shared equally between NRDC, CSMCRI, EIL AND NALCO. New Patents, if any, would be jointly owned by NALCO and NRDC. Currently, the four partners are making efforts to transfer the technology to China.

Building Partnership: The success of this technology process depended largely on the role and initiatives of the intermediary, namely, NRDC. With its broad based experience in transfer and commercialisation of technology, its credibility and networking with R&D agencies, engineering consultants and industry provided the key to building partnerships. Since the process involved a high technology and no company was readily forthcoming to commercialise it, the role played by NRDC in persuading NALCO, a large manufacturing company, and building its confidence by fulfilling all its conditions, was also significant. An important conclusion from this case study is the observation that as the technology matured, the number of partners too increased.

6.4 Case Study – 3: Commercialisation of Rice Husk Particle Board:

This case study involved the technology for producing rice husk boards (RHB) developed by the Indian Plywood Research Institute (IPRI). IPRI approached NRDC for the transfer of this technology. IPRI had obtained Indian patent rights and assigned the rights to NRDC. This was necessary as NRDC takes up only those projects for which patent rights are assigned to it. This facilitates the task of NRDC in searching for technology taker. This was a new agro-waste product in the world and hence the IPR strategy was very crucial for success of this technology. NRDC licensed patents and know-how to Padmavati Panel Boards Ltd (PPBL), a newborn industry and designated PPBL as 'mother licensee'. In the 'mother licensee concept' the industry setting up the first project based on the invention holds the rights to further transfer the technology to other manufacturers and shares the benefits by subsequent licensing.

NRDC invested 50% equity in PPBL to facilitate up-scaling and also arranged Rs. 40 lakhs loan from VCF-IDBI. PPBL set up a technology plant at the cost of Rs.1.2 Cr. A consultant was also hired at a cost of Rs. 3 lakhs. PPBL carried out the up-scaling of the process; improved the product through incremental innovation, further developed 5 new RHB based products, viz. wood veneer laminated RHB, bamboo mat veneer laminated RHB, jute laminated RHB, paper laminated RHB and composite RHB using coconut leaf stems; increased the range of products to cover different sizes and different types (tops covered with bamboo etc.) for better acceptability; provided proven plant scale technology to subsequent licensees; and provided training to personnel of subsequent licensees in its plant. The market feedback was sought through test marketing after the commercialisation of the husk board based products. New 'add-on' patents were filed by NRDC in India and ten other rice producing countries jointly with PPBL. New technologies covering the above RHB based products were licensed to five more Indian companies. At this stage, there were three partners of this technology, namely, IPRI, NRDC & PPBL. PPBL as mother licensee had 50 % of technology share and shares revenues earned from licensing the technology to the subsequent licensees.

NRDC later licensed this technology to a Malaysian client, MHES, which paid a lump sum premium of US$50,000 and royalty of 2.5% on sales for 10 years. The MHES plant was set up by NRDC using PPBL as the turnkey sub-conductor (plant-to-plant technology transfer). MHES also made incremental innovation by developing coloured RHB. New joint patents have been filed by NRDC and MHES. MHES has also become a partner in technology making a total of 4 parties as partners in this technology.

Now the patents have been licensed to an Indonesian company on the following terms:

- 1st Plant: US$90,000 (net of taxes)
- 2nd Plant: US$60,000 (net of taxes)
- 3rd Plant: US$50,000 (net of taxes)
- Royalties: 2.5% on sales for first 3 years; 2% for next 4 years and 1.75% for next 3 years, subject to minimum royalty of US$ 20,000 per year for plant.
- Period of Licensing: 10 years, exclusive for manufacture in Indonesia subject to 3 plants being set up in a specific time frame and exclusive for sale in Indonesia but existing licensee's permitted, and non-exclusive for sale to other countries (except in India and Malaysia where no sales are permitted)

NRDC is currently negotiating with other parties in USA, Vietnam, Mexico, etc.

Building Partnership: In this case study, NRDC used the IPR protection strategy for the technology in building linkages, firstly by identifying an industry from India who would commercialise the technology and assume a role of a mother licensee for subsequent transfer of this technology to other entrepreneurs in India and abroad. For subsequent developments in technology, the patents were obtained and the technology was jointly owned by IPRI, NRDC and PPBL. This strategy further helped in its transfer to companies abroad. The role of NRDC as an intermediary was significant as it also evolved a balanced approach for distribution of the royalties between technology developer, technology taker and the intermediary.

6.5 Case Study - 4: Development of Clot-Busters (Thrombolytics)

The development of novel drug molecules especially in the area of biotechnology is a highly challenging proposition. In India, the endeavour to develop biotech drug molecules began in the pre-globalisation era. The initial focus was on the development of the 'copy cat' technologies. However, it was soon realised that considerable value addition was needed to face the challenge posed by the emerging globalisation and competition. In pharmaceutical production and drug development, the adoption of the new patents regime under the General Agreement on Tariffs and Trade (GATT) / WTO required that survival, especially after 2005, entailed the development of competitive technologies and/or new drug molecules. The case study presented here highlights R&D efforts of the Institute of Microbial Technology (IMT), which has successfully generated a basket of innovative and competitive technologies, some of which are already commercialised. The experience demonstrates the advantages of continuous knowledge networking and ability to achieve significant 'value addition' in a concerted and systematic manner.

Since its inception in the eighties IMT while selecting the R&D programmes was also developing strategies for exploring the potential of recombinant DNA based biotechnology to produce hitherto unobtainable bio-products ranging from growth hormones, clot buster protein drugs as well as myriad therapeutic agents. In view of the cardio-vascular diseases emerging as one of the main health threats in developing countries like India, IMT in late eighties decided to concentrate on clot buster drugs, which are the clot-dissolving and life-saver protein drugs, used for the treatment of various cardiac diseases such as heart attack, strokes etc. The fact that the technology for developing the clot buster was not available in

India and hence it was being imported and as use of the clot-buster drugs such as Tissue Pasminogen Activator (TPA), Urokinase (UK) and Streptokinase (SK) have potential to save upto 30-40% of lives if given at very early stages, emphasised the need to develop new generation clot buster drugs that (a) could be made available at affordable prices and (b) have no side-effects associated with ‘old generation’ clot busters. Therefore, IMT constituted a team to develop facile process know-how for the production of TPA and UK.

In regard to TPA, IMT, to begin with, initiated the research programme to straightaway develop a process technology for the production of TPA through either classical tissue culture route or the recombinant DNA route. This resulted in filing of a patent in India; however, the patented process could not be converted into know-how. One of the major difficulties encountered was that these approaches required the development of state-of-the art animal cell culture facilities that required very large resources and were vulnerable to microbiological contamination. In addition the cloning and appropriately expressing a large, complex gene such as that of TPA presented several challenges before the advent of the PCR technology. This experience of failure nevertheless gave scientists and management a perspective of technology development. The scientists understood that TPA perhaps needed a cutting edge scientific preparedness, which the Institute at that point of time was barely beginning to build. This was the beginning of a learning process which continued thereafter in developing the know-how for other clot buster drugs, viz. urokinase and streptokinase.

For UK, another clot buster drug, it was therefore decided to pursue 'simpler' technological know-how route commensurate with local limitations. A process for the preparation of UK from human urine was initiated, followed by pilot scale production of crude UK, standardisation and transfer to three industrial clients, namely UNICHEM Laboratories, Finowel Enzymes and Cadila Pharmaceuticals Ltd. The know-how transferred was at the 200-ltr scale. However, none of the licensees could put the product into the market due to the logistical difficulties in obtaining the large quantities of starting material (human urine) and the know-how could not be commercialised. IMT learned another lesson and understood that it is not only the science and technology but also the cultural, societal and other angles that one has to keep in mind while developing a marketable technology. However, these disciplines proved crucial later on to successful development of highly competitive processes for the 'old' clot busters like streptokinase (SK), but also yielded altogether new derivatives of the molecule with dramatically improved functional properties.

Even though the technologies of TPA and UK did not take off successfully, the management had conviction that efforts should be continued to develop transferable and commercialisable technology for the clot buster drug. By this time IMT had covered mass of qualitative trained manpower in the highly specialised area of biotechnology as well as procured world-class facilities for upstream as well as downstream processing of proteins. Therefore IMT focused its R&D efforts on streptokinase (SK), which was being used worldwide since the 1970's but was very costly in the Indian market after import from the West. The recombinant DNA (rDNA) route was adopted for SK production since it was potentially capable of generating large amounts of the product in relatively small volumes of fermentation.

This was the time when M/s Godrej Soaps Ltd. decided to make a foray into this area for developing know-how for the production of streptokinase for the first time in the country. M/s Godrej Soaps Ltd approached IMT for the technology for SK. Two years of sustained R&D efforts by the team resulted in the generation of basic know-how for a preliminary DNA based technological package for upstream and downstream processing of the desired product. This emboldened the scientists to carry out toxicology and other pre-clinical studies to obtain regulatory approval prior to commercial launch. Around this time, when the activity was starting and entering its most critical and final phase, Godrej Biotech folded up since the parent company decided that biotechnology could not be a part of their core competency. Fortunately the leadership defended the programme which otherwise would have suffered tremendously due to withdrawal of support from a commercial sponsor. The IMT management rather supported the team and the activity for exploring the possibility of developing not only first-generation rSK, but also its second and third generation improved derivatives with enhanced therapeutic applicability through protein engineering efforts. The management felt that it would provide a technological advantage so that new generation clot buster drugs, competitive internationally, could be designed and produced. This not only boosted the morale and scientific enthusiasm but also led to understanding the fundamental aspects of the mechanism of action of SK, which resulted in the design of new derivatives.

However, after a spurt of rapid initial successes in the rSK front wherein cloning of the gene was accomplished; the work faced difficulties due to partial degradation of the end product during its excretion from the producer bacterium into the fermentation medium. This difficulty was overcome by developing an efficient process for the production of pharmaceutical-grade SK from its natural source by fermentation. This route solved the 'degradation' problem. This partial success led to a revisit of the strategies, and brought fresh thinking, both scientific as well as 'business-strategic' clot buster technology endeavour.

IMT realised that it needed a multi-prolonged and multidisciplinary approach at this stage to be able to generate the new IPR on a modified and improved clot buster. While IMT relentlessly continued to work towards development of classical streptokinase production technology by both the 'natural' fermentation route and by employing rDNA approach, it pursued the fundamental research component geared explicitly to understand how the SK molecule worked at the molecular level, the research necessary for insights into the designing of second-generation SK derivatives with unmistakable value addition as deliverables at the end of the project. The research team was expanded by bringing in other expertise in the subject areas. These subject areas included disciplines such as protein chemistry, crystallography, protein engineering etc. which were earlier not considered as necessary components of a new drug discovery/improvement program in a normal or conventional setting till that time. The overall diversity of the expanded team led to rapid breakthroughs at both technical as well as intellectual levels, and impressive results were obtained regarding the molecular mechanism of plasminogen activation by SK.

Thus in a period of approximately three years (1995-98) the team not only published details of the mechanism of interaction of SK with its target blood protein plasminogen, but also gave rationale for the design and production of entirely novel protein engineered forms of streptokinase that are much more target specific in their mode of action, and potentially of significant clinical advantage. An initiative could go on to explore the possibility of developing technology for natural SK (i.e. not recombinant) from its native source, a bacterium that causes sore throat *(Streptococcus species)*. Both the strain development as well as fermentation and purification work to obtain drug of pharmacological quality were carried out successfully on a high-priority basis. It was felt that by developing the natural drug first, many of the 'pipeline' delays associated with obtaining regulatory approval for the recombinant version of the drug would be appreciably minimised. Hence the technology for natural streptokinase would attract an industrial sponsor more easily than for recombinant SK. Indeed, this effort became a strategic decision that turned out to be critical in making the product (natural SK) reach the market in a much shorter duration and transforming it into a commercial success at a time when demand for this drug is rapidly on the rise.

In addition to the technological exploitation of natural streptokinase, the R&D effort 'degradation' problem. This partial success led to a revisit of the strategies, and brought fresh thinking, both scientific as well as 'business-strategic' clot buster technology endeavour.

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In addition to the technological exploitation of natural streptokinase, the R&D effort has led to the generation of technology for recombinant SK (rSK) as well as novel protein engineered forms with improved therapeutic/clinical properties. While the know-how for rSK is in the process of transfer to a leading drug manufacturing house in South India, the know-how for the new SK derivatives is now ready for transfer to industry and under active negotiations with a few major pharma companies.

A comparative analysis of the three processes, respectively for TPA, UK and SK is given in **Table 6.2**.

Search for the technology taker has not been easy. It took nearly two years to find a suitable industrial partner, although the lab scale technology for natural streptokinase was ready. The experience of IMT suggests that most Indian companies are interested in biotechnology but seem reluctant to make partnerships with national institutions. Moreover, many companies, including the major players, prefer taking the 'safe route' of shaking hands with partners overseas to market a few well-entrenched drugs or vaccines, instead of jointly developing indigenous technologies either for known molecules or for modified / novel ones.

M/S Cadila Pharmaceuticals Ltd. tied up for the commercial exploitation of the know-how on streptokinase. Remarkably, despite its limited experience in biotech drugs, this adventurous and bold company could successfully absorb, upgrade and commercialise the technology. As a result, it could begin marketing natural streptokinase within a short period (approximately one year) of the technology transfer and the first indigenous clot buster drug (STPase) successfully entered the Indian market at a highly competitive price. Directly due to the cost advantage that this technology offered to Cadila, the average price of this lifesaver drug (all of it was imported from MNCs abroad prior to STPase) has come down by nearly 30%, a highly significant advantage for the economically depressed Indian consumer.

Technology for natural SK currently has been licensed to Mis Cadila Pharma Ltd., Ahmedabad. The availability of an indigenous product has led to a very significant fall (nearly half) in the prices of all SK being sold in India. Currently, nearly one lakh doses per year are being produced by the licensee.

Technology for rSK is undergoing advanced stage pre-clinical trials. It is expected that the introduction of rSK, with its intrinsically improved productivities, will further decrease the price of this lifesaver drug and bring it within the reach of large segments of population.

Table 6.2 Comparative Analyses of Processes for Developing Clot Buster Drugs TPA, UK and SK

Factor	TAP	UK	SK
Preparedness	Lack of cutting edge science base, facilities	Qualitative trained manpower	Qualitative trained manpower; world class facilities; Inducted young blood with required expertise
Technology development	Lack of experience. Based on imitation	Some experience in technology development. R&D based on imitation	Rich experience of technology development Innovative technology
Farsightedness	Lack of farsightedness for required infrastructure / facilities/ technical expertise	The technology provider / taker could foresee the difficulty in collecting the human urine, a logistic challenge, but underestimated the magnitude of the problem due to cultural problems.	Pursued cutting edge science to gain capability to develop 2nd & 3rd generation SK derivatives; Decided to first opt for natural SK drug to minimize delay in obtaining regulatory approval for recombinant drug in order to easily attract the industry sponsor and take the product to market
Approach	Lack of multi-dimensional approach; multi-disciplinary expertise including expertise on patent and marketing.	--	Revisited scientific & business strategy; Adopted multi-prolonged and multi disciplinary approach; Focused R&D efforts;
Stage of Technology transfer and current status	Patented but could not be commercialized	Transferred to Industry at bench scale but could not be commercialized because of lack of raw material.	Tech for natural SK licensed to Cadila at bench scale. After one year the drug was in the market. Tech for rSK undergoing pre-clinical trials. Clot specific SK technology under negotiation for commercialization.
Impact	Nil	Nil	Safe and effective technology. This cost effective natural SK technology provided 30% cheaper drug. Collaboration gave health benefit as well as increased creditability of the country in the international market
Analysis	Beginning of a learning process. IMTECH developed necessary capability for developing the know-how for other clot buster drugs.	The UK tech was based on imitation and not innovation. If IMT had clubbed imitation with innovation it would have been perhaps possible to take the technology to the market. IMT should have continued working on UK, involved a social partner for collecting raw material or suggesting methods to collect it.	Focused R&D effort, continued support of the management and faith of industry led to development and commercialization of technology. Innovative technology gave same drug at 30% lower price.

The technology for clot-specific SK is presently at an active stage of negotiation for commercialisation.

IMT has already sold the technology to a company namely "Shashun" even before it was fully developed. It is because the R&D group of this company knew the capability of IMT scientists and their deliverable capacity. Their confidence in scientists has led to generation of programme, which shall develop third generation streptokinase, the clot buster. IMT scientists have done the cutting edge science that has gone behind the third generation streptokinase for the first time in the world.

Building Partnerships: In the first instance, this case study highlights the importance of conducting R&D in a fast moving technology domain – biotechnology, continuous updating of their skills and expertise and benchmarking the technological performances in competition with the global developments by the Indian R&D agencies. The focus remained on novelty. During this process of technology development, initiatives were also taken by R&D agency to interact and look for the involvement of industry right from the idea stage. However, such initiatives did not fructify into matured relationships as at times the industry was not competent to fully commercialise the technology or at other time there were limitations as the technology was still getting evolved. However, these interactions made the R&D agency much more mature which later helped in identifying a partner who successfully commercialised the latest clot buster technology of rSK. The business development unit of IMT and the researchers themselves played the role of intermediaries in this case. The role of IMT management was also crucial in allowing continued development of the technologies involved.

6.6 Case Study - 5: Development of Specialty Monomers

M/s Vinati Organics Limited (VOL) in Lote, Maharashtra has been working in the chemical area since 1990's. The company decided to diversify as well as enhance its production capacity to gain more profits to be able to cope up with additional demands. For this purpose, the company was looking for new technologies / processes in the field of chemicals and approached the R&D agencies in this area.

NCL had earlier developed a process for making specialty monomers, which was not commercialised as was not cost effective. NCL suggested to VOL to develop specialty monomers, namely, 2-Methlyallyl Sulfonic Acid Sodium Salt (SMAS) and 2-Acrylamido-2-

Methyl-1-Propane Sulfonic Acid (AMPS) i.e. ATBS for export purpose. These specialty monomers find applications in the acrylate fibre industry for imparting dye-affinity to the fibre. Polymers prepared by using ATBS as co - monomer are also extensively used in the Enhanced Oil Recovery. Similarly ATBS is used in water treatment chemicals and in preparation of specialty polymers.

VOL agreed to explore the feasibility of this technology. Accordingly, NCL carried out the tech-economic feasibility study, which showed moderate feasibility of this project. However, industry was ready to take risk and decided to go ahead. In May 2000, VOL signed an agreement with NCL to develop a commercially viable technology for producing specialty monomers.

The project was sponsored by VOL to NCL at the cost of Rs 40 lakhs. The entire money was handed over to NCL at the time of signing of the agreement itself. This highlighted the confidence of VOL in the capability of NCL. NCL for the first time gave guarantee for product quality, production capacity and raw material consumption. The deliverables broadly defined as a) to develop and demonstrate the process on bench scale; b) to validate and demonstrate the process on pilot scale with recovery and recycles of excess solvents and reactants; c) to deliver a basic engineering package; and d) to provide assistance for start-up and commissioning of the plant.

NCL started working on its existing failed process, which earlier was not commercially viable. As apprehended by NCL, which had in the beginning itself showed only moderate feasibility, the new process developed by NCL was also not cost effective and hence was not commercially viable. One of the reasons was that this product was available only outside India and it was just not possible to get its exact market rates. The implementing team was under tremendous pressure to develop a revised commercially viable process as it had already taken the full sponsorship money. The VOL in cooperation with NCL had also taken the TDB funds for commercialization. The dedicated team of NCL put in their best efforts and just in three months time developed an entirely new process, which was found commercially feasible.

There had been turmoil during the entire course of project implementation. NCL was failing to provide all the three committed guarantees as it was the first experience of NCL in this area and both the NCL and VOL lacked expertise for commercialisation of specialty monomers. There was no such plant existing in India till then. As TDB had provided 10 Cr. for the commercialisation plant, it was a difficult process to justify the money to the reviewing committee of 6 experts of this area. The dedicated team of NCL and the support of the VOL helped in continuing the work. The industry was involved in developing the technology from the bench level itself. The project staff was trained on all the technical aspects. During preparation of the basic engineering package, special equipment were identified for few specific steps. Trials for these were conducted at vendor's site at the additional cost of VOL. These vendors extended help by providing process / performance guarantee for the specialized equipment. Samples were collected at each technology stage, i.e. bench stage, pilot stage and commercialisation stage and sent to the secondary customer for certification. The next stage was initiated only after such certification. While no complaints were received up-to the pilot stage, the samples tested after the commercialization stage had several problems.

The partnership resulted in successful development of the process for both the monomers at the lab level. NCL successfully demonstrated the process to VOL on the bench scale for SMAS (200 gm/batch scale) and ATBS (1000 gm/batch scale). Further the process was successfully demonstrated to VOL on the pilot plant scale for SMAS (8.00 kg/batch scale) and ATBS (A continuous process of ATBS at 0.5 kg/h scale). NCL delivered the basic engineering package to VOL for 750 TPA SMAS and 1000 TPA ATBS. It extended comprehensive assistance to the detailed engineering firm during engineering, procurement and construction phases of the project. It continued to assist VOL for start-up and commissioning of the plant.

The SMAS and ATBS, two separate dedicated process plants were constructed at the same site with common utilities separated by a common walkway. The ATBS plant was commissioned in October 2002. The recovery and recycle of excess acrylonitrile was established. The material produced is having > 98.6% (by HPLC) purity which is useful for acrylic fibre Industry. The SMAS plant was operated in July 2003 for crude production as well as for purification on campaign basis. The existing facilities were successfully utilised to demonstrate the process and technology, albeit at a lower capacity. VOL through its market trials has identified different market segments, which require different grades of these products.

Although the raw materials for the two plants are the same, they employ an entirely different process technology developed at NCL. The combined manufacturing facility, situated at Lote-Parasuram, Chiplun, is spread over 28000 sq.m. and comprises the process plant, analytical laboratory, raw materials & finished goods storage, utility building and administration building. There are over 125 major pieces of equipment in the process plant. The SMAS plant is based on a batch process, whereas in the ATBS plant the reaction and solvent recovery is in continuous mode, while ATBS purification is in batch mode.

The material prepared on the ATBS commercial plant was submitted globally to various customers for their testing and approval. In general it was found that each customer had his own demand in terms of the product purity and impurity profile. After getting feed back from the customer about the quality of the product, various issues were identified with respect to these market needs, and were resolved by NCL through additional process development work. In general, the extra purification methods were developed and demonstrated on plant-scale for various grades of ATBS.

The SMAS plant also faced similar difficulties in terms of market demands on quality aspects. Therefore extra purification methods were developed and demonstrated at plant scale. Although the process was developed for producing only one type of specialty monomers but NCL was able to produce processes for producing two specialty monomers, namely, ATBS and SMAS. In addition to this the process could also develop a bi-product called Tertiary Butyl Acrylamida (TBA). The possibility of development of TBA was known during the effluent treatment and the know-how was transferred free of cost. ATBS is used for absorbing the colour for synthetic wool and for enhanced oil recovery and specialty polymers (used for making body lotions, contact lenses etc.). SMAS is also used for absorbing the colour for synthetic wool. The product is being mostly (~ 90%) exported. In four years time (2000-2003) the production had started with 2500 tons/annum capacity of ATBS; 1000 tons/annum SMAS and 50-80 tons / annum capacity of TBA.

Even after commercialisation of technology the two partners were interacting. The commercial reactor of ATBS and most of the down stream machinery was capable of producing 3300 kg/day of the fibre grade ATBS except the product filter, which gives productivity of ATBS as 2000 kg/day. This being a physical operation, NCL had recommended a high performance product filter for which the trials were carried out. VOL later approached NCL to create additional facilities for product purification to obtain other highly pure grades of product at a desired through put. The incremental improvement of operational parameters essential for further improving the quality of the product was also successfully accomplished by NCL in the 4^{th} quarter of 2003..

The VOL is paying a royalty of Rs 25 lakhs annually to NCL. The new process has already fetched the following three patents, respectively, 'A process for the preparation of 2-Acrylamido-2-methyl-1-propanesulfonic acid' (US patent granted. No.US-6, 504,050), 'A process for the preparation of 2-Methyl-2-Propene-1-Sulfonic acid, sodium salt' (US patent granted. No.US-6, 660,675), and 'A process for the recovery of highly pure acrylonitrile' (Indian patent granted. World patent filed).

Building Partnerships: This case study highlights the initiative of the industry in looking for technological opportunities for diversification, which led to building up of initial linkages with R&D agency. The important aspect, however, was that as the interaction evolved the relationship between them strengthened. One of the reason for this could be that the industry was more keen to have the technology developed, had confidence in the capability of the researchers, and motivated the researchers to develop confidence and accept challenges of technology development. The R&D agency on its part accepted the challenge and for the first time signed a contract to provide guarantee on process feasibility, product quality and raw material consumption. It also continued its contributions to the partnership by providing incremental innovations even after successful commercialisation of the contracted technology and offering improved by-products and enhancing the production capacity. The business development group of NCL played a significant role in nurturing the partnerships.

6.7 Case Study – 6: Development of Technology for Drug (Amlodipine) Molecule

Emcur Pimpri, an industry in Pune, has been in the business of preparation of formulations since long. It wanted to expand its business by entering into manufacturing of drugs in addition to their formulations. It approached NCL for technological assistance. A contract research project to develop drug (Amlodipine) molecule was sponsored by Emcur Pimpri for 5 lakhs in June 2000. The partnership was forged by signing a formal agreement by the industry with NCL. At that time the drug Amlodipin was already developed by Pfizer and was available in the market. The drug molecule could exist in two chiral forms, one chiral would treat the hyper tension and the other would cause the side effects. The drug developed by Pfizer had the mix of the two chiral forms of the molecule, which caused lot of side effects. The existing drug thus had a technical flaw.

In one years time, NCL developed a process to separate the desired chiral form from the mixture of two chiral forms of the drug molecule, which already existed. The process separated both isomers from asgenic. NCL gave the Active Pharmaceutical Ingredient (API) to the industry in the scheduled time of one year. In another one year the industry further carried out formulation studies followed by the phase III trials and converted the lab scale process into a commercialisable process. Thus in two year time the improved drug called S(-) Amlodipin was launched in the market. Huge quantity of drug was not required as the dosage required was only 2.5 mg. With production quantity of ~2.5 tons / annum the drug captured 80% market share. The industry, i.e., Emcur Pimpri is paying royalty to NCL.

Building Partnerships: It has been a very successful partnership because the choice of the drug molecule was just right and there were frequent reviews with both the partners being located in Pune. The industry took the initiative to establish the partnership while the R&D agncy successfully provided the technology. However, their were certain implications due to the emerging IPR regime under WTO. The researchers did not understand their implications and were apprehensive that the new drug and its process developed by them might infringe upon some of the existing patents. While they understood the technical part of the patents, they were unable to understand the legal implications of the patent and its implications on the technology developed by them.

6.8 Case Study -7: Commercialisation of Leaf Cup Making Machine

A large number of technologies are in the form of simple know-how or a simple machine and cater to the needs of SSI or rural sector. Leaf Cup Making Machine is one such simple rural technology, which has been developed by the Central Food Technology & Research Institute (CFTRI), Mysore for moulding different type of natural forest leaves into plates, cups, saucers etc. It is a simple machine / process based technology of no IPR value, which has an advantage that local raw materials can be utilised with low investment. However, it has to be physically demonstrated to rural people and essentially requires the involvement of NGOs. Moreover it needs the partnership of machine/process plant fabricator, which becomes the licensee not the user.

The machine was initially installed in a village for demonstration purpose. In the beginning these cups were used in the wedding parties etc and gained popularity. Later, various mechanisms were used for giving popularity to this simple technology, which included demonstration of 55 machines by Rural Technology Demonstration Centre (RTDT) of NRDC, SISI, NGOs and polytechnics and also through exhibitions and rural fairs. The technology took 3-10 years in getting fully commercialised and presently it has been licensed to 10 machine fabricators and now there are 1.5 lakh such machines available in the country each one giving employment to two persons.

Building Partnerships: The case study is an example of the Lap Race concept where technology development and transfer involved an R&D agency CFTRI, a promotional agency NRDC; machine fabricators and RTDT for its marketing.

6.9 Case Study - 8: Development and Commercialisation of Biodegradable Plastics

The need for the development of biodegradable plastics arose because of the nuisance created by waste plastic materials and the ensuing government intervention through legislation to ban use of plastics at least for some applications. A number of State governments had banned the use of thin plastic bags like in Delhi, where the use of plastics with less than 20μ thickness has not been allowed, or recently in Maharashtra since mid-August 2005 an all-out ban has been imposed on the use of plastics in view of the havoc caused by the clogging of the drainage system in the rainy season.

Central Tuber Crops Research Institute developed the technology for biodegradable plastics through development of basic formulations containing 40%, 30%, 20% and 10% starch. Central Plastic Research Institute developed at pilot scale different grades of films and injectables. Being a new development, it required setting up new standards to be established for quality and degradation testing and Shriram Industrial Research Institute joined hands in testing the products for bio-degradability and standardization. Among other technology partners were NRDC, which was made the overall coordinator for management of IPR and licensing to industry and DST, which under its HGT scheme provided 50% financial assistance to first licensees of NRDC. Hindustan Levers agreed to use the material for packing their detergents even at higher cost. A consultant was hired for market survey.

The technology was licensed to one industry in each state for making bio-degradable pellets under license of NRDC. Existing plastic industry was allowed to use biodegradable pellets to produce any type of product without license of NRDC. Market testing is however still required. It may be noted that it is not a new product and imported products from Carnegie, USA are available. The developed biodegradable plastic is much more costly as compared to normal plastics, which is a major hindrance to commercialisation, though multiple uses of such plastic are possible, for example as mulch bag, disposable shopping bag, disposable apron, gloves, caps used in hospitals, in pharmaceutical and electronic industry, as moulded articles and packaging material. However, different grades are needed to meet the requirements of different applications.

Building Partnerships: The case study highlights the need for development of the technology necessitated by changes in the government policy viz, ban on use of plastics for some applications. The R&D institute developed the technology, facilitated by other R&D institutes in further developing it to pilot plant scale and in setting up of new standards for quality and degradation testing. The intermediaries, namely, NRDC and DST played an effective role in facilitating the building up of partnerships with industry and subsequent commercialisation of the technology.

6.10 Case Study - 9: Development of Catalytic Process for Butadiene Conversion

The Gharada Chemical Limited (GCL), Mumbai is in the business of developing, upgrading and commercialising the technologies / processes in-house since inception. The owner of GCL was a technocrat and not an entrepreneur. GCL planned to convert butadiene to cyclooctene and cyclooctene to nylone-8 (used for making nylone-8 for special engineering plastic) and approached NCL to develop such a process. This process involved two steps, (a) conversion of butadiene to cyclooctadine; and (b) conversion of cyclooctadine (COD) to cyclooctene (COE), both being catalytic process. As per the agreement GCL had set a target of 95% process efficiency and wanted a commercially viable process at the cost of RS 20 lakhs. GCL offered additional royalty to NCL so that all the IPR belong to GCL only. GCL could terminate the agreement for non-performance of technology/time. GCL was to provide Butadiene and catalyst, the raw material, for the first step of the process that was to be procured from USA. As the raw material for the first step was not made available to NCL, it took decision to go ahead with the 2^{nd} step process to cut corner on time schedule and to deliver the 2^{nd} phase product to GCL. GCL provided the required raw material for the 2^{nd} step.

NCL delivered the process for the 2nd step with 98% efficiency and complete conversion of the raw material. It could deliver the process at 5 litre scale within 6 months only. GCL was very happy and gave Rs 10 lakhs, half the money of the contracted cost, to NCL and took away all the IPR. GCL however, did not produce / commercialise the project. NCL was at a total loss, as its technology never reached the market, and did not get the royalty.

This was a unique experience in which NCL was dealing with a technocrat, who was also a member of the Research Council of NCL and had maintained a constant pressure on the implementing team at NCL. The discussions with concerned NCL team suggests the reasons for success of part of the project being the timely delivery of the raw material and the presence of mind demonstrated by the implementing team by offering to go in for the 2nd step, as cyclooctodine, raw material for the 2nd step, was available in the market. The first step could not be completed as there was a complete lack of foresightedness for availability of raw material on part of the industry.

Building Partnerships: The case study highlights the importance of integrity on part of the industry in establishing the partnership. The involvement of industry in the management of R&D agency should provide a mechanism for establishing healthy working atmosphere rather than being used to serve as a vehicle for benefit of a particular industry. The partnerships cannot grow in such an environment.

6.11 Case Study - 10: Development of Sol-Gel New Generation Abrasives

Abrasives are hard particles, which are used in polishing and surface finishing of metals, glass, ceramic, polymer and all other surfaces. Depending on the type of use, the properties of the abrasives are tailored. One of the most popular materials for abrasives is aluminium oxide (Al_2O_3) also known as corundum. Conventionally, the alumina is manufactured by fusing bauxite in presence of other additives and crushing down the fused rock like material, and the small abrasive pieces are mounted on paper, cloth or ceramic bonded on grinding wheels.

The new generation abrasive has extremely low particle sizes and has about 10 times more efficiency in polishing and the manufacturing process is more complex. The problem of developing such new generation abrasive was referred as a sponsored project to RRL-T for a project cost of Rs. 35 lakhs for development and demonstration of the process at laboratory level, which could be further scaled up and commercialized by the sponsoring company. RRL-T took initiative in proving its capabilities in the development of such products and agreed that it would develop the process for sol gel abrasives in the laboratory scale, which would be absolutely new and also patentable; the reported properties would match the internationally available product at very high costs; the process would be demonstrated at lab scale; the coordinator from the company would make frequent visit to see the progress of the project, would hold reviews every three months and would be associated with the report; and the company would also work out pilot level facility so that they would do the techno-economic studies also. The duration was kept at 18 months.

The sol-gel abrasive has been patented and commercially produced by 3M company in the USA. Hence unless a new approach was made no work could be done. A serious patent search revealed that the 3M patent filed in India had just expired and no renewal had taken place. This meant that at least the product could be sold in India and another patent could be filed. The 3M patent in the USA was based on single seeded route. RRL-T scientists devised a multi-seeded route where multi functional properties could be incorporated in the abrasives and hence the process was novel. The process was optimised and a flow sheet developed and process was demonstrated successfully at laboratory level.

While the process was an advantage at laboratory level, the scale up of the process posed problems. Primarily the process required a fast heating rate which could be achieved in the laboratory very easily in view of the small capacities. It would have been too expensive to fabricate furnaces of such requirements. The drying step was longer than was found at laboratory level when the scale up was done. These problems were examined and acceptable solutions were found which was accepted by the company reviewers.

A parallel facility in the company was planned but due to various considerations and the globalisation effects, made the company dithered in its decisions, which are still pending. Thus a very novel technology, which was developed on a very serious approach, could not be materialised to commercialisation. For the R&D agency RRL-T it was not possible to let the process out to other clients due to the existing agreement. It was also not possible to publish the results in view of the secrecy clause. However, as for the RRL-T scientists, the project was a rich experience in working with the private sector and the expertise gained through the project has developed to taking up a range of novel nano-abrasives, chemical-mechanical polishing agents.

Building Partnerships: The industry showed an initial interest in establishing the partnerships by sponsoring a project to the R&D institute. The institute developed relevant technology, after having examined the global status of patents in the field, as the patents in India had lapsed. The industry did not go in for commercialisation of the technology due to several considerations including the globalisation. The case study highlights that fruitful partnerships cannot be possible unless the partners contribute effectively and relevant intermediaries are involved.

6.12 Case Study - 11: Development of High Volume Flux Bonded Fly Ash Components

A thermal power plant having production capacity of 1000 MW can have about 3000 tonnes of fly ash every day. More than 100 million tonnes of ash is created every year in India from various locations, which poses serious disposal problems. This necessitates finding technical solutions for using the fly ash. However, any technical use of fly ash should keep in mind that the process should utilise as high volume of fly ash as available and should be adaptable to any location where fly ash is available; the process machinery should be familiar to the industry; bulk application such as building component should be the target; the product should appear in colour like the competitive product from clay; and should be competitive in price but at the same time, value addition should also be possible.

A process was developed for fly ash by the RRL-T Ceramic Group as a scientific project based on its research experience on Liquid Phase Sintering in the area of ceramic processes, which has been applied to practical application in low temperature densification of silica. The timing was important because the Government of Kerala was setting up at the same time a coal based thermal power plant in the state although coal is not available in this region.

The existing technology process has many limitations, whereas the RRL's process has not only many advantages, but also has been patented in India under the name 'High Volume Flux Bonded Fly Ash'. The product has 80% fly ash utilisation, brick red in colour and matches all properties of fired clay products. The laboratory process was scaled up in a tile factory through joint funding from the factory and TIFAC (Fly Ash Mission). Initial problems of handling large quantity of fine fly ash like collection of truck loads of fly ash and transportation to the factory site, nearly 1000 km away, and mixing and shaping on large scale, required further optimisation from the laboratory experience. However, in view of the large impact, which this technology could make in the country, there was full cooperation between the R&D agency and the industry and 10,000 pieces of tiles of various shapes and bricks were successfully made in the factory under commercial conditions. The binder as high as 8% were used in the laboratory process but this appeared to be too high under pilot level and caused problems in drying. After many trials under factory conditions, the binder contents were brought down without compromising on the properties of the final product, making the process more economical and practical. Further, the clay used in the laboratory was a screened sample with high plasticity and provided excellent handling properties. The clay available at the commercial firm was not so good quality and further optimisation was done to use a range of clays with corresponding orientation of the process. Moulding shapes was difficult in lab scale, but by using the practical skills and additional facilities available in the factory for clay tiles, it was possible to make such shapes also in the pilot scale, making the whole process very interesting to the commercial firm. Technically the main challenge was in drying and in firing, other than the blending. The industry could not afford to use an electrical drier as was used in RRL and a 'Hot Floor Drying' technique was designed by the RRL scientists within the facilities of the company which was more practicable and cheaper. Similarly 'Gas Fired' kiln was the only option as was understood by RRL, but other fuels could also be used in pilot levels. In this process the RRL scientist learnt a lot of new things and the factory people got convinced about the technology and marketability.

Building Partnerships: In this case study, the process was developed at the laboratory level and scaled up jointly with industry supported by the Intermediary TIFAC fly ash mission. Hence there was ample opportunity for the industry to observe the process carefully and to suggest important points for further improvements. The range of products, which were made were high quality and acceptable than what was done in the laboratory. Based on the convincing experience, the factory has seriously thought to diversify their production and set up a new industrial unit for fly ash products in Tamilnadu near a thermal power plant. Project proposal has been made and hopefully the technology will turn to a commercial transfer and production by next year.

6.13 Case Study - 12: Development of Cokeless Cupola for Foundries

The need for this project arose because the foundries in Agra were facing closure due to the directives from the honourable Supreme Court of India since all the cupola furnaces in Agra were using Coke as fuel. The sulphurous fumes from the emissions of these cupolas were tarnishing the white marble of heritage monuments like the Taj Mahal. The project was sponsored by TIFAC with a soft loan of Rs.45 lakhs to design and develop the Cokeless Cupola. It started in June 1996 and the lab scale work was on track by September 1997. This was on 1Tonne/hr scale in the Pilot Plant area of the National Metallurgical Laboratory (NML), Jamshedpur. The performance of this Cokeless Cupola was shown to the senior officials of M/s Tata Korf Engineering Services (TKES), Jamshedpur and also to the office bearers of Agra Iron Founders Association (AIFA), which showed satisfaction with the demonstration at NML.

The collaborative agreement was reached between NML and TKES for up scaling & commercialisation of the Cokeless Cupola technology by TKES. AIFA entered into agreement with NML for installation of 40 numbers of 2 T/H Cokeless Cupola in the foundries of AIFA for 10 years with effect from15the September 1997. TKES had to share 50:50 in the know how fee and had to pay, in addition, to NML a sum of at least 6% of the value of the installed cupola as royalty. The review and monitoring were to be done by apex committee from time to time for which no fixed schedule was stipulated.

The project had wide use in Agra and TKES were well equipped to do it since they were already in business for Mini Blast Furnaces. TKES first got orders for 40 nos of 2 T/H Cokeless Cupola in Agra provided they showed one such cupola operating successfully at Agra Loh Udyog. The commercial unit gave several problems as under:

- The burners were too much over capacity for the furnace. These were North American burners supplied by Wesmann Engg. India. They had to be changed to the short flame burners of Hot Work design. NML changed to 4 nos HV 350 burners of Hot Work design.
- The refractories of the cupola were not able to sustain the heat in combustion zone. These were changed to 70 Mullite bricks.
- The fluxes were made synthetically to yield low melting slag for easy removal from the cupola.
- During operation it was felt that it was essential to have a justifiable degree of instrumentation, which was ignored initially. This was done to monitor the gas flow, airflow, and to adjust gas - air ratio for optimum operation.

All above activities took 14 months and were done entirely at the cost of NML Finally the successful runs of the furnace were demonstrated to AIFA by melting and pouring all kinds of castings at Agra Loh Udyog on 25th August 1999. The Industry was very cooperative and enthusiastic in the beginning, but showed cold attitude when problems started. The scientists of NML at the cost of NML did the entire job of standardisation.

When in August1999 the 2 T/H cupola was shown to be operating successfully, NML declared to TKES and AIFS that NML will no more bear any cost except that it can help in operating the furnace for a limited period. The things then got worse and AIFA once again approached Honourable Supreme Court to allow them to continue with Coke. This appeal was turned down and on 21st November 2000 the Apex court gave verdict to either adopt Cokeless Cupola or else close the foundry. Again in 2001 TKES entered into a fresh agreement with AIFA to install 10 cupolas of 3 T/H after demonstrating one such cupola in the premises of M/s Goel Engineering Co., Agra. This Cupola started functioning from 3rd July 2001. There was some problem in the instrumentation for which first 5 heats from it were not of required quality. The instruments (gas and air flow measuring systems) were changed and with that the furnace functioning became all right but the metal was not flowing into thin castings even at high temperatures of 1460°C. TKES virtually withdrew at this stage. At the same time NML continued its effort and found that the pig iron, which was being used for melting, was not of foundry grade. It was very low in Silicon (0.8-1%) and Carbon (¡Ü3%), which were cause of problems. NML undertook to make good heats with proper use of inputs. AIFA agreed for making six heats from this cupola by NML on the following terms:

- NML will bring all inputs like pig iron, flux, additives, and materials for lining repairs at its own cost.
- AIFA restricted the heat size to 10 Tonnes in one campaign.
- AIFA asked NML to pay in advance all other charges (like labour charge for moulding, core making, diesel for generator, power cost etc) at the rate of Rs. 6/kg i.e. for a 10 Tonnes heat it turned out to Rs.60,000. This had to be paid by NML in advance to AIFA before taking any heat.
- AIFA will buy all good castings at market rate.

On 24th December 2002 NML agreed to all the above terms because its credibility was at stake, and also since CSIR sanctioned a sum of Rs.20 lakhs to implement the programme. Subsequently the work, which started on 14th May 2003, was completed within 6 weeks, successfully completing it on 30th June 2003. NAL conducted six heats in these six weeks restricting the heat size to 10 Tonnes as per the discussion with AIFA

AIFA paid the cost of good castings to NML after having successfully demonstrated to them the six heats. NML asked M/s Goel Engineering Co., Agra to arrange for 25-30 Tonnes heat size in which they will make all inputs but NML scientists will help in operation of this furnace free of cost. This has not happened till date. There were initial problems when the cost of pig iron had suddenly spring up from Rs.12000/tonne to Rs. 24000/tonne but even afterwards there was no word from the user agencies.

NML has been receiving inquiries from organisations abroad but since the demonstration units are in the premises of the 'hostile' organisations, the demonstration is a difficult task. Efforts are on by the NML scientists to find at least one good party to wash the undoing at Agra. NML scientists are of the view that they should have made a few 25-30 Tonnes heat size with same modality as of 10 Tonnes heat and only then should have left the scene. They feel that it would have been strategically advantageous but they missed the opportunity.

Building Partnerships: The first step for building partnership was initiated by the intermediary, namely, TIFAC in view of the closure of foundries in Agra on directives from hon'ble Supreme Court of India. Intermediary facilitated interactions between R&D institute and industry. The technology was successfully developed by the R&D institute in cooperation with the industry. However, there were problems in furthering the partnership to take the technology to demonstration stage. The case study highlights the lack of confident initiatives by the partners in seriously continuing the partnership project.

6.14 Case Study - 13: Development of New Bioactive Molecules from Plant Extracts as Potential Drugs

Global herbal market and herbal-based pharmaceutical industry have been growing rapidly and the interest in the herbal products is increasing all over the world. Developed countries with their innovative ways of working have the capability to unlock many secrets and get more from global heritage than the originating country could. It is well known that in

India for centuries traditional medicine has been contributing for healthcare. Yet it is not surprising that even today there is hardly any Indian product in the international market. India with her vast resources of rich knowledge and deep wisdom and traditional system of healing practices can have a major share in the global market provided it has a strategy and uses tools of modern science. It is in this context of intellectual pursuit that is on the horizon, efforts need to be made to formulate national perspective to maximize the benefits from Indian capabilities. Requisite systems must be put in place to make the country a global performer and achievers. It has been widely accepted that IT and health care are among the most significant intellectual domains where India has proven capabilities and accredited track record.

In the mid nineties, CSIR identified development of bioactives from plant sources as a thrust area and decided to set up a coordinated and collaborative programme involving about 20 of CSIR institutes to search new bioactive molecules as potential drugs from plant extracts and to standardize the herbal preparations. As the time was ripe for such a development, the central government provided total support and encouragement. Such an initiative was unique in the history of CSIR in several of its aspects. Indian science and its practitioners were waking up to the new developments in the world. The old dictum of "publish or perish" was being replaced by "patent or perish". The rate of generating patents from CSIR was accelerating remarkably. There was an all round enthusiasm and activity in all the CSIR institutes. A Task force was constituted under the chairmanship of a reputed chemical engineer. The CSIR Coordinated programme on bioactives was conceived well and implementation began in 1998. The programme envisaged knowledge networking with the three major Indian systems of medicine, viz., Ayurveda, Siddha and Unani. The first interaction of the programme was with Ayurveda and CSIR initiated collaboration with AVS, a non-profit organisation, in the field of bioactives and plant sources, particularly to study the bioactivity of single herbs using modern tools. CSIR proposed that a few disease conditions could be selected as target areas and herbs could be studied for their activity.

AVS received the proposal with mixed feelings as it had its reservations on this methodology. It agreed that many years of healing tradition of AVS presented a level of wisdom that would complement the textual knowledge. It was however not enthusiastic and in the beginning itself frankly mentioned its apprehensions essentially based on classical notions about the nature of knowledge and its pliability. Firstly, AVS felt that Ayurveda, as a practicing system of health care, dealt with polyherbal formulations rather than with single herbs as curing agents. Secondly, the selection of a therapeutic agent was not based on a one-to-one linear correlation between drug and disease. Instead, the concept of patient as a human being and occurrence of disease as a transient phase within the basic constitutional framework of the patient were the axiomatic approach. A question was raised that the Ayurvedic knowledge was readily available in numerous classical textbooks written in Sanskrit and some other regional languages and the scope for an institution like AVS to contribute to the programme was, therefore, limited. Finally, a philosophical question was also raised whether the principles and tools of the Cartesian approach of modem science and the intuitive and integrative approach of Ayurveda would prove incompatible to each other.

It was the reputed surgeon and educationist, Dr. M.S. Valiathan who interfaced effectively between CSIR and AVS to bring the harmony. The fact that he being a medical practitioner understood the philosophy of Ayurveda transcended beyond the single herb cures and other treatments was conceded. But a larger issue was also raised whether India had been able to offer a single molecule as a medicament to the suffering humanity across the world, in spite of the fact that India boasted about three thousand years of its health care practices.

An MoU was drafted after a series of discussions between senior scientists of CSIR and the Trustees of AVS, which was the first of its kind in CSIR. Apart from specifying the responsibilities of both CSIR and AVS, it provided for equitable sharing of the benefits accruing from the programme. It envisaged the development of new intellectual properties, in terms of new formulations, inspirational molecules and structurally modified analogue molecules. The inventorship and ownership for each of the new knowledge generated were clearly specified. One interesting aspect of the MoU was that the individual expenditure on travel, material, stationary, etc was to be borne by each partner. This MoU provided for strengthening the traditional knowledge partner by giving it the first right to commercialise any new formulation that might emerge out of the programme. The essence of the MoU was that it kept the national interest at the core and the conventional procedural intricacies were avoided. The MoU between CSIR and AVS has become a model for similar other collaborations to emulate.

The programme commenced with screening of traditional formulations for the presence of bioactivity in the national laboratories by use of cell lines. Different discovery groups were set up to take up detailed studies on emerging bioactives. IICT acted as the nodal station for all trial materials while the other CSIR institutes participated actively. When the programme started yielding encouraging preliminary results, it was realised that IPR can be secured only for entirely new formulations, which were not present in public domain. This realisation was responsible for prompting all concerned to have exclusively designed new formulations for screening purpose. AVS took it up in right earnest and came out with entirely new formulations.

The programme has extended an arm of partnership to 13 universities and industries with inherited knowledge on three different Traditional Systems of Medicine (TSM), viz, Ayurveda, Siddha and Unnani. In order to enhance its chances of success through the use of traditional knowledge, CSIR has forged partnerships with specific organisations representing Ayurvedha, Siddha and Unnani systems of medicines and has signed separate MoUs with each of them, that describes the pattern of responsibilities and potential and sharing of accruing benefits (IPRs).

As a measure of better understanding among all the involved partners in the collaborative effort between CSIR and TSMs, a transparent and well laid out guidelines for filing patents and PCTs were developed using consensus approach as while filing a patent application, it is necessary to provide a complete list of inventors who have contributed towards the generation of IPR including the organisation to which the IPR is being assigned. The types of intellectual rights in the form of products and processes expected to develop from the collaboration are mentioned in **Table 6.3**. An understanding has been reached between CSIR and the TSMs that sharing of likely benefits will be in accordance with the terms of MoUs and will be consistent with the operating guideline specified in this Table and it is obligatory for all partners to comply fully with these operating guidelines while filing patents for products/processes emanating from the collaborative effort. To ensure that all those who have contributed towards the IPR get included as inventors, a checklist has been developed and provided to each partner. As per the MoU the TSM partner has the first right to commercialise any modified or new formulation on a royalty-free basis. If desirable, the sale of IPR will be jointly done by the partners. All negotiations for commercialisation of single molecules and processes involving them will be handled by CSIR.

The viability of this networked system has been tried with initial output of about 100 extracts. The journey has been extremely fruitful, rewarding and as a result fractions have been produced as optimised leads, extracts, new formulations and new chemical entities, some of which will eventually become new therapeutic agents having edge over existing products.

Table 6.3 Intellectual Property Expected from Various Partners

Expected Product / Process	Inventors from	Assignees
New/modified/improved formulation starting from an existing one	CSIR and TSM partner	CSIR and TSM partner
A naturally occurring single molecule extracted from TSM product	CSIR and TSM partner	CSIR and TSM partner
New Chemical Entities (NCE) obtained through modification of a naturally existing one	CSIR	CSIR and TSM
Process for obtaining enriched fraction or single molecule	CSIR and TSM partner	CSIR and TSM partner
New Process for synthesis of NCE	CSIR	CSIR

The mammoth coordinated programme networking 20 CSIR institutes, 13 universities and 3 well known entities in the traditional system of medicine has provided many leads, which have the potential of development of products for the international market. The dedicated teams have discovered some new chemical entities and new herbal formulations for cancer, tuberculosis, filarial, malaria, ulcer, Parkinsonism and Alzheimer. Interesting leads have been obtained on hepato-protective cum immuno-modulation as well as memory enhancement. Two entirely new anticancer preparations in the area of women's' cancer are being developed by Indian firms. Also short term toxicity of two entirely antiulcer preparations has been completed and clinical trails protocols have been worked out **[71]**.

The networking with TSM helped in gaining experience in terms of knowledge, establishing facilities, generating IPR through patenting and obtaining leads for the new uses i.e. against the diseases which were not reported in the literature. The leads are at different stages of development as single molecules and new herbal formulations for diseases of national relevance and international importance. Collaborations have been established with international partners. The partners are optimistic that these collaborations will prove effective to take the Indian traditional medicine preparations to international market.

Building Partnerships: This case study demonstrates the networking approach to partnerships involving multiple R&D agencies including universities for carrying out relevant functions for developing new bioactive molecules based on knowledge available in traditional systems of medicine. The collaboration with AVS was worked out by clearly delineating the principle of equitable sharing of benefits resulting from the collaboration. The participation of players from TSM also ensured the sharing of IPR. It indicates a well laid out structured forms of building partnerships, with potential of commercial contributions.

6.15 Case Study - 14: Development of Advanced Techniques for Efficient and Reliable Finite Element Analysis of Structures and Components

An Indo-German collaborative project under the CSIR-FZJ (*Forschungszentrum Jülich*) Cooperative Science Programme on 'Efficient and Reliable Finite Element Analysis of Structures and Components' was started in April 1996 between Structural Engendering Research Centre (SERC) and Institute for Safety Research and Reactor Technology (ISR). An industrial partner each on the two sides was identified to participate in the execution of the project. Thus SERC partnered with NIIT, and Forschungszentrum Jülich with INTES, which showed interest in the transfer of research results to application on terms and conditions mutually acceptable for the collaborating R&D institutions in the project. Each contracting party ensured the contractual inclusion of the supporting partner on its side in accordance with the Agreement for Cooperation. This was the first '2+2-project mode' CSIR project under the bilateral S&T programme of cooperation, when a new concept of 2+2 scheme was evolved and formulated in CSIR.

ISR had main interest in the implementation and optimization of the software for new computer architectures, SERC investigated error estimators and adaptive mesh refinement for the existing FE codes. The scope/objectives of the project were the development of error estimators for 2-D and 3-D finite elements for linear static and linear dynamic problems [SERC]; development of h-adaptive mesh refinement strategies [SERC]; implementation of efficient error estimation and adaptive refinement procedures in FINEART/PERMAS [SERC-ISR-INTES]; development of efficient iterative solvers [SERC-NIIT]; development of a GUI for interactive FE analysis [NIIT-SERC]; parallelisation of FEM code and implementation on a coupled SMP system [ISR-INTES]; and integration of the parallel modules developed under vi) into the parallel version of PERMAS. It may be noted that FINEART (**FINite Element** analysis using Adaptive **R**efinement **T**echniques) is a Finite Element Software/code wholly owned and developed by SERC, whereas PERMAS is parallel finite element analysis software/code wholly owned by INTES (ISR-INTES).

In this partnership SERC provided access to NIIT and ISR to the working module of FINEART as well as the necessary code required for interfacing or integration purposes only within the scope of this project. ISR made available to the collaborators at SERC, NIIT and INTES their hardware including coupled SMP system at ISR for the project requirements. INTES provided a development version of PERMAS, free of costs, for ISR and SERC for the project term. INTES permitted NIIT to use PERMAS at SERC/ISR/INTES within the scope of this project. It also gave support for PERMAS to SERC, ISR and NIIT. Furthermore, interface definitions and source code access to the PERMAS software were enabled to ISR and SERC within the scope of this project. For these development tasks, INTES also provided limited manpower dedicated to the identified goals, free of costs. On the other hand, SERC, ISR and NIIT made relevant source code access available for integration purposes to INTES within the scope of this project. FINEART programme was implemented on LINUX workstations using GCC compilers. It was always ensured that identical versions of FINEART program was available with participating institutions so that data transfer becomes easy.

During the term of this Agreement there were exchange of personnel with about six visits (two visits annually for four weeks) each from India and Germany. The Special Arrangement between CSIR and FZJ gave support to the project. CSIR/SERC looked after the travel expenses of its personnel during the visits to German counterpart institutions and provided free hospitality to the German counterpart during their visits to India while FZJ made arrangements for travel of German personnel and took care of the Indian counterparts during their visits to Germany as per the Agreement.

Software was exchanged as effective and efficient means to achieve the objectives of the project. One of the factors that facilitated the success of this collaborative programme is the excellent hardware facilities available at both the ends and also good networking facilities.

In order to further improve the efficiency of FINEART, provisions have been made to define multiple element groups in the input mesh. Necessary changes constituent modules of FINEART were carried out to define multiple element groups. The restructured program has been tested on Solaris and Linux workstations using SUN and pgi compilers. After successful completion of the project, SERC published 9 reports and 4 scientific papers, completed 1 thesis, edited 2 books and fined 1 copyright for the software FINEART. Technical meets DEFINE '02 and FEADS '03 provided an appropriate forum for SERC to project the technological achievements made not only in this project but also its other capabilities in related areas to the user industries/agencies.

Building Partnerships: The case study highlights the role of official mechanisms for supporting collaboration between R&D institutes and industry of India with those of

Germany. The success of the collaborative project was facilitated by the excellent hardware facilities at both ends as well as good networking amongst them. The collaboration resulted in development of usable software for finite element analysis of structures and components, reports and joint publications. It enabled building up of capabilities of the partners.

6.16 Case Study – 15: Satellite Imagery Digitisation

Satellite Imagery Digitisation (SID) in INSAT-3B is an example of the societal need based technology development, wherein partnership is used in dissemination of information obtained based on high-tech means like space technology, weather forecasting, water harvesting, satellite, photography, weather modelling etc. for the benefit of ultimate user like fisherman, farmers etc. through various channels. SID is a high technology which involves large initial investment and has multiple uses such as identification of water and mineral resources; predicting weather – droughts, floods, cyclones, fish shoals and forest cover; facilitating road and train track surveys (industry can pay for this); preparation of city and town master plans; and predicting new likely river routes. Beneficiaries of this technology would be the people at large like farmers, district level agencies, NGOs, agro-industry associations (sugar, tea, coffee, tobacco etc.).

The possible partners for dissemination of high tech based information are ISRO; Monsoon Prediction Division of DST; Survey of India – Map Digitization; software developing companies; army and air force. To quote an example, ISRO through regional centres of ICAR via their agents like teachers, postman, station master, surpunch etc conveys the information to the farmer about movement of locust towards his fields, which have the capacity to multiply very fast and can ruin the crop in no time. Immediately on receipt of the information the farmer sprays pesticide in his field to kill the locust.

Building Partnerships: This is a typical case of partnership between a national R&D organisation like ISRO and other user agencies. In India quality distant education has become possible through the partnership between ISRO and the Indira Gandhi Nehru Open University. In the coming decade, geographical positioning systems (GPS), which are useful to the transport industry sector, will have to really pay for the total cost, rather subside for the free services to the farmer, the common man.

6.17 Conclusions and Lessons Learnt

The compulsions of the post-globalisation era have driven the institutional R&D centres to continuously generate cutting-edge knowledge and value-added products and services. Thanks to many such achievements of R&D agencies the industry today is more convinced with the capabilities of the R&D agencies and is beginning to partner with them even at early phase of technology development process. The above case studies illustrate a range of institutional mechanisms and were chosen as each of these represents a unique programme, where partners with diverse experience and scientific knowledge gained considerably by breaking the barriers between each other. The knowledge generators discovered new avenues for fruitful applications of their methods and tools. The technology receiver, i.e. the industry got an opportunity to enhance its inherent strengths by receiving useful inputs from modern science, thus equipping itself to meet the challenges of the modern world.

The essential features of the partnerships leading to the development of new technologies, and in some cases, their successful commercialisation have been indicated separately in each case study. **Table 6.4** broadly summarises the above case studies. These insights formed an input in the understanding and formulation of questions for designing the questionnaires.

The case study 4 on the development of Clot Busters by IMT and the case study 5 on the development of specialty monomers by NCL show that useful technologies could be generated through knowledge networking. It is evident that success is assured only when there is a synergy between a competent R&D partner and a committed and economically strong commercial partner. These case studies present an interactive model of partnership, i.e., active participation and cooperation of such partners from inception till commercialisation, who were champions on technology absorption and complete transfer and integrated multi-disciplinary team members. In case of specialty monomer development there were some problems too like the lack of experience for commercialising specialty monomers, fine and specialty chemicals and increased raw materials consumption for testing.

The main factors responsible for success in case study 6 on the development of drug molecule Amlodipine have been that the choice of the drug candidate was just right, it being a new concept on the separation of the required chiral form from the mixture of two chiral

Table 6.4 Summaries of Case Studies

Case Study	Technology Developed	Main R&D Agency	Industry	Inter-mediary	Other Partners	Financing	Status of Commercialisation
1.	Palm Oil Technology	RRL – T, CMRI (CSIR) MERDO, CPCRI (ICAR)	AP Oil Federation	NRDC	DBT, Karnataka, AP & Maharashtra States	1.26 Cr by TDB, NCDC, Oil Mission	Commercialised
2.	Zeolite 'A' Intermediate for Detergent	CSMCRI (CSIR)	NALCO	NRDC	EIL	Equal share of Rs.30-40 Lakhs	Commercialised in India and abroad
3.	Rice Husk Particle Board	IPRI	PPBL	NRDC	-	50% NRDC Equity + 40 Lakh VCF-IDBI loan	Commercialised By MHEL Malaysia + Indonesian company
4.	Clot Busters TPA, UK, SK	IMT (CSIR)	Godrej	-	Cadila	-	Commercialised
5.	Specialty Monomers	NCL (CSIR)	Vinati Organics	-	-	Vinati Rs. 40 Lakh + TDB 40 Cr.	Commercialised
6.	Drug (Amlodipine) Molecule	NCL (CSIR)	Emcur Pimpri	-	-	Emcur Rs. 5 lakhs	Commercialised
7.	Leaf Cup Making Machine	CFTRI (CSIR)	10 Machine Fabricators	NRDC	SISI, NGO etc.	By R&D agency	Commercialised
8.	Biodegradable Plastics	CTCRI CPRI	Hindustan Lever	NRDC	SIRI	50% from HGT (DST)	Licensed and being considered for commercialisation
9.	Catalytic Process for Butadiene Conversion	NCL (CSIR)	Gharada Chemical			Gharada Rs. 20 lakhs	Licensed to industry, but could not get commercialised
10.	Sol-Gel Abrasives	RRL –T (CSIR)	Company 'X'	-	-	Rs. 35 lakhs from 'X'	Licensed, but could not get commercialised
11.	Flux Bonded Fly Ash Components	RRL –T (CSIR)	Company 'Y'	TIFAC	-	'Y' + Fly Ash Mission	Technology transfer in progress
12.	Cokeless Cupola for Foundries	NML (CSIR)	TKES	TIFAC	AIFA	Rs. 45 lakhs (TIFAC) + Rs. 20 lakhs (CSIR)	Technology transfer in progress, but not smooth
13.	Bioactive Molecules fm Plant Extracts	CSIR Labs	Arya Vaidya Sala	Dr. Valiathan	TSM Partners	Share as per Agreement	Technology development in progress
14.	FEM of Structures and Components	SERC (CSIR) ISR	-	-	NIIT INTES	'2+2' bilateral Project	Knowledge Generation
15.	Satellite Imagery Digitisation	ISRO	-	-	MPD, SOI (DST), IGNOU	-	Often free for societal needs

forms, which was exciting to the researchers, and the partners were compatible to each other, who actively participated and cooperated from the inception till the commercialisation. There was also a formal binding agreement and a strong industry drive, as the industry was entering into a new field of manufacturing. Until then it was only in marketing and hence was involved in the project activities at NCL. Geographic location of the both the partners ensured frequent reviews and immediate corrective measures, whenever needed. In case of multinationals the partners were teleconferencing and were able to keep in constant touch.

The case study 13 highlights the success of a major CSIR initiative with the involvement of very large number of public and private partners. The programme started for consolidating the existing knowledge, but several new chemical entities and herbal formulations have been discovered till present through these interactions. In this all the partners have been exposed to and are becoming familiar with new approaches and methodologies of handling information and generating knowledge. The success of this programme has demonstrated that India can work in a networked fashion as a team and convert its biodiversity into wealth and develop agents that are cure for discovery and have market not only nationally but also internationally. The experience indicates that a partnership of formal innovation systems of CSIR with informal and proven innovation systems of traditional systems of medicine offer a formula for 'win-win' partnership for India in the emerging health care market of the world, provided the partnership is based on mutual trust and the partners have confidence in each others capabilities.

The reasons attributed to the success of the above initiative are the micro-level planning, management and execution of the widely dispersed and networked tasks; initial confidence building measures; openness and frankness in dealings; team spirit, mutual trust and confidence in the capabilities of each other; operation through consensus of all the involved partners; proper evaluation and monitoring system; recognition accordingly to the inputs; and a fair legal arrangements for sharing the benefits.

The joint activity on the development of advanced techniques for efficient and reliable finite element analysis of structures and components (case study 14) essentially yielded knowledge product in which the partnership undertaken through bilateral inter-governmental agreement provided a platform for successful and purposeful interaction among research institutes, academic organisations and concerned industrial establishments; gave global visibility and recognition among internationally repute institutes and opportunity to understand the needs of the industry and work together to find joint solutions through collaborative projects for common problems; instilled confidence in the user industries about the capabilities of the R&D agencies and their delivering capacity; and opportunities to frame and implement the projects that meet future requirements of the industry and society. The partners gained access to advanced super computing facilities. Proper and efficient planning of individual tasks led to coordinated execution throughout the project period and dissemination of knowledge generated from this project to the user industries through the industrial partners was very successful.

The lessons learnt from these case studies are summarised below.

- Laboratory level research is a straightforward case where one or a small group of scientists are involved and the commitments are limited to scientific outputs which can be achieved with reasonable success. Process development and demonstration are more difficult and should involve an agency or agencies and many alterations or modifications may be required which may or may not provide scientific data for publication or patent. This step should be teamwork. Often the effort put in this direction goes less noticed.

- R&D agencies should have self-confidence in accepting the challenges and carrying out innovative researches in order to generate new products and capabilities. In addition to carrying out cutting edge science, they should possess a desire to develop 'end products which have markedly higher value. Fundamental science component integration enables development of innovative technologies as it inspires the scientists in the R&D team.

- R&D agencies must induct young blood with multidisciplinary expertise. Motivation of competent scientific team should be geared towards the well-identified product. The project staff should be trained on the new knowledge and all the technical aspects needed.

- There should be a sustained support of top management, commitment and confidence in the scientists, which is the key to success.

- The project leader and also the team members should have positive work culture and attitude as this helps them withstand the turmoil and pressure from the administration, financial institutions and industry.

- Special efforts should be made to manage the human factors (attitude, strong ego, inter-personal relationship, no desire to share credit, etc.)
- R&D agencies should be provided the state-of-the-art facilities to convert the ideas products and enhance the profits significantly besides value addition to their products.
- R&D agencies should give guarantee for product quality, production capacity and raw material consumption, which means that the implementing team should have confidence in its own expertise and potential.
- Timely delivery must be ensured despite turbulences. Non-delivery, however, should not be treated as failure but as learning exercise. There is every reason to be optimistic for the development of world-class products.
- Although the scientist is the key for technology development, it is necessary to create an atmosphere for technology dissemination, implementation, evaluation as well as transfer in a language acceptable to the industry and for this, a cooperative effort involving a competent team with well-defined responsibilities and credit sharing should be involved. Only then will a technology find a long term taker and primarily the scientist who originated the idea attains full satisfaction. But the scientist should be provided with due consideration while passing through all the various steps of technology transfer. If not, many nice ideas will remain within the laboratory and will only get published or patented and will not reach the industry.
- Industry must remain committed to associated risk with the venture. The investment risk can be reduced if industry ties up with R&D agencies for solid scientific base together with sophisticated infrastructure.
- More specifically, in so far as the drug development, broadly speaking biotechnology field, is concerned it is quite attractive but the industry should realise that it is a knowledge and skill intensive field often with a long gestation period. They must therefore remain committed to associated risk.
- Industry must be involved throughout the project implementation process

- Technology transfer is dependent on the quality of the process or technology with respect to technology demand, the development in respect of related areas of the industry, techno-economic feasibility, investment range and the level of industry in the country or abroad. Sometimes, the location of technology development and implementation also matters.

- Commercialisation is the most challenging and successful step in any technology development and is the clear proof of the scientific approach. This may not be possible in most of the process development efforts, but consistent efforts should find success.

- Success is assured only when there is a synergy between a competent R&D partner and a committed and economically strong commercial partner.

- Immediate corrective measures should be taken to resolve problems at commercialisation stage.

- Partnership does not stop even after the technology has been transferred and commercialised.

- There should be a predetermined agreed formula to share the benefits among the partners.

Chapter 7

Responses from Stakeholders to the Questionnaires and Analysis

The literature survey in pervious chapters, specifically pertaining to the promotion of R&D agency - industry partnerships in India and select developed and developing countries, and the case studies have allowed a considerable probe into the processes of building partnerships, some of the reasons for success and failure, and constraints faced by the stakeholders in interfacing for technology development, its transfer and commercialisation. Based on such understandings, the present chapter focuses on formulating specific questions with respect to the role of the concerned stakeholders, the interface between them and the processes of building partnerships; dissemination of these questions in the form of appropriate questionnaires to respective stakeholders; and scientific analysis of their responses to provide relevant suggestions for improving the partnerships.

7.1 Introduction

The present research study is basically an assessment exercise based on the inputs received from the government departments, policy makers and other stakeholders on improving the partnership relations between R&D agencies and industry for development of technologies and their commercialisation to help India become a technologically advanced nation. This exercise is expected to lead to the enunciation of suitable recommendations through an appraisal of the partnership building processes, roles of the stakeholders and problems associated with the interface among them. Accordingly this work, among others, required an investigation into efficacy of existing R&D agency – industry partnership mechanisms aimed at technology development and diffusion, reasons for success and failure of partnerships, and identification of gaps to be bridged and new possibilities to be exploited in this area.

In order to obtain inputs of various stakeholders involved in partnerships for technology development and transfer on their experiences in this field, the questionnaires were designed in an easy to fill format. Specific queries were made in the survey, which were formulated to understand how R&D agencies and industry function and develop the process of interaction, and also what were the reasons for lack of interactions so as to suggest the appropriate remedial measures to overcome the drawbacks of the existing R&D agency-industry partnership mechanisms, identify the *best practices* and minimize the *barriers* that come in the way of implementing the *best practices.* It was expected that based on these responses we would be able to evolve a operating guidelines for enhancing such partnerships.

7.2 Questionnaires, Target Respondents and Method of Data Collection

In view of varying issues it was felt necessary to design separate questionnaires for various stakeholders, viz. those working in the R&D agencies (including academic institutions), industries and organisations supporting / facilitating the research – industry partnership for technology development and transfer, while limiting the variants of questionnaires for easy analysis **[8, 203-205]**. The target respondents were divided into three broad categories, namely, Technology Providers, Technology Takers and Intermediaries facilitating technology partnerships. The Technology Providers included the working scientists and R&D managers in the R&D agencies such as the national institutes and laboratories of CSIR, DST, DRDO, etc, institutes of academic importance such as IIT's, IISc and well recognised universities such as BHU, Hyderabad University etc. The Technology Takers included the working scientists and R&D managers in the in-house R&D units, SMEs, large-scale industries, public sector units, and industry associations. The Intermediaries included the coordinators of the partnership facilitating programmes of the government / public agencies such as NMITLI, TDB, HGT, PATSER, NRDC, etc., which act as technology information provider, technology development promoter, transfer facilitator, financer of technology; academic and public TTO's such as of IITs, IISc, ISRO etc.; international bodies facilitating technology transfer; NGO's and private consultants; and science and technology parks.

Appendices A, B and C respectively give the questionnaires for the R&D agencies and academia (Technology Providers), Industries (Technology Takers) and Intermediaries. All the three questionnaires were sent to 379 individuals in 73 R&D agencies and academic institutions, 159 industries and 17 intermediaries for sharing the individual and corporate experiences. **Appendices D, E and F** respectively list the names of the R&D agencies and academia, industries and intermediaries who were sent the questionnaires.

To expedite the inputs to the questionnaire personal discussions and telephonic conversations were held with a number of working scientists and R&D and planning personnel from the R&D agencies, academia, industry and intermediaries. Interviews with key persons like the Directors of the R&D agencies, Head (R&D Planning) and Head (Business Development) were also held.

7.2.1 Distribution, Sample Size and Return Rate of Questionnaires

Distribution, sample size and return rate of the questionnaires are given in **Table 7.1**.

Table 7.1 Distribution, Sample Size and Return Rate of Questionnaires

Agency	Questionnaires Distributed	Questionnaires Returned	Return Rate (%)
R&D Agencies (Public institutes of GOI, scientific agencies, and academic institutions)	172	46	26.74%
Industries	190	25	13.167%
Intermediaries supporting Technology Partnerships (including Technology Transfer Offices of IITs / IISc / ISRO)	17	10	59%
TOTAL	**379**	**81**	--

While a good number of responses were received from the intermediaries and R&D agencies, most of the industry respondents conveyed their inability to provide inputs because of the confidential nature of their data, stating, for example, that, "The information asked by you is confidential in nature, not possible to share..."; and "The questionnaire is containing very very vital questions as well queries which are sensitive (each) to our Organization or to any other Organization and which I will not be able to disclose to anyone. You can understand, being part or the Higher Management Governing Body of the Company I will not disclose any such information which are sensitive as well as are asked in the questionnaire, am extremely sorry for same".

7.2.2 General Profile of Respondents

As of end-August 2005, 46 responses were received from the R&D agencies, 25 from the industry and 10 from the Intermediaries supporting / enabling partnerships between R&D agencies and industry for technology development / transfer. **Table 7.2** indicates the areas of interest of the responding agencies.

Table 7.2 Areas of Interest of the Responding Agencies

	Agricultural Sc.	Biological Sc.	Chemical Sc.	Physical Sc.	Engg. Sc.	Other Areas	Total
R&D Agencies	1	10	5	12	16	1/1 (Oceanology / Academics)	46
Industries	1	7	5	0	11	1 (Atomic Energy)	25
Intermediaries	One agency (ISAAA) is specifically related to Bio. Sciences						10

A. R&D Agencies

The personnel employed in the business promotion groups of the R&D agencies were generally well qualified with a number of engineers and MBAs and at least a few Ph.D.s. The R&D budget of most of the responding agencies ranged between ~10-30 Cr., except in case of NAL (~90 Cr.) and DMRL and NGRI (~40 Cr. each), about one-third of which was earned on their own. While a few organisations like CCMB and NCL spent almost entire budgeted amount on R&D, the other agencies used up about one-tenth each of their R&D budget on technology development and technology transfer, and the remaining was utilised for implementing R&D activities. Almost all the responding R&D agencies have developed a number of technologies in partnership with the industry, indicating that they are generally keen on industry partnership for technology development and commercialisation.

B. Industry

Like in case with the R&D agencies, the industry too generally employs substantial number of well-qualified personnel having Ph.D., Master and MBA degrees in their in-house R&D units. In addition, most of these also have Partnership Management Groups. R&D investment of industry is usually in the order of only about 10-15% of their annual turnover. However, there are exceptions like in case of Nicholas Piramal India Ltd, and Tata Steel where R&D investment exceeds Rs. 100 Cr. and 150 Cr., respectively.

Based on the responses received, **Table 7.3** shows the number of technologies developed through partnership by some of the industries in last 10 years. Of these, thirteen companies have either developed new technologies through partnership or have inducted / commercialised technologies obtained from R&D agencies. These companies mainly represent Biotech, drugs and pharmaceuticals, chemical and engineering disciplines.

Table 7.3 Number of Technologies developed by Industries through Partnership with R&D Agencies in Last 10 Years

Type / Discipline	Name of Industry	R&D Investment (% of Annual turnover)	New Tech developed through Partnership in last 10 yrs	Tech inducted / commercialised from R&D agencies in last 10 yrs.
Pharma	Nicholas Piramal India Ltd.	>100 Cr.	----	---
Biotech	Shantha Biotechnics Ltd., Hyderabad	10-15%	2	0/1
Drugs	J. Mitra & Co. Ltd., Delhi	Rs. 1.55 Cr. during 2003-04	3	3 / 3
Biotech	Dalmia Centre for R&D, Coimbatore	Rs. 100 lakhs	15	15 / 10
Microbiological & Chemical Sc.	Arbro Pharmaceuticals Ltd., New Delhi	17.59 lakhs	----	NA
Biopharma / Biotech	Millipore India Pvt. Ltd., Bangalore	NA	NA	NA
Agriculture	Sungro Seeds Ltd., Delhi	----	100 new products	100 / 100
Petrochemical Production	Indian Petro-chemicals Corp. Ltd., Vadodra	Rs. 10 Cr.	8	8 /8
Chem (Agro)	Rallis Research Centre, Bangalore	Rs.10 Cr.	Nil	Nil
Chemical	Godavari Sugar Mills Ltd., Mumbai	Rs.80 lakhs	2	
Chemicals, drugs	Rubamin Limited, Vadodra	--------	------	-------
Chemicals & Paints	Mathur Corr-Tech (P) Ltd, Coimbatore	Rs 3 lakhs	6	------
Steel	Tata Steel Mines Division, Jharkhand	~ Rs 150 Cr.	1	1/0
Engineering	Tata Refractories Ltd., Orissa	~Rs.15 Cr. (T/O Rs. 400 cr.)	Nil	Nil/Nil
Electro-chemical	High Energy Batteries India Ltd, Pudukottai	~Rs 434.01 lakhs as on 31.3.2005	3	1/1
Consumer Electronics	Ahuja Radios, New Delhi	Rs.44 lakhs	Many	Nil/Nil
Electronics	Omtek Electronics (P) Ltd., Bhubaneswar	Rs. 50 lakhs (T/O Rs.1.50 cr.)	Nil (36 Self developed Tech.)	36 / 13
Engineering	Basic Technology (P) Ltd., Kolkata	Rs. 20 lakhs	10	6 / 4
Mines	Satna Cement Works, Satna	~Rs.1.5 lakhs	Nil	Nil/Nil
Engineering	St. Josephs Tiles, Ernakulam	--------	1	1/1
Engineering & Infrastructure	Shriram Energy Systems Ltd. Hyderabad	------	1	Nil/Nil
Engineering	Abaqus Engg. India, Chennai	Nil	Nil	Nil/Nil
Engineering	Ador Fontech. Ltd., Bangalore	Nil	Nil	Nil/Nil
Atomic Energy	Indira Gandhi Centre for Atomic Res., Kalpakkam	----	----	----

C. **Intermediaries**

Six of the ten respondent intermediary agencies included the ministries, namely, DST and DSIR; and the government agencies, namely, CSIR, TIFAC, TDB and NRDC. The remaining 4 respondent intermediaries included one each academic and private TTO's, namely, FITT of IIT Delhi and Waterfalls Institute of Technology Transfer (WITT); and two international organisations, namely APCTT and a non-profit organization, International Service for the Acquisition of Agri-biotech Applications (ISAAA).

7.3 Questionnaire Responses Specific to R&D Agencies

7.3.1 Orientation of R&D Agencies towards Partnerships

Responses to the multiple-choice questions related to the objectives, focus, and sources of demand of R&D activities are shown in **Tables 7.4**. It may be added that as the number of respondents in agricultural sciences was quite small, the data on agricultural sciences has been included as part of the biological sciences.

The analysis indicates that objectives of most of the R&D agencies were demand driven and futuristic in nature. The component of inquisitiveness driven R&D activities was just about 1/3rd of the total response. Most respondents from engineering discipline satisfied these observations while in case of biological and chemical disciplines the respondents gave equal weightage to the inquisitiveness driven research as well.

The focus of R&D activities of most of the responding R&D agencies was on technology innovation and generation, followed by developing links with industry /academia and technology up-gradation. There was less emphasis on the spearheading growth of SMEs. As regards the sources of demand of R&D activities, they were largely determined by areas identified by the government, followed by technology processes. There was limited drive owing to market / product - orientation and economic independence. The observations generally cut across all the scientific disciplines.

Responses to the multiple-choice questions related to the focus on prospective customers / user agency are shown in **Table 7.5**. Most respondents from the R&D agencies consider both national and international user agencies as their prospective customers for their product, viz., new knowledge, technologies, processes etc. for promotion of technical knowledge and income generation for the institute. None of responding agencies consider

Table 7.4 Objectives, Focus and Sources of Demand of R&D Activities of the Responding R&D Agencies

	Total Number	S&T Discipline					
		Bio	Chem	Phys	Engg	Oceano-graphy	Academics
Number of Respondents →	46	11	5	12	16	1	1
Objectives of R&D Activities ↓	Number of affirmative responses						
Demand driven	29	5	4	6	14	0	0
Futuristic	30	8	4	5	13	0	0
Inquisitiveness Driven	17	6	4	2	3	1	1
Focus of R&D Activities ↓	Number of affirmative responses						
Technology innovation / generation	41	10	5	11	14	1	0
Developing links with industry /academia	29	6	3	9	11	0	0
Assisting industry in Improving production processes for reducing cost	27	5	4	8	10	0	0
Technology up-gradation for improving current product models	25	5	4	8	8	0	0
Creating next generation product models	16	3	3	5	5	0	0
Providing tech-training to entrepreneurs	14	1	3	5	5	0	0
Spearheading growth of SME's	4	1	2	1	0	0	0
Gaining economic independence	3	1	1	1	0	0	0
Sources of Demand of R&D Activities↓	Number of affirmative responses						
Areas identified by govt. departments	41	9	4	12	14	1	1
Technological process	29	7	4	7	11	0	0
Market / product	14	4	3	3	4	0	0
Economic independence	5	0	1	3	1	0	0

international user agencies as the exclusive users. These agencies strive to remain at par with the international industry and academia to knowledge generation. The R&D agencies involved in defence and strategic areas however focus only on national user. Dr Shashidhara from CCMB mentioned that their institute's decision on national or international user agencies depends on the nature of product. If the product has only national or strategic interest and the idea is to explore its utility the national users are targeted. On the other hand, if it were an industrial product needing large investment for further R&D work, the target would be international agencies. In another national laboratory, CSMCRI, the industrial research is mainly being carried out for the national industries and occasionally only for the international agencies, whereas knowledge output in terms of publications and patents is mostly for the international users.

The significant methods used by R&D agencies for approaching the user agency included trade fairs / exhibitions, media and sending direct information to prospective partners. In some cases the interfacing agencies were also considered relevant. Surprisingly,

Table 7.5 User Agency Focus and Methods in Place for Approaching the User Agency

	Total Number	S&T Discipline					
		Bio	Chem	Phys	Engg	Oceano-graphy	Academics
Number of Respondents →	46	11	5	12	16	1	1
User Agency Focus ↓	**Number of affirmative responses**						
National agencies	15	2	0	7	6	0	0
International Agencies	0	0	0	0	0	0	0
National and international both	29	9	5	4	9	1	1
Methods in place for approaching the User Agency ↓	**Number of affirmative responses**						
Participating in Trade fairs / exhibitions	26	6	3	4	13	0	0
Publicity through interviews / news items in media, newspapers, technical magazines/ floating advertisement	25	9	3	3	8	1	1
Direct information to prospective partners, viz. relevant raw materials suppliers, companies with competing products, importers of product and having existing infrastructure for manufacturing	16	3	2	3	8	0	0
Interfacing agencies such as NRDC for match making	12	3	2	3	3	1	0
Participating in conferences / seminars, industry meets, courses	10	0	0	5	5	0	0
Mailing information to Industrial Associations / Clusters like STEPS	9	1	2	0	6	0	0
Mailing info to project mangers of sector specific industrial park	7	0	2	0	5	0	0
Through funding agency	3	0	0	1	0	0	0
Patent Exchanges	1	0	1	0	0	0	0

the role of funding agencies, patent exchanges and industrial associations was considered negligible or limited.

All the CSIR institutes have a Group / Division for Business Development and Management which in coordination with the scientists liaises and markets the innovations and IP of the institutes. The respondents of this question were the scientists and the Head / member of the Business Development Division. Most of them indicated that it was the Director, who mostly directed the business development activities on case-to-case basis without any specific system and separate budget. The Business Development Group / Division was often not being manned by competent persons and a scientist, who could not prove his worth in R&D, was generally given charge of this division. It was absolutely essential that the scientists and the managers of this group be competent and have mutual respect and trust, which is seen only in some such institutes like SERC, NCL, IMT, NBRI etc. that are very active in their respective areas.

7.3.2 Issues on Intellectual Property and Knowledge Generation

Most of R&D agencies possess New Knowledge / Commercialisable Knowledge / Technology / Process, in which industry could be interested. The product of R&D agencies working in strategic areas, such as defence, does not go to industry. The research outcome of the R&D agencies is communicated through peer-reviewed publications, patents. As mentioned by Dr Nagesh Iyer, knowledge is the subject, which is disseminated through publications, patents, courses etc. and is also used to solve industrial problems. A large number of industries, considering training / expertise and knowledge the scientists possess, are coming to the R&D agencies for contract research work and consultancy to set up their new initiatives.

The IP generated by the R&D agency rests with the R&D agency in case of all the in-house projects in which the institute generates unencumbered patents, which could be marketed for licensing and is co-shared in case of externally funded projects. The IP generated under a partnership (contract) programme with industry are normally shared between R&D agencies and the concerned industry on a mutually agreed basis.

7.3.3 Internal Regulations of R&D Agencies vis-à-vis Employee Scientists

In connection with a question on the rules of the R&D agencies that prevent their employees from being involved in a) partnerships with industry, b) licenses, c) joint ventures, d) floating start-up / spin-off company while holding the position in the organisation and the possibility for a scientist to quit the institute along with his/her IP for floating his/her own company, the respondents mentioned that they can forge partnership with industry with the permission of the Director and as per the guidelines of the administrative agencies, which keep revising for this purpose from time to time. Some respondents from defence sector however mentioned that their organisations do not permit such association, as it is a closed sector.

There are certain set rules and regulations that prevent an employee to take part directly in a company. However, with appropriate permissions one can be on the Board or be a consultant. At the moment, CSIR does not allow scientists to start companies on their own.

Being govt employees, scientists are restricted from profit oriented self-employment schemes, but they are entitled to take entrepreneurship after taking permission from the head of the institute or work as a consultant to an industry. Scientists can be in the management of the companies. As regards the possibility for a scientist to quit the Institute along with his/her IP for floating his/her own company, 13% respondents were not aware of any such possibility; 38% indicated that it was not possible, 49% indicated that such a possibility exists with the IP being owned by the parent organisation. CSIR now permits this while extending the concerned scientists leave without pay for a defined period for trying commercial viability of IP developed by him under the 'Scientist Entrepreneur Scheme'. Scientists can have an agreement with CSIR for licensing / assignment.

In essence, scientists as employees in R&D agencies function under regulations for building independent relationships with industry and at the same time have limited awareness about the related initiatives of the R&D agencies towards using their IP for becoming entrepreneurs.

7.3.4 On Feedback from the Technology Taker / Industry on Technologies Developed and Transferred by R&D Agency

The respondents were asked to share the feedback of the industry on their partnership projects for technology development and technology transfer. All the responding agencies (except one) were receiving feed back through their Business Development Groups. One of them mentioned that this question was not applicable to the R&D agencies working in strategic areas. Except one, 29 other respondents mentioned that they were receiving the feedback of the industry on their technologies through a customer satisfaction evaluation form, intensive interactions in the periodic review meetings, panel discussions and get together with the industry. Experience of the industry has been average to excellent. They were in general of the view that due to govt rules and regulations industry was afraid to give the clear picture of production. In the academic sector such feedbacks are not received very often. A specific recommendation was made that: 'Hand holding was required right from identifying the partner to marketing'. Therefore it could be concluded that most R&D agencies have well-established mechanism for obtaining the feedback of industry on their transferred R&D products such as processes and technologies.

7.4 Questionnaire Responses Specific to Industry

7.4.1 Acquisition of R&D Inputs (New Knowledge, Technology, etc.)

A multiple-choice question was posed to get the information from industry on the need of acquiring R&D inputs, including new knowledge, technology etc. for fulfilling their targets. Out of 25 industry respondents, 95 % respondents felt the need to acquire R&D inputs for meeting their requirements. Of these, 79% were having their own in-house R&D units, out of which 26% also outsourced the R&D inputs. The remaining 21% responding industries depended on outsourcing alone. Thus the respondents generally realised the importance of R&D inputs and acquire them either by in-house R&D or by outsourcing or both.

As regards the R&D activities, the in-house R&D units of all the responding industries were involved in (a) technology innovation and generation; (b) improving production processes to reduce production cost and improve quality; (c) technology upgradation for improving current product models; and (d) creating next generation product models. These activities were often driven by the industry demands. Significant factors in determining the sources of demand of the activities in industry in order of importance included market / product orientation (15); self-assessment by the organisation for increasing productivity, reducing cost, diversification, etc. for sustaining competition (9); internal / global competition (9); technological process (8); and areas identified by the government / strategic departments (2).

Fifteen respondents indicated their preference for the source of R&D inputs, whether in-house or outsourcing from national or international R&D agencies. 5 of these depended only on their in-house R&D, out of which 3 preferred both sources and 2 only Indian sources; 5 respondents, who had their own R&D units and were also outsourcing out of which 4 preferred both the sources and only one preferred Indian source; and out of 5 respondents who depended only on outsourcing for the R&D inputs 3 indicated both and 3 indicated Indian sources.

In essence, the preference was given to outsourcing from both national as well as international R&D agencies. The respondents in general mentioned that the selection, whether Indian or foreign, depended on the capability, importance of technology sought; cost-effectiveness; market for the final product (foreign market to promote this new innovation worldwide.); and availability of data to substantiate the claim, latest technology.

The respondents further indicated that for selecting the right source, whether Indian or foreign, for the desired R&D inputs the methods such as technology licensing info; internet surfing for publications; feedback from their representatives in India and abroad; seminars, formal and informal interactions, visits and result of the previous work were used.

7.4.2 Awareness about the Indian Sources for R&D Inputs

23 respondents attempted the question regarding the awareness about the Indian sources such as R&D agencies and academia, for R&D inputs, out of which 22 had approached the Indian R&D agencies for technical know how, technology, contract research, consultancy, data exchange, etc., while the remaining one having own in-house R&D neither knew the Indian sources nor ever made any attempt to know the same.

7.4.3 Funding from Government and Financial Institutions

On the query, if the industry was approaching the government or the financial institutions for funds and if not awarded, would it still support the same project on its own, 8 did not reply; and only one respondent mentioned that they will not fund the project. One respondent was not certain whether they would support the project. The remaining 15 respondents were of the view that if the programme/project was within the means of budgeted R&D expenditure and could bring new technologies, it would have been supported.

7.4.4 Role of R&D in industry

In response to a question about the role of R&D in educating people working in the industry, particularly with reference to research activities rather than R&D agencies, most of the respondents acknowledged the importance of research activity in the enhancement of product quality, reliability, cost reduction, energy conservation, technology up gradation and diversification. They felt that the role of R&D was important in order to make the awareness of latest technologies developed and their implementation in the industry as well as the benefit to be accrued from their use such as improving the working standard. It primarily inculcates time and cost consciousness and becomes more product-oriented, trains the personnel for modern methods, thinking creatively to find applications for use of common man. R&D helps in identifying proper research projects relevant to industry and focussing the programmes properly.

7.4.5 Institutional and Market Disincentives to Partnership

In regard to the question on whether there were institutional and market disincentives to partnership, only 36% respondents felt in affirmative and indicated that the powerful disincentive to partnerships is the concern of industry on cost and confidentiality of the information as the industry is afraid of leaking marketing information of products developed by R&D organisation to other parties. However, there was a realisation that the industry has to accept the risk and the loss, if not successful.

7.5 Questionnaire Responses Specific to Intermediaries

Ten respondents from Intermediary organisations included the functionaries of NRDC of DSIR [5.4.1(i)], TIFAC of DST [5.4.1(v)], PATSER of DSIR [5.4.1(vi)], TDB of the DST [5.4.1(viii)], NMITLI of CSIR [5.4.1(x)], DPRP and PRDSF of DST [5.4.2(ii)], and FITT of the IIT Delhi [5.6.1], which have been described earlier in Chapter 5. The other Intermediaries were the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), Asian and Pacific Centre for Transfer of Technology (APCTT) and Waterfalls Institute of Technology Transfer (WITT) and the paragraphs below list out the mechanisms followed by them for facilitating the transfer of technology.

International Service for the Acquisition of Agri-Biotech Applications (ISAAA) [206] is a non-profit organisation that delivers the benefits of new agricultural biotechnologies to the poor in developing countries. It aims to share these powerful technologies to those who stand to benefit from them and at the same time establish an enabling environment for their safe use. Individual countries submit request for specific technology and ISAAA identifies and brokers technology transfer from industry institutions in developed countries to public sector institutions in these countries. Criteria adopted for evaluation of supported projects are product development and commercialisation; HRD and institutional capacity building.

Asian and Pacific Centre for Transfer of Technology (APCTT) [207] is an organisation that assists the members and associate members of ESCAP (UN Economic and Social Commission for Asia and the Pacific) through strengthening their capabilities to develop, transfer, adapt and apply technology; improve the terms of transfer of technology; and identify and promote the development and transfer of technologies relevant to the region. It has launched programmes as Tech Transfer Network (IT based) (2004) to support SMEs in

Asia and National Innovation Systems (2005) to support MS Industries. The Criteria for evaluation of supported projects are the UN established project-based mechanisms.

Waterfalls Institute of Technology Transfer (WITT) [208], a private body, was founded in 1994 with the objective to undertake scientific research in the areas of technology development, transfer, adoption, absorption and upgradation of technology, particularly newly emerging and environment friendly technologies. The activities and functions of the Institute include collection, analysis, processing and packaging technological information for wider dissemination; organising training for personnel engaged in development and transfer of technologies; and assist, arrange or provide consultancy relating to technologies. WITT provides wide range of services, such as Status and Survey Reports, Analytical Projections, Policy Inputs, Training and Training Manuals, Publications and Updates, Technology Demonstrations, Information Packages, Technology Forecast & Assessment, Technology Adoption and Absorption, Technology Upgradation and Diffusion, Technology Profiles, and also advisory services to in-house R&D units in industry and scientific research foundations.

7.5.1 Purpose, Stage, Type and Extent of Funding provided under Various Schemes and Returns Thereon

Table 7.6 gives the purpose of support, stage at which the support was extended, type and extent of the support provided and the returns thereon under various schemes on the basis of the responses received from the intermediaries. This analysis indicates that these intermediaries support technology partnerships at one or the other stage of technology development chain and together they support all the stages of technology development right from basic research to commercialisation. Out of these, (a) only NMITLI of CSIR supports partnerships at basic research stage; (b) Only TDB extends equity support for proven technologies; and (c) only NMITLI supports partnership projects with less market certainty / technology certainty, thus covering maximum risk. Most of these programmes provide funds in the form of loan from 3 to 7 percent with NMITLI being the lowest and HGT, the highest.

7.5.2 Special Features, Driving Forces and Role Being Played by the Schemes, IPR and Monitoring Mechanisms

Table 7.7 indicates the special features and driving forces of the schemes as well as ownership of the IPR generated under these schemes and mechanisms for monitoring the supported projects. Notable aspects of all the programmes include encouragement to form the

Table 7.6 Purpose, Stage, Type and Extent of Support extended under Various Schemes and Returns thereon

Name of Agency/ Scheme	Purpose of Support	Stage at which support extended	Type of funding	Funding (% of total project cost)	Return on funding
NMITLI	Funding joint initiative of tech development	-Basic research -Lab level feasibility	Soft loan @ 3%	--- ---	Royalty / IPR sharing
HGT	Funding joint initiatives of tech. development by supporting SMEs to test and pilot trial for the lab technologies	-Production prototype and pilot plant; -Diffusion to other areas	Loan @ 6-7%	50%	Royalty / sharing IPR / direct cash
TDB	Providing soft loans to industry for setting up commercial plants	-Commercial introduction or operation use -Widespread adoption	Equity, Soft Loan @ 5%, and also Grants	50%	Loan / interest/ royalty
PATSER	Support development and demonstration of technology to enable industry to develop indigenous technology	-Engg. prototype and testing -Production prototype and pilot plant	Average project size is Rs. one Cr.	30-50%	Lump sum payment / Royalty
DPRP / PRDSF	DPRD support partnership project for joint tech development in drugs and pharma PRDSF Provides soft loan to industry for tech development in drugs and pharma	-Lab or bench level feasibility	DPRP: Grants to R&D agencies for partnership with industry PRDSF: loan @ 3% interest to industry	70% of recurring & 100% of equipment (30% by industry) 70% of project cost	IPR sharing / Royalty
NRDC	Providing soft loans to the project for upscaling laboratory technologies	-Lab or bench level feasibility -Engg. prototype and testing -Production prototype and pilot plant -Protecting IP -Commercial introduction or operation use	Conditional / soft loan	50%	Technology fee (royalty, premium)
APCTT	Scheme A: Commercial introduction; wide-spread adoption and diffusion to other areas Scheme B: Basic research; lab/bench level feasibility; Engineering prototype and testing and Production prototype and pilot plant.				
ISAAA	N.A. Contribution from philanthropic organizations/ industry & Implementation expenditure from host institute)				
FITT	Supports joint development of technologies by IIT and industry as well as transfer of technologies of IIT to industry. Return on funding is through royalty / down payment				
WITT	Business house for facilitating transfer of technologies				

partnerships, sharing of expertise and practical approach of industry in converting new developments into production. These programmes follow a competitive selection process and the most frequently used method for monitoring the supporting projects is through frequent periodic reviews and visits to the project site. All the programmes contribute to sustaining the economic growth. There is no uniform policy in sharing of IPR.

7.5.3 Outcome of Schemes since Inception in Terms of Knowledge / Technology / Product developed jointly by R&D Agencies and Industry

Table 7.8 lists the projects funded and technologies developed and commercialised along with the financial support and returns thereon under various schemes. Most of these intermediaries did not indicate the returns received from their supported projects. The analysis indicated that there are about 100 technologies / processes developed as a part of the support under these programmes. There appears to be some constraints in fully commercialising these outputs, as intermediaries have not indicated the returns on their investment.

The respondents were also asked to indicate the success rate of the projects supported under their schemes. The CSIR was not able to judge the success rate of the supported projects as the NMITLI schemes was only recently initiated. The respondent from TIFAC indicated that under statistical parameters the success rate was about 60% but from return of money point of view it was not more than 25%. 75% success rate was indicated for the TDB as well DST's supported projects. In case of APCTT and NRDC success rate of projects was nearly 100% and 30-45% respectively. FIIT evaluates the success in terms of conversion of their knowledge into product and therefore indicated that the success rate was highly fluctuating. The analysis indicates different rates of success in commercialisation of partnership projects.

7.5.4 Evaluation of Schemes and Necessary Reforms Made

The Intermediary agencies were asked to indicate how, and how often, their schemes were being reviewed, what had been the assessment, and what were the plans to bring reforms in the existing schemes. All the Intermediaries were in general of the view that revisiting the guidelines and monitoring and evaluation was very important. Reviews were generally undertaken once every five years, usually at the beginning of the 5-year Plan, except in case of FITT, which follows the practice of bi-annual reviews.

Table 7.7 Special Features and Driving Forces of the Schemes, Ownership of the IPR Generated under these Schemes, and Mechanisms for Monitoring of Supported Projects

Name of Agency / Schemes →	NMITLI	TIFAC	TDB	DSIR	DST	NRDC	APCTT	ISAAA	FITT	WITT
Special Features of Schemes ↓	Number of affirmative responses									
Part of history of organization's support to industry		√	√					NA	NA	NA
Industry driven	√			√	√					
Cost-sharing		√		√	√					
Stress on technology / commercial feasibility	√	√		√	√					
Flexibility		√	√							
Limit dead-ends										
Focus on spillover technologies with high social benefits		√								
Focus on developing economic benefit for early stage, high-risk, enabling innovative technologies			√		√	√	√			
Encourage formation of partnerships and consortia to promote tech. devel. / diffusion	√	√	√	√			√			
Meticulous and competitive selection process (evaluation of project's technical merit, commercial worthiness, potential for broad-based benefits)	√	√	√	√	√					
Well-managed and carefully evaluated Schemes	√	√	√	√	√					
Free training					√		√	√		
Driving Forces of Schemes ↓	Number of affirmative responses									
Sharing of cost (supply push)	√	√ Top	√			√ Top	√ Top	NA	√	NA
Sharing of expertise	√ Top	√			√	√			√	
Complimentarily	√						√		√	
Sharing of risk	√		√ Top	√ Top		√				
Access to knowledge		√		√	√ Top				√ Top	
Increased competition					√		√			
Have the end user of technology			√	√					√	
The industry knows what the market wants		√	√				√			
The Industry has good idea what future needs might be		√		√	√					
The Industry has existing outlets for products		√					√			
Industry's practical approach to convert new developments into production	√	√	√	√	√	√				
Role of the Schemes ↓	Number of affirmative responses									
Sustain Economic Growth	√	√	√	√	√	NR	√	√	√	NA
Enhance Citizen Welfare	√			√				√		
Achieve Government Missions		√								
Ownership of IPR generated under these Schemes↓	Number of affirmative responses									NA

Participating individuals		√	√	√	√	√	√			
Participating institutes	√	√	√		√	√	√	√	√	
Funding agency only	√	√				√	√			
Monitoring of supported projects ↓	**Number of affirmative responses**									
Area-specific Review Committees		√	√					√		NA
Periodic reviews and frequency	√ 4 times/yr	√ 2-3 times/yr	√	√ 2-4 times/yr	√ 1 times/yr	√			√	
Visit to project sites		√	√	√	√	√		√		
Strong communication					√		√		√	
Legal agreement on annual milestones					√					

Table 7.8 Projects Funded, Technologies Developed and Commercialised with Funding and Returns Thereon under Various Schemes

Name of Agency / Scheme	No. of Projects funded	No. of technologies developed	Output comercia-lised	Example of successful projects	Sector of development	Expenditure made so far (Rs. in Cr.)	Returns (Rs. in Cr.)
NMITLI	33	3 major and many minor are under pipeline	3	1) New anti-TB molecule 2) Anto-psoriatic formulation 3) Software biosuite	1.Medical 2. Medical 3. Biotech	~ 19 ~ 6 ~ 13	Soon Soon Soon
HGT	Over 50	Over 30	Over 10	-----	All areas	~ 50	10
TDB	131 of 107 industries				All areas	Rs 539.56 (As on March '04)	
PATSER	Over 150 at the total cost of 150 Cr.	65 completed	30		Drugs, food processing	~ Rs 60	~ Rs 3.5
DPRP	70	6 product / 13 process patents filed	One drug is in 2nd phase of human trials		Medicinal	Rs 9	
PRDSF	5	started in 2005	----	----	Medicinal	----	
NRDC	-----						
APCTT	-----						
ISAAA	Couple of technology transfer projects in South East Asia, Africa and Latin America						
FITT	--------------						
WITT	--------------						

Based on its 5-yearly reviews TIFAC discontinued some schemes, allowing the others to continue. It was supporting the entrepreneurs to test the technology for which 50% contribution was required to be made by the entrepreneur. Usually by the time the project was completed and termed as successful by the Monitoring Committee, the entrepreneur had already exhausted all its money and though the project was declared successful, the product for all practical purposes was not commercialised and with all good intentions, the entrepreneur was unable to return the money. As a matter of fact there has never been any prima-facie project for working capital, mutual research matching etc., which is very essential for commercialisation of a product developed under the project. Thus the project is not able to make any impact, as the product developed under it is not commercialised. The money return being a criterion for judgment of success of a project / schemes, generally high-end technologies and high-risk technology projects are not supported. Rather for selecting a project for support the financial capability of the entrepreneurs is mainly seen due to which high-end technology projects capable of making impact in the society are not taken up. This is a serious element in the HGT scheme. TIFAC has realised this problem and is now seriously thinking to revisit the financial guidelines. The evaluation parameters will also consequently be required to be changed. The analysis indicates the importance of evaluation and review of the schemes and continued modifications for effective outcome.

7.5.5 Expectations of R&D Agencies and Industry from the Institutionalised Mechanisms / Programmes

The intermediary respondents indicated that some of the expectations of the R&D Agencies and Industry from their programmes include achieving the set objectives and goals of the schemes in transparent manner; user-friendly and flexible funding mechanisms; timely and quick processing and funding of projects; timely monitoring and release of annual grants; easy terms and advance disbursement of funding; having multiple choices of partnership; and developing new technologies and products through partnerships in different time limits

Respondents from NMITLI, TDB, DST and FITT feel that their schemes fulfil all the above expectations, the ones from PATSER and APCTT feel that the schemes fulfil only partial expectations. No response was received from TIFAC and NRDC.

7.5.6 Impact of Schemes on Technology Development, Diffusion and Commercialisation, Their Assessment and Suggested Action for Improvement

In so far as the impact of the individual scheme is concerned, CSIR considers the NMITLI scheme as an important model of Public-Private Partnership supporting cutting edge research in projects involving high risk factor. The scheme also acclimatises the scientific fraternity to strict periodic reviews. TIFAC of DST is a powerhouse of knowledge and has strength in networking, and is in a position to provide technical help to the entrepreneurs at any stage through the experts whose services it is capable of hiring at any time. The impact of FITT is in establishing wide linkages with professional bodies such as industrial associations and successfully setting up of its own technology incubator. ISAAA and APCTT are playing a catalytic role, the former being particularly involved with in successful acquisition, transfer and commercialisation of biotech products. NRDC helps in multiple licensing of technology with complete technology package after its full development. PATSER contributes to enhancing the turnover of industry. In DST's Drug scheme several proprietary Indian Ayurvedic and Sidha medicines have been studied for standardisation, efficacy and safety profile resulting in filing of 6 product / 13 process patents in India and abroad. State-of-the-art infrastructure facilities have been created in several R&D agencies through this scheme. Finally, through TDB of DST many products and services have been introduced in the market for the first time, for example, before Shanta Biotech's becoming operational, the Hepatitis B was sold in the country @$15 /dose, but later the product price was brought down to $0.50 / dose.

Table 7.9 shows the individual assessment by the respondents about their schemes. Most intermediaries were of the view that their schemes were potential model for other technology programmes, were achieving their legislative objectives and were yielding valuable achievements. In addition to these, the respondent from TIFAC remarked that its capabilities should be associated not only for certifying the milestones of the project but also for steering the project and giving guidance right from the beginning.

Suggested actions for improvements largely included ensuring integration of assessment results and their early dissemination and capitalising on core competency of schemes, viz. ability to screen, select, monitor, and assess projects with technology and commercial promise. Some additional measures for improving success rate of TIFAC were indicated as timely technical input support, and handholding beyond trial of technology till product is reasonably commercially established using other programmes like PATSER.

In response to the query regarding the schemes, whether these should cover the high-risk, high payoff technologies beyond capabilities / hurdle rates of individual firms, over 77% intermediary respondents reaffirmed that this is essential as it would enable the development of high-end technologies and technologies that would make sizably impact on the lives of people.

Table 7.9 Individual Assessments of Respondents about Their Schemes

Name of Agency / Schemes →	NMITLI	TIFAC	TDB	DSIR	DST	NRDC	APCTT	ISAAA / FITT / WITT
Assessment of Schemes ↓	**Number of affirmative responses**							**NA**
These are achieving their legislative objectives	√	√	√		√			
These are carrying out excellent monitoring / assessment mechanisms	√		√		√			
These are establishing record of valuable achievements, some with great promise	√		√		√	√		
These are potential model for other technology programmes	√		√		√	√	√	
They need some refinement	NA	√	NA	√	√			
These are generating high social benefits in specific disciplines	Too early to judge		√		√			
Suggested actions for Improvement ↓	**Number of affirmative responses**							
Adopt a process involving round the year calling the proposals			√	√	√			
Distribute projects in various disciplines, while also retaining general competition	√		√				√	
Ensure integration of assessment results and their early dissemination	√	√	√		√		√	
Assure greater predictability and stability in funding, with the adage that uncertainty is the enemy of proposals for and execution of R&D prog.	√	√			√		√	
Capitalize on core competency of schemes, that is, its ability to screen, select, monitor, and assess projects with tech. and commercial promise	√		√	√	√		√	
Use more funds efficiently and effectively, consistent with the goals set for the scheme	√				√	√	√	
Recommendations for ensuring enhanced success rate ↓	**Number of affirmative responses**							
Frequent Assessment	√	√	√		√	√		
Tight Management	√		√		√	√		
Industry Leadership			√		√	√		
Shared Cost	√		√				√	

Different schemes impact the processes of technology development, diffusion and commercialisation differently. In some cases, the support was given to the projects involving high risk while the impact in other cases was felt by enhancing the turnover of the industry. Most respondents felt that the enhanced success rate of schemes may be ensured through frequent assessment, tight management and industry leadership.

7.6 Responses of R&D Agencies, Industries and Intermediaries on Partnership

7.6.1 Purpose of Partnership

Multiple-choice questions were given to R&D agencies and industry to elicit information on their forging the partnership with each other. The responses of the respondents from the R&D agencies and industry (*in italics*) are given in **Table 7.10**. Most R&D agency respondents described the purpose of partnership as new technology for existing products, cost effectiveness and technology upgradation, there was lesser emphasis on purposes such as increasing efficiency, acquiring new skills and sharing infrastructure. In case of industry the purpose of partnership included acquiring new skills, cost effectiveness and technology upgradation, but sharing of facilities was less emphasised.

Table 7.11 indicates the response of the industry to the partnership proposals of the R&D agencies and also the response of the R&D agencies to the partnership proposals of the industry. 80% R&D agency respondents and over 83% from industry experienced positive response from each other. The former felt that the reasons for the negative response of the industry were that most of the time the R&D agencies did not approach the right industry or the right person in the industry or approached the right industry only occasionally. The R&D agencies were not able to project their achievements and did not try hard enough as long process takes time when working out individually and the results were most often not very good and thus they soon gave up. In some cases, however, the Industry was not ready for adapting the Indian R&D product. Industry has lack of understanding of the science behind innovation. Presence of the required expertise in the industry was another reason for negative response.

The respondents from the R&D agencies made a number of suggestions to facilitate getting a positive response, which included the appropriate projection of the past performance and accomplishments; elaborate techno-commercial information having economic analysis of the technology clearly highlighting the economic gains while realistically estimating process economics; understanding of the working of the industry besides its specific requirements; and business type interaction between industry and developing agency. Scientists should work with the industry to solve the teething problem. The technology developed should be mature and not half-baked. Expeditious administrative clearances would certainly be of help.

A professional project evaluation to identify the prospects for commercialisation followed by framing a project document acceptable to the industry and a professional industrial liaison / tech-transfer system for the organisation, whose efficiency would be monitored periodically, should be the only solution for advanced processes and new products. However, with respect to problem solutions to existing processes and consultancy, this is not important. The strength of R&D lies in the former.

Table 7.10 Purpose of R&D Agency and Industry for Partnership with Each Other

	Number of Respondents	S&T Discipline				
	R&D ***Industry***	**Bio** ***Bio***	**Chem** ***Chem***	**Phys**	**Engg** ***Engg***	**Oceanography** **Academics** ***Atomic Energy***
Total Number of Respondents →	45 *25*	11 *8*	5 *5*	12 ---	15 *11*	2 *1*
Number of Respondents →	40 *22*	11 *7*	5 *5*	9 ---	14 *9*	1 *1*
Purpose of Partnership ↓	**Number of affirmative responses**					
New technology for existing products	31 *13*	9 *4*	*3* *4*	5 ---	14 *5*	0 *0*
Cost effectiveness	27 *14*	5 *4*	5 *1*	7 ---	10 *8*	0 *1*
Technology Upgradation	26 *13*	5 *5*	4 *3*	4 ---	12 *5*	1 *0*
Increasing efficiency	19 11	4 *2*	3 *2*	5 ---	7 *7*	0 *0*
Acquiring new skills	17 *15*	6 7	3 *1*	3 ---	5 *7*	0 *0*
Sharing facilities / infrastructure	16 *8*	5 *5*	2 *0*	4 ---	5 *2*	0 *1*
Validation/Clinical Trials	14 *10*	5 *6*	1 *0*	2 ---	4 *3*	2 *1*
Diversification	12 *11*	3 *4*	2 *2*	2 ---	4 *5*	1 *0*
Scientific surveys	7 *6*	2 *2*	0 *1*	2 ---	3 *3*	0 *0*

Table 7.11 Response of Partners to the Partnership Proposal

Responses of Partners	Positive	Negative	Mixed	NA/NR	Total
Feedback of R&D agencies on the response of industry to their partnership proposal	36 (80%)	5 (11.1%)	3	1	46
Feedback of industry on the response of R&D agencies to their partnership proposal	15 (83.3%)	3 (16.6%)	0	7	25

7.6.2 Formulation of Partnerships with or without the Help of an External Agency

In most of the instances the partnerships were forged by the R&D agencies as well as industry entirely without the help of an external agency. In these cases the partnership by the R&D agencies was forged either a) directly by the scientists; or b) companies came forward on their own; or c) directly dealing with sponsors or through open tenders in newspapers; or d) with the help of experts associated with the Research Councils. The remaining about 20% respondents had been approaching each other directly as well as through the external agency.

The respondents from the R&D agencies mentioned that partnership projects, finalised by the scientists and sponsors were more fruitful as approaching directly had its advantages in terms of understanding, monitoring, better coordination, and implementation. The role of external agency was limited in building the partnership. External agencies were not aware of the expertise available with the R&D agencies. It leads to freedom to work, openness and integrity and high transparency in the system. Moreover too many consuming procedures were added by involving an external agency.

On the contrary, the involvement of an external agency like NRDC helped in increasing the industry contacts and has higher success rate of partnership. In this case the scientists can concentrate on technological matters and admin solutions are taken care of by the external agency.

Dr Nagesh Iyer of SERC Chennai was of the view that the marketing agency should be approached for help if R&D agency / scientist has to market a product, while they themselves can project their knowledge and expertise. Experts are known by their publications, successful projects, and projection through web site etc., many times through the clients of the R&D agencies themselves. As per Dr RP Das of RRL, Bhubaneswara a suitable external agency can do a better professional job, if it has a defined minimum number of projects for successful marketing to get its commission. Perhaps a graded commission will be a better option. Marketing by scientists is more knowledge-centric and so convenient when a project is being marketed to ministries and academic bodies.

The view of the industry respondents on involvement of external agencies was that it was easier to forge partnerships without any external help, as there was a lot of flexibility, which could be accommodated by mutual consent. Once problem was well defined, clear and of mutual interest, there was no need of an external agency, which increased the paper work. Thus direct interaction was the best approach. One respondent however indicated that the R&D agency had a bit of a bureaucratic element and the external agency had the advantage of speeding up things. In essence, both partners prefer to forge partnerships directly rather than seeking the help of an external agency.

7.6.3 Reasons for Failure of R&D Agency - Industry Partnership

(A) For Technology Development:

In so far as the failure of the some projects is concerned, R&D agencies ascribed it to the slow speed of administrative actions in the R&D Agency / Industry; lack of experience of the R&D agency in identifying and developing technologies into products for dynamic commercial markets; lack of stake of industry in the Government funded partnership projects; differences in motives and objectives of partnership not well recognized / accommodated; lack of mutual understanding; inefficient monitoring and review mechanism; cultural differences; difference in structure of the partner organisations; and inappropriate technical participation of the industry partner, in that order.

In view of the Industry, the failure of partnership was due to the slow speed of administrative actions in the R&D agency / industry; inefficient monitoring and review mechanism; and differences in motives and objectives of partnership not well recognized / accommodated. In addition, some respondents also referred to cultural differences; difference in structure of the partner organisations; communication gap; non–reproducibility of claims; lack of flexibility in approach to changing times and needs; lack of commitment, more academic outlook of R&D agency; lack of mutual understanding; and lack of sensitivity to costs also as the possible reasons. It was also stated that Indian R&D lacks equipments input to convert the knowledge for industrial products through indigenously developed process equipment.

(B) For Technology Transfer:

Both R&D agency and industry respondents strongly felt that the main reasons for the failure of technology transfer in a partnership were unripe / unproven technology; their distrust on the technology transfer programmes of the intermediary agencies and unwillingness to share the benefit to be accrued from transfer of technology with them and lack of foresightedness on availability of raw material in sufficient quantity and market; Government restrictions; and improper written agreement, in that order.

Some other factors cited by the R&D agencies for the failure of technology transfer on their part were insufficient homework regarding competitive multi-disciplinary technologies and lack of economic analysis during technology development; poor planning; pushing technologies without proper review; coordination of technology transfer related activities by developer only, who may be dispassionate during transfer process, and not by a professional team; unrealistic criteria / target; lack of experience in identifying and developing technologies into products for dynamic commercial markets; lack of transparency in the system; serious workers not being rightly encouraged by the system due to ego and negative thinking of seniors; and their having at the best a prototype of something, which is already available in a proper shape in international market. On part of industry, its lack of knowledge on technology; lack of trust for deliverables and higher trust in imported and proven technology because of the availability of better technology from abroad; lack of will to overcome the teething problems; violation of technical norms by the industry partners, who prefer cheaper inputs resulting in failure during trials; and logistical problems. In some rare technologies the change in the industry scenario by the time partnership project is conceived and realised may make the technology less viable.

R&D agencies further mentioned that lack of Government protection, which is vital for preset R&D status in the country; differences in motives and structure of the partner organisations; objectives of partnership not well recognized and accommodated; slow speed of administrative actions in the R&D agency and industry; coordination gap; and lack of confidence between the agencies on the scale up-feasibility of certain technologies also resulted in failure of technology transfer.

Industry respondents indicated that beside lack of sense on scale of operation, other reasons could be specific to area / project, such as technological imperfection and proper financial support for the introduction of the result. The priorities of the industry may have changed by the time the results are out of a particular partnership. Hence it is difficult to clearly define.

In view of the intermediaries, the reasons for failure of technology development and technology transfer were again unripe and unproven technology; inefficient monitoring and review mechanism; slow speed of administrative actions in the R&D agency and industry; differences in motives and objectives of partnership not well-recognised and well-accommodated; lack of experience of the R&D agency in technology identification/development/transfer; lack of foresightedness on availability of raw material in sufficient quantity and market; differences in cultural and structure of the partner organisations; and improper written agreement, generally in this order. Furthermore it was felt that industry was not always honest and considered government money from schemes such as TDB, PATSER, HGT, etc. as easy money and had no stake in the government funded partnership projects. R&D agency and industry did not want to share the benefit to be accrued from technology partnership with the agencies supporting the partnership programmes.

The analysis indicates that the principle reasons for failure of partnerships are the inadequacy of administrative procedures, inefficient monitoring and review mechanisms, unripe and unproven technology, and the differences in motives and objectives of partnership not being well-recognised and well-accommodated.

7.6.4 Factors for Success of R&D Agency - Industry Partnership

Table 7.12 shows the responses indicated by the R&D agencies, industries and intermediaries on the reasons for the success of research-industry partnership. It may be noted that most of them ascribe the success to factors such as timely completion of targets, commitment towards work, managing expectations by agreeing to a firm plan / programme of mutual benefit and setting priorities. However, other reasons listed in this Table are also not less significant.

From the inputs received it is evident that most (>80%) of the projects implemented through R&D agency - industry partnership for technology development were successful. The respondents from R&D agencies ascribed the success largely to the experience, skill and expertise of the scientists, but some respondents also felt that novelty of a technology and its efficiency, economics and ease of implementation also led them to enter into partnership with industry. Successful project planning would require clear definition of objectives and its understanding; science based approach; clearly identified output market demands; management inputs / support; motivation among the partners; and good documentation.

Table 7.12 Responses of Stakeholders on the Reasons for Success of Research-Industry Partnership

Reasons for Success of Research Industry Partnership	Times indicated by R&D Agencies (42)	Times indicated by Industry (23)	Times indicated by Intermediaries (10)
Timely completion of targets	30 (4 time top priority)	16 (3 time top priority)	7 (1 time top priority)
Commitment towards work to be demonstrated and not just stated	30 (5 time top priority)	15 (4 time top priority)	5 (1 time top priority)
Managing expectation by agreeing to a firm plan of mutual benefit	23 (16 time top priority)	14 (9 time top priority)	3 (2 time top priority)
Setting priorities	15 (6 time top priority)	12 (3 time top priority)	6 (3 time top priority)
Shared resources– human, infrastructural, financial	20 (2 time top priority)	7	6
Partnership founded on faith, understanding and mutual respect	16 (1 time top priority)	3 (1 time top priority)	4
Flexibility of approach	14 (1 time top priority)	7	3
Well structured Management and review	11 (1 time top priority)	7	4
2-way communication, casual tele-calls	10	9	3
Focus on result rather than process	11	9	5
Room for improvement by doing self-critic and improving performance	7	5	0
Preparedness towards change over long-term length of the Partnership	3 (1 time top priority)	6 (1 time top priority)	2
Working environment of the partner organizations	14 (1 time top priority)	2	2
Incentives through IPR	11	4	3
Well recognized and accommodated differences in objectives	3	6	1
Diverse inputs of the partners are valued	3	1	2
Fair/transparent/open selection of partners	6	0	2

For success of subsequent implementation of a partnered project the highly needed ingredients on part of the industry were thought of as continued supply of material by the industry and availability of facilities and infrastructure, and interest and confidence in technology. The project Implementation process required appropriate planning and execution of the activities; frequent interactions with customers at various stages; working in collaborative mode for developing technologies with industries having their R&D; support from top management; contribution by all stakeholders; periodic reviews, phased execution; in that order.

7.6.5 Sharing of the outcome of partnership between R&D Agency and Industry

Most of the responding R&D agencies have given their technologies to the industry on exclusive basis and very few on non-exclusive basis and some have given on both exclusive as well as non-exclusive basis. The industry respondents indicated that the outcome was shared as per the initial agreement, which includes outright purchase on exclusive basis, patent ownership in certain proportion, outcome of contract research on exclusive basis and further upgradation / expansion on sharing basis. While contract research projects were always on an exclusive basis, the in-house developments / mature technologies could be licensed on exclusive / non-exclusive basis, depending upon the nature of projects and contractual arrangement with the partner industry. It may be noted that in the academic sector the knowledge is available for all the users.

7.6.6 Success Rate of Commercialisation of Outcome of Partnership Projects

20% R&D respondents mentioned not applicable as they were dealing with either defence or strategic areas and 17% were still implementing the partnership projects. 57% R&D respondents however indicated successful commercialisation of the outcome of their partnership projects. Only 6% mentioned that the outcome could not be commercialised due to reasons including a) availability of better, imported or tried technology / know-how; b) lack of rigorous techno-economic analysis of the developed technology; c) reluctance of industry in coming forward in case of biotech products that are expensive and involve risk; d) lack of scale-up economics; e) inappropriate government policy; and f) change in priorities of the industry due to fluctuating demands.

In so far as industry was concerned, 24% respondents indicated that they never partnered with any R&D agency. 42% respondents were able to successfully commercialise the results; partnership projects were still ongoing with 17% respondents; and 17% could not commercialise the results as the results either fell below expectation or took too much time in which the market lost interest in the product.

7.6.7 Multiple-time Partnership between the Same R&D Agency and the Industry

Over 80% respondents from R&D agencies and over 70% from industry partnered with the same industry / R&D agencies at least 3-5 times and most of them had long-term partnership relationships. An example of one such continuous partnership is from RRL-T, where Dr KGK Warrier mentioned that his research group has a consortium of industry in the area of traditional ceramics where 5 companies are regular partners. This is an advantage since it gives opportunity for the R&D agency to interact directly with them and regularly maintain contact. The industry has developed confidence in the group / in the organisation and therefore, the bond is strong. If such bonds can be established with bigger companies the technology interaction becomes much easier and handy. Formation of a consortium and to keep it active requires constant efforts and initiatives on part of the organisational management. The positive experience of building partnership generates confidence leading to formulation of long term partnership relationships. The measures should be taken for forging long-term relationships

7.6.8 Motives of Partners for Partnership

Various motives of the R&D agencies and industry in partnering with each other are listed out in **Table 7.13**. Gaining insights into the research problems of the industry, applying knowledge to solve real business problems, and building on excellence and reputation are the most significant motives of R&D agencies. They did not consider sourcing job opportunity and sharing risk as important. In so far as the industry respondents were concerned, they indicated benefiting from new ideas of R&D agencies, establishing links with their national and international networks, complementing resources and using technologies developed in R&D agencies for renewal and expansion of activities as the primary motives, and did not consider identifying potential employees as important motive for partnering.

In addition to above, some other motives indicated by the R&D respondents were converting research idea into a marketable product; marketing knowledge products developed in the R&D agencies, carrying out sponsored research for industry and other agencies and generating ECF; reducing the lag time in technology commercialisation; proper utilisation, commercialisation and propagation of technology; learning the use of product / process before further modification for faster development; provide support inputs to industry to explore more production capability by new design; development of process technology for industrial application and development of products for production by industry; enhance cost effectiveness and quality of products; refine expertise available; and ego boosting.

Table 7.13 Motives of R&D Agencies and Industry in Partnering with Each Other

Motives of R&D Agency for partnership with Industry	Times indicated by R&D Agencies	Motives of Industry for partnership with R&D agency	Times indicated by Industry
Gaining insights into the research problems of interest to industry for sourcing ideas for projects and new areas for research and training	24 (20 times high priority)	Benefiting from new ideas and past experiences of R&D Agencies	19 (5 times high Priority)
Applying knowledge to solve real business problems and widen the customer base	20	Using technologies developed in R&D Agencies for renewal and expansion of activities	15 (4 times high Priority)
Harnessing private and public funding (Funding for ideas that is more applied in nature)	18	Harnessing public funds by bringing additional financial resources to bear on research	7 (1 time high Priority)
Fulfilling mission of the R&D agency (by adoption of user agency)	13	Combating enhanced internal / international competition	14
Establishing links with industry's national and international networks	12	Establishing links with R&D Agencies' national and international networks	15 (5 times high Priority)
Building on excellence and reputation	19	Smoothing fluctuating in-house demand;	4
Complementing the physical, human and economic resource base (Sharing of domain knowledge)	6	Complementing physical, human resource base (accessing infrastructure, services, and multi-disciplinary expertise of R&D Agency)	14 (6 times high Priority)
Sourcing job opportunities	3	Identifying potential employees for industry	3
Sharing risk	2	Reducing risk and overall expenses by sharing costs, releasing staff time etc	6
Learning new skills and techniques developed in industry, such as concept of process development	12		
Learning business processes / new approaches to managing projects	10		
Helping the industry to contribute to economic development of the country	9		
Broadening the experience of employees to increase their intellect	8		
Attracting skilled personnel for coordinating applied R&D programs	6		

Additional motives for partnering with R&D agencies as indicated by the Industry respondents were sustaining the profits through improved process / product / information and skills; smooth marketing of the product; finding out broader areas of implementation than intended by the R&D agency through networking; and complying with statutory provisions.

7.6.9 Barriers to R&D Agency – Industry Partnerships

There are several factors that can act as barrier to the partnership building process. These could be based on the system and the competence of the partnering organisations and perceptions of the partners about each other.

A. System Related Barriers: The system related barriers in R&D agency – industry partnerships indicated by R&D agencies and industry are listed out in **Table 7.14.**

Table 7.14 System Related Barriers in R&D Agencies - Industry Partnering

Barriers	Times indicated by R&D Agencies (37)	Times indicated by Industry (23)
Lack of information and training	22	13
Institutional capacity	20	12
Financial capacity	13	11
Human capacity	14	8

Both R&D agency and industry were of the opinion that lack of information and training, institutional capacity (particularly in the physical and engineering sciences institutions), financial capacity and human capacity) acted as constraints to building partnerships.

B. Competence based Barriers: In the query on the competence based barriers to research-industry partnership the respondents were asked to restrict their choices to 5. **Table 7.15** shows the responses from the R&D agencies, industries and intermediaries. It may be seen that for factors on part of R&D agencies, all the three stakeholders consider their objectives to be not always industry oriented. While most intermediaries do not agree that there are no incentives for partnerships, the response of industry and R&D agencies is somewhat modest in this regard. Similarly, for factors on part of industry all the stakeholders agree that it has short-term goals with high pressure on time and that it is profit oriented.

C. Perception based Barriers: The factors as perceived by the respondents from the R&D agencies about industry and those from the industry about R&D agencies are indicated in **Table 7.16**. In this case too the respondents were asked to restrict their choices to 5. The need for a proven technology with guaranteed performance was perceived as the top priority factor in building confidence with Industry by R&D agencies. Both the partners considered the diversity of objectives, structure and working environment as important barrier. While

Table 7.15 Responses of R&D Agencies, Industries and Intermediaries linked to the Functioning of R&D Agencies and Industries

A. R&D Agencies; B. Industries; C. Intermediaries

On part of R&D Agency	Times indicated by			On part of Industry	Times indicated by		
	A 45	B 25	C 10		A 45	B 25	C 10
Promotion / Recognition: Depends on peer reviews and papers published.	33	14	8	Depends on technologies developed / commercialised.	18	18	7
Nature of Research: Not always industry oriented.	33	21	10	Directed, strategic and applied research	31	18	8
Objective: Knowledge generation and expansion with valuation through publications	30	17	9	Knowledge generation for development of product and process. Restriction on publication and communication with valuation through patents or revenue generation	22	16	7
Focus: Long-term research with no emphasis on urgency	27	18	9	Short-term goals with high pressure of time.	33	20	9
No incentive for partnership	21	14	3	No incentive for partnership	17	10	0
R&D Agency is non-profit	19	10	2	The Industry is profit oriented	26	13	6
Legal Protection of IP: may not be available / supported	11	14	1	Overstretched provisions of IP	15	10	1

Table 7.16 Factors as perceived by Respondents from the R&D Agencies about Industry, and Those from Industry about R&D Agencies

Perception of R&D Agencies about industry	Affirmations by R&D Agencies (45)	Perception of industry about R&D the Agency	Affirmations by Industry (22)
Industry needs proven technology with guaranteed performance	34 (14 times top priority)	R&D Agency may not have proven technology with guaranteed performance	15 (4 times top priority)
R&D Agency due to diverse objectives, structure and working environment is not sure if industry will appreciate the R&D products offered by them.	30 (6 times top priority)	Due to difference in structure and working environment Industry is not sure if R&D Agency would speak / understand / appreciate its language and concerns	16 (1 time top priority)
Industry has no faith on Indian R&D Agency, (e.g. due to security / confidentiality, IPR, patent considerations etc.) and may prefer international sources.	28 (1 time top priority)	R&D Agency may not give importance to security/confidentiality, IPR issues	10
Industry may want the technology free of cost / on exclusive basis.	24 (2 times top priority)	R&D Agency may not give technology on exclusive basis.	9
Industry has no faith in Indian R&D Agencies and feels that academicians / scientists talk in theory, do not have practical experience and live in ivory towers.	8 (6 times top priority)	R&D Agency has no respect for time schedules and budgets, delays and cost overruns;	17 (3 times top priority)

R&D agency perceived lack of appreciation by industry on their R&D products and lack of faith in their competencies as the primary factors limiting partnerships, the industry was afraid that R&D agencies may not understand and appreciate their language and concerns. R&D agencies further perceived that industry might want the technology free of cost. The significant perception of the industry has been that R&D agency has no respect for time schedules, budget and cost over-runs and it needs proven technology.

In addition to the above-mentioned reasons for lack of research – industry partnership caused either due to functioning of the two organisations or due to perceptions of the two about each other, most of the R&D agency respondents strongly felt that R&D agencies were not well informed about the need of the Industry and were generally not clear about how to make the first approach and whom to contact in industry. Some respondents however also opined that industry presently did not have any long term plan of its own for the Indian customer and did not interact with R&D agency on this issue; Indian industry did not take interest in joint research programmes with R&D agency or required investment of funds; even if the present rules were flexible, mindset restricted interpretation and brought rigidity; there was no proactive presentation for marketing products and services to industry by R&D scientists; there was a need to subsidise technology development for industry, as it is being done for grant-in-aid projects; and R&D agencies normally provided technology on bench/lab level, which was not feasible for the industry as the latter was interested in a proven technology that could be provided and immediately commercialised.

In connection with the commitment, which is presently mostly made on the table and on individual basis that one finds difficult to meet owing to the usual delays beyond control and which leads to a sort of lack of confidence among the industry to offer problem to an individual rather than to an institution, one of the respondent recommended that R&D agencies should inculcate confidence among the R&D personnel so that the commitment would be realised within the time frame as an institution. R&D agency – industry interaction was healthy, whenever the institute took the responsibility of industry related projects and organised the personnel towards objectives.

Some of the barriers indicated by the industry respondents were that organisational rules and regulations and administrative delays in R&D agencies in initiating the implementation of the projects; lack of interest and commitment of the team members for timely execution causing execution delays; and general ignorance of R&D persons of marketing intelligence; and lack of strict monitoring and control of the progress from the top management of the R&D agencies were also given as some other reasons by the industry respondents. Further, the government R&D institutions worked only part time for the industry, which diluted their concentration in partnering with industry. The dilution also occurred when the project fellows engaged on a project sometime concentrated on acquiring higher degrees.

Industry respondents also strongly felt that Industry was often not clear about how to make the first approach and whom to contact in R&D agency and was afraid that the R&D Agency may charge them for talking and may not be able to provide the complete technology package with the speed and in the time frame required by the industries. Further, who would compensate if the lab scale technology and untried know-how taken by the industry did not succeed.

The intermediaries indicated lack of awareness of each others' strengths and needs; lack of proactive role by either of the parties; lack of trust, respect, credibility and confidence of industry about timely and quality developments in R&D agencies; lack of capacity building and work culture in R&D agencies for public-private partnerships; absence of a policy framework for public-private partnerships were responsible for limited or complete lack of partnership; inadequate information about each other; concerns about confidentiality; conflict of interest; and industry not being R&D savvy and opting for turn-key projects in place of innovation as the main reasons for lack of research-industry partnership. In this context, the respondent from IIT (Delhi) mentioned that Sony has a policy to review their designs every two years and are in continuous process of innovation.

7.6.10 Factors Affecting Partnerships

a) Association with a Professional Body

Only 35% responding R&D agencies (IMT, CCMB, NCL, CEERI, NAL, SERC, IARI) are the members of the professional bodies. Most of the respondents felt that it would be useful for an R&D agency to be a member of a professional body because such organisational membership in scientific bodies can provide a lot to interaction with industry and other organisations at the national as well as global level, whereas an individual will have limitations. Such association can act as a platform for industry interaction for technology purgation, common pilot demonstration of new processes and exchanging views on the trends in development and technology transfer, which in turn will enable confidence building in the partnering organisations. These respondents however indicated that membership issue is a policy decision to be taken by the management of the organisations.

Four respondents, whose organisations were not member of any professional body, indicated that R&D agencies need not be a member of professional body as it may bring no benefit, would involve many legal problems and also would have limitations as these are public institutions.

As far as the industry is concerned, over 74% of the responding industries were members of the professional / industrial body and mentioned that the professional bodies were expected to play the role of an intermediary and facilitate interactions between industry, government agencies and academia on issues and problems of the industry.

b) Location and Climate Related Factors

Only 6% R&D respondents felt that the geographical locations of the agency and the extreme climatic and political conditions do not influence the partnerships with industry, but all others were of the opinion that these factors do influence the partnership. In addition, established image of the R&D agency and its inappropriate name were also mentioned as partnership influencing factors. As far as industry is concerned 84% respondents indicated that the geographical location being in the premises / vicinity of an industrial area / Research Park / R&D agency, and political and extreme climatic conditions do not influence the partnerships. Only 16% respondents, mostly SMEs, felt that the location of industry near the R&D organisations and in the industrial area / research park may enhance the cooperation.

7.6.11 Views of Stakeholders on Partnerships (Types and Modes; Appropriate Stage for Forging Alliance, Funding and Facilitating Databases)

a) Formal / Informal Partnerships

As shown in **Table 7.17**, most of the respondents indicated that as the industry would like to get its product at the fixed time and with proper financial agreement, formal partnerships with proper agreement bore more fruits because these would have well defined targets and the partners would not deviate from the goals. Formal partnerships enable serious involvement. Some however felt that informal partnerships could be more successful, in which the partners would develop personal contacts that would ultimately lead to formal partnerships. Such partnership could involve posing challenges to R&D agency and working on one to one basis and frequent meetings; travelling together and reviewing the progress frequently; informal sharing of information and working as a team; active participation in the process and knowledge sharing; and outlining the tasks and time limits with focussed and result orientated goals.

Table 7.17 Preference of Partners for Formal / Informal Partnerships

	Response of R&D Agency in %							Response of Industry in %				
	Total	Bio	Chem	Phy	Engg	Ocean	Academics	Total	Bio	Chem	Engg	AE
Number of Respondents →	43	11	5	12	13	1	1	23	8	5	9	1
Formal	32	8	5	8	11	0	0	15	7	2	5	1
Informal	11	3	0	4	2	1	1	8	1	3	4	0

The R&D respondents have suggested some ways to forge informal partnerships, that include constituting an apex committee with members from the two sides and allowing the scientists like those of the R&D agencies in USA to get involved with an industry to exploit research outcome or spinout and allowing its benefits to be received by the researcher concerned, which would encourage the researcher to work for industrial development in the country. IPR rules should be relaxed to an extent to attract researchers.

While respondents have given their opinion on formal or informal partnership, they have however mentioned that both forms of partnership are required. When the problem gets some encouraging results out of informal partnership, the confidence is established to formalise it by making it a funded project. If the approach is formal from the beginning, the time taken to formalise it, will itself quench the interest. Even writing letters again and again is discouraging to the industry. Industry may like to initiate by telephone followed by a Fax or e-mail.

b) Modes of Partnership

Various modes of partnership and preferences of the R&D agencies and industries are listed in **Table 7.18**. The most preferred modes of partnership are sponsored research, mobility of experts, information exchange and sharing infrastructure. Sub-contracting, informal involvement and consortia were indicated as less preferred modes. All R&D respondents considered formal association of the industry from the beginning of the project.

Table 7.18 Preference of Partners for Modes of Partnership

Mode of Partnership	Times indicated by R&D Agencies (43)	Times indicated by Industry (23)
Sponsored research (sharply focussed in terms of objectives, time, money, IP sharing etc)	32	18
Mobility of experts	28	11
Information exchange on new scientific and technological advances	22	13
Sharing infrastructure	22	10
Exchange of data	12	9
Consortia (provides capability to handle large multi-disciplinary projects)	7	2
Informal involvement of R&D agency in the activities of Industry	7	5
Sub-contracting	5	6

c) Appropriate Stage for Forging Alliance

On a query related to the stage of innovation chain that would be appropriate for forging alliance with partners, including R&D agency or any other partners like consultants, financial institutes, marketing agencies etc., most of the respondents indicated several choices, as seen in **Table 7.19**. It may be seen that while industry is generally ready to partner at any stage, R&D agency is more selective and prefers bench level feasibility, and also sometime, production prototype and pilot plant, engineering prototype and testing, and commercial introduction. Both R&D agencies and industry have indicated their keenness to join hands at the basic research stage itself. It may be due to the growing emphasis on research and its commercialisation in emerging areas like biotechnology and materials.

Table 7.19 Preferred Stage in Innovation Chain for Forging Partnership

Preferred Stage of innovation chain for forging alliance	Times indicated by R&D Agencies (40)	Times indicated by Industry (23)
Lab or bench level feasibility	30	13
Production prototype and pilot plant	27	13
Engineering prototype and testing	27	13
Commercial introduction or operation use	24	9
Testing and modification	21	14
Protecting IP	19	11
Basic research / discovery of a principle	18	12
Diffusion to other areas	18	9
Widespread adoption	17	8
Social and economic impact	16	13

d) Preferred Forms of Partnership Funding

Table 7.20 gives the preference for the kind of financial support. In response to a query on the preferred type of financial support for implementing a partnership project, such as government grant, equity, loan or a combination of these, most R&D agency (62.8%), industry (57%) preferred the government grants, while the least preferred support was through taking loans. The reasons ascribed for preferring government grants were that these helped in building up competency in key areas; were hassle free; had greater accountability; gave more flexibility to the research programme; and reduced time delay in commencing the programme. Moreover as the Indian Industry currently was looking at R&D agencies for carrying out more basic / fundamental research with long gestation period, grants were the most appropriate resource that allowed the R&D agencies to carry out work in the new technology areas without too much pressure. The argument in connection with loans was that it would only be a burden on the industry and there may be no seriousness on part of the R&D agency. It could however be given for certain projects where proven technology is implemented. The intermediary respondents on the other hand indicated equal preference for loans and equity.

Table 7.20 Preferred Forms of Partnership Funding

Kind of Financial Support	Times indicated by R&D Agencies	Times indicated by Industry	Times indicated by Intermediaries
Grant	27	12	1
Equity	5	4	3
Loan	3	0	3
Grant and Equity	4	3	0
Grant and Loan	2	4	1
Grant, Loan, Equity	2	0	2
NR	3	4	0
Total	46	25	10

The respondent from NMITLI was of the view that the equity is the best funding form as the industry may not be in a position to pay loan and invest in commercialisation of technology simultaneously and as grants will loose the sense of commitment.

e) Need for Technological information and Databases

A multiple-choice question was posed to all the stakeholders to seek their response on the need and availability of the information and databases, which could become handy in forging the partnerships. All the stakeholders indicated need of specific databases as shown in **Table 7.21**. Databases on technological information were considered important in forging partnerships. Most of the respondents from R&D agencies were maintaining some of these databases on their own initiatives. Information was fragmented and not centralised. Barring information on technical barriers to trade, all the stakeholders desired to have information on all the listed items. Many industry respondents recommended that R&D agencies should prepare a list of industry that could benefit from a particular agency.

Table 7.21 Need for Technological Information and Databases

Necessity of Databases / Information for forging partnerships	Times indicated by R&D Agencies (38)	Times indicated by Industry (19)	Times indicated by intermediaries (10)
Information on indigenous and foreign technologies	37	18	9
Patent Information	38	16	9
Information on Testing Facilities / Pilot Plants available in the country	32	18	9
Database on individual experts	33	14	8
Database on Certification / Regulatory Agencies for quality control and tests carried out by them	32	17	8
Information on Short Term Technology Training programmes	31	13	8
Information on technology development funding agencies	34	14	8
Information on Technical Barriers to Trade	18	15	8

7.6.12 Preference to Partner with SME / LSI

The R&D agencies and intermediaries were asked to share their opinion whether preference should be given to SME sector for forging partnership. Over 51% respondents from R&D agencies indicated that it should be free from restrictions as both SME's and LSI's have their importance. Equal opportunities should be given to both SME's and LSIs and the selection should depend upon the type of R&D envisaged, specific area of R&D, scope of R&D, location of R&D agencies, nature of technology and product. This will enable improvement in process / cost / quality of the existing products.

Only 29% respondents from R&D agencies preferred to partner with SMEs as they felt that large companies often resist innovation or change because they are worried about their stock value. Any project, which has substantial risk factor (as is the case in most of the R&D projects), would be of very low priority for large companies. They thrive on manufacturing of existing time-tested projects. Large companies induce change in their portfolios only by buying proven technology products or by taking over / buying successful small companies. In large industries the scope of partnership is less significant. On the other hand, small companies are more receptive to novel ideas that R&D agencies may have and can make a dent only when they innovate or develop new technologies; it creates better linkages and direction for them to work for R&D agencies; they involve more informal approach; and there would be a close monitoring of the approved schemes.

19% respondents felt that large-scale industries (LSI) should be the preferred partner due to strategic reasons and involving heavy investments; all these respondents were from the Engineering Sector. There support for LSI was due to the nature of R&D in the institute (such as NAL); availability and affordability of infrastructure, resources and willingness to take risks etc.; possible long term targets to excel and innovate rather than the SMEs, which may seek short-term solutions only that are difficult in R&D environment; and help to collaborate and develop technologies at a large scale which could then be transferred to SMEs. They also were of the view that it might widen the horizons and experience in international trade.

The majority of intermediary respondents indicated that SME sector should be given preference as they do not have the muscle and money power, whereas the large companies have the wherewithal to support their R&D programme. 30% respondents were of the view that there should be no restriction. Selection should depend upon technology (high end and high-risk technology). All the three categories of industry should be addressed according to their needs and works as each of these sectors have different problems. Only one respondent indicated preference for large companies as they will have capability and capacity to launch the technology / product in market in a big way.

7.6.13 Inputs of Stakeholders towards Developing a Broad Framework of Partnership

The partnerships take place in the broader perspective of policy with respect to the impact of technological change on products, services, processes and organisations; technology development advancements; role of industry in technology development, transfer and diffusion; organisational structure, attitudes and objectives supporting innovation and diffusion; ingredients of technology development, marketing and transfer strategy; role of policy instruments with reference to technology management at enterprise level; policy measures and fiscal incentives for partnerships; Government initiatives and reforms for enhancing partnerships; and global practice vs. Indian preference in technology partnership programmes. In this context, the responses of stakeholders were obtained on different aspects related to the partnership building processes and their significant observations alongwith the analyses are given below.

A. Impact of Technological Change on Products, Services, Processes and Organisations

Almost all the stakeholders indicated that the technological changes on products, services, processes and organisations have made revolutionary impact leading to the availability of better quality trained manpower; enhanced time and quality consciousness and competitive approach of working; development of eco-friendly technologies with maximised energy conservation; automation; better quality, economically viable and higher output oriented processes; improved designs; better quality, reliable and cheaper products; quality services provided based on customer demand; better efficiency and reduced cost of production; shorter duration for delivery; and higher profitability. As a result capability has been built to compete with the world market and the techniques developed by the Indian R&D agencies were better and cheaper as compared to the ones developed by foreign R&D institutions, thereby saving the foreign exchange to a large extent and giving overall better life for citizens of the country. Another major impact was that the technologies were fast getting obsolete and it needed continuous generation of new technologies in order to replace the outdated ones.

Some industry respondents indicated that if an R&D agency is up to date, it is likely to forge better partners with industry. Respect and image of both the organisations will also increase. A great deal in today's world revolves around technology and that the technological processes have excellent positive effect leading to Innovations. The industry was realising the worth of technology and innovation in both design and production due to increased completion, which can be fought only through improved quality of designs, products and services. However, in the WTO regime the imported products were now freely available, specification of which should motivate R&D agencies to develop similar technologies and products in India.

The Intermediary respondents were also of the view that the technological changes have improved the quality and efficiency and reduced the cost. They further mentioned that technological change is a continuous process and one has to constantly prepare for it as it makes all the technology go obsolete very soon necessitating continuous upgradation or introduction of new technology to survive the global competition. The respondents agreed that the Indian Industry is getting increasingly conscious for such inputs but needs to further strive to acquire and develop new technologies in collaboration with R&D agencies. The technological changes have brought changes in partnership pattern. However, one respondent mentioned that: 'some palpable transformations have taken place but their number is too small in proportion to the vast human and natural resources of this country'.

B. Technology Development Advancements in India

There is a general impression that technology developments in India are generally not very encouraging while science has made great strides in the country. Almost 78% of both the R&D agencies and industry respondents and almost all the intermediary respondents agreed with this and some of the significant reasons ascribed by the former are listed below along with their recommendations, if any, in parenthesis in italics.

- Technology development per se has been very good and India has excelled in several technology-intensive areas like satellite technologies, launching rockets, nuclear power plants and agriculture. However, hardware electronics and pharmaceuticals industries are some of those that have to entirely depend on imported technology. *(India should focus and invest in future technologies such as nano-technology and biotechnology for which it has the manpower and expertise. More efforts should be made to take the scientific achievements into technical and industrial domains.)*

- Most of the R&D agencies are funded by the government, which has not laid any stringent rules for taking up the projects of national importance. The scientists are given the freedom of work, which though is much needed for the advancement of science, but the researches going on in most of the institutes do not match with the national and industry needs. *(There should be a stringent evaluation of the R&D programmes undertaken by the R&D agencies).*

- There is no serious approach, not to speak of the sustained effort, on part of the government on technology development. R&D leading to technology development is not adequately appreciated. There is a low investment in manufacturing sector. *(It has to be realised that there are no short cuts in technology.)*

- Historically speaking, emphasis in India has always been on publications and peer recognition always comes through basic research publications. Additionally, publication in basic research journals is given higher impact factor than applied research publication. As significance of research is being weighed more by number of publications in high impact factor journals, applied research leading to technology gets undermined. Technology development or achievements in industrial research is always seen inferior to achievement in science in India. Moreover, working on technology development is considered not rewarding. Therefore scientists do not wish to take up technology-oriented projects, as it may not add to their career growth. *(Incentives should be given to R&D personnel to change the approach, if required.)*

- Analyses of award and fellowships data clearly bring out that the procedures for promotions / awards / fellowships heavily favour basic research, and not applied research. Even in CSIR, which is supposed to promote scientific industrial research, there are no special incentives for applied research and SRF is granted to candidates with more research papers with patents not valued any higher *(Evaluation criteria should be changed)*.

- The effort required to convert scientific knowledge to technology is as strenuous, if not more, as the generation of scientific knowledge. Most of the scientists do not put this effort as in the past the results were not commensurate with their efforts. (This trend is changing and increasing the rewards for tech development in our R&D agencies will further hasten it.)

- Technology generation is a dicey game. It may succeed or fail and in the latter case, the scientist gets the flak, whereas basic research is safe. *(This perception needs to change.)*

- Technology development needs team effort and a minimum pilot scale work, which is not popular in labs.

- It has been observed that due to delay in getting administrative clearances at various points, even though the developed technology may be good, it becomes soon outdated and industry loses interest in acquiring such technology.

- There is a lack of sponsorship and funding from industry to undertake industrially oriented projects. (*Projects should be financed and driven by the industry. There should be more close cooperation between R&D agency and industry.)*

- Indian research is being mostly copied from the West. *(India should undertake original research for Indian requirements.)*

- Indian industries are least interested in making long term plans. Rather they have more confidence on technology that has been acquired, tested and popularised elsewhere in the world, even though they may not be the latest. Most industries do not have vision of developing things indigenously. (*There is more that the industry could have done by trusting and collaborating with Indian R&D organisations than always believing that import is the best solution.)*

On the other hand the significant comments made by the industry respondents in connection with the slow technological progress in India were:

- Achievements in medical (related) sciences have been remarkable. But in other fields it is the re-research and technology developments have mainly come through outsourcing from abroad. *(There should be a focussed approach towards the industry and towards development of the country. Brain drain should be discouraged and emphasis should be laid on application oriented research work rather than on academic research.)*

- The technological developments are slow to take off due to commercials. It is unlike China, which thinks global. India is still with the hangover of protectionism.

- Technology development is a long-term strategy and requires a lot of patience and pursuance, whereas making publication is easier.

- Pure and basic research is not easily transferable into creation of wealth.

- There is a shortage of financial agencies to promote the technology development. Incentives to industry for technology development / R&D expenditures are small that started only in 1999. There is a lack of moral and financial support and doing R&D from ones own pocket is very difficult and not enthusiastic. Industry on its part does not support R&D due to non-risk attitude. *(Scarcity of funds needs to be resolved. More incentives should be given to industry for technology development).*

- All the technological development look good on papers, but most of the times they are not preferred to be commercially viable.

- Scientists are abysmally ignorant of marketing information on products they would develop.

- There is a lack of mutual appreciation between R&D scientists and industrial managers. In cases where such relationship is smooth, the success in their partnership is remarkable.

It is noteworthy that some respondents had an entirely different view. For example, a scientist from RRL - Bhub mentioned that neither technology nor science has progressed spectacularly in India, because if one considers publication in scientific journals as a measure of scientific development, the scientific progress is on a decline. A CEERI Pilani scientist felt that India was so-so on both the aspects. Industry was advancing due to market forces in India and was actually backed by R&D inputs for value addition, etc.

The reasons indicated by intermediary respondents for the slow technological progress in India included lack of research-industry partnership programmes to facilitate conversion of science into technology that needs different skills and involvement of industry *(The outreach programs should be strengthened');* and lack of commitment of R&D agencies *('Proactive role of the government and R&D agencies should be enhanced).* They further mentioned that there are no spin-offs from the R&D agencies and underscored a strong need of policy framework for it *(A good working mechanism should be developed to succeed in the market).* A vision for futuristic technologies and environment friendly technology is required.

C. Expectations of Industry from the R&D Agencies

The responses on the expectations of the industry from the R&D agencies are summarised in **Table 7.22**. In addition, a respondent from R&D agency in Bio-sector mentioned that the industry expects the R&D agencies to provide ready to market products. While industry expects the R&D agency to provide solution through consultancy, develop new technologies, products and processes for the growth of industry, and provide assistance in adaptation of new technologies, the R&D agency is not much inclined to provide assistance in adaptation of new technologies.

Table 7.22 Expectations of Industry from R&D Agencies

	R&D Agency							Industry				
	Total	Bio	Chem	Phy	Engg	Ocean	Academics	Total	Bio	Chem	Engg	AE
Expectations of Industry from R&D Agencies↓	**Affirmations**											
Number of Respondents →	**32**	8	5	2	15	1	1	**24**	9	5	11	0
Give solutions to technological problems through consultancy	**30**	6	5	2	15	1	1	**20**	7	4	9	0
Develop new technologies, products and processes for the growth of industry	**27**	8	5	2	10	1	1	**19**	7	2	10	0
Provide assistance in adaptation of new technologies	**19**	2	5	0	10	1	1	**18**	6	3	9	0

D. Role of Industry in India in Technology Development / Transfer / Diffusion

78% of respondents from R&D agencies were convinced of very little or limited role of the industry in technology development and its diffusion and transfer, except that it was felt to be somewhat higher in case of Medicare. However, some respondents indicated that with WTO and TRIPs being a reality and foreign companies making a mark on the Indian scene, the Indian Industries have activated themselves and joined hands with the government R&D institutions (like NIMTLI) or have set up their own R&D units. There were hardly any barriers now and the role played by industry was good, though their intellectual capability put restrictions everywhere.

Some specific barriers to industries' greater participation, as cited by R&D agency respondents, are listed below:

- The Indian subsidiaries of multinationals depend on their parent organisations to provide them with technology and are unsure of their own capabilities. They also are very hesitant to step into unexplored areas. Limitations of the local market and deviations from WTO guidelines allow them to parasitize on the original developers and the resulting economic difference prevents them from investing in indigenous development. Also the industry does not have confidence in the Indian R&D institutes. It is only now after opening of the Indian economy that more emphasis is being placed on R&D and with competition it should increase.

- Though R&D agencies have commitment to develop new and relevant technologies and the technologies available with industry can be easily upgraded, industry often looks for quick short-term solutions as technology development takes long time. Industry mostly banks on foreign collaboration for technology development for fast track profit making. Moreover, R&D in industry generally remains as tax evasion.

- Industry has a mindset of trying proven technologies, is not willing to take risk and views the industrial operation as a quick profit making activity and is thus not keen to develop technologies indigenously.

- To-day industry will buy a technology if it is competitive irrespective of its source. This is the reason, why several Chinese technologies from labs and institutes are being sold in India. An example of such technology is the manufacture of sponge iron.

- There are a number of areas in which barriers to interactions between R&D agencies and industry undermine our innovative capacity. These areas include the links into international S&T networks and investment in R&D; the scale, connectivity and focus of networks in areas of competitive advantage; research commercialisation; and cross-portfolio coordination of programmes.

Dr. Shashidhara from CCMB, Hyderabad mentioned that almost all the success so far in independent India is due to the work done in government institutes using public funds. In USA and UK, total expenses on research (including some very basic research) are more from private organisations rather than from federal government. All universities have several labs entirely funded by the industry. Partnerships are built right from the beginning of research, rather than trying to license a developed technology, which helps in making the product suitable for the industry to produce in bulk quantities and incorporating market oriented features. Stringent QQ guidelines, for example in drug development, required according to FDA can be followed right from the beginning of developing a product. One cannot do this in an academic environment. Academic institutes are not designed (they are supposed to be functioning with full freedom and cannot be tied with too many regulations) for such focused product development. One of the reasons indicated for small role of the industry was lack of information and funding mechanisms.

The respondents have suggested that industry should form an association of similar types of companies. The association should adopt an R&D agency for a period of 10 years identifying itself with the goals of R&D agency. Industry should work with the R&D agency attached to it for its technology development and up gradation.

The quoted response of an industry respondent amply elucidates the position of Indian industry on technology development: "*I am rather interested in running my industry profitably. I want to realise the maximum profit when my products have demand. I will manufacture any item, which will have market and will have good margin. I may not have time to look around*". This was typically the case in majority. The comments made by some other industry respondents and their recommendations are given below.

- Indian industry is largely production oriented. It does not have a clear understanding of R&D as a function and does not appreciate the type of work involved and the contribution it makes.

- The role played by industry in technology development is nominal at present. In fact it should contribute financially as well as manpower on R&D and technology development programmes.

- Industry is happy to deal with imported products available under the government policy and is not interested to take risk of indigenous technology. Mostly the technologies developed outside India are being used in India, though it could become the technology development and manufacturing hub.

- Only industries are developing new products, which were not available in India in a cost effective manner. This is beneficial to the society.

- IP was an issue in transfer and diffusion. Now that this is likely to change with the new patent regime, there can be more awareness created as the first step before attempting to diffuse.

- In last 2-3 years Indian industry is aggressively looking towards R&D agencies for technology development and transfer through sponsored research. It can help R&D institutions in identifying areas of focus for research.

- There is often unethical competition in industry.

- Industry should aim at improving life and comfort of a common man.

- Indian industry is only now being forced to develop technologies. So far, it has been using technology, but with exceptions, and rarely created new technology. Hence there was no question of transferring the technology.

Most of the intermediary respondents were of the view that industry had played a very little or limited role in technology development particularly in disciplines such as IT and Biotechnology, moderately active role in technology transfer and no role in technology diffusion.

E. Organisational Structure, Attitudes and Objectives supporting Innovation and Diffusion

All the respondents from R&D agencies generally indicated that there is a need to have flexibility in structure, approach and procedures, and that the following attributes are required within the organisation in order to have enhanced innovation and its diffusion:

- R&D agency should be objective-led rather than a procedure-led organisation.

- There should be commitment, accountability, motivation, teamwork and self-belief with innovative leadership, dedicated scientists, good knowledge base and its upgradation, and willingness to take risk. Attitudes and objectives of the individuals should be towards a common goal with team spirit to acheive.

- System should be free, fair and transparent built on trust rather than suspicion, so the workers are motivated to work more for the output oriented R&D programmes.

- Fair review system: Not only the peers from academia but also from industry should judge the performance of scientists based on creative and innovative index.

- There should be a non-bureaucratic set-up with a non-hierarchical structure (to quote the former Prime Minister Vajpayee: "...free research from red tape"), so that talent and encouragement at individual level is appropriately recognised, seniority of R&D personnel is not a criteria for managing the R&D efforts and R&D persons are recognised by specific expertise and not by the position in the organisation. For enhancing innovations the individuals should be identified and empowered. Most scientists will prefer to work in.

- There should be a clear demarcation of work assigned to different persons and their timely monitoring and removal of hurdles. Organisational structure should be such that a specialist group has freedom and is small enough to be manageable.

- Project leader should have the powers to exercise his decisions and there should not be any interference from the higher-ups. Decentralisation of research to bench level with financial power. R&D agency should design and concentrate on its core activities with enhanced investment.

- There should be a more professional approach for partnership with industry. R&D agencies should not make false commitments, should offer only validated technology and be a part of the programme up to its commercialisation.

- An unmediated contact with scope for plenty of interaction and prompt relaxations of existing formalities and a feeling of being in the same level on both sides.

- There should be participatory management of in-house and partnership projects.

- The managers of R&D agencies and industries should realise that developing a new technology or product is not a short-term programme. They should give enough time to the investors to develop the area.

- Information on the requirement of industry and simultaneously the outputs of the R&D agencies should be prepared.

- Objectives and responsibilities must be clearly defined for the benefits of innovators and diffusions.

On the other hand the intermediary respondents submitted that while for industry R&D should be treated at par with manufacturing in terms of budget allocation, manpower and other resources, R&D should be milestone-driven in case of R&D agencies. The structure of the R&D agencies should be facilitative, flexible and faster decision-making, that should support enhanced infrastructure. Researchers should have freedom to operate in the way they want; failures should be accepted and success should be rewarded. There should be a comprehensive market study on contemporary technologies. Appropriate models for industry oriented technology incubation should be set up.

F. Ingredients of Technology Development, Marketing and Transfer Strategy

The R&D agency responses indicated that the ingredients to be included in the strategy for technology development should be the commitment and confidence; identification of the demand for technology and market information; sharply defined product goals; assessment of competition for the product and its commercialisation through suitable marketing strategy; wherewithal and resources; and validation of data.

There were several other factors mentioned by the R&D respondents, which were also the ones indicated by the industry respondents, and included high quality research, good team work, commitment of scientific personnel, mutual trust and frequent interaction; clear-cut farsightedness, clarity of objectives, rigorous planning of targets and milestones; clear and well defined policy guidelines, mechanisms and planning; technologically advanced infrastructure; skilled and motivated manpower and risk capital; sound understanding of technology, economic analysis, competition awareness and presentation skills for transfer. Technology to be developed should be competitive, technically and economically feasible; time frame should be adhered to; and patenting of the technology should also be kept in view. At the same time technology development should be transparent between R&D agencies and industries. There should be no hassle of a complex agreement or financial burden on the industry. For developing the technology the industry has to be convinced that it does not need to spend much money on R&D agency, rather they have to have their own futuristic plan for the market and let the technology be developed by R&D agency in steps (Research → Evaluation → Commercialisation).

In regard to the transfer of technology R&D agencies were of the view that any new technology should be evaluated to the available standards before its transfer and the action plan for transfer technology should be formulated by the industry and reach grass-root level. Transfer strategy should be simple with no multiple calculations of royalties etc. Materials; process technology, know-how documentation and training, establishing a technological plant, provision for backup services etc. were some other important ingredients for technology transfer.

The industry respondents mentioned that the ingredients of technology development should be based on a specific technology covering a) future requirement; b) affordability; c) cost of R&D; and d) practical usage. It should be a superior and cost effective technology with eventual marketability and profitability. The cycle to be followed is Laboratory → Pilot - Plant Scale → Field Trials → Fine Tuning → Launch. Pilot scale studies and scale-up of processes should be clearly understood and adaptation procedures should be quick. A roadmap with firm and clear objectives and financial / social commitments should be provided. Availability of trained and technically sound personnel, sourcing of new material at affordable price and testing equipment, frequent review and analysis were some other significant elements indicated by the Industry respondents for successful technology transfer.

The intermediary respondents indicated that the approach should be top driven (identify problem → identify scientific group and industry → develop proposal → generous funding → strict monitoring → technology transfer to industrial partners → marketing of technology / product). Cost effective, reliable, environment friendly, competitive and efficient technologies should be developed, which is the need of the hour. The other ingredients indicated were scientific and energetic leadership, periodic assessment, revisiting practices, resource management, skilled manpower and R&D facilities, time of execution, market study and marketing plan and technology package with value addition and balanced economic strategy.

The mechanisms adopted by the R&D Agencies for marketing and transfer of technology involve either (a) a Planning and Management Division; or (b) a structure wherein right from identifying the end-user, IP protection, bench-scale demo, preparation of technology transfer document and licensing agreements were done in-house; or (c) a separate division working on technology transfer and business development affairs. In Japan and China they use the terminology 'Technology Transfer Office (TTO)' as the facilitating mechanism.

G. Role of Technology Policy and Policy Instruments with Reference to Technology Management at Enterprise Level

The respondents from R&D agencies and intermediaries felt that technology policy and policy instruments with reference to technology management at enterprise level play a very important role. These are the key component that guide and regulate the affairs at enterprise level. Technology policy and policy instruments of promotional nature can result in efficient technology management as they clarify technology management issues at the implementation stage. The policies must be focused and objective oriented with a specified time frame. On the other hand, they indicated that there were no policies, and whatever were there, were rather arbitrary and impulse oriented. Hence their role was limited only in select directions.

Some comments received from various respondents were:

- Liberal technology policies are required for technology management. The role of the policy should be to encourage the industry to co-exist with R&D agency.
- While policy should be to develop the technology and when it is ready, to offer it to the industry, some industrial tie-up should be formed from the beginning itself in order to know what the industry expects.
- Private agencies are keen on business; Public agencies for technology; Government agencies on knowledge towards technology; and NGOs on information. They should have mutual understanding with proper growth oriented strategies.
- Industry should be encouraged for partnership in development of product and support for up gradation of product without encumbrance.
- Areas catering to urgent need for human welfare should be identified; immediate actions and implementation should be taken up; best use of existing facilities should be made; and new facilities should be set up.
- Since LSIs have set up their own R&D units and have become self-sufficient, they need the support of R&D agencies only on critical issues, necessitating strengthening of cutting edge research in the R&D agencies.

- In fact, with growing competition in the market the industry was facing declining profit margins but to remain in the market industry itself is getting involved in R&D activities.

The intermediary respondents indicated that the technology policy and policy instruments with reference to technology management at enterprise level should support problem solving and policy making and cater to product patent regime, market competitiveness, hassle free research-industry partnerships, confidentiality of results, friendly implementation procedures, time and cost effectiveness.

H. Policy Measures and Fiscal Incentives for Partnerships

R&D agency respondents expressed that they would like to have changes in rules and regulations for scientists to take part in commercial projects. Those who develop the technology and projects that are commercialised should be granted promotion out of their turn and recognised properly. They should even have freedom to float an industry. Rules in R&D agencies should be flexible while dealing with industry and multinationals and for foreign contracts, and more power should be given to executives dealing with industry. While R&D spending should be made mandatory to all industries, government funding should match the industrial funding within R&D institutes. There should be subsidy to industry for using the services of the R&D agency and tax incentives to industry should be enhanced for supporting R&D organisations. In fact, research-funding organisations should insist on industrial partnership for immediate application of research. The research proposals should at least include application / demonstration of technologies. Sponsored projects should be encouraged that are time bound and develop healthy environment. There should be a balanced equity and low taxation on the products developed out of partnership between Indian R&D agency and Industry. Personnel (investigators) involved should be able to benefit from the generated profits. Industries who gain through these technologies should come forward to allocate funds to support the scientists concerned for further development in the area.

Some other R&D agency respondents felt that in India there are umpteen numbers of policies, ostensibly all framed to help. If they do not work nothing else would work. R&D organisations should timely utilise the funds on account of several administrative problems. The inventors should be given free hand to see how best and properly he/she utilises the funds. Encouragement should be given for exchange of scientists and technologies on assignments. Scientists should be deputed to visit and work in foreign universities and R&D institutes and attend international conferences.

The industry respondents wanted more academia-industry collaboration, clear-cut guidelines, more grants in aid schemes and norms for obtaining such funds with clear long-term vision, tax holiday, incentives for sponsoring research projects and using indigenously developed technology, performance incentives, improved monitoring and coordination, and commercial aim to size and plan the project. Core group should be created to study problem areas. Focus should be on application research development in tandem with industry. There should be experts who have been industrial leaders to co-ordinate.

The industry respondents felt that R&D institutions should be broadly linked to undertake the challenging problems in the country. Partnership should be such that both get benefit and in case of failure both should share the losses. Manufacturing conditions should be introduced in R&D organisation for their product development projects.

On the other hand there were some industry respondents who opined that they did not feel that fiscal incentives played important role for a collaborative project by industry. Only selective areas of R&D holding future for creation of wealth and opportunities should be promoted. Research should ensure some lifetime for the products in order to enable the industry to survive. Developments should be the sole property of industry during tenure of patents

Mobility of scientists from R&D agency to industry and vice-versa, development of performance indicators and incentives to scientists like early promotion and enhanced pay for innovations, very liberal and fast track funding support to industry in the form of grant–in–aid, incentives like tax exemption to industry for investing in R&D, new mechanisms to be tailored to specific groups, promotion of venture capital for self-sufficiency and equity participation by Government agencies were some policy measures and fiscal incentives cited by the intermediary respondents as essential for promoting / enhancing the research – industry partnership.

I. Government Initiatives for Enhancing Partnership

In response to the query about experiences, if any, vis-à-vis the government schemes such as PATSER (Programme Aimed at Technological Self Reliance) and schemes of the autonomous bodies like NRDC, HGT of TIFAC and TDB, and strong and week points of these schemes as well as make suggestions to improve their efficacy, if required, 67% R&D respondents mentioned that they had never utilised any schemes as while some of them were working in defence areas and could not partner with industry and felt that these schemes were attractive only on paper and in actuality their outcome was zero. The respondent from academia did not find these schemes, particularly those of TIFAC, encouraging the academic sector.

About one-third of the respondents from the R&D agencies, including those from Biology (14%), Chemical (60%), Physical (45%) and Engineering (40%) disciplines, participated in HGT of TIFAC - 6 times, NRDC - 3 times, PATSER of DSIR - 2 times and TDB - 2 times. It was mentioned that TIFAC funds for demonstration / techno-economic feasibility of technology to the industry with partnership have proved to be very successful as these help in establishing confidence of industry in the technology of the R&D agency. Thus the proven technology could subsequently be demonstrated to other industries as well convincing them involvement of zero risk. The industry gets financial support only after the transfer of technology. In all, the industry wants confidence that a process developed in R&D agencies would be successfully commercialised; Unless demonstrated industry would not be keen to accept the technology. However, one of the respondents mentioned that these schemes are operated by bureaucratic agencies that take a long time to make decisions.

As against the R&D respondents, many of the industry respondents (Bio - 4, Chem - 1, engg - 2) had used the programmes such as TDB and NIMTLI and were of the view that these programmes helped in understanding problems and provided vast network. The respondents mentioned that these schemes were good and could do even better with greater commitments. However, the officials should shed the pseudo-socialistic image and behave like banks dealing with venture capital. In so far as NRDC is concerned, their process of approval is very tedious, long and discouraging such that after first failure in getting the approval, people often never apply again. The NRDC staff needs more practical experience.

J. Reforms in the Government Initiatives for Enhancing Partnership and Impact of R&D on Industry

Most of the R&D agency respondents replied that the present reforms and initiatives of the government agencies for enhancing partnership and impact of research on industry were not sufficient, although situation has considerably improved, and should improve further. In the fields of chemicals, medicines and agriculture the reforms have yielded good results because of demonstration at pilot and bench scales. Same impact has not come in other areas like metal extractions and its working in which the scale of operations is in tonnes and may be due to large quantity, heavy investments etc. They mentioned that various stakeholders including research agencies and industry should be involved at all levels of reforms and investigators should share the emergent profits. R&D agencies should have more equity and open-house approach towards industry.

The industry should be backed up to take indigenous technologies and be given more incentives and encouragement, soft loans and tax incentives with benefits of low taxation on products developed as a result of partnership between Indian R&D agency and industry. R&D spending should be made mandatory to all industries. Selection of technology should be user based to meet the demand of a common man.

An R&D agency respondent mentioned that research institutions were slow to deliver and their deliverables were neither prompt nor (sometimes) up to the mark. In his experience at individual scientist level, the prompt response was missing even with all the talk about partnership. Most of the scientists with a few exceptions were poor to deliver. Let scientists be more accountable and performers be rewarded with non-performers getting a knock on their knuckles by denying them incentives. R&D agencies should identify scientists who can deliver products and provide support out of their turn.

63% Industry respondents felt that the present reforms and initiatives of the government were not adequate for enhanced research–industry partnership. They recommended more academia - industry collaboration, grant in-aid funding to the industrial R&D and bringing together industries to do complementary product / process development programmes with competition. A special Technical Cell should be formed and funded. Additional discounts and financial sops should be given to research related activities. Incentives should be given on timely completion of projects. Industry should take up application-oriented research whose need is expressed by industry and not R&D agency. Government can provide basic infrastructure to the industry to enhance the impact of research on industry. Industry that is proven should be awarded a lot to proceed further for new development. The weighted tax reduction should be increased to 2-times the R&D

expenditure for research – industry partnerships. However to avail particular benefit of tax incentives etc., the amount to be spent on R&D should be made compulsory.

Government restrictions on partnerships should be reduced and it should encourage industry to invest in R&D. Exchange of employees between industry and R&D agencies should be encouraged. R&D agencies involved in joint projects with industry should exhibit attitude suited to production activity of manufacturing unit.

Government initiatives and agencies were doing good jobs through DST, DBT, CSIR, etc. NIMITLI was one such initiative in which industry involvement was from early stage of research. Industry and national labs have to work together to achieve the targets. However, an industry respondent mentioned that government was merely making assurances in terms of tax holiday, custom duty and excise exemptions for a specific period of time for absolutely new products. Another industry respondent mentioned that there were always more scopes though the path and direction were correct. It was only the apportioning of resources, which was questionable. There was a need to be more project-centric in approach than spreading thin. If the trend is biotechnology, then focus should be given to this area for the next 10 years for India becoming the world leader.

Almost all the intermediary respondents replied that the present government initiatives and for enhancing partnership and impact of research on industry were not sufficient. The programmes provided meagre funds and their implementation had not been commensurate to the spirit. Hardly one or two of the existing programmes encouraged partnerships. One of the respondents was of the view that not many target groups were aware of such schemes.

K. Global Practice vs. Indian Preference in Technology Partnership Programmes

R&D agency respondents generally expressed a view that global preferences were based on market demands. Many foreign companies were supporting R&D activities of governmental organisations, whereas in India research was not supported by industry. Global corporations had focussed programmes that were both in-house as well as outsourced. The in-house R&D of global players was very much looked after by government R&D agencies, which were duty bound to yield quick and good results, and to some extent also by the academia, although they were generally busy with academic activities. It also existed in universities because of the degrees to be awarded. Industry was involved right from the project proposal stage. Well-defined and time bound programmes in real sense yielded guaranteed success. A respondent gave the example of M/s Siemens, which funded the stay of a student trainee at the Physics Department of Erlangen University in Germany in 2000-01 for about a year to carry out feasibility of a switch. At the end of the year, Siemens utilised the result to make a product switch using the skill of the student at the factory.

In general, the industrial development abroad was strongly associated with private participation. The partners and the scientists involved had considerable freedom and were able to represent in boards and decision-making bodies. While the government acted as a facilitator, the private industries actually performed all activities leading to country's economic growth. Foreign competitors had larger technology support programmes because they could afford huge investments in the sectors like food, health and agriculture. The percentage share of foreign companies was much more than Indian industry.

On the other hand, Indian industries were still working in isolation and had very little experience in global market at present. Indian programmes were lagging behind since there was little or no incentive for the actual researchers. Here the practice so far has been to provide jobs and opportunities only though the government-run agencies and industries. With economic liberalisation and new world order, India was also slowly moving towards better Industry–oriented technology programmes. It was a transition period and some time was required to reach the same level as other advanced countries.

An R&D respondent mentioned that: "*I think India is on the right track, even though Indian industries, unlike the foreign competitors, are often not coming forward to pay more to R&D. Indigenous technologies turn out to be more suitable and cost effective in applications specific to national / geographic climate and other conditions.*"

The industry respondents too agreed that the foreign competitors had larger as well as well defined technology support programmes for research agencies. Their programmes had long-term technology transfer and ongoing interaction process, laying emphasis on delivering on time and they were well aware of industries limitations on funding. On the scale of 1-10, the foreign industries were enjoying best benefits of partnership and the brain-chain was very high. In the USA and Europe, R&D agencies and industry worked together on projects (e.g. NASA). Even in-house spending of industries on R&D was very high as compared to the Indian industry. The spending on R&D was focussed more towards safety, product reliability, better processes, automation etc. Most foreign companies like GE-R&D in Bangalore were outsourcing knowledge from R&D agencies. International agencies had large funds and were more quality oriented. The global practise was to encourage technological developments, while Indian practise was to prefer profit making with minimum risks through one time technology purchase and up-gradation in its in-house R&D unit to reduce the costs. India had mostly been recipient of transferred technology (foreign) and was now preparing itself for such activities. Indians were better research oriented but due to lack of support and financial need they were not exposed. There was no national R&D support structure and India had a long way to go in this area.

An industry respondent had a critical comment that "*Indian programmes are not commendable. The casual attitudes of R&D worker either in R&D organisations or academia that are enjoying grants from government unnerve the industry people who doubt their seriousness and involvement. Thus the present situation is not very encouraging.*"

The intermediary respondents also agreed that the global programmes were much above and well established and were more sponsored by the industry. Innovation in industry was part of its work culture. The programmes in some countries even received grant-in-aids by their government. On the contrary, the Indian programmes needed more funds for R&D, grant-in-aid to industry; and required science being made more lucrative. The changing environment required enhanced partnership as well as the measures to enhance partnerships.

7.7 Summary of Findings

A summary of the findings from the analysis of the responses of various stakeholders is given in the following paragraphs.

- 46 R&D agencies, 25 industry representatives and 10 intermediaries responded to the questionnaires. Most responding R&D agencies had developed a number of technologies in partnership with the industry, indicating that they were generally keen on industry partnership for technology development and commercialisation. Industry respondents included 13 industries from biotech, drugs and pharmaceuticals, chemical and engineering sectors that have either successfully developed new technologies through partnership or have inducted / commercialised technologies obtained from R&D agencies. The intermediaries were the government ministries and agencies and academic / private TTOs.

- R&D agencies direct their activities mostly towards technology innovation and generation, followed by developing links with industry / academia and technology up-gradation. In case of those with engineering discipline, the objectives are demand driven and futuristic in nature, and only about one-third inquisitiveness driven, but for those with biological and chemical disciplines, the researches undertaken are both demand and inquisitiveness driven.

- Most of R&D agencies possess new knowledge / commercialisable knowledge / technology / process of interest to the industry. They strive to remain at par with the international industry and academia to knowledge generation and depending on their product, consider both national and international user agencies as their prospective customers. While they are keen to provide solutions to technological problems through consultancy and develop new technologies, products and processes for the growth of industry, they are not much inclined to provide assistance to industry in adaptation of new technologies.

- Though the significant methods used by R&D agencies for approaching the user agency included trade fairs and exhibitions, media and sending direct information to prospective partners, in some cases the interfacing agencies were also considered relevant.

- The employees of the R&D agencies, except in defence sector, are allowed to forge partnership with industry with the permission of the Director and in accordance with the administrative guidelines that keep revising from time to time. Scientists are restricted from profit oriented self-employment schemes, but with due permission, they can take entrepreneurship work as a consultant to an industry. CSIR presently forbids its scientists to start companies on their own.

- Most research institutes, and also some academic institutes like IITs and IISc, have certain units like the Technology Transfer Office (TTO) to liase and market the innovations and IP. In CSIR system, all the national laboratories have a Business Development and Management Group or Division for this purpose, which generally does not have a separate budget and is mostly driven by the Director in coordination with the scientists. Most R&D agencies have well-established mechanism for obtaining the feedback of industry on their transferred R&D products such as processes and technologies, which is generally through these units.

- Industry acknowledges the importance of R&D in the enhancement of product quality, reliability, cost reduction, energy conservation, technology up gradation and diversification. It quite often feels the need to acquire R&D products and approaches the R&D agencies for technical know how, technology, contract research, consultancy, data exchange, etc. for meeting its requirements, whether it has its own in house R&D or not. It expects the R&D agency to provide solution through consultancy, develop new technologies and processes, and provide assistance in adaptation of new technologies.

- In case of in-house R&D, the activities are often driven by the industry demands and include technology innovation and generation, improving production processes to reduce production cost and improve quality, technology upgradation for improving current product models, and creating next generation product models.

- Industry outsources R&D products from both national as well as international R&D agencies, depending on the capability, importance of technology sought, cost-effectiveness, market for the final product (foreign market to promote this new innovation worldwide.), availability of data to substantiate the claim and current status of the product. The selection of source is made by using the methods such as technology licensing information, internet surfing, publications, feedback from representatives, seminars, formal and informal interactions, visits and results of the previous work.

- Industry welcomes funds from the government or the financial institutions. But if the programme/project is within the means of budgeted R&D expenditure and could bring new technologies with benefit to it, industry would generally always support such activity using its own resources.

- In partnerships, industry is always concerned on cost and confidentiality of the information, because it is afraid of leaking marketing information of products developed by R&D organisation to other parties. However, industry agrees that it has to accept the risk and the loss, if not successful.

- Intermediaries support technology partnerships at one or the other stage of technology development chain and together they provide support at all the stages of technology development right from basic research to commercialisation. Of these, (a) only NMITLI of CSIR supports partnerships at basic research stage; (b) Only TDB extends equity support for proven technologies; and (c) only NMITLI supports partnership projects with less market certainty / technology certainty, thus covering maximum risk. Most of the programmes provide funds in the form of loan from 3 to 7 percent with NMITLI being the lowest and HGT, the highest.

- All the schemes institutionalised by the intermediaries provide encouragement to form the partnerships and sharing of expertise and induce industry to have practical approach in converting new developments into production. These schemes follow a competitive selection process. Most frequently used method for monitoring the supporting projects is through frequent periodic reviews and visits to the project site. All the schemes contribute to sustaining the economic growth. There is no uniform policy in sharing of IPR.

- Different intermediaries quote different rates of success in commercialisation of partnership projects, which may have been evaluated either by using statistical parameters or by considering the return of money. Thus while the success rate of the projects supported by APCTT is nearly 100%, DST agencies and TDB indicate it to be nearly 75%, and NRDC, only about 30-45%. In some TIFAC projects, even though the Monitoring Committee had declared the project successful, the entrepreneur had already exhausted all its money, so that the product for all practical purposes was not only not commercialised, but the entrepreneur was also not able to return the money. As the money return is a criterion for judgment of success of a project, the intermediaries are inclined to generally not support high-end technologies and high-risk technology projects.

- The purpose of partnership is regarded by the R&D agency as generating new technology for existing products, cost effectiveness and technology upgradation, and not so much as increasing efficiency, acquiring new skills and sharing infrastructure, the industry mostly attributes the purpose to acquiring new skills, cost effectiveness and technology upgradation.

- R&D agencies and industry mostly respond positively to each other's partnership proposals. But in those few cases, where the industry response is negative, R&D agencies view it as they generally not being able to approach the right industry or the right person in the industry (or approaching the right industry only occasionally), not being able to project their achievements and not trying hard enough. In some cases, the Industry is not ready for adapting the Indian R&D product and has lack of understanding of the science behind innovation.

- While industry is generally ready to partner at any stage, R&D agency is more selective and prefers bench level feasibility, and also sometime, production prototype and pilot plant, engineering prototype and testing, and commercial introduction.

- In most cases, partnerships are forged by the R&D agencies and industry entirely without the help of an external agency as the latter may not be aware of the expertise available with the R&D agencies and their involvement may add many consuming procedures. NRDC is however an exception as it is acknowledged to being helpful in increasing the industry contacts and having higher success rate of partnership so that the scientists can concentrate on technological matters and admin solutions are taken care of by NRDC.

- Most (>80%) of the projects implemented through partnerships are successful. The reasons for the success are mostly the timely completion of targets, commitment towards work, managing expectations by agreeing to a firm plan / programme of mutual benefit and setting priorities. Failure of partnerships is however attributed by all the key stakeholders generally to the inadequacy of administrative procedures, inefficient monitoring and review mechanisms, unripe and unproven technology, and not well-recognised and well-accommodated differences in motives and objectives of partners.

- The desired ingredients for the success of subsequent implementation of a partnered project are continued supply of material by the industry and availability of facilities and infrastructure, and interest and confidence in technology. Some other requirements are appropriate planning and execution of activities, frequent interactions with customers at various stages, support from top management, periodic reviews and phased execution. All the stakeholders prefer formal partnership with proper agreement with well-defined targets, so that they do not deviate from the goals.

- In partnerships, the contract research projects are always on an exclusive basis with sharing of outcome as per the initial agreement, which includes outright purchase on exclusive basis, patent ownership in certain proportion and further upgradation / expansion on sharing basis. The in-house developments / mature technologies are licensed on exclusive or non-exclusive basis, depending upon the nature of projects and contractual arrangement with the partner industry.

- Partnerships generally end with successful commercialisation, except in very few cases, which may be due to a) availability of better, imported or tried technology and know-how; b) lack of rigorous techno-economic analysis of the developed technology; c) reluctance of industry in coming forward (such as in case of biotech products that are expensive and involve risk); d) lack of scale-up economics; e) inappropriate government policy; and f) change in priorities of the industry due to fluctuating demands.

- R&D agencies are primarily motivated to partner with an industry for gaining insights into its research problems, applying knowledge to solve real business problems and building on excellence and reputation. The maim motivation of the industry is in benefiting from new ideas of R&D agencies, establishing links with their national and international networks, complementing resources and using technologies developed by them for renewal and expansion of activities. About two-third of partnerships maintain long-term relations and the same R&D agency and industry partners continue to work together on various projects because of mutual confidence.

- Barriers to the partnership building process are either (a) system related out of the lack of information and training, and institutional, financial and human capacities, or (b) competence based through differences in promotional policies, nature, objectives and focus of research, or (c) perception based such as availability of proven technology, respect for time and maintaining confidentiality. Some of the constraints include absence of a policy framework for public-private partnerships; diversity of objectives, structure and working environment; lack of appreciation by industry of the products of the R&D agencies, lack of faith in their competencies and concerns on adherence to time schedule and budget; organisational rules and regulations and administrative delays in R&D agencies in initiating the project implementation; general ignorance of R&D personnel about marketing intelligence; and industry not being R&D savvy and opting for turn-key projects in place of innovation. The most important factor in building confidence with industry however is the need for a proven technology with guaranteed performance.

- Databases on technological information are important in forging partnerships. In respect of the likely influence of geographical location being in close vicinity and political and climatic conditions on building partnerships, the views of the R&D agencies and industry are totally contrary to each other. The latter considers these factors as being insignificant.

- In regard to financing, government grants are mostly preferred because they help in building up competency in key areas, are hassle free and give more flexibility to the research programme, have greater accountability and lead to reduction in time delays in commencing the programme. Equity is acceptable to some extent, but loans have practically no takers.

- R&D agencies and intermediaries both do not have any strong opinion on selection between SMEs and LSIs for forging partnerships and address this association according to their needs and works. But small companies are believed to be more receptive to novel ideas, involving more informal approach, creating better linkages and direction to work for R&D agencies, and amenable to close monitoring of the approved schemes. On the other hand, LSIs are sometime opted due to strategic reasons, availability and affordability of infrastructure, resources and willingness to take risks.

- While foreign countries have larger as well as well defined technology partnership programmes with long-term technology transfer and ongoing interaction process laying emphasis on delivering on time and also with awareness of the limitations on funding, Indian programmes are lagging behind since there is little or no incentive for the actual researchers and Indian industry is still working in isolation having very little experience in global market.

- Almost all the stakeholders are unanimous in their view that: (a) Technological changes on products, services, processes and organisations have made a revolutionary impact; (b) Technology developments in India are less pronounced than those in science, which has made great strides; (c) Industry has a limited role in technology development and its diffusion and transfer (except somewhat in Medicare), but WTO and TRIPS being a reality, Indian industry is getting activated to partnering and bring innovations; (d) Technology policy and policy instruments with reference to technology management at enterprise level play a very important role; (e) The present reforms and initiatives of the government agencies for enhancing partnership and impact of research on industry are inadequate, though the situation has considerably improved, and is expected to should further improve.

7.8 Recommendations

Based on the above findings and conclusions, the following recommendations have been drawn that present a broad framework of a workable model, which is flexible to cater to future requirements and demands of different stakeholders to further enhancing the R&D agency – industry partnerships.

- Technology developed by the R&D agencies should be mature and not half-baked. Besides this, to remain competitive in the global arena the R&D agencies should strictly observe a system of monitoring the prospective technologies periodically for setting the priorities and meeting the objectives.

- R&D agencies should take measures to understand the working of the industry besides its specific requirements. Scientists should work with the industry to know and solve the teething problems. Business type interaction should be established with the industry that would facilitate getting a positive response. Expeditious administrative clearances would be of further help.

- Scientists in the R&D agencies should be allowed to retain the title of their innovations for the purpose of marketing, transfer and commercialisation. Individual agencies in India such as CSIR have this provision to encourage the scientists to turn into entrepreneurs. However, there is no policy measure at national level to amend the situation in this regard vis-à-vis the scientists of other national R&D agencies.

- Effective Business Development Group (or Technology Transfer Office) should be set up in each R&D agency to facilitate marketing of knowledge products, forging alliances and transfer of technology. It should have the capability to acquire elaborate techno-commercial information for necessary techno-economic analysis of the technology clearly highlighting the economic gains while realistically estimating process economics. It should also have excellent industrial contacts both in the country and abroad. A person of scientific plus management background and relevant experience should lead the Business Development Group. Scientists and managers of this Group should have mutual respect and trust. The Group should either have its own legal experts who could interpret the patents or outsource the legal and other necessary expertise.

- In academia there should be more exposure to students and faculty of the industrial environment. Curriculum should be designed in consultation with the industry and post-graduate research theses should be industry relevant.

- Industry is generally not aware of what R&D agencies are doing and how they could contribute to the cause of the industry. Therefore it is essential that appropriate projection of the past performance and accomplishments of the R&D agencies is made available through mechanisms such as exhibitions, brochures, Internet and informal meets.

- Industry should play an enhanced role in technology development. It should be more open and aggressive and should partner with R&D agencies in adapting technologies. Apart from profit motive it should focus on supporting R&D efforts on emerging areas of development in S&T. Besides this, to save time and money it should approach the R&D agencies instead of creating own infrastructure facilities.

- Industry should take up large-scale projects of benefit to society in the sectors of health, agriculture, energy and rural infrastructure development, which will increase employment opportunities. Investment is the main problem faced by the industry and for this it can seek government subsidies in the areas of common interest.

- Industry should make increased allocation of funds to their in-house R&D activities and also to the R&D agencies for sponsored projects for meeting future demands and promoting grass root innovation and gaining access to innovation. It should sponsor special research chairs in R&D institutes. For enhanced research-industry interactions industry should proactively work and come to R&D agencies and intermediaries such as TDB, who should interface the partnership with equity.

- The institutionalised programmes of the government and public institutions should carry out exhaustive survey on the industrial needs and technology requirements; keep track of the current IP policies; carry out technology foresight and assessment at the national and global levels to catch up with the latest technology trends and access to market information; and create awareness about challenges and opportunities being unfolded by the emerging trends. Large number of R&D agency – industry partnership projects in all possible sectors of industry should be commissioned.

- These partnership facilitating programmes should aim at achieving their set objectives and goals in transparent and user-friendly manner covering high-risk, high payoff technologies beyond capabilities and hurdle rates of individual industry. These should be industry-friendly and preferably, even industry-driven like the NMITLI.

- Funding mechanisms should be flexible, i.e. these should provide grants-in-aid for strategic projects and those in frontier areas, soft or preferably tax free loan for projects dealing with proven technologies and equity participation for risk sharing. The programmes should provide for timely monitoring, quick processing of funding of projects, easy terms and advance disbursement.

- Government policies should extend incentives to industry and impose compulsions on industry to invest in R&D. The industry should be backed up to take indigenous technologies and be given more incentives and encouragement, soft loans and tax incentives with benefits of low taxation on products developed as a result of partnership between Indian R&D agency and industry. Apart from financial support the facilities of the government R&D agencies should be made available to the industry.

- India should take legal measures in line with the Bayh-Dole Act of the USA. Scientists like those of the R&D agencies in USA should be allowed to get involved with an industry to exploit research outcome or spinout and allowing its benefits to be received by the researcher concerned, which would encourage the researcher to work for industrial development. IPR rules should be relaxed to an extent to attract researchers.

- There is a need to develop award and incentive structures to encourage entrepreneurship by academicians, researchers and in the process, support more entrepreneurial role models for research students such as those practiced by CSIR every year.

- There is a need to have flexibility in structure, approach and procedures being followed by all the stakeholders involved with technology partnerships.

- R&D agencies and industry should have proactive approach for forging and implementing partnerships. The culture of partnership with industry should become an integral part of every R&D agency. Industrial approach should be to pass on the practical problems to the R&D agencies for problem solving. The industry should make the longer-term innovation plans and associate the R&D agencies with it for implementation of these plans.

- Partnership project should be framed primarily with the help of the partner scientist after detailed technical discussions. The funding requirements should be negotiated and a formal MOU should be signed to ensure timely delivery. Very fast track response and simplified procedures are required to ensure quick start of the project. This should be followed by frequent reviews to ensure timely delivery.

- Tie-up between R&D agencies and industry could be enhanced by making the policy more liberal and removing the bureaucratic hurdles. Integral plans be made between industry and R&D agency for enhancement and sustainability of the partnership and there should be more interaction and brain storming sessions between the two to identify effective links and mechanisms. There should be frequent inter-transfer of scientists and managers between industry and R&D agencies. Programmes should be well-defined and time bound and should be focused to execute the goals honestly. A market-oriented approach is required.

7.9 Conclusions

The participants of the survey were generally of the view that the present government initiatives for enhancing partnerships and impact of research on industry are not adequate. It is apparent that the R&D activity has great value in the enhancement of product quality, reliability, cost reduction, energy conservation, technology up gradation and diversification, and up gradation of knowledge base to sales force for better understanding of the industry. The role of R&D is vital to make the awareness of latest technologies developed and their implementation in the industry as well as the benefit to be accrued from their use such as improving the working standard. R&D primarily inculcates time and cost consciousness and becomes more product-oriented, trains the personnel for modern methods, thinking creatively to find applications for use of common man. It helps in identifying proper research projects relevant to industry and focussing the programmes properly.

It was also evident from the survey that in partnerships the industry is generally afraid of leaking marketing information of products developed by R&D agency to other parties. However, there was a realisation that the industry has to accept the risk and also the loss, if not successful.

In so far as the impact of the individual scheme is concerned, CSIR considers the NMITLI scheme as an important model of Public-Private Industry-Driven Partnership supporting cutting edge research in projects involving high risk factor. The scheme also acclimatises the scientific fraternity to strict periodic reviews. TIFAC of DST is a powerhouse of knowledge and has strength in networking, and is in a position to provide technical help to the entrepreneurs at any stage through the experts whose services it is capable of hiring at any time. NRDC helps in multiple licensing of technology with complete technology package after its full development. PATSER contributes to enhancing the turnover of industry. In DST's Drug scheme several proprietary Indian Ayurvedic and Sidha medicines are being studied for standardisation, efficacy and safety profile. State-of-the-art infrastructure facilities have been created in several R&D agencies through this scheme. Through TDB of DST many products and services have been introduced in the market for the first time. The impact of FITT is in establishing wide linkages with professional bodies such as industrial associations and successfully setting up of its own technology incubator.

To summarise, the above analysis of the perception of the stakeholders in building partnerships indicates that handholding is required from idea generation to its commercialisation.

Chapter 8

Summary, Recommendations and Conclusions

8.1 Introduction

The need of partnerships between R&D agencies and industry as the essential instrument to providing a means of better leveraging limited public R&D funding, fostering innovation and ensuring stronger industry commitment has been increasingly felt by all the key stakeholders including the government, R&D agencies, national laboratories, academic institutions and industry. The Government of India supports such partnerships under a number of programmes and schemes overseen by its various departments under different ministries, R&D councils and other establishments. Realising that R&D agency – industry partnerships are essential to improving returns from public investments in research, the Government and the related agencies are attempting to work out a framework and formulate a mechanism that will work and sustain on a long-term basis. Policy makers, technology providers, technology takers and the intermediaries facilitating technology partnerships are regularly brainstorming on this theme.

The present research work on the topic 'R&D Agency – Industry Partnership for Technology Development and Transfer: An Assessment Study' has been undertaken with an overall objective to suggest appropriate recommendations to improve the partnership building processes, role of stakeholders and interface between them for development and transfer of technology in Indian context. In order to achieve this goal, the tasks laid out were to (a) understand R&D agency – industry partnership systems followed in other countries and in India and correlating them; (b) investigate and analyse the success and failure in existing partnerships; and (c) suggest possible improvements towards enhancing sustainable R&D agency – industry partnerships in India for technology development and transfer. In this concluding chapter, an attempt has been made to consider the conclusions and findings of the analysis in previous chapters aimed at suggesting possible improvements to various stakeholders for enhancing sustainable partnerships in India for technology development and transfer, as well as facilitate in revisiting the Indian government policies supporting R&D agency – industry partnerships for successful execution.

8.2 Summary and Findings

The conclusions in the following sections 8.2.1 – 8.2.3 have been derived based on the analysis and correlation of R&D agency – industry partnership systems followed in other countries and in India, and meet the requirement laid out in the first task identified for the present study. Further, the conclusions stated in the sections 8.2.4 and 8.2.5 are based on the analysis of the observations in case studies and responses of the individual questionnaires to stakeholders in regard to the successes and failures in partnerships, accomplishing the second task laid out under this study.

8.2.1 The literature review and the salient features of the analysis of key initiatives by the select developed countries (Chapter 3) and those with fast emerging economies (Chapter 4) towards promotion of technology development, transfer and commercialisation through partnerships reveal that:

- University - industry research partnership is the primary factor in the growth of the US S&T. These entities are quite comfortable with each other as partners, developing structured approaches to harmonising the independence of research with the transfer of technology. Mobility of researchers from science to industry and vice-versa usually is very high. Clusters, which are the regional hubs of innovation for producing high-value products and services supporting high-wage jobs, are widespread in the USA. Most of the US national laboratories concentrate on defence-oriented research, though the Government emphasises on dual use technologies necessitating the partnership between these labs and the industry. The Government has taken a number of legal measures for the promotion of transfer and commercialisation of technology that provide significant impetus to the processes of building partnerships.

- Germany focuses research funding on long-term basic research and in those areas, which have greater leverage for growth and employment. Major share of R&D in Germany is performed by industry, largely in the area of applied research and experimental development. The industry is technologically matured and shares 60-70% of the total R&D expenditure whereas the universities and R&D institutes have a share of only 10-15% and 15-20%, respectively. Partnerships in Germany are characterised by industry collaboration with university as well as research institutions. However, the Government has not instituted any specialised programmes or schemes for promoting partnership though a number of flexible and customer-orientated partnership promoting efforts encourage industry for R&D by financial incentives and provide enhanced government support for private R&D and special technology programmes particularly for SMEs and regional innovation development through innovation centres. Germany is in the process of a planned reorganisation reform in its education and research system and there is a shift in partnership policies away from the institution-based collaboration towards project and programme based partnerships.

- An element in Japanese S&T policy is the promotion of cooperation between industry, universities and government R&D agencies. The Government supports joint research projects between universities and industry, promotes entrepreneurships among researchers, encourages research personnel to produce industry-oriented output and facilitates mobility of researchers and industry personnel to each other's institutions. As Japan has a dual system of large enterprises and SMEs, the policy encourages formal networking with inclusion of SMEs in science-research-industry networks, development and strengthening of regions by means of such networking and increased mobility of employees. Japan looks towards the USA as the model and has enacted special laws for the orientation of S&T and building partnerships.

- In the UK, partnerships are generally sector and field specific. Industry-science relations are of fundamental importance in the UK research and innovation policies that are aimed at maximising the contribution of S&T to the UK's economic development and stimulating stronger university-business links to turn its science and engineering excellence into successful and innovative products and services. Government's strategy increasingly aims at strengthening innovation through cluster development in the regions. Commercialisation by spin-offs and licensing of technology receives central attention. Other innovation policies relevant to the industry-science interactions originate from the Patent Office and concern aspects of the patenting process.

- The Korean innovation policy system is characterised by a strong hierarchical structure in decision-making. The emphasis is on assimilation of imported technology, generation of new products and innovations in manufacturing sectors, and creation of its own innovations in knowledge based industries. The Government actively supports the development of networks and clusters in strategic fields of innovation and aims to attract foreign investment to these clusters. It provides equal opportunities for funding of R&D projects to foreign R&D centres as well as to the domestic R&D centres and has taken measures ranging from the establishment of free economic zones, financial support to R&D projects and tax incentives. The private sector in Korea generally concentrates on rapid commercialisation of outside technologies and imitating global front-runners.

- In China, the current Government policy pays attention to the acquisition and assimilation of foreign technology while developing S&T capabilities primarily on indigenous efforts and strong IPR protection through legal measures. An important element of China's technological development is the technical renovation of industry and enterprises. China does not have any specific programmes and schemes to promote R&D agency – industry partnerships for technology transfer and commercialisation, though there are national technology transfer centres and research parks for this purpose. China has not been successful at transferring domestic R&D results and applying it to industrial production. At the same time, high-tech industries in China are very dynamic and the high-tech development programmes like "863" and 'Torch' apply the research and technical development towards industrial production. Technology in China is often imported through FDI that is instrumental in increasing the competitiveness of its industries, creating new high-tech industries, improving the infrastructure of the existing ones that was severely underdeveloped prior to economic reform, and compensating for China's shortage of capital.

- Brazil has a significant infrastructure for R&D and innovation with most of the research projects being in the universities. It also has a few high-tech, science-based industries. The industry is not very knowledge intensive and is not exposed to competition and therefore it is not quality conscious. There are a number of university foundations with power to sign contracts and agreements without the bureaucratic restrictions on public bodies that enables them to guide negotiations with the private industrial sector and carry out research work in industry. About 10% of public investments in R&D in Brazil are made by a small group of state-owned corporations with their own R&D centres. However, Brazil needs closer linkages between S&T and the industrial sectors and stimulating the private sector to increase its share of the country's R&D efforts. A new policy for Industry, Technology and Foreign Trade has been launched by the Government in May 2004 for industrial development and spawning innovations through partnerships between research institutions and industries.

- From the above it is evident that partnerships in each country evolve in its respective context around the organisation and management of S&T and the policies for its promotion and growth, its institutional framework, structure of industrial organisations and the market, role of financial institutions and the approaches adopted by the government in networking. Promotion of partnerships are to be viewed in terms of the policies, the maturity of the specific stakeholders and the nature of problems associated with building of their networks.

8.2.2 The assessment of the efforts made in India (Chapter 5) for promoting technology development, its transfer and commercialisation particularly through partnerships shows that:

- The new Science Policy of India is aimed at raising the investment in S&T to 2% of Gross Domestic Production (GDP) by 2007 and suitably moulding the S&T strategies to integrate the R&D agency (including academia), the Government and the industry to meet the growing expectation from S&T to be in the forefront and not be a follower. India is moving in the direction of integrating the Indian economy with the global economy.

- The Government has taken a number of initiatives to foster the R&D agency – industry partnerships for transforming knowledge into saleable commodities. The programmes like NMITLI of CSIR, PATSER of DSIR, HGT of TIFAC and TDB of DST that have been institutionalised and operated by the government and public and those of the financial institutions enable and support the partnerships at different stages of technology development cycle. They together facilitate the partnerships right from the conceptual stage to commercialisation of the innovation in all the areas of S&T.

- Besides above, the Government has sector-specific programmes like DPRD and PRDSF of DST that have been successful in establishing alliances of R&D agencies with Indian industries. Advanced Research Centre for Powder Metallurgy and New Materials (ARC-I) in Hyderabad is an unparalleled unique step of the Government for technology development, upgradation, transfer and commercialisation in the Materials Science sector integrating expertise from other countries. At the institutional level, the initiatives of IIT's and IISc for supporting partnerships for technology development and transfer are working well.

- Most of the above programmes are need based and not out of future long-term strategy. These are distributed across various government agencies, which are meeting a diversity of specific needs. What has been lacking to date is a coordinated effort to forge links between these disparate activities in ways that will deliver enhanced outcomes for innovation.

- The Government has established Science and Technology Entrepreneurship Parks (STEPs) in and around academic and R&D institutions of excellence to facilitate closer linkages on continuing basis between R&D agencies and industry and Technology Business Incubators (TBIs) as tool for catalysing the development and growth of technology based small enterprises and the initiative.

- Most research institutes, and also some academic institutes like IITs and IISc, have certain units like the Technology Transfer Office (TTO) to liase and market the innovations and IP. In CSIR system, all the national laboratories have a Business Development and Management Group or Division for this purpose, which generally does not have a separate budget and is mostly driven by the Director in coordination with the scientists. Most R&D agencies have well-established mechanism for obtaining the feedback of industry on their transferred R&D products such as processes and technologies, which is generally through these units.

- There are a number of areas in which barriers to interactions between R&D agencies and industry undermine the Indian innovative capacity. Such areas include limited linkages between research institutions and academia; links into international S&T networks; investment in R&D; scale, connectivity and focus of networks in areas of competitive advantage; and research commercialisation.

8.2.3 A comparison of the efforts made by the select countries with those in India in the promotion of technology development, transfer and commercialisation shows that:

- The policies of the selected countries as well as India lay emphasis on increased S&T spending.

- In the select developed countries, the private sector usually finances at least half of the R&D. In contrast, about 70% of R&D in India is performed by the central and state governments, an additional 27% by enterprises (both public and private sector industries), and less than 3% by universities and other higher educational institutions.

- R&D agencies in the select developed countries undertake the cutting edge research along side application oriented programmes of industrial relevance. However, due to CSIR laying more emphasis on industry oriented partnership projects in its national laboratories, the latter in most cases interpret the CSIR decision in terms of focusing more on the contract research rather than on cutting edge research. This may eventually lead to these laboratories in not having any breakthrough innovations of their own.

- Almost all the select countries have diverse S&T collaborative programmes, whether general or sector-specific, networking the universities, research institutes and industry. In this respect India is quite at par with these developed countries in the variety of schemes / programmes of the government and its affiliated bodies for funding the R&D agencies and industries / SMEs and promoting partnerships at every stage of technology development. These programmes do encourage participation of academic institutions, but with a few exceptions like IITs and IISc, they do not find these programmes relevant to their activities. There is an obvious serious lack of means in India to bring the academic institutions and industry together.

- While foreign countries have larger as well as well defined technology partnership programmes with long-term technology transfer and ongoing interaction process laying emphasis on delivering on time and also with awareness of the limitations on funding, Indian programmes are lagging behind since there is little or no incentive for the actual researchers and Indian industry is still working in isolation having very little experience in global market.

- In so far as the S&T Parks are concerned, India is quite at par with the select countries. Such parks have been established in premier institutes of India and many technologies have emerged as a result of the activities in these parks. However, India is relatively weak in promoting regional development of technology, clusters, TTOs and Discussion Forums for identifying future areas of importance to be addressed by S&T and for identifying and resolving problems of interfacing the stakeholders.

- Most of the select countries have laws and acts in place to help the researchers and inventors. However, the relevant laws in India have yet not been enacted that could motivate the researchers to develop commercialisable knowledge and products and at the same time encourage industry personnel and researchers to form linkages with each other to mutual advantage.

8.2.4 The significant lessons learnt from the variety of case studies (Chapter 6) on development, transfer and commercialisation of technologies through partnerships are summarised below:

- Laboratory level research involves only a small group of scientists, whose commitments are limited to achieving some S&T outputs. On the other hand, process development and demonstration are more difficult and need teamwork. Fundamental science component in the innovation process enables development of innovative technologies.

- Technology transfer is dependent on the quality of the available process or technology with respect to technology demand, development in respect of related areas of the industry, techno-economic feasibility, investment range and the level of industry in the country or abroad. Sometimes, the location of technology development and implementation also matters.

- Commercialisation is the most challenging and successful step in technology development and is the clear proof of the scientific approach. This may not be possible in most of the process development efforts, but consistent efforts yield success. Immediate corrective measures are helpful in resolving problems at commercialisation stage.

- Necessary ingredients for a successful R&D agency – industry venture are knowledgeable project staff with multidisciplinary expertise and training on the desired technical aspects; self-confidence of R&D agencies to accept the challenges and carrying out innovative researches to generate new products and capabilities; sustained support of top management; commitment and confidence in the scientists; positive team work culture and attitude; state-of-the-art facilities to convert the ideas into products for value addition and enhancing the profits; assurance of R&D agencies on product quality, production capacity, raw material consumption and timely delivery; and abundant commitment of industry to associated risk with the venture. Another important factor influencing the eventual success of the venture is to have a predetermined agreed formula to share the benefits among the partners.

- Success is assured only when there is a synergy between a competent R&D partner and a committed and economically strong commercial partner, as well as the involvement of industry throughout the project implementation process.

8.2.5 Important conclusions drawn from the analyses of the responses of various stakeholders, viz. R&D agencies (technology developers), industry (technology takers) and intermediaries (agencies, enabling or facilitating the partnerships) (Chapter 7) are as below.

- R&D agencies direct their activities mostly towards technology innovation and generation, followed by developing links with industry / academia and technology up-gradation. In case of those with engineering discipline, the objectives are demand driven and futuristic in nature, and only about one-third inquisitiveness driven, but for those with biological and chemical disciplines, the researches undertaken are both demand and inquisitiveness driven. Most of them possess new knowledge / commercialisable knowledge / technology / process of interest to the industry. They strive to remain at par with the international industry and academia to knowledge generation and depending on their product, consider both national and international user agencies as their prospective customers. While they are keen to provide solutions to technological problems through consultancy and develop new technologies, products and processes for the growth of industry, they are not much inclined to provide assistance to industry in adaptation of new technologies.

- Though the significant methods used by R&D agencies for approaching the user agency included trade fairs and exhibitions, media and sending direct information to prospective partners, in some cases the interfacing agencies were also considered relevant.

- The employees of the R&D agencies, except in defence sector, are allowed to forge partnership with industry but are restricted from profit oriented self-employment schemes. However with due permission they can take entrepreneurship work as a consultant to an industry. CSIR presently forbids its scientists to start companies on their own.

- Industry acknowledges the importance of R&D in the enhancement of product quality, reliability, cost reduction, energy conservation, technology up gradation and diversification. It quite often feels the need to acquire R&D products and approaches the R&D agencies for technical know how, technology, contract research, consultancy, data exchange, etc. for meeting its requirements, whether it has its own in house R&D or not. It expects the R&D agency to provide solution through consultancy, develop new technologies and processes, and provide assistance in adaptation of new technologies.

- Industry outsources R&D products from both national as well as international R&D agencies, depending on the capability, importance of technology sought, cost-effectiveness, market for the final product (foreign market to promote this new innovation worldwide.), availability of data to substantiate the claim and current status of the product. The selection of source is made by using the methods such as technology licensing information, internet surfing, publications, feedback from representatives, seminars, formal and informal interactions, visits and results of the previous work.

- In partnerships, industry is always concerned on cost and confidentiality of the information, because it is afraid of leaking marketing information of products developed by R&D organisation to other parties. However, industry agrees that it has to accept the risk and the loss, if not successful.

- Intermediaries support technology partnerships at one or the other stage of technology development chain and together they provide support at all the stages of technology development right from basic research to commercialisation. Of these, (a) only NMITLI of CSIR supports partnerships at basic research stage; (b) Only TDB extends equity support for proven technologies; and (c) only NMITLI supports partnership projects with less market certainty / technology certainty, thus covering maximum risk. Most of the programmes provide funds in the form of loan from 3 to 7 percent with NMITLI being the lowest and HGT, the highest. Industry welcomes funds from the government or the financial institutions. But if the programme/project is within the means of budgeted R&D expenditure and could bring new technologies with benefit to it, industry would generally always support such activity using its own resources.

- All the schemes institutionalised by the intermediaries provide encouragement to form the partnerships and sharing of expertise and induce industry to have practical approach in converting new developments into production. These schemes follow a competitive selection process. Most frequently used method for monitoring the supporting projects is through frequent periodic reviews and visits to the project site. All the schemes contribute to sustaining the economic growth. There is no uniform policy in sharing of IPR.

- Different intermediaries quote different rates of success in commercialisation of partnership projects, which may have been evaluated either by using statistical parameters or by considering the return of money. Thus while the success rate of the projects supported by APCTT is nearly 100%, DST agencies and TDB indicate it to be nearly 75%, and NRDC, only about 30-45%. In some TIFAC projects, even though the Monitoring Committee had declared the project successful, the entrepreneur had already exhausted all its money, so that the product for all practical purposes was not only not commercialised, but the entrepreneur was also not able to return the money. As the money return is a criterion for judgment of success of a project, the intermediaries are inclined to generally not support high-end technologies and high-risk technology projects.

- The purpose of partnership is regarded by the R&D agency as generating new technology for existing products, cost effectiveness and technology upgradation, and not so much as increasing efficiency, acquiring new skills and sharing infrastructure, the industry mostly attributes the purpose to acquiring new skills, cost effectiveness and technology upgradation.

- R&D agencies and industry mostly respond positively to each other's partnership proposals. But in those few cases, where the industry response is negative, R&D agencies view it as they generally not being able to approach the right industry or the right person in the industry (or approaching the right industry only occasionally), not being able to project their achievements and not trying hard enough. In some cases, the Industry is not ready for adapting the Indian R&D product and has lack of understanding of the science behind innovation. Industry is generally ready to partner at any stage, but R&D agencies are more selective and prefer bench level feasibility, and also sometime, production prototype and pilot plant, engineering prototype and testing, and commercial introduction.

- In most cases, partnerships are forged by the R&D agencies and industry entirely without the help of an external agency as the latter may not be aware of the expertise available with the R&D agencies and their involvement may add many consuming procedures. NRDC is however an exception as it is acknowledged to being helpful in increasing the industry contacts and having higher success rate of partnership so that the scientists can concentrate on technological matters and admin solutions are taken care of by NRDC.

- Most of the projects implemented through partnerships are successful. The reasons for the success are mostly the timely completion of targets, commitment towards work, managing expectations by agreeing to a firm plan / programme of mutual benefit and setting priorities. Failure of partnerships is however attributed by all the key stakeholders generally to the inadequacy of administrative procedures, inefficient monitoring and review mechanisms, unripe and unproven technology, and not well-recognised and well-accommodated differences in motives and objectives of partners.

- The desired ingredients for the success of subsequent implementation of a partnered project are continued supply of material by the industry and availability of facilities and infrastructure, and interest and confidence in technology. Some other requirements are appropriate planning and execution of activities, frequent interactions with customers at various stages, support from top management, periodic reviews and phased execution. All the stakeholders prefer formal partnership with proper agreement with well-defined targets, so that they do not deviate from the goals.

- R&D agencies are primarily motivated to partner with an industry for gaining insights into its research problems, applying knowledge to solve real business problems and building on excellence and reputation. The maim motivation of the industry is in benefiting from new ideas of R&D agencies, establishing links with their national and international networks, complementing resources and using technologies developed by them for renewal and expansion of activities. About two-third of partnerships maintain long-term relations and the same R&D agency and industry partners continue to work together on various projects because of mutual confidence.

- Barriers to the partnership building process are either (a) system related out of the lack of information and training, and institutional, financial and human capacities, or (b) competence based through differences in promotional policies, nature, objectives and focus of research, or (c) perception based such as availability of proven technology, respect for time and maintaining confidentiality. Some of the constraints include absence of a policy framework for public-private partnerships; diversity of objectives, structure and working environment; lack of appreciation by industry of the products of the R&D agencies, lack of faith in their competencies and concerns on adherence to time schedule and budget; organisational rules and regulations and administrative delays in R&D agencies in initiating the project implementation; general ignorance of R&D personnel about marketing intelligence; and industry not being R&D savvy and opting for turn-key projects in place of innovation. The most important factor in building confidence with industry however is the need for a proven technology with guaranteed performance.

- In regard to financing, government grants are mostly preferred because they help in building up competency in key areas, are hassle free and give more flexibility to the research programme, have greater accountability and lead to reduction in time delays in commencing the programme. Equity is acceptable to some extent, but loans have practically no takers.

- R&D agencies and intermediaries both do not have any strong opinion on selection between SMEs and LSIs for forging partnerships and address this association according to their needs and works. But small companies are believed to be more receptive to novel ideas, involving more informal approach, creating better linkages and direction to work for R&D agencies, and amenable to close monitoring of the approved schemes. On the other hand, LSIs are sometime opted due to strategic reasons, availability and affordability of infrastructure, resources and willingness to take risks.

- Almost all the stakeholders are unanimous in their view that: (a) Technological changes on products, services, processes and organisations have made a revolutionary impact; (b) Technology developments in India are less pronounced than those in science, which has made great strides; (c) Industry has a limited role in technology development and its diffusion and transfer (except somewhat in Medicare), but WTO and TRIPS being a reality, Indian industry is getting activated to partnering and bring innovations; (d) Technology policy and policy instruments with reference to technology management at enterprise level play a very important role; (e) The present reforms and initiatives of the government agencies for enhancing partnership and impact of research on industry are inadequate, though the situation has considerably improved, and is expected to should further improve.

8.3 Recommendations

The findings in Section 8.2 characterise the efforts undertaken in select developed countries as well as some countries with fast emerging economies for promoting technology development, its transfer and commercialisation through R&D agency – industry partnerships while correlating them vis-à-vis Indian initiatives in this area. The important strengths and weaknesses of the prevailing system are also indicated. The findings also ascribe the reasons for success and failures in existing partnerships in Indian context from the lessons learnt from a number of case studies, analysis of the responses of key stakeholders to specifically designed questionnaires, and also personal discussions with eminent persons involved with the technology transfer issues. Based on these assessments, possible improvements are suggested towards enhancing sustainable partnerships in India for technology development and transfer and a set of recommendations is made, which are general and broad in nature, but cater to the present and future needs of the partners in various disciplines of S&T. These recommendations are presented below in separate paragraphs respectively for R&D agencies,

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For R&D Agencies

- R&D agency should strictly observe a system of periodically monitoring the prospective technologies

- Research activities in R&D agencies in engineering discipline are mostly demand driven and less inquisitiveness driven. On the other hand, researches in agencies in chemical and biotechnology disciplines are both demand as well as inquisitiveness driven. The latter have been able to make a higher impact in commercialising their outcome. Therefore R&D agencies should endeavour to include the component of inquisitiveness driven research while making their R&D plans.

- R&D agency should make business plans in addition to R&D plans and should monitor and periodically review the plans and their implementation for setting the priorities and meeting the objectives. While policies should include emphasis on industry-oriented research, a balance between contract research to attend to the industry needs and cutting edge research, which would lead to breakthrough innovations and bring higher returns and visibility, should be maintained.

- R&D agency should make efforts to enhance its innovation capability by inducting young blood and increasing multi-disciplinary expertise. Individuals capable of generating breakthrough innovations should be identified and given freedom to develop an idea that would lead to a market-oriented technology.

- The research programmes should include application / demonstration of technologies for their validation and techo-economic feasibility study to substantiate the claims made by them to the industry.

- R&D agency should have adequate responsibility of utilising the government / public money grants enjoyed by it under proper government audit. It should develop assessment systems and performance indicators to estimate benefits delivered to the society as a whole as a result of public investments in S&T. The performance indicators suggested by Dr. R.A. Mashelkar, DG CSIR **[209]** placed at **Appendix – G** may be considered for this purpose.

- Entrepreneurship is a major focus of the work for strengthening the nexus between science and its applications. To encourage academicians and researchers to play entrepreneurial role, R&D agency should develop award and incentive structures in addition to utilising the government incentive schemes.

- The experience of other countries and of some academic institutions like IITs and IISC as well as findings from analysis of responses emphasise the need to establish an effective Business Development Group (or Technology Transfer Office) in every R&D agency to facilitate marketing of knowledge products, forging alliances and transfer of technology. Such Group should have the capability to acquire elaborate techno-commercial information for necessary techno-economic analysis of the technology clearly highlighting the economic gains while realistically estimating process economics. It should also have excellent industrial contacts both in the country and abroad. A person of scientific plus management background and relevant experience should lead the Group. Scientists and managers of the Group should have mutual respect and trust. The Group should either have its own legal experts who could interpret the patents, or outsource the legal and other necessary expertise.

- R&D agency should make appropriate projection of its past performance and accomplishments through mechanisms such as licensing information, brochures, exhibitions, Internet and informal meets to make industry aware of its R&D capability and competences.

- R&D agency should be milestone-driven, be objective-led organisation rather than a procedure-led one. Its structure should be facilitative and flexible for faster decision-making and expeditious administrative clearances. There should be more flexibility in terms of rules to negotiate contracts with industry.

- Top management of the R&D agencies should extend sustained support, have confidence in the scientists, encourage positive teamwork culture and attitude, provide state-of-the-art facilities and accept the failures and reward the success.

- Researchers should be liberally involved with industry in a transparent mode and have permission to avail benefits with an appropriate share to the R&D agencies.

- Business type interaction should be established with the industry that would facilitate getting a positive response to their partnership proposal. As a measure of confidence building with industry, the scientists should gain faith of the industry by demonstrating indigenous technologies and assuring it on product quality, production capacity, raw material consumption and timely delivery. R&D agency should share its scientific infrastructure with the industry preferably free of cost.

- R&D agency should take measures to understand the working of the industry besides its specific requirements. The researchers should be placed in the industry environment for real time home exposure to appreciate its requirement and ways of working.

- R&D agencies should be committed to meet the targets in defined time in cost effective manner. Specialised manpower may be assigned to deal with the industry.

- R&D agency should ensure confidentiality of information, as industry is always afraid of leaking marketing information of products developed by R&D agencies to other parties.

- The culture of partnership with industry should become an integral part of every R&D agency. The main purpose of industry to partner with R&D agency is to acquire new skills, cost effectiveness and technology upgradation. Therefore R&D agency should focus on these aspects.

- R&D agency should be associated with a professional body as such organisational membership could provide a lot to interaction with industry and other organisations at national as well as global levels, whereas an individual would have limitations.

For Industry

- Industry should play an enhanced role in technology development. Apart from profit motive it should focus on supporting R&D efforts on emerging areas of development in S&T. It should take up large-scale projects of benefit to society in the sectors of health, agriculture, energy and rural infrastructure development which will increase employment opportunities. Investment is the main problem faced by the industry and for this it can seek government subsidies in the areas of common interest.

- Industry should be clear of its requirements and should identify suitable processes and technologies for implementation and make appropriate plans for long-term commercialisation. Peer committee reviews should periodically scrutinise and update to study the trends. Future targets in specific areas should be set based on clues from the trend analysis. Management should take commercial trials and risks.

- In terms of budget allocation, manpower and other resources, R&D in industry should be treated at par with production. Industry should make increased allocation of funds to their in-house R&D activities and also to the R&D agencies for sponsored projects and programmes for meeting future demands and promoting grass root innovations and gaining access to innovations and skills.

- Industry should make long-term research plans and associate the R&D agencies for their implementation. Its approach should be to pass on the practical problems to the R&D agencies for problem solving in be involved with them throughout the project implementation process. It should give opportunity to its employees to work on these R&D projects.

- Industry should be more open and aggressive and should partner with R&D agencies in adapting technologies. It should proactively work and approach R&D agencies as well as intermediaries such as NMITLI, HGT and TDB for support.

- Industry should associate itself with R&D agencies in formal as well informal way. It should help them in identifying areas of focus for research, sponsor special research chairs in R&D institutes and evolve other appropriate mechanisms. It could form an association of similar companies, which adopt an R&D agency for a period of 10 years identifying itself with the goals of R&D agency. Industry should work with the R&D agency attached to it for its technology development and up gradation.

- There should be mutual trust, commitment and frequent interactions between the partners.

Partnership Building Processes

- Formal partnerships with well-defined objectives and terms for sharing the benefits among the partners should be forged as they help meeting the defined targets in fixed time. However partners should initially endeavour to get associated in an informal way, because informal partnerships are expected to eventually lead to formal ones. R&D agencies and industry should have proactive approach for forging and implementing partnerships.

- Partnership project should be framed primarily with the help of the partner scientist after detailed technical discussions. The funding requirements should be negotiated and a formal MOU should be signed to ensure timely delivery. Very fast track response and simplified procedures are required to ensure quick start of the project. This should be followed by frequent reviews to ensure timely delivery.

- Tie-up between R&D agencies and industry could be enhanced by making the policy more liberal and removing the bureaucratic hurdles. Integral plans be made between the partners for enhancement and sustainability of the partnership and there should be more interaction and brain storming sessions between the two to identify effective links and mechanisms. Frequent inter-transfer of scientists and managers between industry and R&D agencies are highly desirable.

- There is a need to have flexibility in structure, approach and procedures being followed by the two partners in technology partnerships. A market-oriented approach is required.

- Industry and R&D agencies, including universities, should evolve mechanisms to support the exchange of personnel. Industry should fund the chairs in the universities. It should induct researchers for at least 6 months or more for training and collaboration. Universities should design the application-oriented curriculum necessitating industrial training at various stages of the course. Degree should be awarded only on completion of industrial training.

- For advanced processes and new products, it is vital to initially carry out a professional project evaluation to identify the prospects for commercialisation, which should be followed by framing a project document acceptable to the industry and setting up a professional industrial liaison / tech-transfer system for the organisation, whose efficiency should be periodically monitored. However, this is not important to finding solutions to existing processes and consultancy.

For Intermediaries promoting Partnerships through Institutionalised Programmes

- The ongoing partnership programmes should be revisited for evaluating their efficacy and introducing necessary modifications for achieving enhanced impact and stimulating participation of industry. This includes (a) revisiting the administrative guidelines for reducing bureaucracy and bringing transparency; (b) revisiting the financial guidelines for introducing flexible funding mechanisms, i.e. grants-in-aid for strategic projects and those in frontier areas, soft or preferably tax free loan for projects dealing with proven technologies and equity participation for risk sharing;; and (c) appropriate selection and monitoring the guidelines, since quite often the high-end technologies and high-risk technology projects capable of making an impact do not get supported because in selecting a project the financial capability of the entrepreneurs is seen as a criteria.

- The institutionalised programmes of the government and public institutions should carry out exhaustive survey on the industrial needs and technology requirements; keep track of the current IP policies; carry out technology foresight and assessment at the national and global levels to catch up with the latest technology trends and access to market information; and create awareness about challenges and opportunities being unfolded by the emerging trends. Large number of R&D agency – industry partnership projects in all possible sectors of industry should be commissioned.

For Policy Makers

- The three major aspects of the technology policy, i.e., technology acquisition, technology generation and technology diffusion, should be well balanced and consistent with the industrial policies.

- While individual R&D agencies such as CSIR and ISRO have taken initiatives to promote entrepreneurship among their researchers and encourage them to forge alliances with industry for enhanced commercialisation of their output, researchers in most academic institutions do not receive such incentives. The national policy should provide for award and incentive structure to encourage entrepreneurship by academicians and researchers and encourage them to produce industry-oriented output. Appropriate laws in line with the Bayh-Dole Act of the USA should be enacted to allow the researchers to get involved with the industry to exploit research outcome and allowing its benefits to be received by the researcher concerned. IPR rules should be relaxed to an extent to attract researchers and industry.

- Industry should be backed up and encouraged to invest in R&D through attractive fiscal incentives. For example 5-year flat tax exemption on the profits generated though the partnership product could be given to industry particularly to the new technology based spin offs.

- There should be a policy to facilitate and provide incentives for closer cooperation between R&D agencies and industry, which would include incentives to industry for establishing and nurturing in-house R&D units and linkages with R&D agencies and incentives to R&D agencies to establish linkages with industry and technology transfer. R&D agency may even be made a part of the industry for carrying out R&D programmes useful for the growth of the industry.

- Different departments and agencies are coordinating the ongoing partnership promoting programmes that meet different specific needs. These programmes should be linked to provide a coordinated effort for supporting the innovation from idea to commercialisation stage to make enhanced outcome and impact.

- All the key stakeholders find that the existing partnership promoting programmes are not adequate. R&D agencies and industry both are keen to forge alliance at the bench-level feasibility stage itself. Therefore in addition to the ongoing programmes new programmes for supporting idea generation to commercialisation on the lines of NMITLI in all S&T disciplines as well as in specific sectors should be initiated. Special schemes for networking the universities with industry should be launched. Mobility of researchers and industry personnel to each other institutions should be encouraged.

- SMEs, an essential component for the success of partnership programmes should be fully represented in the national programmes. The government should encourage greater participation of SMEs, by lowering or even deleting entry barriers, such as by allowing participation of industry associations and by formation of partnerships in fields where SMEs play a significant role. Policy can also have an influence on the participation of foreign industry, which could be an important source, in the partnership programmes.

- The cluster approach in networking has been found very fruitful in other countries. In India too the networking between R&D agencies and industry should be stimulated through cluster development in different regions in strategic areas of innovation.

- The needs of the industry are not well-documented and known to R&D organisations in India. Similarly, awareness of technologies and level of development are not well-documented and known to industries. A coordinated effort should be launched to compile and continuously update this information, which should be available on the Internet. Additionally, other related information such as on patents, indigenous and foreign technologies, individual experts, regulatory agencies, which is helpful in building partnerships, should be maintained.

- India should keep a watch on partnership promoting efforts being taken by other countries with an aim to learn from their experiences, but being aware that the 'model' has to be adjusted to suit the national culture, conditions and objectives. Even the 'Best Practice' and 'Success Stories' cannot be simply copied and expected to work.

- Presently, the involvement of all the stakeholders in the knowledge generation to knowledge transfer and utilisation is generally fragmented and not well networked. Therefore India should take steps to further improve its innovation system, not only by taking advantage of the new knowledge created at home, but also by tapping knowledge from abroad and disseminating it for greater economic and social development. It should also improve the efficiency of public R&D and increase private R&D, as well as encourage greater university - national laboratory - industry linkages. There is a greater need and urgency than ever before for all the stakeholders to work together and substantially reduce the technology development cycles. This will also require increased funds and capacity for pursuing relevant basic research.

- Technology partnerships should be carefully designed and managed so as to engage partners with different cultures, management practices and objectives. Success depends on how well the partnership programme ensures industry commitment while balancing public and private objectives, fits into national innovation systems, optimises financing arrangements, creates appropriate international linkages, engages SMEs, and is periodically monitored and evaluated. For example, using a competitive, bottom-up approach to selection appears effective in ensuring that partnerships attract capable industries and draw upon established competencies, but top-down criteria may also be needed so that partnership programmes address areas of strategic importance for the country. The balance of financial contributions from the public and private sectors and the duration of public funding should also be adjusted to reflect the degree to which the research aims to fulfil government needs versus improving support to business R&D.

8.4 Conclusions and Future Perspectives

As the industry is gaining maturity, the role of R&D agencies too is undergoing a transformation. The Indian automobile industry, for example, is already somewhat matured and looks at the foreign R&D agencies for the R&D inputs as Indian R&D agencies are not in a position to meet all the R&D needs of this sector. While developing its own in-house R&D base, the industry in other sectors would similarly know what R&D input and new ideas it wants from the Indian R&D agencies, and what it would like to outsource from abroad, if not available within the country. It would however want to keep the sources of the skill base secret as outsourcing fetches the cutting edge skill base and core skilled team and access to these skills is a competitive advantage. The industry would be able to break the required new technology into parts and contract out the R&D inputs and new ideas on specific themes to different sources and integrate them into one commercialisable technology package. The ability to integrate such knowledge will be very important. During the fully mature industry phase, the distinction between Indian and foreign industry would more or less vanish.

A major focus of investment in innovation should be to support collaborative links at the local, regional and national levels between business, universities and public research institutes in seamless networks that integrate commercial, scientific and technological innovation. Unfortunately the 'innovation timeline' for Indian industry is far, far longer. What can be done to shorten this timeframe? How can an environment be conceived that would be conducive and supportive of innovation? How can a situation be arranged that would attract the entrepreneurial spirit? The need to create an environment that is receptive to innovative and entrepreneurial thinking is critical to maintaining and enhancing economic competitiveness. Currently our ability to move innovation to the marketplace is often viewed as an immovable barrier. There exists considerable scope to improve upon the existing Indian programmes and schemes by involving R&D agencies with industries more intensely through enhanced funding support mostly in terms of grant-in-aid, equity participation and zero interest loans. It is only through increased communication, cooperation and coordination that the currently segmented industry can work as one unified powerful force.

For India to remain competitive in a vibrant global innovative and research environment, it must have access to the best minds. There is a need to understand that the nation's pre-eminence rests on its technological strength which in turn depends entirely on its ability to attract, educate, recruit, and retain the best researchers. This would ensure the number and quality of scientists and engineers that is a national imperative upon which the nation's security and prosperity rests entirely.

In the short term, government agencies should examine the extent to which their programmes that support interactions between R&D agencies and industry encourage international collaboration with a view to making this a priority objective. Mechanisms should be established to enhance the coordination of support for university, R&D - industry interactions and facilitate more integrated life-cycle support for research and research commercialisation.

It is said that, "***The best way to predict the future is to create it.***" Our job today is to find a way to the marketplace. This means we must link all the forces: industry, R&D organisations and institutions, academia, government, and labour.

8.5 Specific Contributions by the Author

The contributions made by the author in this thesis are summarised below:

- ✓ Review of the existing practices, policies and procedures followed in India, in developed countries viz., USA, Germany, Japan and UK, as well as in developing countries viz., Brazil, China and Korea with critical appraisal, identification of gaps in Indian context and scope for improvement.

- ✓ Presenting fifteen selected collaborative projects of Indian R&D agencies with industry on development of technologies covering various sectors of applications and utilisation of these technologies in partnership with the industry and in some cases, their successful commercialisation, with a view to draw lessons in strengthening such partnerships on the basis of micro level experience.

- ✓ Based on the review of experiences of developed countries and countries with fast emerging economies including India and comparing their efforts for promoting S&T particularly through partnerships, gained insights into the salient features of the partnerships and used them in formulating the questions in Indian context. Designed three questionnaires, one each for research agencies, industry and intermediary bodies, based on the experiences gained, findings of the initial study and examination of the practices followed in India and other countries.

- ✓ Scientific analysis of the responses and suggestions received from the key stakeholders for enhancing the partnerships and drawing appropriate conclusions.

- ✓ Presentation of a summary of the analysis from primary and secondary data and appropriate recommendations to respective stakeholders for improving the partnership building processes, role of stakeholders and interface between them.

- ✓ *To the best of the author's knowledge, this is for the first time in India that a giant exercise of such magnitude and nature with a view to provide some recommendations for enhancing R&D agencies – industry partnerships has been taken up.*

8.6 Future Scope of Work

The present study considers the global challenges and the globalisation scenario in the country and is based on the collection of secondary as well as primary data on the knowledge generation, innovation, technical developments and prerequisites upon the R&D agencies, industry and the government and its various arms responsible for enabling and supporting the partnerships aimed at technology transfer and commercialisation. But in this study the partnership mechanisms have been looked into in a specific manner, as there was limited access to information from R&D agencies and industry as well as the governmental departments. Therefore the conclusions drawn from this study can form an excellent base for the future extension of the investigations, which could include, besides others, the comprehensive financial and funding aspects, patterns and structural arrangements of support to partnerships, detailed educational and research systems and arrangements vis-à-vis the industrial needs for innovative and workable technologies, long term planning for technological advancement and competence, etc.

It would also be advantageous to supplement the study by including more countries experiencing fast technology growth in the recent period, especially those like the Central Asian Republics and also the Commonwealth Independent States that were once considered as highly advanced, entered their rock bottom for several years after the disintegration of the Soviet Union, but are re-emerging with economic and technological might. Technology partnership mechanisms in some other developed and developing countries like France, Canada, Australia, Nordic States, Mexico, South Africa, etc. should also be considered in future work.

Further, it is necessary to develop a framework for organising statistical information about formal and informal interactions between R&D institutions and industry. Such a framework has the potential to serve as a useful tool in analysing quantitative and qualitative aspects of these interactions. For example, an analysis of investment, funding flows and the movement of personnel could serve to highlight areas in which interactions are highly developed, or where there are gaps in activity, as signposts to areas of potential strength and weakness.

Lastly, it may be appreciated that partnership issues are highly dynamic engaging the attention of most countries. New policies are being adopted and laws being enacted to protect the interest of the researchers and industries alike and boost the partnership efficacy. It is very important to keep pace with these developments and also keep analysing in depth the reasons behind inclusion of the new mechanisms in context of the developments taking place in the concerned country. The success of such moves in other countries could then form a basis for adoption of similar measures in India for accelerated technology growth.

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STUDY ON R&D AGENCY-INDUSTRY PARTNERSHIP FOR TECHNOLOGY DEVELOPMENT AND TRANSFER

Questionnaire

Requested response from working scientists and R&D Managers in the R&D Agencies

Note: (a) ***This questionnaire has been designed to complete this part of the study; (b) It is not mandatory to provide information in each and every column of the proposed questionnaire; (c) Some questions are routine in nature but a few are selective; (d) We will appreciate if the data filled in is as accurate and up-to-date as possible; (e) If desired, the information provided by the respondent shall be kept confidential; (f) Your cooperation will enable me to complete the study.***

Would you like the information to be kept confidential? **Yes / No**

Contact Details of Organisation

Name of Organisation	
Address	
Type of Organisation	R&D Institute / Academic Institute
Name of the Person responding	
Designation	
Department/Division/Wing	
Phone Number	
Fax Number	
Email address	

Background information on the Organisation

Sector, which the Organisation serves (Viz. Biotechnology, Informatics, Engineering, Chemical, etc.)			
Total number of Employees in the Organisation	PhD's	Masters/ Engineers	Support Staff

Is there any Special Group within the Organisation, which is primarily responsible for Technology Partnership Activities? If yes, please name and give number of persons associated.	Ph.D.	
	M.A. /M.SC./MBA	
	Engineers	
	Support Staff	
Annual R&D budget of the institute		
% of annual budget that organization may need to earn on its own (external cash flow)		
Investment made on R&D / Technology Development / Technology Transfer and its relationship (in %) with Total Annual Expenditure	• R&D	%
	• Technology Development	%
	• Technology Transfer	%
No. of patents filed / granted	Filed ______ (National) _____ (International)	
	Granted ______ (National) _____ (International)	
No. of new technologies developed / transferred		
Knowledge/Technology/Process/Product developed through Partnership with Industry (SME's, Large Industry, PSU, Industrial Associations/Clusters etc)		
Accomplishments in terms of the number of licences, joint ventures and spin out companies based on the IP generated under partnership projects supported by your organisation in last 5 years?	Licences	
	Joint ventures	
	Spin out companies	

Income generated each year from IP	In recent years	Currently	Planned

'Research-Industry Partnership' means R&D Agency - Industry Partnership for Technology Development and Transfer.
'Industry' means all Small & Medium Enterprises / Large Scale industry /Public Sector Units / Industry Associations / Clusters etc.

R&D Activities and Research-Industry Partnership

1. **What is the objective of your Organisation's R&D activities? Is it**
   - Inquisitiveness driven
   - Demand driven
   - Futuristic
   - Any Other, please specify

2. **Please mention the sources of demand influencing your R&D activities:**
   - Areas identified by the Government / strategic departments
   - Market / product surveys
   - Technological Process
   - Economic independence
   - Any other, please specify

3. **Does your organization focus on:**
   - Technology innovation / generation;
   - Assisting industry in Improving the production processes to lower cost and improve quality;
   - Technology upgradation for improving current product models;
   - Creating next generation product models;
   - Providing demand driven and technology oriented training courses for entrepreneurs;
   - Spearheading the growth of SME's;
   - Developing strong and sustainable linkages with Industry and Academia
   - Economic independence
   - Any other, please specify

4. **What are the targets of your Group / Division.**

5. **Do you focus on local / national / international / all user agencies for your products (new knowledge, technologies, processes etc.)? Also please state reason.**

6. **Who owns/shares the Intellectual Property generated under projects supported by the organisation- Individuals, R&D agency, Funding Department or any other combination?**

7. **Do you / your Group / organisation possess New Knowledge / Commercialisable Knowledge /Technology / Process, in which industry could be interested? If no, who is the user/beneficiary of your research work and how is the outcome of the research work transferred to them?**

8. **If you have new or commercialisable Knowledge /Technology / Process, in which industry may be interested, have you approached any industry for giving the same? If yes, how?**
   - Through Publicity (free publicity through interviews / news items in media, newspapers, relevant technical magazines, floating advertisement - paid / complementary
   - Participation in Trade fairs / exhibitions
   - Directly mailing information to prospective Partners, viz. suppliers of raw materials required in the process of manufacturing in the relevant area; Companies having competing products; Importers of the product; Companies having existing infrastructure for manufacturing
   - Mailing information to project mangers of sector specific industrial parts like STEPS
   - Mailing information to Industrial Associations / Clusters like STEPS
   - Interfacing agencies such as NRDC for match making
   - Any other, please specify

   Do you take the above steps yourself or is there a special group in the organisation, which is responsible for business development and management activities?

9. **How was the response of the industry?**
   a) Negative b) Positive

   9(a) **If negative,**
   - Were you able to project your achievements / offer properly?
   - Did you approach the right persons / industry?
   - Did you try well enough or gave up very soon
   - Any other please specify

   What would have helped you to receive a positive response from the industry?

   9(b) **If positive, for what purpose the industry needed your R&D inputs / technology?**
   - New technology for existing products
   - Technology Upgradation
   - Cost effectiveness
   - Increasing efficiency
   - Diversification
   - Acquiring new skills
   - Validation / Clinical Trials
   - Sharing infrastructure/facilities
   - Scientific surveys
   - Any other, please specify

10. Please give below some examples for each of the applicable purpose indicated above.

Purpose of Partnership	*Nomenclature of Project*	*Mode of Partnership* (Consultancy, sponsored research, Contract R&D, Collaborative R&D, training, Exchange of info. /data, etc)	*Name of the Partner Industry*	*Stage of Partnership in Tech.. Development Chain*
New technology for existing products				
Diversification				
Technology Upgradation				
Cost effectiveness				
Validation				
Clinical Trials				
Increasing efficiency				
Scientific Survey				
Sharing facilities / infrastructure				
Acquiring new skills				
Any other, please specify				

11. How did you formulate your Partnership?

a) Without the help of an external agency. Please mention the percentage of projects supported without the help of external agency ..... %

b) With the help of an external agency like NRDC. Please indicate the name of the agency as well as the percentage of projects supported with the help of such agency. %

In both the above cases please elaborate the pros & cons and the problems faced along with suggestions.

12. **Were the objectives of your partnership successfully achieved?**

    (a) Yes (b) No

    12(a) If yes, what % of objectives was achieved? What do you feel were the factors that contributed to the success?

    12(b) If No, then what do you feel was the problem? Please share your experience.

13. **How was the outcome of partnership shared? If it was on non-exclusive basis, how many industries shared the same technology?**

14. **Have the results been commercialised? If no, what was the problem?**

15. **How may times the same industry that has partnered with you earlier, has approached you / your organisation again for R&D inputs/technology?**

Factors affecting Partnerships

16. **Is your organization a member of a Professional/Industrial Association/Cooperative/ Society?** a) Yes b) No

    a) If yes, please name the Association and mention the role you expect the association to play.

    b) If no, and you feel it is useful to be a member of an industrial association, why hasn't your organisation joined hands with an Association?

17. **What in your opinion, do the following location related attributes of your Organisation influence the Partnership? If yes, how?**

Geographical	Political /Climatic
• Part of Industrial Area / Research Park	• Border area
• In the premises of R&D Agency	• Disputed area
• Extreme climate conditions	• Any other

18. **Are there any rules in your organisation that prevent employees from being involved in: i) Partnerships with industry ii) Licences, iii) Joint Ventures, iv) Floating Start-up / Spin-off Company while holding the position in the organisation?**

19. **Can a scientist quit the organisation along with his/her IP for floating his/her own company?**

20. **What in your opinion, are the factors limiting Research-Industry Partnership? Please tick (√) all relevant.**
    - Institutional capacity
    - Human capacity
    - Lack of information and training
    - Financial capacity
    - Institutional & market disincentives to partnership?
    - Any other, please specify

21. What in your opinion are the motives of R&D Agencies for Partnership with Industry? Please select top 5 in the order of priority. (Some examples of such motives could be: Gaining insights into the research problems of interest to industry for sourcing ideas for projects and new areas for research and training; Applying knowledge to solve real business problems and widen the customer base; Learning new skills and techniques developed in industry; Learning business processes and new approaches to managing projects; Harnessing private and public funding; sharing risk; Building on excellence and reputation; Complementing the physical, human and economic resource base; Sourcing job opportunities; Establishing links with industry's national and international networks; Fulfilling the mission of the R&D agency; Broadening the experience of employees; Enhancing regional economic development; Attracting skilled personnel for coordinating applied R&D programmes)

22. At what stage of the innovation chain do you find it appropriate to forge alliance with R&D Agency or other partners like consultants, financial institutes, marketing agencies etc.?

Stage of the innovation chain	Option		Priority
Basic scientific research / discovery of a principle	Yes	No	
Lab or bench level feasibility	Yes	No	
Engineering prototype and testing	Yes	No	
Production prototype and pilot plant	Yes	No	
Testing and modification	Yes	No	
Protecting IP	Yes	No	
Commercial introduction or operation use	Yes	No	
Widespread adoption	Yes	No	
Diffusion to other areas	Yes	No	
Social and economic impact	Yes	No	

23. What in your opinion are the reasons for lack of Research-Industry Partnership? Please select the top 5 in the order of priority.

R&D Agency	Priority	Industry	Priority
The R&D Agency is non-profit		The Industry is profit oriented	
Main mission is knowledge generation and expansion with valuation through publications		It has restriction on communication and publication with valuation through patents or revenue generation	
The nature of research is not always industry oriented.		Research is directed, strategic and applied and is exploited for development of product/process.	
Focus is mostly on long-term research with no emphasis on urgency		It has short-term goals with high pressure of time.	
There is no incentive for partnership		There is no incentive for cooperation	
Promotion/recognition depends on peer reviews and papers published.		Promotion depends on technologies developed / commercialised.	
Legal protection of IP may not be available / supported by R&D Agency.		Provisions of IP are over stretched.	
Any other, please specify		Any other, please specify	

24. **Do you feel the necessity to have technological information and databases on the items listed here for deciding about which technology to develop, with whom to partner etc.?**

Information on indigenous and foreign technologies	Yes	No	**If yes, then has your organisation made any attempt to develop and update the same?**	Yes	No
Patent Information	Yes	No		Yes	No
Information on Testing Facilities / Pilot Plants available in the country	Yes	No		Yes	No
Database on individual experts	Yes	No		Yes	No
Database on Certification / Regulatory Agencies for quality control and tests carried out by them	Yes	No		Yes	No
Information on Short Term Technology Training programmes	Yes	No		Yes	No
Information on technology development funding agencies	Yes	No		Yes	No
Information on Technical Barriers to trade (TBT)	Yes	No		Yes	No
Please indicate any other information/database not listed above:					

25. **What in your opinion are the factors arising from the perception of R&D Agencies about industry that restrict the Agency to approach the Industry for Partnership? Please select top 5 in the order of priority.**

- R&D Agency is not well informed about the need of the Industry.
- R&D Agency is not clear about how to make the first approach and whom to contact in the Industry;
- Due to diverse objectives, structure and working environment, R&D Agency is not sure whether Industry people will appreciate what is being offered to them by the R&D Agency.
- Industry would need proven technology with guaranteed performance, which may not be easily available under the circumstances in which the R&D Agency operates.
- Industry may want the technology free of cost / on exclusive basis.
- Industry has no faith on Indian R&D Agency, for example, due to security/confidentiality, intellectual property, patents considerations etc. and may want to approach international sources.
- Any other, please specify

26. **What in your opinion are the important reasons for failure of any Research-Industry Partnership for Technology Development? Please select top 5 in order of priority.**

- Cultural differences
- Difference in Structure of the Partner organisations
- Slow speed of administrative actions in the R&D Agency / Industry
- Lack of mutual understanding
- Differences in motives and objectives of partnership not well recognized / accommodated
- Lack of experience of the R&D agency in identifying and developing technologies into products for dynamic commercial markets
- Lack of communication / two way communication
- No stake of industry in the Government funded partnership projects
- Improper written Agreement
- Inefficient monitoring and review mechanism
- Any other, please specify

27. **What in your opinion are the important reasons for failure of any Research-Industry Partnership for Technology Transfer? Please select top 5 in the order of priority.**

- Industry and R&D Agency distrust the technology transfer programme or agency;
- R&D Agency and Industry do not want to share the benefit to be accrued from transfer of technology with the technology transfer programme/agency;
- Unripe / unproven technology;
- Lack of foresightedness on availability of raw material in sufficient quantity and market
- Government restrictions;
- Improper written Agreement;
- Any other, please specify

28. **In your opinion which ones of the following factors define success of Research-Industry Partnership? Please select top 5 in the order of priority.**

- Managing expectation by agreeing to a firm plan / programme of mutual benefit
- Setting priorities
- Commitment towards work that should be demonstrated and not only stated
- Preparedness towards change over the long-term length of the Partnership
- Shared resources - human, infrastructural, financial
- Room for improvement by doing self-critic and improving performance
- Timely completion of targets
- Two-way channel of communication, including casual phone calls
- Focus on the result, rather than the process
- Working environment of the partner organizations
- Partnership founded on faith, understanding and mutual respect
- The diverse inputs of the partners are valued
- Flexibility of approach
- Well recognized and accommodated differences in motives and objectives
- Fair, transparent and open Selection of partners
- Well structured and practiced Management, including review
- "Non-prescriptive" Approach to ownership and use of the results, based upon the levels and nature of inputs by each of the partners
- Incentives through intellectual property rights
- Any other, please specify

29. **Do you agree that recently there has been an increase in research-industry partnership? If yes, what do you feel is the reason?**

- Supply push (R&D labs looking for external cash flow and approaching the Industry.)
- Demand Pull (Industry itself is involved in R&D collaborations because of increased competition, which demands increased innovation and shorter development cycles.)
- Facilitating schemes of govt / financial institutions promoting Research-Industry Partnership
- Growing appreciation for the quality of research conducted by R&D Agencies, partly due to the emergence and expansion of science-based high-tech industries, eg. Biotechnology, microelectronics, nano-technologies etc. where Industry needs access to skills and research inputs of R&D Agencies.
- Industry outsourcing a greater share of basic research from R&D agencies as it is facing declining profit margins.
- Changes in IPR regulations
- Fiscal incentives
- Any other, please specify

30. Which type of partnership, in your pinion, bears more fruits and why?

a) Formal   b) Informal

If informal, how does your organization involve industry in its activities?

31. Which mode of partnership with industry you feel is the most appropriate for strengthening your / organizations activities and why?

- Mobility of experts
- Sub Contracting
- Consortia
- Information exchange on new scientific and technological advances
- Any other
- Sharing infrastructure
- Sponsored research
- Exchange of data
- Informal involvement of R&D agency in your activities

Assessment of Institutional Mechanisms supporting Research-Industry Partnership

32. Have you ever used the schemes of the Government Department, viz. Programme Aimed at Technological Self Reliance (PATSER) / Autonomous body [Schemes of National Research and Development Corporation (NRDC), Home Grown Technology Programme (HGT) of TIFAC, Technology Development Board (TDB)] / Financial Institutions? If yes, please share your experience on strong and week points of these programmes. Please give your suggestion for improving the efficacy of such schemes.

33. What form of finance you feel is most appropriate for Research-Industry Partnership, viz. Grants; Loans; Equity?

Views and Recommendations

34. What in your opinion are the expectations of an Industry from the R&D Agencies?

- Develop new technologies, products and processes for the growth of industry
- Provide assistance in adaptation of new technologies
- Give solutions to technological problems through consultancy
- Any other, please specify

35. In your opinion what impact the researches carried out in R&D agencies have made on the performance of the industry over the past, say, 20 years:

☐ 1. Very large
☐ 2. Large
☐ 3. Medium
☐ 4. Small
☐ 5. Very small/nonexistent

If your response is "Very large", could you please identify the specific areas of research which have made such a big impact.

36. In your opinion, what is the effect of technological change on products, services, processes and organization?

37. **What do you think are significant emerging trends or problems that the industry may face in the future that could benefit from R&D?**

38. **What changes are required, if any, in R&D if it is to be responsive to these industrial trends and problems?**

39. **What single step could be taken by R&D Agencies to enhance the impact of R&D on the industry?**

40. **Which ones of the following steps by R&D Agencies could enhance the Partnerships?**

- Carry out market research and study the world market status.
- Have ability to project the offer and demand.
- Appoint competent and committed project manager for planning, preparing detailed project report, key monitoring factors for the partnership proposals
- Stress on design/engineering development; documentation; introduction of a quality system.
- Generate mechanisms for continuous upgradation and improvement of development process.
- Validate its technologies using test equipments for process & quality control, best production machines and volume production at a global standard economic scale of operation.
- Establish a technical/Liason Group to for validation and transfer of technologies, even when the concerned scientist might have retired.
- Streamline the procedure for filing of patents to match the worldwide speed.
- Any other, please specify

41. **Do you agree that technology developments in India have not been very encouraging while achievements in science have been remarkable? If so please list the reasons. Please give your recommendations for improving the situation.**

42. **In your opinion what role the private sector in India is playing in technology development / transfer / diffusion? What additional role can the private sector play? What barriers prevent their greater participation?**

43. **What single step the Industry can take to enhance the impact of research on industry?**

44. **What in your opinion are the organizational structure, attitudes and objectives that can support the innovation and diffusion?**

45. **Should the marketing and transferring of technologies be mechanism-based or mechanism-free? If mechanism-based, then what are the processes/methods in place in your organisation for identification of buyer and transfer of technology?**

46. **How does your organisation receive feedback from the technology taker / industry on the technologies developed and transferred by the organisation? What has been the experience of the technology taker ?**

47. **Should the partnerships of R&D agencies be given preference with SME's or with the large companies? Please state the reasons.**

48. **Do you have any view on the following stages and whether they should be followed for building a technology partnership? Please tick (√) the relevant response.**
    a) Establish internal framework
    b) Decide to enter into partnership
    c) Prepare implementation plan
    d) Select a preferred partner
    e) Negotiate the contract
    f) Work with the partner
    g) Any other step

49. **In your opinion, what is the role of technology policy and policy instruments with reference to technology management at enterprise level?**

50. **What are the ingredients of technology development / transfer strategy and action plan?**

51. **In your opinion what policy measures and fiscal incentives are essential for promoting Research-Industry Partnership? Please give your Recommendations / Suggestions.**

52. **Are the present reforms and initiatives of the Government Agencies sufficient to undertake enhanced Research –Industry Partnership? What single step could be taken by the government to enhance the impact of research on industry?**

53. **In your opinion what is the global practice vs. Indian preference vis-à-vis technology partnerships? Do foreign competitors have larger technology support programmes? Where do the Indian programmes supporting/encouraging partnerships stand?**

54. **Please give your recommendations / suggestions for enhancing the partnership between R&D Agencies and Industry for Technology development / transfer, thereby enhancing the impact of R&D on industrial performance?**

55. **Any comments, pointers to other studies or suggestions would be appreciated.**

Signature

STUDY ON R&D AGENCY-INDUSTRY PARTNERSHIP FOR TECHNOLOGY DEVELOPMENT AND TRANSFER

Questionnaire

Requested response from Industry

Note: (a) *This questionnaire has been designed to complete this part of the study;* (b) *It is not mandatory to provide information in each and every column of the proposed questionnaire;* (c) *Some questions are routine in nature but a few are selective;* (d) *We will appreciate if the data filled in is as accurate and up-to-date as possible;* (e) *If desired, the information provided by the respondent shall be kept confidential;* (f) *Your cooperation will enable me to complete the study.*

Would you like the information to be kept confidential? Yes / No

Contact Details of Organisation

Name of Organisation	
Address	
Type of Organisation (please tick the applicable)	In-house R&D / Small & Medium Enterprises / Large Scale industry /Public Sector Unit / Industry Association or Cluster
Name of the Person completing the Questionnaire	
Designation	
Deapartment/Division/Wing	
Phone Number	
Fax Number	
Email address	

Background information on the Organisation

Brief Genesis of the Organisation		
Year in which established		
Sector, which the Organisation serves (Viz. Biotechnology, Informatics, Engineering, Chemical, etc.)		
Total number of Employees in the Organisation		
Number of Qualified Employees serving R&D / Technology Development / IPR Generation / Technology Sourcing	Ph.D.	
	M.A./ M.SC./ MBA	
	Engineers	
	Support Staff	
Is there any Special Group within the Organisation, which is primarily responsible for Technology Partnership Activities? If yes, please indicate below the name of such Group and No. of persons associated in the table.	Ph.D.	
	M.A. /M.SC.	
	Engineers	
	Support Staff	
Investment made on R&D / IPR generation (Annual turnover)		
How many new Technologies / Products were developed through Partnership with R&D Agencies in last 10 years?		
How many new technologies were inducted from R&D Agencies / commercialised in last 10 years?	Inducted	Commercialised

'R&D Agency' means R&D Institutions and Academic Institutions

'Industry' means all Small & Medium Enterprises / Large Scale industry /Public Sector Units / Industry Associations / Clusters etc.

'Research-Industry Partnership' means R&D Agency - Industry Partnership for Technology Development and Transfer.

Research-Industry Partnership

1. Have you ever felt the need of Research-Industry Partnership for acquiring new knowledge / technology to successfully implement your targets?

If yes, then for what purpose? (please tick all applicable)

- New technology for existing products
- Technology Upgradation
- Diversification
- Cost effectiveness
- Acquiring new skills
- Increasing efficiency
- Validation
- Sharing infrastructure/facilities
- Clinical Trials
- Scientific surveys
- Any other

Please give below some examples for each of the applicable purpose indicated above.

2. How does your organization source the new knowledge / R&D inputs / technology?

a) In-house R&D Unit b) Outsourcing - Foreign / Indigenous

2(a) If the source is In-house R&D Unit:

(i) Are your R&D activities only your company demand driven or you also perform inquisitiveness driven R&D? Please mention the kind of activities being done in-house, viz, Tech innovation/generation; Improving production processes to reduce production cost and improve quality; Tech upgradation for improving current product models; Creating next generation product models.

(ii) Sources of demand influencing your R&D activities (Please √ all applicable).

- Market / product
- Areas identified by the Govt. and strategic departments
- Competition-internal/ global
- Self assessment by the Organisation for increasing productivity, reducing cost, diversification, etc. for sustaining competition
- Technological Process
- Any other, please mention

2(b) If the source of new knowledge / R&D / technology is not In-house R&D, would you opt for Foreign Sources or Indian Sources? Please state the reason.

What are the processes/methods in place in your organisation for identification of technology supplier and induction of technology?

3. If you prefer Indian sources for technology/R&D inputs, do you know the Indian sources?

(a) Yes (b) No

3(a) If yes, then have you approached any Indian R&D Agency for technology / R&D inputs? In this case, please give the information below.

Name of the Partner R&D Agency	*Purpose of Partnership*	*Mode of Partnership* (Consultancy, Sponsored/ Collaborative / Contract Research, Exchange of info. /data, training, etc)	*Nomenclature of Project*	*Stage of Partnership in Techn. Development Chain*

3(b) If you do not know the Indian sources, have you approached any agency for such information? If so, please name the agency.

4. How was the response of the R&D Agency you approached for R&D inputs/technology?
(a) Positive (b) Negative

4(a) If the response was positive how did you formulate your Partnership?

a) Without the help of an external agency. Please mention the percentage of projects supported without the help of external agency %

b) With the help of an external agency like NRDC. Please indicate the name of the agency as well as the percentage of projects supported with the help of such agency. %

In both the above cases please elaborate the pros & cons and the problems faced along with suggestions.

4(b) If the response of the R&D Agency was negative,

- Did you approach the right persons / Agency?
- Were you able to project your demand / offer properly?
- Did you try well enough or gave up very soon?
- Any other please specify

What would have helped you to receive a positive response from the R&D Agency?

5. **Were the objectives of your Partnership with the R&D Agency successfully achieved?**

(a) Yes **(b) No**

5(a). If yes, what % of objectives was achieved? What do you feel were the factors that contributed to the success?

5(b) If No, then what do you feel was the problem? Please share your experience.

6. **How was the outcome of partnership shared?**

7. **Have the results been commercialised? If no, what was the problem?**

8. **Have you / your organisation again approached the same R&D Agency for R&D inputs / technology? If yes, how may times?**

Factors affecting Partnerships

9. **Is your organization a member of an Industrial Association?** a) Yes b) No

a) If yes, please name the Association and mention the role you expect the association to play.

b) If no, and if you feel that it is useful to be a member of an industrial association, why has your organisation not joined hands with an Association?

10. **In your opinion, do the following location related attributes of your Organisation influence the Partnership? If yes, how?**
    - Geographical
    - Part of Industrial Area / Research Park
    - In the premises of R&D Agency
    - Extreme climate conditions
    - Political /Climatic
    - Border area
    - Disputed area
    - Any other

11. **What in your opinion, are the factors limiting Research-Industry Partnership? Please tick (√) all relevant.**
    - Institutional capacity
    - Human capacity
    - Any other, please specify
    - Financial capacity
    - Lack of information and training

12. **What in your opinion is the motivation of industry for Partnership with R&D Agency? Please select top 5 in the order of priority.**

- Establishing links with R&D Agencies' extensive national and international networks;
- Benefiting from new ideas and past experiences of R&D Agencies;
- Using technologies developed in R&D Agencies for renewal and expansion of programmes;
- Complementing Industry's human and physical resource base by accessing the multi-disciplinary expertise, infrastructure and services of R&D Agency not available in house;
- Identifying potential employees for the Organisation;
- Reducing risk and overall expenses by sharing costs, releasing staff time etc;
- Harnessing public funds by bringing additional financial resources to bear on research;
- Smoothing fluctuating in-house demand;
- Combating enhanced internal/international competition;
- Any other, please mention

13. **At what stage of the innovation chain do you find it appropriate to forge alliance with R&D Agency or other partners like consultants, financial institutes, marketing agencies etc.?**

Stage of the innovation chain	Option		Priority
Basic scientific research / discovery of a principle	Yes	No	
Lab or bench level feasibility	Yes	No	
Engineering prototype and testing	Yes	No	
Production prototype and pilot plant	Yes	No	
Testing and modification	Yes	No	
Protecting IP	Yes	No	
Commercial introduction or operation use	Yes	No	
Widespread adoption	Yes	No	
Diffusion to other areas	Yes	No	
Social and economic impact	Yes	No	

14. **What in your opinion are the reasons for lack of Research-Industry Partnership? Please select the top 5 in the order of priority.**

R&D Agency	Priority	Industry	Priority
The R&D Agency is non-profit		The Industry is profit oriented	
Main mission is knowledge generation and expansion with valuation through publications		It has restriction on communication and publication with valuation through patents or revenue generation	
The nature of research is not always industry oriented.		Research is directed, strategic and applied and is exploited for development of product/process.	
Focus is mostly on long-term research with no emphasis on urgency		It has short-term goals with high pressure of time.	
There is no incentive for partnership		There is no incentive for cooperation	
Promotion/recognition depends on peer reviews and papers published.		Promotion/recognition depends on technologies developed / commercialised.	
Legal protection of IP may not be available / supported by R&D Agency		Provisions of IP are over stretched.	
Any other, please specify		Any other, please specify	

15. Do you feel the necessity to have technological information and databases on the items listed here for deciding about which technology to develop, with whom to partner etc.?	Information on indigenous and foreign technologies	Yes	No	**If yes, then has your organisation made any attempt to develop and update the same?**	Yes	No
	Patent Information	Yes	No		Yes	No
	Information on Testing Facilities / Pilot Plants available in India	Yes	No		Yes	No
	Database on individual experts	Yes	No		Yes	No
	Database on Certification / Regulatory Agencies for quality control and tests carried out by them	Yes	No		Yes	No
	Information on Short Term Technology Training programmes	Yes	No		Yes	No
	Information on technology development funding agencies	Yes	No		Yes	No
	Information on Technical Barriers to Trade (TBT)	Yes	No		Yes	No
	Please indicate any other information/database not listed above:					

16. What are the factors arising from industry's perception about R&D Agencies inhibiting it to partner with R&D Agency? Please select the top 5 in the order of priority.

- Industry has no faith in Indian R&D Agencies and feels that academicians and scientists talk in theory and do not have practical experience and live in ivory towers;
- Industry is not clear about (a) how to make the first approach and whom to contact in the R&D Agency; (b) whether the R&D Agency charges the industry for talking;
- Due to difference in structure and working environment Industry is not sure whether people in R&D Agency speak / understand and appreciate industries language and its concern;
- R&D Agency may not give importance to security/confidentiality, IPR issues;
- R&D Agency has no respect for time schedules and budgets, delays and cost overruns;
- R&D Agency may not have proven technology with guaranteed performance;
- If Industry accepts lab scale, untried know-how, who will compensate if it fails.
- R&D Agency may not give technology on exclusive basis.
- Scientists, when interacts or visits the industry, may steal the existing technology and pass it on to others/competitors.
- Any other, please specify

17. What in your opinion are the important reasons for failure of any Research-Industry Partnership for Technology Development? Please select the top 5 in the order of priority.

- Cultural differences
- Difference in structure of the Partner organisations
- Slow speed of administrative actions in the R&D Agency / Industry
- Lack of mutual understanding
- Differences in motives and objectives of partnership not well recognized / accommodated
- Lack of experience of the R&D agency in technology identification/development/transfer
- Lack of communication / two way communication
- No stake of industry in the Government funded partnership projects
- Improper written Agreement
- Inefficient monitoring and review mechanism
- Any other, please specify

18. **What in your opinion are the important reasons for failure of any Research-Industry Partnership for Technology Transfer? Please select the top 5 in the order of priority.**

- Industry and R&D Agency distrust the technology transfer programme / agency;
- R&D Agency and Industry do not want to share the benefit to be accrued from transfer of technology with the technology transfer programme/agency;
- Unripe / unproven technology;
- Lack of foresightedness on availability of raw material in sufficient quantity and market;
- Government restrictions;
- Improper written Agreement;
- Any other, please specify

19. **In your opinion which ones of the following factors define success of Research-Industry Partnership? Please select top 5 in the order of priority.**

- Managing expectation by agreeing to a firm plan / programme of mutual benefit
- Setting priorities
- Commitment towards work that should be demonstrated, and not only stated
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- Shared resources - human, infrastructural and financial
- Room for improvement by doing self-critic and improving performance
- Timely completion of targets
- Two-way channel of communication, including casual phone calls
- Focus on the result, rather than the process
- Working environment of the partner organizations
- Partnership founded on faith, understanding and mutual respect
- Valuing the diverse inputs of the partners
- Flexibility of approach
- Well recognized and accommodated differences in motives and objectives
- Fair, transparent and open Selection of partners
- Well structured and practiced Management, including review
- "Non-prescriptive" Approach to ownership and use of the results, based upon the levels and nature of inputs by each of the partners
- Incentives through intellectual property rights
- Any other, please specify

20. **Do you agree that recently there has been an increase in Research-Industry Partnership? If yes, then please state the reason from the below-mentioned?**

- Supply push (R&D labs looking for external cash flow and approaching the Industry.)
- Demand Pull (Industry itself is involved in R&D collaborations because of increased competition, which demands increased innovation and shorter development cycles.)
- Facilitating schemes of govt / financial institutions promoting Research-Industry Partnership
- Growing appreciation for the quality of research conducted by R&D Agencies, partly due to the emergence and expansion of science-based high-tech industries, eg. Biotechnology, microelectronics, nano-technologies etc. where Industry needs access to skills and research inputs of R&D Agencies.
- Industry outsourcing a greater share of basic research from R&D agencies as it is facing declining profit margins.
- Changes in IPR regulations
- Fiscal incentives
- Any other, please specify

21. **Which type of partnership, in your opinion, bears more fruits and why?**
a) Formal b) Informal

If informal, how does your organization involve R&D Agencies in its activities?

22. **Which mode of partnership with industry you feel is the most appropriate for strengthening your organizations activities and why? Please √ all applicable.**

- Mobility of experts
- Sub Contracting
- Consortia
- Information exchange on new scientific and technological advances
- Any other
- Sharing infrastructure
- Sponsored research
- Exchange of data
- Informal involvement of R&D agency in your activities

Assessment of Institutional Mechanisms supporting Research-Industry Partnership

23. **Have you ever used the institutionalised schemes / programmes of the Government and financial institutions, viz. PATSER, NRDC, HGT, TDB etc? If yes, please share your experience on their strong and week points and give suggestions to improve their efficacy.**

24. **What form of finance in your view is most appropriate for Research-Industry Partnership and why?** (a) Grants (b) Loans (c) Equity

25. **If your organization approaches Govt./ financial institutions for funds and if not awarded, would your organization still support the same project on its own?**

Views and Recommendations

26. **What in your opinion are the expectations of an Industry from the R&D Agencies?**
- Develop new technologies, products and processes for the growth of industry
- Provide assistance in adaptation of new technologies
- Give solutions to technological problems through consultancy
- Any other, please specify

27. **In your opinion what impact the researches carried out in R&D agencies have made on the performance of the industry over the past, say, 20 years:**
☐ 1. Very large
☐ 2. Large
☐ 3. Medium
☐ 4. Small
☐ 5. Very small/nonexistent

If your response is "Very large", could you please identify the specific areas of research which have made such a big impact.

28. In your opinion, what is the effect of technological change on products, services, processes and organization?

29. What is the role of R&D in educating people who work in your industry? Please focus on research activities, rather than R&D agencies.

30. What do you think are significant emerging trends or problems that the industry will face in the future that could benefit from R&D?

31. What changes are required, if any, in R&D if it is to be responsive to these industrial trends and problems?

32. What single step could be taken by R&D Agencies to enhance the impact of R&D on the industry?

33. Do you agree that technology developments in India have not been very encouraging while achievements in science have been remarkable? If so please indicate the reasons. Please give your recommendations for improving the situation.

34. What role in your opinion is the Industry in India playing in technology development / transfer / diffusion? What additional role can the Industry play? What barriers prevent its greater participation?

35. What single step the Industry can take to enhance the impact of research on industry?

36. Which ones of the following steps by the Industry could enhance the Partnerships?

- Prepare an inventory of the future needs of human resource and skills;
- Provide support for projects of students, research fellows;
- Sponsor long-term research;
- Hold periodic seminars in collaboration with R&D agencies;
- Share equipment and facilities with R&D agencies;
- Any other, please specify

37. Are there institutional and market disincentives to Partnership?

38. What are the ingredients of technology development / transfer strategy and action plan?

39. **In your opinion what policy measures and fiscal incentives are essential for promoting Research-Industry Partnership? Please give your Recommendations / Suggestions.**

40. **Are the present reforms and initiatives of the Government Agencies sufficient to undertake enhanced Research –Industry Partnership? What single step could be taken by the government to enhance the impact of research on industry?**

41. **In your opinion what is the global practice vs. Indian preference vis-à-vis technology partnerships? Do foreign competitors have larger technology support programmes? Where do the Indian programmes supporting/encouraging partnerships stand?**

42. **Please give your recommendations / suggestions for enhancing the partnership between R&D Agencies and Industry for Technology development / transfer, thereby enhancing the impact of R&D on industrial performance?**

43. **Any comments, pointers to other studies or suggestions would be appreciated.**

Signature

STUDY ON R&D AGENCY-INDUSTRY PARTNERSHIP FOR TECHNOLOGY DEVELOPMENT AND TRANSFER

Questionnaire

Response requested from intermediaries facilitating Technology Development / Transfer

Note: (a) ***This questionnaire has been designed to complete this part of the study; (b) It is not mandatory to provide information in each and every column of the proposed questionnaire; (c) Some questions are routine in nature but a few are selective; (d) We will appreciate if the data filled in is as accurate and up-to-date as possible; (e) If desired, the information provided by the respondent shall be kept confidential; (f) Your cooperation will enable me to complete the study.***

Would you like the information to be kept confidential? **Yes / No**

Contact Details of Organisation

Name of Organisation	
Address	
Type of Organisation (please strike out the ones, not applicable)	♦ Technology Information Provider / Transfer Facilitator / Enabler ♦ Technology Development Promoter ♦ Technology Financer / Risk Capital ♦ Venture Capital ♦ Professional Body ♦ Technology Business Incubator ♦ STEPs
Name of the Person completing the Questionnaire	
Designation	
Phone Number	
Fax Number	
Email address	

Background information on the Organisation

Brief Genesis of the Organisation		
Year in which established		
Is there any Special Group within the Organisation, which is primarily responsible for Technology Partnership Activities? If yes, please name and give number of persons associated.	Ph.D.	
	M.A. /M.SC./MBA	
	Engineers	
	Support Staff	
Investment made on Schemes promoting R&D / Technology Development / Technology Transfer and its relationship (in %) with Total Annual Expenditure	♦ R&D	%
	♦ Technology Development	%
	♦ Technology Transfer	%

'Research-Industry Partnership' means R&D Agency - Industry Partnership for Technology Development and Transfer.
'Industry' means all Small & Medium Enterprises / Large Scale industry /Public Sector Units / Industry Associations / Clusters etc.

Support to Research-Industry Partnership Projects

1. **Does your Organization support Research-Industry Partnership projects under its identified areas?**

   Yes / No

2. **If yes, please mention how the areas are identified and what are the current priority areas.**

3. **How does your Organization support / facilitate Research-Industry Partnership?**

4. **Are there any schemes viz. Home Grown Technology (HGT), REACH, PATSER, NMITLI, etc. for enabling Research-Industry Partnership? If yes, please name the schemes**

   A.

   B.

   C.

   D.

5. **What has been the genesis of the above schemes?**

6. **What are the primary objectives of the above schemes, when initiated and their target market (Local / Global / Regional / Sectoral)?**

Name of Scheme	Brief Objectives (Funding joint initiative of technology development / upgradation / commercialization; Facilitating transfer of technology to Indian / international Industry by technology sourcing; Facilitating patenting, licensing, matchmaking, validation, export etc.; Granting Technology Award; Facilitating fiscal incentives)	Year of launch	Target Market
A.			
B.			
C.			
D.			

7. **What is the kind of funding [grant; loan (loan at par / conditional / on interest); equity] provided by your organization for enabling Research-Industry Partnerships? Also please indicate the maximum funding (% of total cost of project) in the second column.**

Scheme A		*Scheme B*		*Scheme C*		*Scheme D*	
	%		%		%		%

8. **What are the special features of the schemes? Please select top 5 in the order of priority.**

- The schemes are part of a long history of organisation's support to industry;
- The schemes are industry driven;
- Cost-sharing in the schemes acts as a reality check;
- The schemes give stress on technical and commercial feasibility;
- The schemes provide for flexibility;
- The schemes limit dead-ends;
- Spillover technologies with high social benefits are kept in focus;
- The schemes focus on developing the economic benefit for early stage, high-risk, enabling innovative civilian technologies;
- The schemes encourage formation of partnerships and consortia to promote technology development and diffusion;
- The schemes have meticulous and competitive selection process with an independent evaluation of the project's technical merit, commercial worthiness and potential for broad-based benefits The schemes are well-managed and carefully evaluated;
- Any other, please mention

9. **At what stage of the innovation chain do your schemes support Research-Industry Partnership (please tick √ the stage)?**

Stage of Innovation Chain	*Scheme A*	*Scheme B*	*Scheme C*	*Scheme D*
Basic research / discovery of a principle				
Lab or bench level feasibility				
Engineering prototype and testing				
Production prototype and pilot plant				
Protecting IP				
Commercial introduction or operation use				
Product testing and modification				
Widespread adoption				
Diffusion to other areas				
Social and economic impact				

10. **What are the driving forces of Research – Industry Partnership under these schemes? Please select top 5 in the order of priority.**

- Sharing of cost (supply push)
- Sharing of expertise
- Complimentarity
- Sharing of risk
- Access to knowledge
- Increased competition
- Have the end user of technology
- The industry knows what the market wants
- The Industry has good idea what future needs might be
- The Industry has existing outlets for products
- The Industry has practical approach to taking new developments into production
- Any other, please mention

11.

Who owns the intellectual property generated under projects supported by the organisation?	Participating individuals
	Participating institutes
	Your organization alone
	All the above

12. **How does the organisation ensure / outsource the requirement of institutional structure and human capacity to facilitate Research-Industry Partnerships?**

13.	**How is your organization managing and monitoring the R&D projects supported under its schemes? Please tick all relevant.**	Area specific Review Committees
		Periodic reviews; If so, then how frequent?
		Visit to project sites
		Strong communication system
		Any other, please specify

Outcome and Evaluation of Scheme

14. **New Knowledge / Commercialisable Knowledge / Technology / Process / Product developed jointly by R&D Agencies and Industry under above schemes since inception**

Name of Scheme	No. of Projects funded under scheme	Total number of new and Commercialisable Knowledge/ Technologies/ Processes developed	Out of these, number of Knowledge/ Technologies/ Processes/ Products commercialized	Nomenclature of knowledge/ Technologies / Processes developed (Pl. attach a sheet, if required.)	Sector of development viz. Medical, Biotechnolog y Chemical, Engineering, etc.	Expenditure made so far	Returns
A.							
B.							
C.							
D.							

15. **What is the Annual Expenditure on the Scheme vis-à-vis the Returns thereon?**

Name of Scheme →→	A.		B.		C.		D.	
	↓ AE - Annual Expenditure under the Scheme ↓ ↓ R - Returns on Annual Expenditure ↓							
	AE	**R**	**AE**	**R**	**AE**	**R**	**AE**	**R**
1994-95								
1995-96								
1996-97								
1997-98								
1998-99								
1999-2000								
2000-01								
2001-02								
2002-03								
2003-04								

16. **How does the organisation get the returns from the funded projects (viz. Royalty, Sharing IPR, etc)?**

17. **Please mention the Income generated each year by your organisation from Intellectual Property generated under R&D projects supported.**

In recent years	
Currently	
Planned	

18. **How does your organization evaluate the success of the projects supported under your schemes? Please indicate your parameters for measuring success.**

19. **What is the success rate of the projects / programmes supported under these schemes?**

20. **What impact your Schemes have made in terms of technology development / diffusion / commercialization?**

21. **Does your organization provide free training courses for entrepreneurship development? -** Yes / No

22. **Does your organisation have any relationship with the Industry for commercializing the results of R&D achieved under your schemes? If so, what are the initiatives taken to encourage / support such commercialization?**

23. **Does your organization review the scheme? If yes, with what frequency and what has been the assessment? Does your organisation have any plans to bring reforms in the existing schemes / initiate new programme to enhance Research - Industry Partnership?**

Factors Affecting Partnerships

24. **What in your opinion are the perceptions of R&D agencies and Industry about each other, that restrict them to approach each other for Partnership for Technology Development and Transfer?**

25. **Do you agree that the following factors are responsible for lack of Research-Industry Partnership? Please select the top 5 in the order of priority.**

R&D Agency	Priority	Industry	Priority
The R&D Agency is non-profit		The Industry is profit oriented	
Main mission is knowledge generation and expansion with valuation through publications		It has restriction on communication and publication with valuation through patents/ revenue generation	
The nature of research is not always industry oriented.		Research is directed, strategic and applied and is exploited for product/process development	
Focus is mostly on long-term research with no emphasis on urgency		It has short-term goals with high pressure of time.	
There is no incentive for partnership		There is no incentive for cooperation	
Promotion/recognition depends on peer reviews and papers published.		Promotion depends on technologies developed / commercialised.	
Legal protection of IP may not be available / supported by R&D Agency.		Provisions of IP are over stretched.	
Any other, please specify		Any other, please specify	

26. **Do you / your Organization feel that lack of information is a key reason for missing links between R&D Agencies and Industry. If yes, is it necessity to have technological information and databases on the items listed here?**

			If yes, then has your organisation made any attempt to develop and update the same?		
Information on indigenous and foreign technologies	Yes	No		Yes	No
Patent Information	Yes	No		Yes	No
Information on Testing Facilities / Pilot Plants available in the country	Yes	No		Yes	No
Database on individual experts	Yes	No		Yes	No
Database on Certification / Regulatory Agencies for quality control and the tests carried out by them	Yes	No		Yes	No
Information on Short Term Technology Training programmes	Yes	No		Yes	No
Information on technology development funding agencies	Yes	No		Yes	No
Information on Technical Barriers to trade (TBT)	Yes	No		Yes	No
Any other, not listed above:					

27. **Do you agree that recently there has been an increase in Research-Industry Partnership? If yes, then please state the reason from the below-mentioned?**
    - Supply push (R&D labs looking for external cash flow and approaching the Industry.)
    - Demand Pull (Industry itself is involved in R&D collaborations because of increased competition, which demands increased innovation and shorter development cycles.)
    - Facilitating schemes of govt / financial institutions promoting Research-Industry Partnership
    - Growing appreciation for the quality of research conducted by R&D Agencies, partly due to the emergence and expansion of science-based high-tech industries, eg. Biotechnology, microelectronics, nano-technologies etc. where Industry needs access to skills and research inputs of R&D Agencies.
    - Industry outsourcing a greater share of basic research from R&D agencies as it is facing declining profit margins.
    - Changes in IPR regulations
    - Fiscal incentives

28. **What in your view are the reasons for failure of the Research – Industry Partnership? Please select top 5 in the order of priority.**

- Cultural differences
- Difference in structure of the Partner organisations
- Slow speed of administrative actions in the R&D Agency / Industry
- Lack of mutual understanding
- Differences in motives and objectives of partnership not well recognized / accommodated
- Lack of experience of the R&D agency in technology identification/development/transfer
- Lack of communication / two way communication
- No stake of industry in the Government funded partnership projects
- Unripe technology (not-proven technology)
- R&D agency and industry do not want to share the benefit to be accrued from technology partnership with the agencies supporting the partnership programmes
- Industry is not always honest and takes Govt. loans/money from schemes such as TDB, PATSER, HGT etc. as easy money
- Lack of foresightedness on availability of raw material in sufficient quantity and market;
- Government restrictions;
- Improper written Agreement
- Inefficient monitoring and review mechanism
- Any other, please specify

29. **In your opinion which ones of the following factors define success of Research-Industry Partnership? Please select top 5 in the order of priority.**

- Managing expectation by agreeing to a firm plan / programme of mutual benefit
- Setting priorities
- Commitment towards work that should be demonstrated, and not only stated
- Preparedness towards change over the long-term length of the Partnership
- Shared resources - human, infrastructural and financial
- Room for improvement by doing self-critic and improving performance
- Timely completion of targets
- Two-way channel of communication, including casual phone calls
- Focus on the result, rather than the process
- Working environment of the partner organizations
- Partnership founded on faith, understanding and mutual respect
- Valuing the diverse inputs of the partners
- Flexibility of approach
- Well recognized and accommodated differences in motives and objectives
- Fair, transparent and open Selection of partners
- Well structured and practiced Management, including review
- "Non-prescriptive" Approach to ownership and use of the results, based upon the levels and nature of inputs by each of the partners
- Incentives through intellectual property rights
- Any other, please specify

Views and Suggestions

30. **Do you perceive that Research-Industry Partnership Schemes / programmes of the Government / financial institutions are the key to new technologies, in order to:**

- Achieve Government Missions
- Sustain Economic Growth
- Enhance Citizen Welfare

31. What in your opinion are the expectations of the R&D Agencies and Industry from the institutionalised mechanisms / programmes, such as of your organisation, supporting Research-Industry Partnership?

32. Are your schemes meeting the above expectations?

33. What is your individual assessment about the schemes?

♦ These are achieving their legislative objectives.	Yes	No
♦ These are carrying out excellent monitoring / assessment mechanisms.	Yes	No
♦ These are establishing record of valuable achievements, some with great promise.	Yes	No
♦ These are potential model for other technology programmes.	Yes	No
♦ They need some refinement.	Yes	No
♦ These are generating high social benefits in specific sectors. Pl.name the sectors	Yes	No

♦ Any other, not listed above:

34. What in your opinion are the suggested actions for improvements in the implementation of these schemes?

♦ Adopt a process involving round the year calling the proposals.	Yes	No
♦ Distribute projects in various sectors, while also retaining the general competition.	Yes	No
♦ Insure integration of assessment results and their early dissemination.	Yes	No
♦ Assure greater predictability and stability in funding, with the adage that uncertainty is the enemy of proposals for and execution of R&D programmes.	Yes	No
♦ Capitalize on core competency of schemes, that is, its ability to screen, select, monitor, and assess projects with technological and commercial promise.	Yes	No
♦ Seek greater with a focus on generation and demonstration of new research ideas and not commercial development	Yes	No
♦ Use more funds efficiently and effectively, consistent with the goals set for the scheme.	Yes	No

♦ Any other, please mention

35. Please indicate the factors (viz. Industry Leadership, Shared Cost, Frequent Assessment, Tight Management, etc.) that in your opinion could enhance the success rate of the supported projects and programmes. Please indicate the reasons.

36. Should in your view the marketing and transferring of technologies be mechanism-based or mechanism-free? If mechanism-based, then what are the processes/methods in place for identification of buyer and transfer of technology?

37. In your opinion should the scheme be designed in such a way that it covers the high-risk, high payoff technologies beyond capabilities / hurdle rates of individual firms?

38. What in your opinion influences the decision-making process for technology development?

39. In your opinion what has been the role of technology at enterprise level in India? What are the factors that may affect the management decisions concerning technology?

40. What in your opinion is the effect of technological change on products, services, processes and organization?

41. What do you think are significant emerging trends or problems that the industry may face in the future that could benefit from R&D?

42. What changes are required, if any, in the Partnership facilitating schemes, such as of your organization, to be responsive to these industrial trends and problems?

43. Do you have any view on the following stages for building a technology partnership and whether they should be followed? Please tick (√) the relevant response.

Establish internal framework	Yes	No
Decide to enter into partnership	Yes	No
Prepare implementation plan	Yes	No
Select a preferred partner	Yes	No
Negotiate the contract	Yes	No
Work with the partner	Yes	No

Any other step

44. **In the list below (illustrative, but not exhaustive) please tick (√) all significant barriers to R&D agency - Industry partnership for technology development and transfer.**

- Institutional capacity
- Human capacity
- Slow speed of administrative actions
- Lack of experience (of R&D Agencies) in identifying and developing technologies into products for dynamic commercial markets
- Improper agreement and IPR sharing problems
- Financial capacity
- Lack of information and training
- Mismatches in the incentives for partnerships
- Diverging time horizons: Industry, particularly SSI/MSI focused on specific solutions to specific problems and R&D institutes focused on long term research
- Institutional and market disincentives

Any other, please specify

45. **What form of finance in your view is most appropriate for Research-Industry Partnership and why?** (a) Grants (b) Loans (c) Equity

46. **Should the partnerships of R&D agencies be given preference with SME's or with the large companies? Please state the reasons.**

47. **Do you agree that technology developments in India have not been very encouraging while achievements in science have been remarkable? If so please indicate the reasons. Please give your recommendations for improving the situation.**

48. **What in your opinion are the organizational structure, attitudes and objectives that can support the innovation and diffusion?**

49. **What role, in your opinion, is the Industry in India playing in technology development / transfer / diffusion? What additional role can the Industry play? What barriers prevent their greater participation?**

50. **What single step could be taken by the Industry to enhance the impact of research on industry?**

51. **What single step could be taken by the R&D Agencies to enhance the impact of R&D on the industry?**

52. **What single step could be taken by the government to enhance the impact of research on industry?**

53. **In your opinion what is the global practice vs. Indian preference vis-à-vis technology partnerships? Do foreign competitors have larger technology support programmes? Where do the Indian programmes supporting/encouraging partnerships stand?**

54. **Are the present reforms and initiatives of the Government Agencies sufficient to undertake enhanced Research –Industry Partnership?**

Yes, Why	No, why

55. **In your opinion, what are the ingredients of technology development / transfer strategy and action plan?**

56. **In your opinion what policy measures (such as new mechanisms, etc) and fiscal incentives are essential for promoting/enhancing the Research – Industry Partnership?**

57. **Please give your recommendations / suggestions for enhancing the partnership between R&D Agencies and Industry for Technology development / transfer, thereby enhancing the impact of R&D on industrial performance?**

58. **Any comments, pointers to other studies or suggestions would be appreciated.**

Signature

List of R&D Agencies whom the Questionnaire was sent

(**Shown in ***bold italics***, if response received)

Sector	Administrative Agency	S.N.	Name of the R&D Agency	No. of Individuals to whom sent
Biology and Bio-technology	CSIR	1.	***Centre for Cellular and Molecular Biology, Hyderabad***	3
		2.	***Central Drug Research Institute, Lucknow***	5
		3.	Central Food Technology Research Institute, Mysore	3
		4.	Central Institute of Medicinal & Aromatic Plants, Lucknow	3
		5.	Institute of Himalayan Bio-resouce Technology, Palampur	4
		6.	Institute of Genomics and Integrative Biology, Delhi	3
		7.	***Indian Institute of Chemical Biology, Kolkata***	3
		8.	***Institute of Microbial Technology, Chandigarh***	3
		9.	Industrial Toxicology Research Centre, Lucknow	3
		10.	***National Botanical Research Institute, Lucknow***	5
		11.	***Regional Research Laboratory, Jammu Tawi***	5
	DBT	12.	National Centre for Plant Genetic Research, JNU Campus, New Delhi	1
		13.	National Institute of Immunology, New Delhi	1
	DST	14.	Agharkar Research Institute, Pune	1
	ICMR	15.	Indian Council of Medical Research, New Delhi	1
Agri-culture	ICAR	16.	***Indian Agriculture Research Institute, New Delhi***	1
		17.	Nuclear Research Laboratory, Indian Agricultural Research Institute, New Delhi	1
Chemical Sciences	CSIR	18.	***Central Electrochemical Research Institute, Karaikudi***	3
		19.	***Indian Institute of Chemical Technology, Hyderabad***	4
		20.	Indian Institute of Petroleum, Dehradun	4
		21.	Central Leather Research Institute, Chennai	3
		22.	***Central Salt & Marine Chemicals Res. Inst., Bhavnagar***	6
		23.	***National Chemical Laboratory, Pune***	4
		24.	Regional Research Laboratory, Jorhat	2
Physical Sciences	CSIR	25.	***Central Electronics Engineering Research Institute, Pilani***	10
		26.	***National Geophysical Research Institute, Hyderabad***	4
		27.	National Physical Laboratory, New Delhi	5
		28.	Regional Research Laboratory, Bhopal	4
	DAE	29.	Bhabha Atomic Research Centre, Mumbai	1
		30.	Physical Research Institute, Ahmedabad	1
Engineering	CSIR	31.	Central Glass and Ceramic Research Institute Kolkatta	3
		32.	Central Mechanical Engg. Research Institute, Durgapur	3
		33.	Central Mining Research Institute, Dhanbad	2
		34.	Central Road Research Institute, New Delhi	2
		35.	Central Scientific Instruments Organisation, Chandigarh	2
		36.	***National Aerospace Laboratories, Bangalore***	5

		37.	*National Metallurgical Laboratory, Jamshedpur*	4
		38.	*Regional Research Laboratory, Bhubaneshwar*	2
		39.	*Regional Research Laboratory, Thiruvananthapuram*	3
		40.	*Structural Engineering Research Centre, Chennai*	5
	DRDO	41.	*Defence Metallurgical Research Laboratory, Hyderabad*	2
	DST	42.	*International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad*	3
	NGO	43.	The Energy and Resources Institute, New Delhi	2
Oceanology	CSIR	44.	*National Institute of Oceanography, Goa*	5
Management	CSIR	45.	URDIP	1
Defence	DRDO	46.	INMAS, Timar Pur, New Delhi	1
Academic	DRDO	47.	Institute of Armament Technology, Pune	1
	MoHW	48.	All India Institute of Medical Science, New Delhi	1
	MHRD	49.	Indian Institute of Technology, New Delhi	3
		50.	Indian Institute of Technology, Kanpur	1
		51.	Indian Institute of Technology, Mumbai	1
		52.	Indian Institute of Technology, Guwahati	1
		53.	Indian Institute of Technology, Roorkee	2
		54.	Indian Institute of Technology, Kharagpur	1
		55.	Indian Institute of Technology, Madras	1
		56.	Indian Institute of Science, Bangalore	1
		57.	Andhra University, Hyderabad	1
		58.	Anna University, Chennai	1
		59.	Banaras Hindu University, Banaras	1
		60.	*Delhi College of Engineering, Delhi*	1
		61.	Jamia Millia Islamia, New Delhi	1
		62.	Netaji Subhash Institute of Technology, Delhi	1
		63.	Punjab Technical University, Jalandhar	1
		64.	Roorkee University, Roorkee	1
		65.	Univ. Department of Chemical Technology, Mumbai Univ.	1
		66.	University of Poona, Pune	1
	Private	67.	Ansal Institute of Technology, Gurgaon	1
		68.	Madras School of Economics, Chennai	1
		69.	Maharaja Agrasen Institute of Technology, Delhi	1
		70.	New Delhi Institute for Information Technology, New Delhi	1
Professional Research Bodies	Private Society	71.	Talwar Research Foundation, New Delhi	1
		72.	National Foundation of Indian Engineers,New Delhi	1
Private Individual	--	73.	Dr Y R Sarma, Former Director, IISR, M 10/5 Aramam KSAHB Colony, Malaparamba, Calicut	1
Total No. of Questionnaires sent				**172**

List of industry whom the questionnaire was sent

(**Shown in ***bold italics***, if response received)

Sector	S.N.	Name of the Industry	No. of Individuals to whom sent
Biotechnology	1.	***ARBRO Pharmaceuticals Ltd., New Delhi***	1
	2.	***DALMIA Centre for Research & Development, Coimbatore***	1
	3.	***J. Mitra & Co. Ltd., New Delhi***	1
	4.	***MILLIPORE India Pvt. Ltd., Bangalore***	1
	5.	***NICHOLAS PIRAMAL India Ltd., Mumbai***	2
	6.	***SHANTHA Biotechnics Ltd., Hyderabad***	2
	7.	AGILENT LSCA, Kalkaji, New Delhi	1
	8.	AMERSHAM Biosciences, Channai	1
	9.	ARYA Vaidya Pharmacy (Coimbatore) Ltd, Coimbatore	1
	10.	BECTON Kickinson India Ltd., Gurgaon	1
	11.	BHARAT Biotech International, Hyderabad	1
	12.	BHARAT Serums and Vaccines, Mumbai	1
	13.	BIOCON India Limited, Bangalore	2
	14.	BIO-RAD Laboratories, Gurgaon	1
	15.	CADILA Pharmaceuticals Ltd., Ahmedabad	1
	16.	CHEMINOVA India Ltd., Distt. Bharuch, Panoli	1
	17.	DABUR India Limited, Ghaziabad	1
	18.	DABUR Research Foundation, Sahibabad	3
	19.	DR REDDY'S Laboratories, Hyderabad	1
	20.	EID Parry (India) Ltd., Chennai	1
	21.	ELDER Pharmaceuticals Ltd., Navi Mumbai	1
	22.	ELI LILLY & Co., Gurgaon	1
	23.	EMCURE Pharmaceuticals Ltd., Pune	1
	24.	EMERGENT Genetics India Pvt. Ltd., Hyderabad	1
	25.	GLENMARK Pharmaceuticals Ltd., New Delhi	2
	26.	HAFFKINE Biopharmaceutical, Mumbai	1
	27.	INDIAN Immunologicals Ltd., Hyderabad	2
	28.	LIFECARE Innovations Pvt. Ltd.,Gurgaon	1
	29.	LUPIN Laboratories Ltd., Mumbai	1
	30.	LUPIN Laboratories Ltd., New Delhi	1
	31.	MODI Mundipharma Pvt. Ltd., Modipuram	2
	32.	NATURAL Remedies Pvt. Ltd., Bangalore	1
	33.	PANACEA Biotech, Mathura Road, New Delhi	1
	34.	PRATHISTA Industries (PIL), Nalgonda Dist. Andhra Pradesh	1
	35.	QUINTILES Research (India) Pvt. Ltd., Bangalore	1
	36.	QUINTILES Spectral, Ahmedabad	1

	37.	RANBAXY Laboratories Ltd, Gurgaon	2
	38.	RANBAXY Laboratories, Nehru Place, New Delhi	1
	39.	SAMI Labs. Ltd., Bangalore	1
	40.	SIRO Clinpharm, Mumbai	1
	41.	SPAN Diagnostics, Surat	1
	42.	TRANSASIA Biomedicals Limited, Mumbai	1
	43.	WIPRO Healthscience, Bangalore	1
	44.	WOCKHARDT, Mumbai	1
	45.	XCYTON Diagnostics Limited, Bangalore	1
	46.	ZANDU Pharmaceutical Works Ltd., Mumbai	1
Agriculture	47.	***SUNGRO Seeds Ltd., New Delhi.***	1
	48.	JK Agri Genetics Limited, Hyderabad	1
	49.	AVESTHA Gengraine Technology Pvt. Ltd., Bangalore	1
	50.	CROP Life India, New Delhi	1
	51.	EXCEL Industries Limited, Mumbai	1
	52.	NIRMAL Seeds (P) Ltd., Pachora	1
	53.	PHYTOTRON Agro Products (India) Pvt. Ltd, Bangalore	1
	54.	TATA Tea Limited, Kolkata	1
Chemical	55.	***GODAVARI Sugar Mills Ltd., MG Road, Mumbai***	1
	56.	***INDIAN Petrochemical Corporation Ltd (IPCL), Vadodra***	1
	57.	***RALLIS Research Centre, Peenya Industrial Area, Bangalore***	1
	58.	***RUBAMIN Limited, Synergy House, Vadodra***	1
	59.	***MATHUR Corr-Tech Private Lt., Coimbatore***	1
	60.	KREBS BIOCHEMICALS, Hyderabad	1
	61.	ACTIVE Carbon India Pvt. Ltd., Hyderabad	1
	62.	ANIL Starch Product Ltd., Ahmedabad	1
	63.	EXCEL Industries Limited, Mumbai	1
	64.	GUJARAT Alkalies & Chemicals Ltd., Vadodara	1
	65.	GUNJAN Paints Ltd., Ahmedabad	1
	66.	HIGH Polymer Labs. Ltd., Ballabhgarh, Faridabad	1
	67.	INDIA Glycole Ltd., Kashipur	1
	68.	JUBILIANT Organosys Ltd., Gajraula	2
	69.	JUBLIANT Organosys, Noida	5
	70.	NAMIEX Chemical Pvt. Ltd., Pathankot	1
	71.	PEST Control (India) Pvt. Ltd., Mumbai	1
	72.	RELIANCE Industries Ltd., Polymers & Olefins Business, Mumbai	2
	73.	SARASIJAM Technologies, New Delhi	1
	74.	SUD Chemie India Ltd., New Delhi	1
	75.	THIRUMALAI Chemicals Ltd., Ranipet	1
	76.	UNICHEM Laboratories Ltd., Mumbai	1
Engineering	77.	***ST.JOSEPHS Tiles, Ernakulam***	1
	78.	***ABAQUS Engineering India, Chennai***	1
	79.	***TATA Refractories Ltd., Belpahar***	1

	80.	***OMTEK Electronics (P) Ltd., Bhubaneswar***	1
	81.	***SHRIRAM Energy Systems Ltd., Hyderabad***	1
	82.	***SATNA Cement Works, Sagmania Limestone Mine***	1
	83.	***BASIC Technology (P) Ltd., Kolkata***	1
	84.	***AHUJA Radios, New Delhi.***	1
	85.	***ADOR Fontech Ltd., Delhi***	1
	86.	***HIGH Energy Batteries (India) Ltd., Mathur***	1
	87.	***TATA Steel, Naomundi, Singhbhum West***	1
	88.	CONMAT Technologies Private Limited, Kolkata	1
	89.	SARASIJAM Technologies, New Delhi	1
	90.	SHRIRAM Institute for Industrial Research, Delhi	2
	91.	INTERNATIONAL Tractors Ltd., Delhi	1
	92.	INTERNATIONAL Tractors Ltd., Hoshiarpur	1
	93.	NATURA Fibretech Pvt. Ltd., Bangalore	1
	94.	LARSEN and Toubro, Mumbai	1
	95.	NORTHERN Minerals Ltd., Gurgaon	1
	96.	ONDEO Nalco India Ltd., Kolkata	1
	97.	J.K. Paper Mills, Rayagada	1
	98.	BALLARPUR Paper Mill, Chandrapur Dist	1
	99.	INDIAN Tobacco Company Ltd., Bhadrachalam Paperboards Division, Sarapaka	1
	100.	POLYMER Papers Ltd., Faridabad	1
	101.	CENTRAL Electronics Limited, Ghaziabad	1
	102.	BHARAT Electronics Limited, Bangalore	1
	103.	WAVE Systems Technologies Pvt. Ltd., Bangalore	1
	104.	RAJASTHAN Electronics & Instruments Ltd., Jaipur	2
	105.	NEPTUNE Equipment Pvt. Limited, Bombay	1
	106.	PBJ-Industrial Electronics Pvt.Ltd., New Delhi	1
	107.	GENUS Overseas Electronics Ltd, RIICO Indl. Area, Sitapur	1
	108.	FIBCOM India Ltd., Gurgaon	2
	109.	MOSER Baer, Corporate Office, New Delhi	1
	110.	ANANTH Technologies Ltd. (ATL), Hyderabad	1
	111.	STAR International, Krishnagiri	1
	112.	ITC Limited, ITC Group Research & Dev. Centre, Bangalore	3
	113.	EFFTRONICS Systems Pvt. Ltd., Vijayawada	1
	114.	DIVINET Access Technologies Limited, Pune	1
	115.	ENCORE Software Ltd., Bangalore	1
	116.	MOSCHIP Semiconductor Technology Private Ltd. Hyderabad	1
	117.	TATA Consultancy Services, Hyderabad	1
	118.	CDC Linux Pvt Ltd., Bangalore	1
	119.	FRONTIER Information Technologies Ltd., Secunderabad	1
	120.	APCP (drk-APCP@apcp.ltindia.com)	1
	121.	STEEL Authority of India Limited, New Delhi	1

	122.	TATA Steel, Jharkand	1
	123.	BHARAT Heavy Electricals Ltd., New Delhi	2
	124.	BHARAT Heavy Electricals Limited, Hyderabad	1
	125.	BHARAT Heavy Electricals Limited, Hardwar	1
	126.	CENTRE for the Development of Glass Industry, Firozabad	1
	127.	HERO Honda Motors Limited, Dharuhera	2
	128.	JAI Bharath Maruti, Gurgaon	1
	129.	TVS Motor Company Ltd., Harita Hosur	1
	130.	TVS Motor Company, Chennai	2
	131.	JK Industries Ltd., Kankroli Tyre Plant, Kankroli	1
	132.	ASHOK Leyland Ltd., Chennai	1
	133.	RICO Auto Industries Ltd., Gurgaon	1
	134.	MAHINDRA & Mahindra Ltd, Mumbai	1
	135.	EICHER Motors Limited, Indore, Madhya Pradesh	1
	136.	SUNDRAM Fasteners Limited, Dr. Radhakrishnan Salai, Chennai	1
	137.	BAJAJ Auto (ssbhambure@bajajauto.co.in, sssane@bajajauto.co.in	2
	138.	TATA Motors (nitin.kamble@tatamotors.com, arvindakshan@tatamotors.com)	2
	139.	VIRTUSA (prasadk2@virtusa.com)	1
	140.	SHREE Cement Limited, Beawar	1
	141.	CERA Sanitaryware Ltd., Kadi	1
	142.	Cement Manufacturers Association, Noida	1
	143.	INDIA Cements Ltd., Chennai	1
	144.	GRASIM Industries Ltd., Cement Business-Technology Coordination and Planning Cell, Mumbai	1
	145.	FERROCEMENTS Pre Fab Ltd., Bangalore	1
	146.	JUBILENT Enpro Pvt Ltd., Oil and Gas Division, Noida	3
	147.	INDIAN Oil Corporation Ltd., R&D Centre, Faridabad.	2
	148.	ONGC LTD., KDM Institute of Petroleum Exploration, Dehradun	1
	149.	RELIANCE Power Limited, New Delhi	1
	150.	SHRIRAM Energy Systems Ltd., Hyderabad	1
	151.	SANGEETH Carter Wind Power (P) Ltd. Coimbatore	1
	152.	National Thermal Power Corporation India Ltd., R&D Centre, Noida	2
	153.	National Hydroelectric Power Corporation India (anilkumargupta@nhpc.nic.in, parmesh_ns@nhpc.nic.in)	2
	154.	MULTI ARCINIA (umhatre@multi-arcinia.com)	1
	155.	DIRECTORATE General of Hydrocarbons, New Delhi	1
	156.	INDIAN Rare Earths Ltd. (IREL), Mumbai	1
Professional Body	157.	AHMEDABAD Textile Industry's Research Association, Ambawadi Vistar	1
Atomic Energy	158.	*INDIRA Gandhi Centre for Atomic Research, Kalpakkam*	2
	159.	INDIAN Explosives Ltd., Distt. Bokaro, Jharkhand	1
Total No. of Questionnaires sent			**190**

List of Intermediary Agencies whom the Questionnaire was sent

(**Shown in ***bold italics***, if response received)

S.N.	Name of Organisation	Type of Organisation
1.	***Council of Scientific and Industrial Research, New Delhi***	Autonomous
2.	***Technology Information Forecasting & Assessment Council, Delhi***	Autonomous
3.	***Technology Development Board, New Delhi***	Autonomous
4.	***Department of Scientific & Industrial Research, New Delhi***	Government
5.	***Department of Science & Technology, New Delhi***	Government
6.	***National Research Development Corporation, New Delhi***	Autonomous
7.	***Asian & Pacific Centre for Transfer of Technology, New Delhi***	International
8.	***ISAAA, New Delhi***	International
9.	***Waterfalls Institute of Technology Transfer, New Delhi***	Private TTO
10.	***Foundation for Innovation & Technology Transfer, IIT Delhi***	Academic TTO
11.	Antrix Corporation Limited, ISRO, Bangalore	Academic TTO
12.	Society for Innovation and Development, IISC, Bangalore.	Academic TTO
13.	Centre for Scientific and Industrial Consultancy, IISC, Bangalore	Academic
14.	Indian Institute of Technology, Roorkee	Academic
15.	Biotechnology Consortium India Limited, New Delhi	Autonomous / Private
16.	Sathguru Management Consultants, Hyderabad	Private Consultant
17.	ICICI Knowledge Park, Hyderabad	Knowledge Park

Performance Indicators

Category of benefits	Benefit	Suggested Possible indicators (To be decided by the laboratory)
Public goods	Generation of and dissemination of generic knowledge	Number of papers published in international peer-reviewed journals/ publications
		Number of papers published in national journals
		Number of books or monographs authored or edited (do Not include authorship of book chapters here)
		Number of presentations/ posters in international conferences
		Number of presentations/posters in national conferences and seminars
		Number of patents filed nationally
		Number of patents filed outside
		Number of policy reports authored or edited for the national or state government
		Number of major national/ regional collections, compilations, databases
	Highly trained man-power	Number of PhDs produced
		Number of post-PhD positions
		Number of Research Interns
	Science awareness, popularization etc; culture of science and innovation	Number of popular S&T articles published
		Number of school children exposed to science etc
		Number of students (under graduate and Masters level) who underwent project training/ internships etc
		Number of public lectures organized for the general public
		Number of national and regional workshops, seminars, technology demonstrations
	National image, Pride and standing among nations;	Number of international awards won (With details)
		Memberships of major international academies and learned societies (Cumulative Membership years)
		Memberships of editorial boards of international peer-reviewed journals (Cumulative Membership years)
		International certifications and recognitions for the institutions
		Number of papers in international peer-reviewed journals
		Number of foreign patents granted
	Representation in global affairs	Official roles in global/ trans-national organizations like the UN, WIPO, etc. (cumulative years of office held)
		Official roles in global/ trans-national scientific societies and bodies like IUPAC (cumulative years of office held)
Social goods	Socially relevant services and technology	Case studies of special services like maintaining standards, collections, surveys, etc.
		Case studies of socially relevant technology developed and deployed successfully.

Private goods	Research, consulting, teaching and analytical services	Total earnings from projects done for Turkish businesses/ industry
	Continuing education	Number of Industry persons trained
		Total earnings from continuing education/ training programs
	Licensing and technology transfer	Total earnings in the form of royalty, know fees etc from clients
		Case studies on the larger impact of technologies commercialized for an industry or sector of the economy.
Strategic goods and options	National security needs	Money inflow corresponding to projects done for the strategic sector (defense, etc.)
	Strategic positioning in other industries	Money inflow corresponding to projects done with businesses where the goal was to be self-reliant, capture niche markets,etc (Rs. Crore)
	Other tactical and strategic developments	Number of national patents granted
		Number of foreign patents granted
	Contributions to creating of technology options	
		Money inflow from national technology initiatives
Intellectual assets and reputation	Quality, reputation and standing of scientific man-power	Number of papers in international peer-reviewed journals
		Number of scientists who are members of editorial boards of international peer-reviewed journals
		Number of PhDs granted where lab scientists were research guides
		Number of national patents granted
		Number of foreign patents granted
		Number of EU Framework programs
		Number of new hirings with PhDs from reputed universities (national and abroad)
	Uniqueness of facilities	Unique national instrumentation or information or other facilities
		Special international accreditations and certifications
	Lab's reputation with industry	Total worth of projects with industry
		Fortune Global 500 (Relevant Year list) clients
		Total worth of projects with Fortune Global 500 clients

BRIEF BIOGRAPHY OF THE CANDIDATE

Mrs. Rama Swami got her Master's degree in Computer Science and Engineering from Moscow Railway Engineering Institute in 1991. After having briefly taught computers at the Technical Teachers Training Institute, Chandigarh, she joined the International Division of the Department of Science & Technology, Government of India (DST) in 1992. In the beginning her excellent command over Russian language was extensively used in coordinating the visit of the scientists from the CIS and CAR countries under the Integrated Long Term Programme of Cooperation in Science & Technology (ILTP) between India and the countries of the erstwhile Soviet Union. Later, for about 5 years she worked as Delhi Office In-Charge of the International Advanced Research Centre for Powder Metallurgy & New Materials (ARC-I), Hyderabad. In addition, she assisted in the management of the bilateral programmes of India with several countries in the fields of science & technology. Since 1997 Mrs. Rama Swami is working as a Scientist in the Council of Scientific & Industrial Research (CSIR) and is responsible for initiating and looking after the implementation of a number of programmes of S&T cooperation of CSIR with several countries, including Germany and the Russian Federation and other CIS / CAR Countries.

BRIEF BIOGRAPHY OF THE SUPERVISOR

Prof. Arun P. Kulshreshtha is heading the Centre for Science and Technology of the Non-Aligned and other Developing Countries (NAM S&T Centre) as its Director. The Centre is an inter-governmental body like the United Nations.

Prof. Kulshreshtha was born in Agra, India in 1941. After having graduated in Physics from Agra University in 1959 he joined Banaras Hindu University as a research scholar in Radio Engineering. Subsequently, he completed his doctorate in 1965 from Moscow State University in Physical & Mathematical Sciences (Semiconductor Physics). Early part of the professional carrier of Dr. Kulshreshtha encompassed his affiliation as a scientist at the National Physical Laboratory (NPL), New Delhi; Assistant Professor and Head of the Solid State Physics Laboratory at the Indian Institute of Technology (IIT), New Delhi; Senior Research Associate at NASA Marshall Space Flight Centre, Huntsville in USA; Associate Professor at Middle East Technical University (METU), Ankara; Visiting Professor at Lancaster University, UK; Scientific Manager at the Solid State Physics Laboratory (SSPL) of the Defence Research & Development Organisation (DRDO), New Delhi; and In-Charge, Quality Control of Remote Sensing Satellites at ISRO Satellite Centre (ISAC), Bangalore of the Indian Space Research Organisation (ISRO).

He served as Counsellor (Science & Technology) at the Embassy of India, Moscow during 1984-88, when he conceived and formulated an Integrated Long Term Program of Cooperation in Science & Technology (ILTP) with the then Soviet Union, which has been the biggest ever bilateral scientific program of not only India, but also of the Soviet Union. During 1993-2001 he headed the International Division in the Department of Science and Technology DST of the Government of India. Prof. Kulshreshtha was instrumental in initiating bilateral, multilateral and regional cooperation with a large number of countries. He extensively contributed to conceiving and establishing the International Advanced Research Centre for Powder Metallurgy & New Materials (ARC-I) at Hyderabad, which is a model organization for technology transfer and development of high performance materials and processes for niche market, and Bharat Immunologicals & Biologicals Corporation Ltd. (BIBCOL) at Bulandshahr, a public sector organisation for the production of cell culture based oral polio vaccine. He was the Chairman of the SAARC and BIMSTEC S&T Committees, National Focal Point for India's cooperation with UNESCO in S&T and Co-Chairperson of several bilateral inter-governmental S&T Joint Committees. He was the principal negotiator for India-EU S&T Agreement and signatory to its draft. He was totally involved in various facets of creating and setting up of the Indo-US Science & Technology Forum right from its conceptualisation. Prof. Kulshreshtha headed the Indian national program for the development of space quality silicon solar cells, which have been flown in solar panels put on Indian satellites. He has published about 50 research papers in international journals and knows several languages, including Hindi, English and Russian, over which he has excellent command