UNIVERSITY — INDUSTRY LINKAGE

THE MOST ELUSIVE OBJECT
# UNIVERSITY – INDUSTRY LINKAGE

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1. **INTRODUCTORY**

1.1 Medical institutions have the distinction that they have a very strong linkage between teaching / research and practice through mandatory attachment of integrated hospitals. Engineering institutions of higher learning are not enjoying the same benefit. In an era of knowledge – based economy, in principle, the relationship between the knowledge creators and end-users has to be well defined and settled.

1.2 In the following discussion the term “industry” includes economic activities in the manufacturing as well as service sector, for example electric power generation, water supply, and construction will be classified as industrial activities.

1.3 The term “University - Industry Linkage” refers to interaction between all parts of the higher educational system and the industrializing economy (UN, 1974) [50].

1.4 The advantages of technology transfer process go both ways, to the research centers as well as to the industry.

1.5 Advantages to university and its research centers may be listed as follows:
— the opportunity to access the needs of the economy and to develop its activities accordingly through income from the sales of technology;

— the opportunity to place students in industry so that classroom learning can be related to practical experience;

— access to industry for both fundamental and applied research;

— access to the protected markets;

— business stature enhancement;

— improvement in new technology implementation;

— creation of goodwill;

— new product development and spin-offs;

— cost savings (lower production costs);

— patenting

1.6 Advantages to industry are listed as under:

— supply of better qualified graduates having more relevant training because industry’s needs have been identified;

— access to a variety of post-experience training facilities it has helped to design;

— access to the university’s physical facilities and the expertise of its staff;
— access to research, consulting and data collection of the university;
— an improved public image in the society in which it operates, which means that more talented students will be attracted to the industrial sector;
— gained technical knowledge;
— gained technology services not available before;
— quality improvement;
— cost savings;
— new markets;
— manufacturing and lead time reduction

1.7 Attempts have been made in the past to establish a University-Industry Council for the NEDUET (Annexure [9.1] ). There was a good response from the industry. However, the objectives could not be realized because proper mechanisms were not in place.

1.8 Pakistan is a signatory to the global compact known as UN Millennium Project (Annexure [9.2] ), which prescribes Millennium Development Goals (MDGs) to be achieved by 2015. Enlistment of support from the university system will be absolutely indispensable in this respect.

1.9 A review of the international practices in higher education is necessary in order to identify the best and most appropriate practices for Pakistan. Barriers to the realization of a healthy
relationship between university and industry have to be correctly spotted and mechanisms developed to overcome them.

1.10 Different mechanisms can be applied in technology transfer between university research centers and industry according to their motivations and available resources:

— collegial interchange, conferences, publications
— consultancy and technical services provision
— Exchange programmes
— Joint venture of R & D
— cooperative R & D Programme
— Licensing
— Contract research
— Science park, research park, technology park or incubators
— Training

1.11 Every university should be obliged to carry out a genuine SWOT analysis before embarking upon specific programmes for collaborative work.

1.12 Intrinsically there are conflicts of interests between the academe and industry. “Companies prefer that a new technology be a well-kept trade secret, like the formula for Coca-Cola. But academicians say that they must have freedom to discuss and publish their research. An interesting sampling of the nature of conflicts in the
American Environment has been provided by the Editor, Johns Hopkins Magazine.

- “The average car has about 16,000 parts; all 16,000 of those parts will come to gather and make a perfect car. If you, as manufacturing supervisor had to be sure that this car appeared on schedule, you might just go a bit overboard to make sure that you used nothing but absolutely proven technology …… Consequently, when you approach manufacturing people with the idea of new technology, they are something less than enchanted.”
  — Thomas O. Matlues, Vice President
  General Motors

- “If we assert that industry’s welfare depends on the basic infrastructure of research at universities, then a mechanism is needed. Is it unreasonable to conceive of an ‘Industrial Science and Technology Foundation’ to match in size and scope to government’s National Science Foundation?”
  — Robert M. White, President
  National Academy of Engineering

- “How do we address the needs of the smaller companies? …Such companies can and do compete effectively for our student. They can and do send students here for continuing education programs. But such a company cannot afford to be a member of [M.I.T.’s] liaison programs; the fees are too high. Yet we know that some of the most innovative companies in the country are these smaller ones. How do we interact with them?”...
  — James D. Bruce, Director
  Industrial Liaison Programme, M.I.T

- “Skill and dedicated graduate students are one of the last remaining pools of cheap labor anywhere in the world today. Industrial labs are hard pressed to match the quality of this working force in the better universities, even at a significantly higher cost.”
  — Lewis B. Gustafson,
  Conoco executive
• “If universities train people who are not state-of-the-art, then it’s several years before they become effective for industry. So it’s really cheaper to keep us state-of-the-art – but they’ve got to help us with the equipment. Otherwise, their own people with their sophisticated scientific temperaments will have doctorates from where? Of what quality? I think that’s really the issue.”

— Steven Muller. President
Johns Hopkins University

1.13 Jane Marceau [9] has discussed the complex equation of university – industry – government relations and the government efforts to link knowledge production and a knowledge-based production system. Government policies need to be fine tuned and one should look at the issues more closely in order to avoid disappointments in the efforts.

1.14 Claire L. Zepka. And Kevin Warick [10] have made out a prime case for university – industry interaction through the vital role of cybernetics in industrial development “Technical expertise is at a premium, and universities have to sell their services as a desirable commodity”.
2. MAPPING THE ISSUES

Global experience has shown that most of the issues that crop up and need to be addressed in the treatment of university-industry linkage can be mapped in the following manner:

2.1 The developing countries are falling behind industrial countries in terms of their science and technology capacities and achievements.

2.2 The universities are not responding to the changes in global economy.

2.3 The realization that the relationship between university and industry has to be transformed from co-existence to partnership has still to dawn on our decision makers.

2.4 The higher education institutions will no longer have a monopoly on their own services and will be more accountable to society, which is demanding greater productivity and efficiency.

2.5 Our industries will never be in a position to sustain in-house R&D work. They have yet to discover whether they can draw upon the manpower resources of the university system for their commercial advantage.

2.6 Some initiatives have been taken by MoST and HEC to promote collaborative partnership between academia and industry.
However, they are not clear as to how to structure the relationship between the university and industry.

2.7 Excellent opportunities for collaborative work are being missed daily. Examples can be viewed in the Annexure [9.3]. The key reason is that the appropriate mechanisms for cashing in these opportunities are not in place.

2.8 In this country the wisdom of making “track record” as a precondition for funding and support is highly questionable. It simply pre-empts the deployment of potential skills and innovation. Funding and support criteria for R & D work has to be fundamentally changed.
3. THE CASE OF MISSING OPPORTUNITIES

3.1 Water and Energy are the two most important areas for the country. There are variety of issues related to these sectors, which need to be addressed by the R&D manpower. Regrettably, one finds that there is no national agenda, backed by a coherent policy in these fields. The gap in qualified and competent manpower could have been bridged by involving the engineering universities in undertaking R&D work on real life-like problems. However, due to the lack of initiatives both on the part of the universities and industry, effective mechanisms for conducting the business have not been put in place. The result is that innumerable opportunities that appeared for a very productive linkage between university and industry, could not be cashed in and were badly missed.

3.2 Two outstanding examples from the international opportunity landscape will suffice to show that our universities could not react to utilize the funding available for R&D work from international agencies:

3.2.1 International Drinking Water and Sanitation Decade was initiated by the UN(1981-1990). Subsequently it was decided that it should continue through a Second Decade (1991-2000). The year 2003 was designated the International year of Freshwater by the UN (Fresh Water Future, Ed by Jon Ingelton) [46]. The WHO and UNICEF made a Mid-Term Assessment of Progress in meeting the
MDG (Millennium Development Goals) Drinking Water And Sanitation, which shows a total void as far as the participation of universities is concerned [14].

3.2.2 The second example is that of the so called World Bank’s Solar Initiative, which commenced in March, 1995 [3]. It is a new effort by the World Bank to work with its member countries and energy industry, research and non-governmental organization communities to hasten the commercialization of solar and other renewable energy technologies and to expand their applications significantly in developing countries. The initiative has two main thrusts:

- Preparation and finance of commercial and near commercial applications.
- Facilitation of international research development, and demonstration (RD&D).

3.3 Tracking of international bodies like UNESCO, UNIDO, WHO, EC etc. is indispensable for our universities, if we wish to establish linkages with their assistance and funding.

3.4 The local landscape is full of exciting opportunities, particularly in the service sector. All development projects in the water and sanitation sector, energy conservation, and renewable energy fields have the potential of providing collaboration of universities with
municipal bodies and industries for mutual benefit. An overview of real business opportunities is given in the Annexure [9.3].

3.5 This brief review of the missing opportunities bring us the stark reality, that the existing set up of the universities is not going to suffice. It would need restructuring.
4. **REVIEW OF INTERNATIONAL PRACTICES**

4.1 Collaborative partnership between academia and industry or private and public funded research organizations have energized as a critical imperative necessity to sustain transfer of knowledge and innovation.

4.2 Many countries – Argentina, Brazil, Chile, China, Colombia, the Arab Republic of Egypt, India, Kenya, Malaysia, and Nigeria – have taken active steps to forge stronger links between their academic and industrial sectors. They have taken a clue from the practice in developed countries.

4.3 It will therefore be of benefit if we review what the international organizations have done so far and the innovation programmes that have been pursued by the developed nations.

4.4 Therefore, let us **navigate through the global practices** in order to identify the various modes and mechanisms and their success rates in achieving sustainable university-industry linkages. The authors’ and institutional view points have been reproduced faithfully in their own languages.

4.4.1 UNESCO

- The relation of higher education institutions with their socio-economic environment have become a
topical issue in the literature on higher education for the last 25 years.

- International Institute of Education Planning (IIEP), UNESCO, prepared a study on “Managing University – Industry Relations, 2000” a study of institutional practices from 12 different countries [50].

- University – industry relations comprise a wide range of very different formats.

- Benefits for higher education institutions are perceived from strong collaboration with enterprises, both in developed and developing countries. Blackman and Segal [50] list the following benefits:

  — Opportunity to attract additional funds for initial teaching and research increasing financial autonomy of higher education institutions, especially if governmental core funding is tightly linked to specific academic purposes;

  — Co-operative research with enterprises pulling in more public funds if there are
governmental project funds for collaborative research or teaching programmes;

— Acquisition of or access to up-to-date equipment;

— Opportunities for staff and students to become familiar with state-of-the-art industrial science and technology and management systems and enhancement of their familiarity with the constraints of industry;

— Improved interaction of higher education departments and employers for the development and adaptation of (technology oriented) degree programmes;

— Improved training and employment prospects for students;

— Supplemental income from consulting, allowing academic staff to improve their salaries;

— Enhancement of the HEI’s image as a contributor to the economy.
• Broad categories of linkage mechanisms are:

— Consultancy (conducted on a formal or informal basis)

— Teaching and curriculum development (such as sandwich courses, jointly developed degree courses, continuing education courses of short, medium and long duration, exchange of staff, etc.);

— R&D activities (including contract research and co-operative and sponsored research initiated and administered by internal or external structures), some of which lead to the setting up of so-called spin-off companies involved in capitalizing on research discoveries and inventions, assisting faculty in commercializing their R&D expertise and in providing business-development assistance to entrepreneurs involved in these activities;

— Others (such as regular mutual visits, jointly organized meetings, conferences and seminars, joint publications, joint
participation in exhibitions and fairs, industrial support to individual students or their associations, industrial representation on the governing boards of higher education establishments etc.)

- Professional management of university industry relations is a crucial success factor for the development of sustainable collaboration. The span of management, besides policy formulation, comprises management of interfaces, financial management, of intellectual property.

- The study makes the following conclusions:

  — Relation of university with industry have developed considerably over the past decade.

  — External requests for collaborative work are mostly made by the government for increased relevance and impact on economic development.

  — Driving forces have been identified.

  — Pre-dominant mechanism is still internships.
More recently continuing professional development and consultancies have emerged as significant forms of linkages.

The latest modes are enterprises, developments incubators, innovative centers and start-up firms which make university an important partner in local economic development.

The issue is finally whether the universities have comparative advantage over other organizations and institutions in this domain.

The best example of successful and productive linkage has been provided by the Hebrew University of Jerusalem, which created a subsidiary for the commercialization of R&D results, called Yissum, in 1964. Details of this unique and effective tool will be found in the Annexure 9.5.

To what extent development of linkages is part of the university mission should be properly explored. As a general rule the universities, whenever they have the choice,
should give priority to linkages which strengthen, not weaken, their traditional mission of knowledge generation and transmission, basic and applied. Accordingly, first preference should be given to **collaborative activities which have the potential of generating knowledge and enrich the professional experience of students and staff.** A second preference should be given to linkages which are able to supplement diminishing governmental core funding in such a way as to strengthen the core activities of higher education institutions, which are teaching and research.

Strategic management of university-industry relations is necessary, however, to avoid that universities may be seeking immediate profit and compromising their longer term vision, in particular in a context of financial stringency from the public budget.
4.4.2 UNISPAR

- In 1993 UNESCO established a University Industry Science & Technology Partnership Programme known as UNISPAR [4]. This is the result of conscious realization of the fact that “The promotion of cooperation between science & technology knowledge producers in universities & R&D institutions, and S&T knowledge users in industry and the private sector is vital in the process of innovation and commercialization of R&D. This is especially important for developing and countries with economies in transition at a time of globalization and changing work organization”.

- The main goals of the UNISPAR are:

  a) Identification of effective ways and means to improve cooperation between university and industry and promote the transfer of R&D.

  b) Provision of assistance to member states in the creation and strengthening of university-industry cooperation in science, engineering and technology.
c) Adaptation of university engineering education to address and promote industrial, economic and social needs.

d) Promotion of partnerships between universities and industries in continued engineering education for professional engineers.

- UNISPAR working groups have been established in China, Egypt, India, Mexico, Papua New Guinea, Poland, Turkey, Thailand, Trinidad and Tobago.

- UNISPAR chairs have been established in developing countries to enhance engineering education and R&D through technology transfer and industry cooperation.

- UNISPAR has developed Toolkits in respect of innovation for Development Technology, Business Incubators, Globalization and Changing Work Organization in Engineering and Technology, Technology Advisory Centres, Technology and the Management of Maintenance.

- Other initiative such as establishing Foresight for Development have been taken up [50].
4.4.3 UNIDO

- United Nations Industrial Development Organization is actively promoting the concept of **business incubation**, particularly affiliated to the university system [12].

- Business incubation is a relatively recent and innovative system. Its characteristics are given in the Annexure 9.5. Incubators provide local on-the-spot diagnosis and treatment of business problems. They promote commercialization.

- Knowledge–intensity and high costs of research progress in frontier technologies reinforce the need for effective linkages to universities and research institutions. As the sophistication of a nation’s requirement rises, it is becoming more difficult to import proprietary know-how in advanced fields.

- The new computing and communicating techniques have changed the concept of time and space, altering traditional patterns of work and spurring growth of small and medium entrepreneurial companies.
• Knowledge based innovations are inherently more risky than others. The management of this unique risk requires assessment techniques and vision.

• Principal sources of entrepreneurs for knowledge-based ventures are often the university and government research laboratories, large industrial and military establishments, and professional services firms.

• Technology-based ventures can benefit from linkages to sources of knowledge, that is the technical university or research laboratory. Such mentoring needs are to be cultivated.

• The techno-entrepreneur anywhere has the challenge of moving a concept through the prototype and production phases to meet market needs at a price consistent with the value created and with the ability of customers to pay.

• Incubators have undergone transformation from first generation to second and then to third. The “third generation system” known as “International Enterprise Center” provides full range of services under a single aegis for development of knowledge-based business, with linkages to universities,
research institutes, venture capital and international joint ventures.

- This trend is already evident at the convergence of support mechanisms of business incubators / techno-parks in South-East Asia.

- In 1997 there were 500 incubators in developing and transition economies with a world total of 2000. Their annual growth rate has been 20%.

- In the European Union there are 850 incubators, which create 40,000 new jobs each year. The EU plans to setup 450 more incubators and enhance the creation of new jobs to 100,000. Significantly the incubators are receiving subsidies [40].

- In many developing countries the university-linked technology-business incubator is predominant. All the innovative centers in China, and most of them in Mexico, Czech Republic, Indonesia and Turkey have university affiliations and technology commercialization objects.

- Technical support for the incubators is available from Multilateral and Bilateral Service Providers including UNESCO, UN/DDSMS, UNCTAD,

- Incubators are increasingly being linked to universities or sited inside research parks and industrial estates. This creates synergy to mutual advantage.

- “People are still wedded to the idea of four walls and a roof. **But in essence incubation is a process, not a place**”. (Malan and Hammarlend). The concept of virtual incubation is now very much on the anvil.

- **The statement of Swedish Industry is very revealing.** “Once we started working together (i.e. with the industry), we rapidly developed a strong understanding of each other’s working conditions.”
4.4.4 HEC

- Higher Education Commission, Government of Pakistan recently initiated two programmes, one in March 2004, designated as Science & Technology Economic Development Fund (STEDF) for establishing national technology incubator centers within the premises of the public sector universities in order to boost the knowledge-based economy in Pakistan. And the second in Sept. 2004, known as University Industry Technology Support Programmes. (UITSP), which aims at supporting university research in collaboration with industry (Annexure [9.4]).

- HEC commissioned STEDEC, Technology Commercialization Corporation of Pakistan, to conduct a National Technology Incubator (NTI) Survey. It would be too early to forecast the outcome of this survey. From the manner in which the survey was conducted, it appeared that neither the recipients of the questionnaire (viz. Universities) nor the surveyors had a clear concept of the incubators and incubation process. Hardly any decisions can possibly be made on the basis of responses to the survey questionnaire.
• It does not however mean that the universities should look at the opportunities passively. They should be prepared to cash in.

• Now, the crucial question that need to be answered is whether the universities have appropriate mechanisms in place to realize a wholesome and productive linkage with the industry.
4.4.5 UNITED STATES

4.4.5.1 Critical Relationship

- Donald A. Dohlstrom [6] reported that many changes had occurred in US engineering education that had effected the critical relationship between higher education and industry.

- The universities are finding it difficult to keep the technologies instruction modern. The chief difficulty is that “the rapid changes and growth in technology make it more complex to furnish excellence in breadth as well as depth in engineering education.

- Even in the US 80-90% of engineers started practice in their profession after graduation. Concurrently, however, they are required to keep their technical skills updated.

- The concept of “clinics” has been introduced to involve the participation of industry in cooperative teaching.
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- It is interesting to see that although the industry is funding about 10% of the R&D expenditure in the universities, the universities are spending good 1/3rd of their R&D funds on applied research and development research, reflecting obviously the keenness on the part of universities to be relevant to the industry.

- The National Science Foundation (NSF) initiated in 1973 Industry / University Cooperative Research Centers Programme (I / UCRCs) in order to develop long term partnerships among industry, academia and government.

- Five year awards are offered to the Engineering Research Centers (ERC). The five year time period allows for the development of a strong partnership between the academic researchers and their industrial and government members.

- There are 50 I / UCRCs, all administrated by the NSF.
• Features if the ERCs and I / UCRCs are given in the Annexure [9.6].

• J. D. Adams, E. P. Chiang and K. Starkey [32] have looked at the effect of Industry-University Cooperative Research Centers (IUCRCs) on Industrial R&D laboratories. ICCRs are small academic centers designed to foster technology transfer between university and firms.

• IUCRCs are one of a large set of policies, most of them put in place since 1980, that are designed to foster technology transfer between universities and firms.

• Industry-university joint research has expanded in spite of many transaction costs, suggesting that the policies have had an effect.

• On the surface IUCRCs seem to generate more benefits than costs since firms largely support them. Add to this the possibility of knowledge spillovers, the cost – benefit outlook seems favourable indeed.
4.4.5.2 Engineering Research Centers

- In 1983, in the midst of a perceived U.S. “competitive crisis”, a National Academy of Engineering panel recommended that the National Science Foundation (NSF) establish interdisciplinary centers for engineering research.

- The NAE made a report on the Engineering Research centers and proposed “Guidelines for Engineering Research Centers”. (Annexure [9.6]).

- N. P. Suh [1], while discussing the concept and goals of Engineering Research Centers, observes that the National Science Foundation reorganized the engineering directorate to deal with the following issues:

  — Research support
  — Quality of engineering manpower
  — Facilities and equipment
  — Effective institutional resource utilization
  — Academic infrastructure for engineering critical technologies
• The Engineering Research Centers (ERC) Program was created by the National Science Foundation (NSF) in 1985 to develop a government-industry-university partnership to strengthen the competitive position of US firms in World Trade and the culture of engineering research and education in the U.S.

• The ERC Programme served notice of a sea change in university research funding and institutional designs, representing a transition from department based principal investigator-oriented university science to a new center-based model encouraging universities to work with industry and to work beyond the strictures of academic disciplines, write B. Bozeman and C. Boardman [63] while recounting the history of ERCs.

• The past three decades of U.S science and technology policy have not seen an institutional change of greater importance.
- The goal of the ERC programme is to revolutionize engineering research and education by focusing more on interdisciplinary problems, building closer ties between industrial and academic research, and providing a different, more hands-on education for engineering undergraduates and graduate students.

- The goal of the centers according to a panel of the National Academy of Engineering (NAE), is to improve engineering research so that US engineers will be better prepared to assist U.S industry in becoming more competitive in world markets. Thus, engineering research and education must be judged by their success in achieving the linkage.

- In 1994, the NSF’s Engineering Education and Centers (EEC) Division initiated study of key aspects of the ERC Program: ERC-industry interaction and the effectiveness of former ERC graduate students in all sectors of employment.
Wide range of benefits were reported by the study such as:

**Examples of Significant Benefits Received by Firms**

<table>
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<th>Benefit</th>
<th>Percent of Firms</th>
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<tbody>
<tr>
<td>Access to new ideas, know-how, or technologies</td>
<td>84</td>
</tr>
<tr>
<td>Receiving technical assistance</td>
<td>63</td>
</tr>
<tr>
<td>Interaction with other firms participating in the ERC</td>
<td>50</td>
</tr>
<tr>
<td>Access to ERC equipment and facilities</td>
<td>40</td>
</tr>
<tr>
<td>Hiring ERC students and graduates</td>
<td>40</td>
</tr>
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</table>

As of October 2003, there were 22 centers receiving funds through ERC programme.

The ERC programme has served as a model for many other science center programmes in the United States and elsewhere.

The ERC concept has been extremely influential in other nations. For example just a few years after the ERC implementation in the United States, the United Kingdom implemented a programme based explicitly on the ERC model.
4.4.5.3 Industry Technology Roadmap

- Companies in the semiconductor industry have pioneered in creating a comprehensive approach to collaboration with government and universities, one that includes a cooperative or funding R&D in universities and a detailed Industry Technology Roadmap, write D. G. Rea and H. Brooks [11].

- The Technology Roadmap is particularly important in guiding university personnel in preparing their research proposals. A key feature of the roadmap is the willingness of the individual companies to bond together and share views on technology needs and potential solutions.

- This comprehensive set of initiatives has resulted in excellent working relations with government and utilization of the university community, in addition to technology
development for the benefit of Semiconductor Industry Association (SIA) members. This initiative can also serve as a model which is generalizable to many other industries that are particularly dependent on continual and rapid innovation.

- The research programme, sponsored by the Semiconductor Research Corporation, produces over 1,000 research reports that are distributed to the SRC members. Workshops to examine emerging research areas and topical research conferences provide opportunities to review research results and share viewpoints on evolving technology and future trends. In addition, over 500, industry mentors periodically visit the universities to interact with the faculty and students to improve the communication between the two communities. This is a major technique for mutual education – the universities learn more about the industry’s assessment of its needs and the industry learns about cutting-edge technology and becomes familiar with students as potential employees.
- Although the semiconductor industry, in conjunction with the government and universities, has made great progress in its global competitiveness, the challenge remains as world competition increases for shares of a vital market.

- The universities will continue to play a major role in the research programme particularly if industry continues to concentrate on short-term objectives at the expense of long-range research. The university community is ideally suited to conduct long-range research which is pre-competitive and which benefits the entire US semiconductor industry. Universities also have the important function of educating technical personnel for employment in the industry.

4.4.5.4 Advanced Technology Programme

- B. H. Hall, A. N. Link and J. T. Scott [30] have brought out evidence on barriers inhibiting industry from partnering with universities from the Advanced Technology
Programme (ATP) enacted by the US Congress.

- There is a long and well-documented history of industry / university research relationships. In Europe, such relationships can be traced at least to the mid to late 1800s and in the United States to at least the industrial revolution.

- It is generally accepted, at least in the United States, that research partnerships are a critical strategic response to global competition.

- The American Technology Preeminence Act of 1991 later clarified the mission of ATP. – The ATP … will assist U.S businesses to improve their competitive position and promote US economic growth by accelerating the development of a variety of pre-competitive generic technologies by means of grants and cooperative agreements

- The following are some of the barriers identified by the authors in their study:
a. Since university research is often portrayed as public good (e.g. characterized by free circulation), the spread of IPR [intellectual property rights] protection into university R&D activities has attracted considerable attention. Where once industry benefited from exchange systems, with academia based upon transactions such as informal barter relationships, those in industry now find universities seeking contractual, value-based exchanged relationships.

b. The goal of business and university in producing and protecting intellectual property is innovation for the production of revenue. Beyond this ultimate shared goal, the interests of universities and business diverge. Universities value intellectual property not only as a revenue producing resource but also a tool in the advancement and dissemination of knowledge. These divergent interests can result in conflicts.
c. We might expect particular tensions to arise in settings where the conventions of one world (private industry) come up against the conventions of another (public R&D and university science).

d. In general companies such as ours believe that we own the intellectual property developed for us under sponsored research. This view is often not shared by potential university partners.

e. IP is often a stumbling block for collaborations because many universities want to publish results prior to IP protection, and sometimes will not grant exclusivity of results.

f. In general, the difficulties that usually prevent a successful partnership (with a university) are (i) intellectual property issues and (ii) the university partner’s lack of understanding of our business.
g. Universities feel that if their brainpower and equipment were used to develop a new technology then they should benefit financially as an industrial partner would. However, to do so they should be prepared to take an equity position in any commercial ventures derived from the technical work.

h) University licensing offices have an over-inflated view of the value they bring to the project. [The have] unrealistic licensing expectations [and] an over-inflated view of the value of intellectual property.

4.4.5.5 Advanced Research & Technology Institute

- The Advanced Research and Technology Institute (ARTI) is the technology transfer organ of the Indiana University system created in 1996, write S. Jackson and D.B. Audretsch [62].

- As globalization has increased, the industrial societies have seen an erosion of certain
segments of their economic base as firms have sought to optimize their factor inputs. This has meant a dramatic decrease in manufacturing employment across all the industrialized countries, and profound shifts in the composition of their labor force from heavy industry to service and knowledge.

- As the importance of knowledge, creativity and innovation has increased, there is a growing recognition that neither industry nor government can continue along the path of mutual isolation.

- In utilizing the wide array of policy alternatives, however, probably the most important initial step is to marshal the assets and resources already available within a geographic area.

- Such initiatives employ novel funding and ownership strategies to optimize the commercialization of discoveries, inventions and technologies to

a) provide additional revenues to the university through licensing activities,
b) enhance university recognition and visibility in the business community,

c) provide additional outlets and incentives to attract and retain talented faculty and students, and

d) more directly affect the employment landscape of the community through company and job creation via incubators, joint ventures and licensing activities.

- Despite an early if somewhat slow start, ARTI is beginning to see a dramatic acceleration in their ability to prospect for new technologies within the university community, to translate those disclosures into new patents and license those technologies to interested private parties.

4.4.5.6 Organizational Issues

- A conference was organized at Purdue University on the subject: “Organizational Issues in University-Industry Technology
**Transfer**”. An overview of the symposium issues has been provided by D.S. Siegel, Jerry G. Thursby, M. C. Thursby and A.A. Ziedonies [31].

- This special issue evolved from our common interest in university-industry technology transfer (UITT) and a shared belief that the rapid rise in this activity raises several salient organizational issues. These include:

  a) The quality of relation between universities and firms.

  b) Strategy formulation and implementation by universities and firms.

  c) Determinants and consequences of faculty involvement in UITT.

  d) Economic impact/evaluation of institutional performance in UITT, including the role of UITT in fostering entrepreneurship.

- A critical organizational issue is how universities and firms manage these
relationships, in the light of the fact that the key players in UITT (i.e., scientists, university administrators, and firms .entrepreneurs) have different motives and incentives and operate in different organizational cultures.

4.4.5.7 Technology Transfer Office

- A new organizational entity has emerged at research universities: the technology transfer office (TTO). TTOs were established to facilitate commercial knowledge transfers from universities to practitioners or university / industry technology transfer (UITT). D.S. Siegel, D. A. Waldman, L. E. Atwater, and A. N. Link [59] have conducted a systematic analysis of the role of organizational practices in this process.

- There are numerous impediments to effectiveness in UITT: cultural and informational barriers among the three key stakeholder types (university administrators, academics and firms entrepreneurs), TTO staffing and
compensation practices, and inadequate rewards for faculty involvement in UITT.

- It is important to identify the key structural and institutional barriers to UITT so that management theories can be developed to shed greater light on what can be done to extirpate them. If university technology managers and administrators can identify ways to manage their intellectual property more effectively, the end result will be a more rapid rate of technological diffusion and greater economic prosperity.

- In many universities, the TTO director may have limited discretion and responsibility for technology transfer. That is, a vice-provost or vice-president for research will bear ultimate responsibility for these activities. Furthermore, a university president or provost may be responsible for establishing an organizational culture that fosters technology transfer.

- Administrator who wish to foster commercialization need to be mindful of the following organizational and managerial factors:
a) reward systems for UITT

b) staffing practices in the TTO

c) designing flexible university policies on technology transfer

d) devoting additional resources to UITT, if that is consistent with the university’s mission.

e) working to eliminate cultural and informational barriers that impede the UTT process.

4.4.5.8 Member Retention

- D. O. Gray, M. Lindblad and J. Rudolph [33] have done a multivariate analysis of member retention for Industry-University Research Centers.

- Although a growing literature documents the benefits of industry-university research centers, most centers experience a significant amount of turnover among their industrial members.
Almost seventy percent of industry’s support for academic research is channeled through the roughly 1100 industry-university centers identified in 1993.

At one level, an industry-university research center is simply an organized research unit (ORU), that is a semi-autonomous research entity within a university that operates independently of academic departments. ORU, typically involve **multidisciplinary teams of research, a portfolio of research projects** (which generally are organized into thrusts) and some-times own or have access to some, significant piece of equipment and / or facilities.

Cooperative research centers typically address a broad range of research from basic to mission-driven, they serve multiple sponsors from an industry or sector (including government and non-profit organizations) as opposed to a single company or government sponsor; and they serve as a training environment for graduate students and, therefore, must address educational and other goals …. In short,
CRCs tend to be very complex, multi-faceted research enterprises.

4.4.5.9 Pre-Employment Look

- Writing on Educational Implications of University-Industry Technology Transfer P.E. Stephan observes [26]: *Faculty ties with industry have the potential for updating the curriculum and initiating new programmes.*

- A positive way in which technology transfer impacts students is through jobs. Technology transfer offers the possibility of linking students to industry more efficiently, by providing industry and students a pre-employment look at each other.

4.4.5.10 Research Parks

- While describing the innovative activity of university in the United States, Y.Miyata [16] observes that “it is difficult for universities to finance their research by license revenue, so the role of the central government is critical to maintain research quality”.
• In the last two decades, their role as innovator has attracted the attention of the policymakers, business leaders, and academic personnel. This result from the fact that several regions successfully have high-tech firms clustered around a research university.

• For example Stanford University and the adjacent Stanford Research Park successfully attract many high-tech firms, and have become a nucleus of development of the wider Silicon Valley region. Also, the State of North Carolina developed a research park called Research Triangle Park by using three prominent universities in the state.

• Alypios Chatziioanou and Edward Sullivan [68], while discussing University Technology & Research Parks, bring out that ‘Standford University built the first Research Park’ in 1950 with the intention of accelerating technology transfer and deployment, while at the same time enjoying some of the proceeds. For many, the park-starting with Hewlett – Packard was the
main force behind the creation of the famous silicon valley. Today, research and industrial parks are the norm in the USA for every medium-sized and large university. In Europe, they are known as science parks, technology parks and techno poles. However, European universities have been slower to embrace the idea.

- A research park is supported to have seven key components:
  
  - a link to a research university
  
  - entrepreneurial faculty members who comprise at least 10-20% of the total faculty
  
  - faculty members who are conducting ground-breaking innovative research that has commercial potential.
  
  - a good and resourceful technology transfer office that works closely with the park.
— an incubator facility that offers fledgling companies space and services

— enough space to capture and house business once they are ready for prime time, and

— access to venture capital to fund the whole process

• There is an Association of University Research Parks in USA.

• During World War II, the role of university research was highly recognized by the federal government: the advancement of scientific knowledge generated by university basic research was expected to solve economic, social, by the nation.

• Industry also began seeing universities as a source of scientific and technological expertise, which was necessary for emerging high-tech industries such as biotechnology, microelectronics, and new materials. The interests of industries and universities,
therefore coincided. In addition, Congress passed the Patent and Trademark Amendments of 1980 (Bayh-Dole Act), which allowed universities to own patents resulting from federal research money and to license them to small firms. The restrictions on licensing to large firms were also relaxed in 1984.

- According to Cohen et al (1994), in 1990, the composition of more than 1000 University Industry Research Cooperation (UIRC) projects that were established to promote cooperative R&D among universities, industry, and state and federal governments, was basic research 41.1%, applied research 43.2% and development 15.7%.

4.4.5.11 Faculty Internship

- S. Foroudastan and A. Nasab [37] describe their experience of faculty internship in industry.

- Based on a study by the National University Continuing Education Association, more
than half the technical knowledge or skill of engineers becomes obsolete in two to seven years, depending on the area of specialization.

- According to a 1991 National Research Council study university curricula, in general, did not reflect the modern design practices used in most companies, because, among other reasons, the academics teaching these courses were rarely aware of the most recent design techniques.

- Therefore, it becomes essential for the practicing engineer as well as the engineering technology educator to treat their careers as dynamics entities that require ceaseless updating.

- Exposure to technological advancement can be most effectively accomplished through faculty internships at local firms.
4.4.6 Europe

4.4.6.1 Government – University – Industry (GUI) R & D Partnerships in the US, Germany and France

- E. G. Carayannis, J Alexander, and Anthony Ioannidis [15] while discussing leveraging of knowledge, learning and innovation in forming strategic GUI R & D Partnerships observe that “the linkage between theory on knowledge management and strategic management provides a framework for understanding the imperative for collaborative research partnership, particularly those involving government, university and industry actors.

- In particular, government and industry can learn from past experience on how to design intelligent trans-organizational knowledge interfaces to ensure that knowledge sharing occurs across organizational boundaries.

- Significant government – university – industry strategic partnerships (GUISPs) have been formed around the world, including Microelectronics Advanced Research Corporation (MARCO) in the
United States, the Pan – European Microelectronic Development for European Applications (MEDEA) consortium based in France, and the Fraunhofer Gesellschaft in Germany. These are examples of new trans-organizational knowledge structures to facilitate the flow of ideas, information and innovation between sectors of the economy.

- In post-capitalist economies, wealth flows not to those who control financial capital, but to those who can acquire and direct intellectual capital.

- Government – university – industry strategic partnerships (GUISPs) represent an organizational form designed to integrate disparate pools of intellectual capital. GUISPs play a role of growing significance in national innovation systems. Percentage of firms cooperating with universities and research institutes is provided in Annexure [9.5].

4.4.6.2 Framework Programmes

- The importance of university-industry collaboration has generally increased in the industrialized world since the late 1970s,
write Y. Caloghirou, Aggelos Tsakanikas and N. S. Vonortas [28] while investigating the characteristics of university-industry collaboration in a large set of research joint ventures (RJVs) established in the context of the European Framework Programmes over a period of fourteen years.

- The link between academia and industry has traditionally been weaker in Europe than in the United States. In more recent years, however, European governments have taken actions to support research interaction between the two sectors through national research programmes.

- The launch of the **European Framework Programmes (FWPs) in 1984** created the mechanisms for collaborative research and development (R&D) between actors from different countries. FEPs were set up to operate as the Umbrella of all R&D programmes sponsored by the European Commission, including programmes on various technologies such as information and communication, energy, transportation, industrial technologies, biotechnology, and so forth.
The vast majority of programmes under the FWPs share the following characteristics:

a) They support collaborative R&D between firms, universities, and other research institutes across Europe.

b) The RJVs must include partners from at least two EU member countries.

c) The funding is on a shared-cost basis for industrial participants; the commission funds up to fifty percent of the cost of industrial partners.

d) Applications for funding are judged by independent reviewers.

e) The commission determines broad priorities for the programmes following extensive consultation with all stakeholders.

The FWPs essentially encapsulate the S&T strategy of the European Commission. These
are 4-year Programmes covering all R&D activities of the community. Available evidence indicates that FWPs have made an important contribution to the development of cooperation between firms and universities. Not only in money terms – substantial anyway – but importantly in terms of achieving this closer relationship with industry.

- The primary objectives of firms to collaborate with universities include research synergies, keeping up with major technological developments and R&D cost sharing. The increase in their knowledge base is the greatest reported benefit of firms from such collaboration.

4.4.6.3 Conceived-Design-Implement-Operate

- Khalid El Gaidi, while discussing the CDIO (Conceive – Design – Implement - Operate) initiative, observes that the task of higher education is to produce technically expert, socially aware and entrepreneurially astute engineers.
The CDIO initiative began as a joint endeavor involving four engineering schools in Sweden and the USA viz. Chalmers Institute of Technology Gothenburge, Linkoping Institute of Technology (LiU) and the Royal Institute of Technology (KTH) in Sweden and the Massachusetts Institute of Technology (MIT) in the USA.

CDIO focuses on four activities – curriculum development, teaching and learning, workshops, and assessment projects – with a view to improving engineering education programmes by redesign and through the introduction of real engineering skills as well as hands-on experiences.

From its conception as a profession, through the development of formal engineering education in the nineteenth century until the middle of the twentieth, engineering education was based on practice. It offered an effective exposure to hands-on practice and was taught by practicing engineers. It focused on solving tangible programmes as students learned to conceptualize and design products and
systems. However, as scientific and technical knowledge expanded rapidly during the later half of the twentieth century, engineering education evolved into the teaching of engineering science, de-emphasizing actual engineering practice.

- The vision was turned into a model programmes by developing and codifying a comprehensive understanding of abilities needed by the contemporary engineers. This was accomplished through the use of stakeholders focus groups comprising engineering faculty, students, industry representatives, university review committees, alumni and senior academicians.

- As a response to the global economy the countries of the European Union have recognized the needs of small and medium-sized enterprises (SMES) in relation to graduate skills. They have, through programmes such as TEMPUS and PHARE, provided finance for the development of new thinking in university-firm (particularly SME) relationship. John Hobrough has conducted an analysis focusing on general
transferable skills appropriate to SMEs in an expanding Europe and in the context of a globalizing economy.

4.4.6.4.1 Entrepreneurial University

- Henry Etzkowitz [54] writing on the “European Entrepreneurial University” traces the history of university development since 12th century starting that the entrepreneurial university, combining a ‘third mission’ of economic and social development with teaching and research, is a growing contemporary phenomenon, with academia taking a leading role in an increasingly knowledge-based society. He concludes by predicting that in the near future the European and US academic entrepreneurial formats will converge as each adopts the innovations of the other. “Europe will experience an increase in faculty start-ups. The USA will see more firms organizations by students emerging from an educational process, with incubators integrated into departments and research cultures. Academic entrepreneurship is becoming an academic mission”.

-
The European Union has launched “Framework Programmes for Research and Technologies Development to enable the European industry more competitive at an international level.

Higher education establishments are receiving increasing grants for university-industry collaboration research which is of the order of $\frac{1}{4}$th of the total funds.

Janice Culler [8] lamented that the national governments have only restricted resources to support from academic research. The universities therefore had to learn to attract funds through joint work on projects of national interest of the industry and others.

The salient features of the programme priorities are support to small and medium enterprises linked with universities, good project management and commercialization of result of R&D.

The economic aspect of the research work and of the accompanying demonstration work is at the heart of Europe’s approach.
This is a decisive factor if we are to open up and make the most of this market which has already attracted a large number of SMEs and has a high potential for job creation.

- In respect of the industry-university partnerships in the curriculum development Malcolm Skilbeck and Heller Connel [5] have traced the trends and developments in OECD countries. Variety of arrangements now exist such as common determination of goals and curriculum objectives, shared teaching and assessment.

- The Irish Industrial Policy Review Group made a key recommendation: “A higher priority must be attached to the education system to the acquisition of usable and marketable skills. This is evident both from the perspective of the requirements of industrial development and for employment prospects and self-fulfillment of young people”.
4.4.7 United Kingdom

4.4.7.1 University for Industry

- The relationship between universities and industry in the United Kingdom has been a topic of considerable public debate in recent years, with a number of developments taking place in policy, write R. Grady and J. Pratt [18].

- Links between higher education and industry are of vital economic importance. These links provide the environment for innovation and technology transport and are crucial for sustaining competitiveness, reinventing organizations, creating new businesses, fighting unemployment and accelerating development programmes.

- Recently, Britain realized its deficiencies in the areas of education and technology, and major efforts are being made to enhance its international competitiveness.

- More recently (1997), a National Committee of Inquiry into Higher Education (the Dearing Committee) confirmed the
importance of partnership between higher education and industry, and the Government has supported the establishment of a new “University for Industry”. Although name is misleading because it will not be another university nor be designed entirely towards industry, the name has stuck. The University for Industry (UFI) is proposed a new enterprise with the aim to mobilize the expertise and energy of government, business, and education through six key functions (1998):

a) Analyse the needs of the market and potential customers.

b) Drive demand for learning, through mass marketing and production.

c) Provide people with information, advice and guidance.

d) Ensure the availability of, and connect customers to, high quality learning programmes.

e) Commission new content.
f) Ensure the quality of products and services

- In the United Kingdom, there are more than 80 institutions with the title “university” and another 60 or 80 colleges funded by the higher education funding councils. In recent years many universities are becoming more involved with business. Many established industrial liaison offices to link academic outputs to the needs of industry; business incubators and science parks to assist in exploitation of new ideas; clubs to focus on specific projects or local business needs; companies to exploit research findings; consultancy programmes for private and public sectors, continuing professional programmes for companies, secondments or exchange including sponsored academics; and students placements in industry.

4.4.7.2 University Spinout Companies

- The spinning-out of university-based scientific inventions into separate companies represents a potentially important, and increasingly utilized option to create wealth
from commercialization of research. The conventional route to market for university intellectual property (IP) has been through licensing the rights to use technological discoveries controlled by university owned patents. In recent years, university spinout companies (USOs) have become an increasingly popular mode of exploiting potentially valuable scientific discoveries. M. Wright, A. Vohora and A. Lockett [64] have explored the joint venture route to commercializing university owned intellectual property.

- The argue that creating a spinout company as a joint venture with an industrial partner, may be a means of overcoming some of the potential problems associated with managing resource weaknesses and inadequate capabilities that may be difficult to achieve as a free-standing spin-out company with or without venture capital backing.

- During the financial year 2001 UK universities created 175 new spin-out companies, which account for 31% of all 554 spinouts formed in the five years 1996-
2001. However, in 2002 the number of spin-outs created fill by a third, suggesting a reappraisal of the most effective processes for the commercialization of university IP.

- A USO is a new company founded by employees of the university around a core technological innovation which had initially been developed at the university.

- While university are capable of generating intellectual property (IP), to begin with they typically lack the resources and capabilities to commercialize successfully the IP through USOs.

- The authors suggest that Joint Venture spin-outs (JVSOs) may provide a faster, more flexible, less risky and less costly business venturing route to commercialization university intellectual property in comparison to venture backed university start-ups. JVSO, can provided greater access to critical resources such as marketing, technology, raw material, equipment, facilities, financial assets, managerial expertise and political influence. JVSOs may allow universities and industrial
partners to pool their resources and improve the competitive position of the new ventures in a way that they could not do alone.

- Cooperative strategies, such as JVSOs, may provide a platform for organizational learning, giving new ventures access to knowledge of their parent firms.

- Cooperative strategies such as JVSOs may be an important organizational form with which to transform intangible assets owned by the universities such as scientific know how and intellectual property, into wealth creating new ventures.

4.4.7.3 Science Enterprise Centers

- The creation, and sharing, of intellectual property is the core role of a university- the prime asset. Managing it for commercial profit is a serious challenge, write M. Wright, S. Birley and S. Mosey [65].

- To promote spin-outs, the UK Office of Science and Technology (OST), government, established the £ 59m
“University Challenge” venture capital fund and created 12 Government sponsored “science enterprise centers” (SECs).

- The culture in the universities is changing. From being quite varied and in some cases openly hostile, there is a greater acceptance of and more positive attitude towards entrepreneurship across science departments in universities.

- Researchers are beginning to recognize that spin-outs are not homogeneous. An important policy debate concerns the nature of support to be provided to spin-out companies. Policy measures need to be more sophisticated than simple one-size fits all supports.

- R. D. Handscombe [52] writes, while discussing “The promotion of an entrepreneurial culture in the universities”, that the broad aims of the Science Enterprise Challenge were to foster the commercialization of research and new ideas, stimulate scientific entrepreneurship, incorporate the teaching of enterprise into science and engineering curricula and
support centers of excellence for the transfer and exploitation of scientific knowledge and expertise”.

- Those universities bidding for grant of support were required to set out closely their ideas on how award would be used to establish new and additional activity with the following aims:

  — incorporating enterprise training in university curricula

  — developing innovative approaches to the teaching of enterprise teachings to scientist and technologists at all stages of their careers.

  — promoting an entrepreneurial culture in universities at all levels.

  — achieving a critical mass of knowledge transfer from researchers and laboratory environment to the commercial arena, and
increasing the rate of new business creation and improved performance and competitive of existing business through technical innovation and managerial excellence.

4.4.7.4 Corporate University

- C. Princes and G. Beaver [45] discuss the concept of the corporate university and suggest redefining its role.

- The corporate university is without parallel, one of the most powerful business and organizational development interventions to evolve in the past two decades, writes Dealtry.

- A broad definition of a modern corporate university can be proposed: 
  
  the strategically oriented organizational processes for the centrally coordinated development of learning and knowledge throughout an organization's value chain and amongst its stakeholders with the purpose of achieving the organization's business goals.
• The rapid proliferation in the number of corporate university can be gauged from US data. There were 400 corporate universities in 1988, over 1000 in 1997, and 1,800 by 2000 in North America.

4.4.7.5 Technology Watch

• Small and medium sized enterprises (SMES) producing “smart products need to maintain their awareness of new technologies and markets and thereby seize opportunities to innovate they might otherwise miss write C.A. stokes P. J. Palmer [73]. A so called Technology Watch is aimed to redress this situation.

• Supported by the UK Department of Trade and Industry (DTI), this experimental service is provided by the PRIME Farady Partnership (PRIME Faraday Partnership, 2004). The partners are Loughborough University, the university of Nottingham and Pera(an engineering R & D firm). The Stuttgart-based Fraunhofer TEG (Fraunhofer-Technologie-Entwicklungsgruppe) is an associate partner.
• The PRIME Faraday Partnerships Technology Watch is a technology observatory, providing the kind of information needed by small and medium-sized PRIME manufacturers to take a strategic view of technologies.
4.4.8 Belgium

- In a recent report titled "Fostering Entrepreneurship" the organization for European Cooperation and Development (OECD, 1998) stresses that universities need to develop structural and formal policies to facilitate the transition from research to the creation of new technology, write F. N. Ndonzuau, F. Pirnay and B. Surlemont [41].

- In the USA, the birthplace of academic entrepreneurship, the spin-off phenomenon achieved its first success many years ago. Popularised by the development of the legendary "Silicon Valley", and "Route 128" around prestigious universities such as Stanford and MIT, academic spin-offs (ASOs) have been part of the American academic landscape for decades. In Europe, the phenomenon is still in its infancy.

- From the in-depth analysis of the data collected by the authors, four stages emerged as relevant in explaining the transformation of academic research results into economic value:

  Stage 1: to generate business ideas from research
  Stage 2: to finalize new venture projects out of ideas
  Stage 3: to launch spin-off firms from projects
  Stage 4: to strengthen the creation of economic value by spin-off firms
The model gives people interested in the valorization of research by the creation of ASOs a general framework on which they can rely for conceiving suitable institutional mechanisms for supporting and fostering academic entrepreneurship.

The times during which academic science and technology were largely ‘exogenous’ to the economic system are over. Academic research now has become much endogenized and integrated into the economic cycle of maintenance and growth, observe K. Debackere.

As the economic pressure on academic research grows, universities have to cope, with how they reconcile both, ‘exogenous’ (i.e. curiosity-driven invention) and endogenous’ (i.e. market-driven innovation) component of the academic research community / enterprise. Managing academic R&D as a business therefore requires an appropriate context, structure and processes within the university so that fundamental values of teaching and research are complemented rather than hampered by the university’s active engagement and involvement in the emerging process of industrial and entrepreneurial innovation.
- Universities as incubators of entrepreneurial innovations, can create the context, structure and processes that facilitate new venture creations.

- K. U. Leuven Research & Development (LRD) was founded in 1972 to manage the industry component of the university’s R&D portfolio. What started as a minor fraction of the total university R&D activity has, over the past 28 years grown into a significant portion of the university’s total R&D portfolio. The LRD, although fully integrated within the university, manages its own budgets as well as the research personnel employed on the these budgets. From an incentive point of view, creating a context with such high level of budgetary and human resource autonomy is critical, since this allows for flexibility and degrees of freedom to operate that an often lacking within the traditional university administration.

- 34 spin-offs have been created by the LRD so far.
4.4.9 Greece

- The literature on science parks evaluation mainly covers the developed countries of OECD. There is a lack of evidence about the role of science parks in the less developed countries, write Y. L. Bakouros, D.C., Mardas and N.C Varsakelis [42], while examining the performance of the three science parks of Greece.

- The UK Science Park Association defined a science park as follows:

“The term Science Park is used to describe a property based initiative which:

— has formal and operational links with a university or other higher educational institutional or major center of research.

— is designed to encourage the formation and growth of knowledge based business and other organizations normally resident on site.

— has a management function that is actively engaged in the transfer of technology and business skills to the organizations on site.”
• Three science parks have been established during the mid 1990s in Greece so far in the proximity of universities. The establishment of these parks were due to government’s initiative rather than a university’s. The investment in land and infrastructure was made by the state through the main Greek research institute. Technological Institute of Greece (ITE), which is a government institution.

• The management of the science parks is dependent from the state but in the administrative council of each park members of the ITE are present together with representatives of the local industry.

• The results presented indicate that the picture of the three science parks of Greece is not same in terms of the links between university and industry. The science parks are not as successful as was expected.
4.4.10 Italy

- R. Grimaldi and A Grandi [36], while examining the contribution of university business incubators to new knowledge-based ventures, observe that many institutions of higher education are transforming themselves by broadening their traditional mission of teaching, research and public service to embrace more active participation in their region’s economic development. The traditional perception of universities as merely institutions of higher learning is giving way to one of universities as engineers of economic growth and development.

- European universities and public research centers, promoted by regional, national and EU policy measures and by the example of some major US universities, have increasingly been adopting a direct entrepreneurial role. Among these initiatives are university business incubators (UBIs). Their characteristics are given in (Annexure [9.7]).

- UBIs are described as effective mechanisms for overcoming weakness of the more traditional public incubating institutions. They offer a range of university-related benefits, such as access to laboratories and equipment, to scientific and technological knowledge and to networks of key contacts, and the reputation that occurs from affiliation with a university.
• The Turin Polytechnic Incubator (TPI) was established at the beginning of 2000 by the Polytechnic of Turin and other institutional partners. It was the first experience of university incubators in Italy, but was immediately followed by the Milan Polytechnic and Bologna University incubators.

• Empirical investigation was carried out using direct and structured interviews with six academic spin-off companies hosted at TPI. The six spin-off companies value the following services provided by TPI.

— access to university R&D laboratories and scientific instrumentation

— access to advanced technological and scientific knowledge and advice

— positive outcomes in terms of visibility and reputation through affiliation with a leading R&D institution, and

— access to extended and key networks.

• The paper of V. Chiesa and A Piccaluga [22] focuses on the analysis of academic spin-off companies as one of the most
promising ways to transfer research results to the market place.

- Since the beginning of the eighties the debate among scholars and policy makers has intensified about exploitation of research results (but also valorization and commercialization are often used).

- There is also increasing social accountability pressures with regards to the university system as a whole, which is asked not only to be more efficient in training and more performing in scientific production, but also-more and more often – to be directly active in the diffusion and exploitation of results and in regional development.

- During the late nineties, the spin-off phenomenon became more relevant in Italy, for several reasons. Among the most important ones were the wider use of non-permanent position at universities, the growing autonomy of universities, which can choose to support spin–off companies and even own shares in them, willingness to experiment new ways to foster regional development through knowledge based activities.

- In general, it seems possible to conclude that there is an Italian (and perhaps partly European) model for research spin–off companies, which is different from the American
(and perhaps Anglo–Saxon) one. The Italian model is characterized by low level risks.
4.4.11 Spain


- An entrepreneurial spin-off arises when an entrepreneur leaves an organization to start a firm of her/his own.

- Two major sources of new technology-based firms are higher education institutions (university spin-offs) and well established industrial firms (corporate spin-offs).

- Spin-offs have a catalyzing effect on technology transfer.

- An interface cell is located within the university, known as Research Results Transfer Office. Its aim is to link university R & D and its socioeconomic environment.
4.4.12 Austria

- The accumulation of knowledge and its spillover into new products, new technologies, and productive capacity is considered as primary engine of economic development in the new growth theories, write D. Schartinger, A. Schibany and H. Gassler [27] which examining the interaction between universities and the business sector.

- The results of their analysis demonstrate that the main channel of knowledge transfer from universities to the business sector still occurs through the mobility of human capital.

- The university systems of highly industrialized countries are going through a period of profound change due to a rise in society’s expectation for economic returns of basic research.

- The authors analyze some of the ways knowledge transfer between universities and firms may take place, particularly the following four types of interactions:
  
  — joint research projects
  
  — contract research
— joint supervision of Ph.Ds and Masters Theses by university and firm members,

— the mobility of university researchers into the private firms
4.4.13 Hungary

- In order to promote the economic utilization of the research and development results, several scientific parks were established in 1980s in Hungary. “These parks were supposed to enhance the entrepreneurial and business activities of the university professor” writes Z. Palmai [58] while presenting a case study on INNOTECH, an Innovation Park of the Budapest University of Technology and Economics established in 1987.

- In 1989 the park was converted into a limited liability company eventually with three owners, Budapest University of Technology and Economics (BUTE) 52%, the local Government of the 11th district 38%, and the Ministry of Education 10%. The main target of the owners is the economic utilization of the university’s expertise. Altogether there are 129 laboratories, workshops and offices etc.

- In a broader sense the technology transfer provided by the INNOTECH Innovation Park is a kind of service that is directed towards the industry and the whole economy. This is carried out in a way that INNOTECH buys services:
— from the university professors, or the research and development teams managed by them quite independently

— from the BUTE itself, which provides an innovative environment as well.

- The INNOTECH Innovation Park is an organization pursuing different activities:

  — it provides usual park services for the companies located on its site, in this respect it operates as a traditional park.

  — being a limited company, it is a business association, the main task of which is to utilize the university research and development results, thus it is also a typical technology transfer company.

  — it sells the research and development abilities of university professors, who are not obliged to establish their own companies this way, but use INNOTECH as if it were their own company, so the innovation park functions as a virtual incubator.

  — it enhances regional development and supports the small and medium sized enterprises based on the
elaborated methods and collected experiences during its operation.
4.4.14 Sweden

- P. Lindelof and H. Lofsten [66] surveyed 273 new technology-based firms (NTBFs) to investigate the proximity as a resource base for competitive advantage.

- Proximity between NTBFs and universities promote the exchange of ideas through both formal and informal networks.

- The level of interaction in the innovation process between firms located in Science Parks and local universities is generally low, but it is higher than the level of interaction exhibited by firms that are Science Park firms.

- In today’s technologically intensive industries firms are finding it harder to retain sources of competitive advantage. Competitors respond very rapidly to new products, even if product development time is shortened. Strategy as a means for achieving competitive advantage (rate of product development, price competition, technology development, competitor behaviour etc), takes into account both the positioning analysis of what business to be in, where to complete and the resource-based analysis of how to compete.
- Resource-based theory is used to argue that cooperative competencies are complementary to technical competencies and may serve as a source of competitive advantage. In the resource-based theory resources are classified as tangible, intangible and personnel-based. Tangible resources include, for example, plant and equipment. Intangible resources include reputation, technology and human resources include training and expertise of employees.

- There are two principal forms of academic-science Park links at the level of the individual Park NTBF.
  
  — The establishment of spin-off firms formed by academic staff taking research out of the laboratory and onto the Science Park, starting their own commercial firms.

  — The occurrence of research links facilitating technology and knowledge transfer.

The total number of Science Parks in Sweden in 1999 was 23, according to the Swedish Park Association.

- Networks are vital to the discovery of opportunities and to the testing of ideas. The collaboration with universities provides a means of developing technical knowledge. Universities and research centers also provide consulting
assistance to new firms and opportunities for continuing education. However, only NTBFs with internal resources can effectively absorb knowledge and technologies that are cooperatively developed with universities.

- The commercialization focus of new technologies has increased in importance for companies in order to stay competitive, write D. Nobeluis [60] while studying “linking product development to applied research”.

- New technologies that need to be tracked, developed, evaluated, transferred, or elsewhere managed by the company have become more numerous, as have their potential sources. The difficulties in transferring industrial research into commercial products have long been an issue for practitioners as well as researchers. Especially the link between research and development, often known as internal technology transfer, has been identified as crucial in managing the new stream.

- Manufacturing companies are to an increasing extent depending on the ability to develop, transfer, and integrate new technologies into the product portfolio in a strategic and operationally effective manner. This has become even more apparent in recent years, for example following the rapid progress of electronics and informatics and their introduction into products that previously were mainly mechanical.
- Internal technology transfer is a multi-faceted issue, involving challenges related to:
  
  — Synchronizing applied research tasks with product development.
  
  — Strategic synchronization
  
  — Operational Synchronization
  
  — Managing the transfer scope of applied research
  
  — Transfer management.

- M. Johansson, M.Jacob, T. Hellstoin [74] investigated the relationship between universities and academic spin-offs, with special emphasis on the antecedent conditions of, and the nature of the linkages that the spin-offs form, as well as means for sustaining them.

- Recently, national governments have begun to restructure policies for funding science in order to encourage universities to commercialize their research results. As a result, academic science is increasingly being redefined by national policy-makers as a contributing factor to international competitiveness.
• One of the mechanisms for transforming scientific knowledge into products and process is the founding of new firms on the basis of results produced at universities.

• As new firms often lack resources, academic spin-offs based on high technology are likely to be dependent on continued relations with universities also after the initial phase of spinning off.

• The most frequent cited reason for spinning out seems to be personal interest or value propositions rather than university policies.

• The fact that in Sweden, researchers generally have the legal right to any intellectual property accruing from their research findings explains this situation to a certain extent. Incentives for individual researchers to commercialize their findings are high for would-be innovator-entrepreneurs because of the potential financial gains compared to for instance a smaller percentage of the possible income of a patent or license held by the University.

• Sustainability seems to be key characteristic of these linkages, considering the long history of many relationships and general preference for long term commitments. In view of the importance of knowledge transfer processes between the spin-offs and universities this is not surprising, since
such transfer is likely to require a mutual language, similar knowledge assimilation processes.

- Academic spin-offs are highly dependent on a sustainable link to university research for a number of reasons, thus it should come as no surprise that their network relations are characterized by a small number of strong ties which are in turn characterized by a high degree of trust and informality, that due to history, reciprocity and location (social capital aspects), and the specificity of the knowledge transferred, becomes difficult to substitute.

- In summary, academic spin-offs are the product of an evolution of ties between individual researchers, departments and successive generation of students.

- One practical result of the advent of the knowledge society has been an increased reliance on academic industry partnerships as important sources for the creation of economic value, argue M. Jacob, T. Hellstrom, N. Adler and F. Norrgren [21] in their paper “From sponsorship to partnership in academic – industry relations”.

- The emergence of the knowledge society has initiated a fourth phase in academy-industry relations that may be described as the knowledge partnership phase.
• The approach involves the researcher and the practitioners in a process of continuous dialogue.

• Institutional constraints have implied that research working in this fashion often have to move out from the traditional university setting and set up new institutional formats to accommodate their way of working.
4.4.15 Denmark

- The concept of problem – based learning has been used in all educational programmes in one of the universities, writes Jens O. Riis [39]. Industry involvement in research and development is embedded in a new initiative, the Center for Industrial Production.

- Like industrial companies, universities will need to adopt the paradigm of “mass customization”. The problem-based learning approach has the potential to stimulate creative thinking and the development of innovative solutions.
4.4.16 Russia

- One peculiarity of the Russian system of engineering and technological education is its close relationship and cooperation with leading Russian companies and R&D centers. This linkage is particularly effective in the aerospace industry. It may be one reason why Russia maintains a significant position in the world economy, despite its economics recession and the closure of production in a number of industries, write B.S. Mitin and A. S. Grabilnikou [34].

- Almost all technical universities of Russia have established branches at the leading companies and R&D institutions, corresponding to the type of specialists they train.

- It is vital for a modern aerospace company to be able to adapt rapidly to new technologies: thus “production” and “personnel training system” are inseparable concepts.

- The national system of engineering education in Russia is about 150 years old. The first technological university was founded in 1828. There are 315 higher education institutions specializing in engineering education, of these 203 are engineering universities. The total member of students is around 610,000. More than 5,500 doctoral graduates are employed by the universities.
The proportion of engineers among the able-bodied citizens in Russia is 4.6%, in USA 1.3%, in France 1.7% and in Japan 1.9%. 
4.4.17 Canada

- Jerome Doutriaux and Margaret Barker [7] observed that university-industry relationships in science and technology in Canada are changing. There is a continuing rise in industrial sponsorship.

- The university industry programming is becoming more relevant to small and medium-sized industries. Industrial share in R&D funding is good 10% of the total.

- Federal government has created in 1980 university-industry knowledge transfer mechanisms in the form of national Networks of Centers of Excellence. The objective is to stimulate university-based research and training in nationally critical fields, and integrate R&D involving academic research at different universities, firms and government.

- Centers are being managed by a consortium of universities, large and small firms headed by a Board of Directors of university and industry representatives.
4.4.18 South America

- Maltilde Luna and Jose Luis Velasco [53] discussed an important issue: Bridging the gap between firms and academic institutions. The concept of “translators” has been developed, who in university – industry relationships facilitate communication among individuals, institutions, business organizations and groups.

- Translation takes place at five levels of the process of integrating knowledge with commercialization: the cognitive organizational disciplinary, codification and motivational levels.

- Personal and professional characteristics that enable some individuals to act as “bridges” between academia and industry have been identified.

- They suggest that institutionalizing the translation structure and purposefully training translators may significantly improve communication between business and academia.
4.4.19 Puerto Rico

- L. S. Piazza, R. Buxeda, and others [56] while writing on the biotechnology cluster development in Puerto Rico, observe that successfully knowledge-based economic models rely on synergy between government, industry and academia.

- Knowledge-based economic development is being implemented by many small countries worldwide to improve their socio-economic status. Singapore, Ireland and Puerto Rico, for example, have all realized that technological advance generates important and profitable economic development niches.

- To shift from an entirely manufacturing economy to a knowledge-based economy, government, industry and academia must be able to interact in innovative and unconventional ways, one starting strategy to achieve this goal is to establish clusters, where representatives of the three sectors can meet, discuss, delineate and implement a sound economic model.

- A “Cluster” may be defined as an association of entities with common or related objectives, needs, products, process and / or services working together to promote and
develop their respective enterprises and to create new business opportunities in a defined region.

- The University of Puerto Rico (UPR) is one of the main strategic partners in the biotechnology cluster. The UPR system is formed by eleven campuses in various parts of the island.

- The Biotechnology and Bioprocessing pilot plant is an ambitions project whose main objective is to establish Puerto Rico as a global biotechnology site by providing the capability to perform research and development projects in biotechnology and bioprocess engineering.
4.4.20 Israel

- O. Meseri and S. Maital [29] conducted a survey analysis of University – Technology Transfer in Israel and reached to the conclusion that the decision criteria used by Israeli universities are similar to those employed by venture capitalists and by the relatively entrepreneurial – focused Technology Transfer Office at MIT.

- According to IMD’s World Competitiveness Yearbook (2000), out of 47 countries Israel ranks 11th in “Science and Technology” and 8th in “People” (human resources), yet only 23rd in overall global competitiveness.

- A wave of research on technology transfer was generated by enactment by the US Congress of the Bayh – Dole Act in 1980. This act gave universities property rights to federally funded technologies that until then has to be placed by law in the public domain. Universities with significant technological research programmes established Technology Transfer Offices (TTOs), whose function it was manage and enhance the value of the university’s intellectual property.

- Israeli universities operate one or more organizations dedicated to facilitating technology transfer.

- The most effective organization is Yissum, private limited company established by the Hebrew University in 1964 (Annexure [9.9]).
4.4.21 India

- The globalization and liberalization of economy has brought the industries and the institutions together for technology development. Government funding agencies insist on industry participation in projects taken up by universities and institutions, notes a case study conducted under UNISPAR on the Indian Institute of Technology Madras, 2003 [50].

- Manufacturing revolution is starting at the high end. The manufactured exports from India in 2002 was US $37 billion and in 2004 US $ 54 billion. The target in 2015 is US $ 300 billion.

- The formation of Technology Information, Forecasting and Assessment Council (TIFAC) by the Government of India has also helped in identifying and assessing the status of technologies and development of indigenous technologies suited to the Indian conditions.

- The nature of interaction with industries covers a wide spectrum of activities, such as:

  — Academic

  — Research & Consultancy
IIT Madras introduced a new programme of M.S. in Entrepreneurship in 1983. It has aimed at helping engineering graduates and encouraging entrepreneurship talent among them, and the products/process developed during the course of their study which can be commercialized. The programme which is normally of two years duration has been structured to enable the candidates to devote more time on product development testing and initiate steps for setting up an industry. The emphasis, in this programme, is on a hi-tech or import substituted product.

About 40 candidates joined this programme over a period of about 12 years and about 30% of these candidates have set up industries of their own. Some of the products developed by them include.

- Non-contact laser dimension measuring instrument
- Programmable laser dimension measuring instrument
- Programmable process controllers
— Microprocessor based instrument for manufacturing industries
— Epoxy resin from CNSL
— Torque Limiters
— FRP insulators and carbon fibre machine elements
— Earth leakage circuit breakers
— Microprocessor based telephone metering system
— Personal computers for Indian languages
— Microprocessor based instrument transformer test set
— ‘MODEMS’, Modulators, De-modulators
— Development of neo-natal care system
— Microprocessor based ignition timing control for automobiles
— Polymer concrete tiles
— Microprocessor based electronic weighing system
— Fibre glass reinforced joineries
Some of the areas in which research and consultancy activities have been taken up are as follows:

* Computational Fluid Dynamics
* Propulsion integrated systems
* Finite Element Analysis and Design
* Water jet cutting
* Fracture Assessment
* Refrigeration and Heat pump system
* Fluidized Bed Technologies
* Cryogenic Engineering
* Catalysis
* Process heat and mass transfer
* Fuel Cells
* Fluidization technique
* Environmental Protection
* Absorption and Adsorption heat and cooling system
* Polymeric materials
* Biomass Gasification
* Composite Structures
* Energy Efficient Centrifugal systems
* Cyclone & Earthquake resistant structure
* Non Destructive Evaluation
* Irrigation & other Hydrological Studies
* Smart Structure Concept
* Artificial Intelligence
* Computer Aided Simulation / Design
* Neutral Networks
* Welding Technologies
* Wireless in Local Loop
* Corrosion Protection
* Network Management and Architecture
* Nano Technologies
* Web Technologies
* Naval Structures
<table>
<thead>
<tr>
<th>VLSI Design facilities</th>
<th>Offshore and Onshore Technologies</th>
</tr>
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<tbody>
<tr>
<td>Digital Signal Possessing</td>
<td>Thin Film Materials</td>
</tr>
<tr>
<td>Multimedia Technologies</td>
<td>Optical Instrumentation</td>
</tr>
<tr>
<td>Fibre Optics</td>
<td>Hydrogen Storage Devices</td>
</tr>
<tr>
<td>Sensor Technologies</td>
<td>Permanent Magnetic materials</td>
</tr>
<tr>
<td>Parallel and Distributed Computing</td>
<td>Laser Technologies</td>
</tr>
</tbody>
</table>
4.4.22 Malaysia

- A Center for Product Design and Manufacture has been established in one of the major universities. It is set up to promote research and development in product design and manufacturing in collaboration with Malaysian industries.

- R&D work is focused in four main areas:
  - ergonomics
  - engineering design
  - manufacturing
  - robotics

- Academic staff serves as consultants to the projects.

- Post-graduate students supervised by the staff serve as mentors to the undergraduate students.
4.4.23 Singapore

The two national universities in Singapore viz. the National University of Singapore (NUS) and the Nanyang Technological University (NTU) provide perhaps a very successful, dynamic and productive examples of university-industry linkage. The government takes an active hand in building the bridge between the academic, especially the university and institutes, and industry, write J. Lee and H. N. Win [57].

- These two universities play host to a significant number of research centers and institutions each of which concentrate on specific industry sector’s R & D particularly applied research.

- Kent Ridge Digital Labs (BRDL) of NUS is a national applied R & D organization established in 1998 and builds intellectual assets vital to keeping the nation, industry and business ahead globally and positioning Singapore as a strategic IT hub in the world. KRDL’s most valuable assets are embedded in 400 odd engineers and research scientists. They are made up of people coming from as many as 25 countries from around the world. KRDL, structured parallel to its five research labs viz knowledge, learning, ubiquity, biomedical and transportation – the or competency – has the Strategy Group and the Business Dealing Group. The Strategy Group is constantly scanning the environment on market, competitors and customers and the latest changes in the technology market. Management is also provided with precise and timely information of critical decision making process. KRDL conducts three kinds of research.
a) Sponsored research, where funding is provided by outside sources for their own usage.

b) Joint research, where KRDL partners with external organizations to carry out applied research in the fields the firms are interested in;

c) Development of new IT technologies, which will later be licensed, patented or sold to commercial firms or to help start entrepreneur companies.

- Gintéc Institute of Manufacturing Technologies (GINTIC) is a national research institute situated within the NTU campus and is well known as an industry incubator. GINTIC’s mission is to be the leading R & D institute in the area of manufacturing technology to transform Singapore into a center for intelligent and precision manufacturing. It upgrades local-based manufacturing companies by applying and transferring newly developed manufacturing technology to these companies. Its other role is to attract new high-tech companies in the manufacturing fields. The institute has around 350 employees, two-third of which are the researchers working under the 15 research labs. GINTIC receives help and support from the NTU faculty and performs collaborative project with them: Final Year and graduate student’s supervision programms by GINTIC personnel also exist. It has 6 major departments, each headed by a director:

a) Automation Technology Department
b) Manufacturing Information Technology Department

c) Process Technology Department

d) Business Division

e) Finance & Administration Division

f) Graduate Programmes Division

- **Center for Advanced Construction Studies (CACS)** was established in 1989 and is located at NTU in the School of Civil and Structural Engineering. The mission of CACS is to broaden the knowledge and skills of local professionals in construction management and related fields. Its primary roles are to conduct advanced training, research and technology transfer for the construction industry and to broaden the knowledge, skills and technological expertise of local construction industry professionals in areas such as construction management, construction technology international financing and marketing.

  Academic staff from the school support the center's activities. The director of CACS is also a staff of the school of Civil and Structural Engineering. The center is strengthened by the presence of eminent professors from overseas universities as visiting faculties and the presence of eminent local engineering professionals as adjunct staff. The advisory committee comprising members of well known professionals from construction industry provides guidance to the center's research.

- Among different technology transfer mechanisms, joint R & D project is an efficient way to ensure high commitment of
industry and increase the transferability and willingness to industry.

- Singapore has clearly perceived that the most critical resource in R & D is human resource. It has also realized that cutting edge technological research can only be conducted in state-of-the-art R & D facilities.
4.4.24 Taiwan

- Vincent F and S. Wu [70] report that as far as the types of university-industry interactions are concerned, there has not been a universally accepted classification. However, the following modes of linkages are in vogue:
  
  d) General Support
  
  e) Contract Research
  
  f) Research Centers & Institutes
  
  g) Research Consortia
  
  h) Industrial Associate / Affiliate Programme
  
  i) New Business Incubators & Research Parks

- In the early 80s, the government of Taiwan was able to enact industrial technology policies, to setup institutes, and to attract Chinese engineers and scholars overseas to come back. Therefore, the high-technology industries were able to arise and some industries, are even placed on top in the world. Nevertheless, we can still find the industrial firms, innovative capabilities and profitability are still low compared to those in developed countries. Hence, the next step for Taiwan to move forward is to strengthen the linkage between the industry and university in order to
enhance the level of technological sophistication. However, the issue and related practices are new to universities, government agencies, and industries in Taiwan. Therefore, all of them need to learn regarding university-industry interactions.

- Taiwan has experienced a transition from labour-intensive to knowledge-intensive economy.

- External sources of technologies have become more and more important.

- University–industry cooperation has been considered a top issue.

- There were 15,947 engineers with doctoral degrees in 1998 with the following break-up:

  Industry – 1,732

  Research Institutes – 3,869

  Universities – 10,346

- Linkage provide following advantages to the industry:

  — Access to qualified manpower, well trained graduates and knowledgeable faculty.
— Access to basic and applied research results from which new product and process will evolve.

— Solutions to specific problems or professional expertise, not usually found in an individual firm.

— Access to university facilities not available in the company.

— Assistance in continuing education and training.

— Obtaining prestige or enhancing the company’s image.

— Being good local citizens or fostering good community relations.

• The advantages of linkages extended to the universities are perceived as follows:

— Industry provides a new source of money.

— Industrial funding involves less “red tape” than government money.
— Industrially sponsored research provides students with exposure to real world research problems.

— Industrially sponsored research provides university researchers a chance to work on an intellectually challenging research programmes.

— Some government funds are available for applied research, based upon a joint effort between university and industry.

• There are 50 incubators at present operating in Taiwan, which is an excellent example of collaborative R&D work leading ultimately to commercialization of product.
4.4.25 China

- China has 1900 universities and colleges out of which 460 are engineering institutions.

- 7 million students are studying in engineering disciplines (50% of total).

- 100,000 engineering graduates were produced in 2003.

- 30-40% of engineering graduates are doing MS.

- Every engineer is obliged to acquire **72 hrs of continuing engineering education**.

- About 64,000 Chinese students are receiving higher education in USA.

- Enormous investment in education has been made for the past several years.

- There is a very close university – industry linkage.

- The results are extremely rewarding as reflected in the following two tables:
Import of Electronics Goods by Germany from China

<table>
<thead>
<tr>
<th>Year</th>
<th>Value (billion €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>7.884</td>
</tr>
<tr>
<td>2002</td>
<td>9.419</td>
</tr>
<tr>
<td>2003</td>
<td>11.939</td>
</tr>
<tr>
<td>2004 (upto sept.)</td>
<td>11.049</td>
</tr>
</tbody>
</table>

Top Ten Mechanical Engineering Equipment Manufacturers Production and External Trade for the Year 2003

(Value in billion Euro)

<table>
<thead>
<tr>
<th>Country</th>
<th>Production</th>
<th>Export</th>
<th>Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. US</td>
<td>233</td>
<td>57</td>
<td>60</td>
</tr>
<tr>
<td>2. Japan</td>
<td>165</td>
<td>57</td>
<td>12</td>
</tr>
<tr>
<td>3. Germany</td>
<td>145</td>
<td>87</td>
<td>32</td>
</tr>
<tr>
<td>4. Italy</td>
<td>67</td>
<td>44</td>
<td>17</td>
</tr>
<tr>
<td>5. China</td>
<td>66</td>
<td>16</td>
<td>39</td>
</tr>
<tr>
<td>6. France</td>
<td>37</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>7. UK</td>
<td>32</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>8. South Korea</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>9. Switzerland</td>
<td>16</td>
<td>13</td>
<td>–</td>
</tr>
<tr>
<td>10. Sweden</td>
<td>15</td>
<td>–</td>
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</tr>
</tbody>
</table>

- Since 1992, a new Chinese innovation system has been emerging in terms of university-industry-government
relations. In recent years, science parks, incubators, and high-tech development zones have been provided with string incentives, write Loet Leydesdorff and Zeng Guoping [35].

- About twenty new science parks were certified at university campuses by the government in 1999. The goal is set up more than one hundred university science parks all over the country in the near future.

- The combination of Intranet and Internet resources has provided a wealth of opportunity for Chinese research, development, and business.

- The construction of a Chinese innovation system has been favoured by the increasing knowledge-intensity of the economy, the internal resources of the academic system (such as the sheer number of academics, students, and intellectuals), the return from abroad (especially the USA) of academics, and the firm commitment of the national government to the creation of a market economy.

- High-technology development has become the driving force of social evolution and economic progress, write Chen Jin and Dai Lingyan [51]. For China, a key priority for the new century is to make major strides in technological and economic development to narrow the gap
between it and the currently more technologically advanced countries.

- The concept of the university science and technology park (USTP) is relatively new in China.

- Chinese universities suffer from a critical scarcity of innovative people and exploitable innovations – the proportion of research results converted into products is low and there are few profitable ideas.

- As a result of extensive research and discussion, the following functions have been identified for a USTP in China:

  a) **Incubation:**

     It is fundamental for a USTP to provide incubating facilities for new high-tech firms. It is important that academics, students and other technologically skilled people are encouraged to start up their own enterprises. By providing all-round service and an innovation-oriented climate, USTPs can help entrepreneurs to set up and develop new firms, to analyse market demand, to go to market at the right time, and ultimately to operate as fully independent companies.
b) **Integration & Innovation:**

Where there is integration, there is innovation. With information technology as the basis, the USTP should gather together people with different academic backgrounds, integrate current technological achievements and knowledge, exploit the potential for cross-fertilization among different subject areas, and work to promote technology renewal and industrial upgrading.

c) **Cultivation**

In the process of nurturing the growth of high-tech companies, the USTP will enhance and develop managerial and technological skills in entrepreneurs and technical experts alike. In so doing, it will also help to shape a modern corporate culture in China.

d) **Radiation**

Successful firms in a USTP are the outcomes of a combination of business and research skills. They are, by their nature, useful carriers of technology information – and in most cases they will also help to increase employment. They may give rise to a new industrial clustering within their region. Furthermore, institutions within the USTP will help solve technological problems for local firms,
cooperate with them to develop new products and techniques, and promote their technology renewal. Through such ‘radiating’ effects, the USTP contributes to local economic prosperity and social progress.

e) Feedback

Because of the USTP’s continuous interaction with local industry and the community, it is able to provide the university with timely feedback, in light of which the institution can adjust its educational and research activities to fit more appropriately with regional needs.

- **An advanced and appropriate management structure** is essential if the strategic goals of the USTP are to be attained. The structure must enable the park to deal successfully with the university, government, the local community and international technology networks.

- Now the China has joined the World Trade Organization (WTO), the parks should be operated in accordance with international rules and the modern corporate system.

Education Institutions have already become major source of new technology.

- Since the early 1980’s HEIs in many countries such as those in the USA, UK, Germany, France and Japan have witnessed a transformation by broadening their traditional mission of teaching, research and public service and becoming a more active participant in their region’s economic development.

- MIT developed its Industrial Liaison Program in 1948. MIT graduates and faculty have spun-off 3998 high-technology companies, which employ 1.1 million people, and have annual world-wide sales of US $ 232 billion.

- Since the economic reform, initiated in 1979, China has been moving from a planned to a market-oriented economic system.

- Before 1980, government S&T policy was to shorten the huge technological gap between western countries and China as soon as possible. Since the early 1980s, government S&T policy has shifted to economic development and has stressed the transfer of results of S&T research to productivity and consumer industries. Therefore, the focus of S&T research in most research institutions has become economic-effect oriented.
In late 1995, a programme known as Project 211” was set up, which has stepped up technology transfer from universities to local economic sectors and promoted information and technology sharing among universities and economic sectors nation-wide. The project cost US $ 1.57 billion, and has been the largest of its kind related to HEIs since the founding of the People’s Republic of China in 1949.

A national network has been established linkage enterprises with HEIs. It is loaded with information on “what-we-have” technological research findings from universities to meet “what-we-need” requests by enterprises.

As an example Tsinghua University, the top university of China, established University-Industry Cooperation Committee (UICCTU) in 1995. Recently 96 large Chinese and multinational companies, including IBM, Siemens, Motorola, Hitachi, and NEC have joined the UICCTU.

Upto now, Tsinghua university has signed collaborative contracts with 8 provincial and municipal governments and 40 country-level governments. The collaboration contracts contain three main contents:
— The transference of new technology to enterprises with local governments as the medium.

— The establishment of R&D risk investment foundations in collaboration with local governments.

— The establishment of technology transfer bases in collaboration with local governments.

• In recent years, more & more HEIs have begun to establish high technology companies jointly with enterprises. Generally, enterprises input capital while HEIs invest in technology and become a share holder by converting technology into capital. So far, Tsinghua University has established 28 high technology companies in partnership with enterprises in such a manner.

• Tsinghua university has a tradition of collaboration with enterprises, and it has been one of the great success stories at the university.

• An overview of technology transfer from HEIs to industry in China has shown that HEIs have already become an important part of China’s science and technology system and a major source of new technology.
4.4.26 South Korea

- In South Korea, the public-to-private transfer of technology has been of growing policy interest since 1967, when the Korean Institute of Science and Technology (KIST) was created, write Y. Choi and J. Lee [17].

- The government laboratories jointly developed technology with industrial firms in government-initiated R&D projects in which the former were supposed to play the primary role. After the collaboration was completed, research results were transferred to participating firms in the collaborative setting.

- The Economic Five Year Plan (1993 – 97) directed the government to fully utilize its domestic R&D capabilities by facilitating R&D collaboration among government laboratories, universities, and industrial firms, thereby promoting global technological and economic competitiveness.

- The Technology Property Rights Concession Programme for SMEs represent the first and only Korean Program designed to systematically facilitate the transfer of technology to spin-off applications in SMEs.
4.4.27 Japan

- The Japanese government has embarked on a series of reforms aimed at stimulating technology transfer from universities to industry. As a result, technology licensing offices (TLOs) are springing up at many national universities, write S. Collins & H. Waoh [19].

- Academic researchers, especially in engineering and physical science, have a long record of collaborative research with industry. Decisions about patenting, however, were usually left to the corporate partner.

- For its part, the government’s main role was to identify technology crucial to national needs, negotiate deals to import it then entrust it to the imperial universities, national research institutes, or a government-owned company for detailed study and reverse engineering. Once a suitable entrepreneur had been identified, the technology was sold to a private company, often at fire-sale prices. It was a pattern that would be repeated during the period of past war reconstruction in the 1950s and 60s.

- Until well into this century, the Japanese government has no formal system for promoting academic research.
• The First World War greatly boosted awareness of the importance of scientific research. Consequently, the government in 1918 passed the University Act, which for the first time charged universities with the responsibility of doing research in addition of teaching.

• Boosting *industry-university-government* cooperative research first became a serious topic of discussion in policy circles in the early 1970s.

• “The Basics of Comprehensive Science and Technology Policy in the 1970s” report specifically urges development of *organic linkages* among researchers in universities, national research institutes and private research laboratories.

• Cooperative research programmes aimed at stimulating interaction between industry and academic researchers have grown steadily in number, scale, and importance since their introduction in the early 1980s.

• Perhaps most important, is the system of *cooperative research and development centers*, each of which is housed in a national university, that the ministry of Education began setting up in 1987. These centers bring together researchers from universities, firms and national and regional research institutes to work together in a
common facility on a particular problem or theme, usually with particular relevance to the regional economy. To date, centers have been established at 52 of the country’s 98 national universities.

- As the post-bubble economic downturn entered its sixth year, the Japanese legislature in 1996 enacted the Science and Technology Basic Plan. This new blueprint for R & D policy charts an ambitious five-year strategy for improving the national infrastructure supplying public R & D and better linking scientific research to societal needs. A national debate is unfolding on the appropriate role of the university in modern society and the extent and means it should employ in reaching out to industry and the local community.

- The government also passed the University Technology Transfer Promotion Law, which provides new incentives for universities to establish technology transfer offices (TLOs) and market their technology to industry.

- In order to overcome some of the legal problems one of the universities (Tsukuba) found a solution in setting up a TLO as a joint-stock company, whose organization and staff are independent of the university; as a separate legal entity, the office need not worry about violating rules that normally restrict interactions with business.
• A slightly different approach has been adopted at Tokyo University’s Research Centers for Advanced Science and Technology (RCAST). A group of researchers on their own initiative have founded the Advanced Science and Technology Incubation Center. By providing subsidies to offset start-up expenses, the new Technology Transfer Promotion Law is expected to fuel further growth in number of TLOs.

• Hokkaido University through the cooperation of Hakkaido Bank and the venture capital firm Jafco launched the Hukudai Ambitious Investor Enterprises Association in 1997. This is the third area that is seeing significant activity in pairing of university research and venture capital to form a hybrid technology transfer organization that can support formation of new businesses based on the university’s research.

• The growing importance of science and technology in society has created new demands and expectations as to the role of university research in helping to solve many of society’s problems.

• Ministry of Economy, Trade And Industry (METI) is the brain behind the initiatives. Their hallmark is global assessment of technology and preparation of national R&D
menu in consultation with the Agency for science & Technology.

- Japan provides the **best and most successful models of university industry-linkage.**

- Mechanisms have been developed for R&D collaborative work at national level with a **well focused, time targeted** and **adequately funded project** management.

- There is a variety of modes for university industry linkage such as:
  
  — Joint research with industry
  
  — Contract research
  
  — Centers for cooperative research
  
  — Joint research under Monobusho grants
  
  — JSPS Programme

- There are two very prominent programmes sponsored by the METI (formerly known as MITI) in consultation with the Agency of Industrial Science and Technology on a long term business. The programmes are implemented under the collaboration between industry (private sector), academic association (universities, etc.), and government (national institutes).
• **The New Sunshine Programme** is aimed at energy technologies. The success of this programme is pretty evident from the progress achieved in PV cell production and remarkable reduction in prices. The target of 200 ¥/Wp is likely to be achieved by 2010 (Annexure [9.8]).
4.4.28 Australia & New Zealand

- J. Marceau [44] in his paper suggests that any “national” rather than industry-specific approach is likely to be ineffective in stimulating the R&D needed for the development of all industries. This is particularly the case in countries such as Australia and New Zealand where many decisions about R&D investment are made overseas, in the headquarters of the multinational firms that dominate most sectors of the economy.

- In smaller countries such as Canada and Australia, and even more so in New Zealand, issues of priority and capacity are central to decision about policy directions and instruments.

- The OECD also published a study in 2000 which used a new methodology to evaluate claims made about the effects of public subsidies to R&D, using the experience of 17 countries over a period of 15 years. The principal conclusions of the OECD studies were that:
  
  — direct government funding R&D preformed by firms has a positive effect on business-financed R&D;
— tax incentives have a positive (although short-lived) effect on business-financed R&D;

— direct government funding and R&D tax incentives are substitutes;

— the stimulating effect of government funding varies with respect to its generosity; it increases up to a certain threshold (about 13% of business R&D) and then decreases;

— direct funding and public research are complements: public research becomes more effective when government funding of R&D increases, thereby increasing the capacity of firms to digest the knowledge generated through public research (OECD 2000, pp. 185-186). This last funding is of especial relevance to governments considering broader and more coherent innovation policies.

• The proposal made in the paper comes to grips with difficulties now recognized by many to be facing R&D encouragement policies which do not take into account the differences in structure and opportunities which characterize different industries. It uses a new research tool – product system approach – to indicate the broader range
of players who need to be included and proposes a way in which those players can be involved in the decisions taken.

• The Action Agendas as currently constituted bring together government and industry players in a range of sectors to examine collectively what is needed to improve the competitiveness of the industry concerned. Taking building and construction as the exemplary area again (but other industries would have similar lists), such long term R&D programmes would have six major goals:

— the development and use of new materials and components (already the area of most R&D – intensity but not necessarily focused on considerations broader than those of the small handful of individual firms involved and their immediate clients);

— the development of new and improved process technologies (including some with the social objectives of improving health and safety in the industry);

— improving the environmental performance of the industry, including improving embodied energy levels in materials and process as well as energy in
use, and the development and use of new energy related technologies;

— the rapid and effective diffusion of awareness of new technologies to architects, developers, and users/planners as they are tested and become available;

— the development of the skills to use the new technologies;

— the development of the business-related skills needed for more cooperative relational contracting and other mechanisms for getting the scale and competencies necessary for international competition and local success.

• The programmes of R&D thus developed would have the support of industry because they would reflect the priorities selected after analysis of the functioning of the product system as a whole, both at home and in international context, and may encourage firms to invest their own resources to a greater extent.

• Recent research has indicated that firms can no longer work in isolation. They need to scan the international environment for trends and for this they need to
collaborate. Similarly they need to scan the technological horizon. Several OECD countries, including Australia have undertaken Foresight exercises.

- There are six major advantages to the Action Agenda approach to deciding on industry-specific R&D programmes as a mechanism for encouraging greater and more effective national investment in both public and private sector R&D and to link industry interests and public sector research through co-determination of priorities. The advantages are:

  — the process leads to major long term programmes of coherent research oriented to shorter term use or to basic investigation as required, recognizing the interaction and feedback loops of much R&D and its use, without the public sector ‘picking winners’;

  — players in the product system develop new ways of interacting for the good of the industry and not just individual firms and can develop longer term priorities for investment in knowledge-generation;

  — greater responsibility is given to industry participants to lift the performance of their industry as a whole and not to wait for government to act
(end of the ‘government oughta’ approach, still very common);

— all benefits are social and spill over to players which tax-related R&D concessions or credits to individual companies do not permit;

— research programmes selected improve both the general level of knowledge-generation in the product system and, equally important, the capacity to absorb and use knowledge by firms in the industry and the more organized transmission of knowledge along supply chains;

— the Action Agenda process makes it possible to link R&D and other development programmes together into packages of policies and programmes rather than simply encouraging R&D as the tax related policies do. Thus, for example, training and skills development programmes can be developed in concert with the creation and use of the new knowledge generated. These programmes too can benefit the whole industry.
5. PROSPECTS FOR LINKAGES

5.1 Forms of Partnership or Linkage

- There is already a variety of modes of university industry collaboration, which is being practiced in the developed countries and in the emerging knowledge-based economies. The forms are:

  — Joint curriculum development.

  — Continuing education offered on campus, on site or through distance education, known as Knowledge Connection Programme.

  — Specialization academic programmes introduced to meet the business needs.

  — Specialization professional and vocational programmes.

  — Contractual technical or management services offered by the universities to business.

  — Technology Partnership Programmes.

  — Industrial Research Assistance Programmes.
— Establishment of joint Research Centres.

— Business Incubation Programmes.

- The international trend for closer relationship is clearly visible. Barriers are being lifted. However, there are still some questions that need to addressed:

— Partnership between universities and industry should be seen as a relationship of equal but different agents – equal in that each has something of value to contribute and each needs to derive something of value from the relationship, different because what one brings complements the contribution of the other and together these contributions constitute a unique whole which neither by itself could achieve.

— It is necessary to ask whether the partnership idea is really permeating both industry and education or instead, whether it is confined to a relatively small number of highly specific, specially funded projects. This raises a more general question about the diffusion of innovations.
These questions are raised not as a challenge to the partnership concept for which the need for productive linkage is of profound importance for the developing countries and the emerging knowledge-based economies.

5.2 Existing Linkages of the NEDUET

- The NED University of Engineering & Technology does have some loose linkages at present such as internships offered by the local industry to the senior students during the vacations and the conduct of continuing engineering education programmes by the university. The latter could serve as a useful medium for linkage, if it is further expanded to web-based teaching for the industrial trainees remaining in their work stations. The basic infra-structure is available. However, these mode of linkages will have very limited effect on the overall life of the university.

- As far as research is concerned there is no industrially sponsored research being conducted at the moment. The question of its commercialization therefore does not arise. That leaves “D” from R&D and another “D” could be added to mean “Development and Demonstration”. That would be the best bet for the university for realizing substantial and sustainable linkage with the local industry.
As a first step an appropriate mechanism has to be put in place, which would work for prospecting and harvesting of new ideas, and igniting creativity in groups. It would also create technology platforms. A University Company on the lines of Yassum is essentially required.

Much would depend upon the dynamic and professional leadership of the university company. Immediately after constitution the company will be expected to generate a clear and viable agenda for generating development and demonstration activities. The service sector may provide the starting point. Available latest technologies in the water and wastewater treatment sector could be acquired to design, develop and demonstrate the facilities for the utility organizations of the city and coastal areas.

The agenda for linkages should distinguish between short term and long term development plans. In respect of long term plans the focus should be on futuristic but marketable technological products. Manufacturing of products locally may attract small and medium enterprises as they badly need niche markets. Creation of supply chains by deliberate design will ensure successful market penetration of the new products. Development of the balance of power items for the Photovoltaic systems, for example, may offer bright prospects for the SMEs. It is obvious that for success initially such items on the agenda should receive priority, for which international funding is available.
Another fruitful area to concentrate upon is “Enhancement of Processes” for the purpose improving productivity, reducing cost and enhancing life-cycles. Exergy conservation is a field which should be exclusively monopolized by the university. However, one should not overlook the industrial requirement to have well-engineered development projects that could be readily implemented. The environmentally related development projects that need to be executed in conclusive fashion could attract public funding. The university will be well positioned to face competitive bidding, should the need arise.

5.3 Future Agenda For Linkage

Industry will be attracted to work with the university if there is a viable commercial proposition and a competitive advantage compared to other modes. Experience in the developed countries indicates that the following activities may generate interest in the industry or further prospective entrepreneurs:

* Research — leading to the commercialization of a product or process

— Sponsored by the industry itself for discovering a phenomenon, improving a product or enhancement of a process

— Spin offs from major broad-based research themes
* **Patents** — Acquisition of intellectual property rights from individuals or institutions and transfer technology.

* **Development & Demonstration** — Design and development of a product or process on the basis of available technological know-how, development of pilot plants / prototypes
  — Thematic Centers involved in multidisciplinary activities.
  — Bringing development activities to demonstration level.

* **Incubation** — Promoting and managing incubation programmes in collaborative manner

* **Start-up** — Initiating and participating in start-up firms cashing and offering business opportunities to venture capital.
6. **HOW TO BREAK THE ICE**

- Globalization of engineering education has already become an inescapable reality. Equivalence and parity of educational programmes are compulsions generated by the legitimate desire and economic need for mobility on the part of engineers and their employers.

- This study has briefly mapped the issues that have cased a reform agenda of higher engineering education throughout the world. Relevance of the educational programmes to the immediate and long terms societal needs has emerged as a key requirement for survival of the institutions administrating the programmes.

- Innovative measures have been adopted by the universities to meet the challenges of the new millennium. Linkage with the industry is the main theme pursued all over the world implying that “learning by doing” is the best mode of educating the future generation of engineers. This has of course necessitated some structural changes in the university system.

- Although a number of attempts have been made in the past (Annexure 9.1) and a renewed interest shown by MoST and HEC in providing support for establishing university – industry linkages, the objective has proved to be extremely elusive. The main reason is that the public sector engineering universities at present are simply not in an appropriate organizational mode to realize the linkage on the ground.
The universities should take the lead in charting the course of action, as they are the prime stake holders. It could briefly be proposed as follows:

a) Take bold policy decisions to establish university – industry linkage in tri-partite format i.e. university – industry-government (UIG).

b) Scan the best practice that the international university scenario offers and take measures to put them in place.

c) Constitute a **private limited company** on the lines of “Yissum” with the controlling shares of the university and to represent the university in matters of university – industry linkage.

d) Involve MoST and HEC to integrate their efforts with the initiative of the university.

e) Involve SMEDA in the product and process developing activities for eventual financing of the commercialized projects.

f) Constitute project teams for the execution of specific projects, comprising representatives of

   — University

   — Public Institutions
— Government
— Industry / Entrepreneur
— Bank

g) Develop first “In –House Menu” for development and demonstration (D&D). At the moment at least three development projects could be addressed:

— Stand-alone Drinking Water Plant for the Children of Primary Schools

— Balance of the Electric Power Components of Photo-Voltaic Systems, particularly the Inverter.

— Portable Micro Fuel Cells for Lap Tops, Mobile Phone and other electronic consumer goods.

h) It is presumed that arrangement will be made for funding the development projects and a reasonable time frame prescribed for the completion of proto-types and their testing. Planning for the manufacturing facilities for the prospective entrepreneur may be undertaken subsequently.
7. **SWOT ANALYSIS**

It would be desirable to carry out a SWOT Analysis of the University in the context of technology transfer process in order to make a fair assessment of its capability and prospects for success.

**Strengths**

- The present top management is enlightened and takes prompt decisions, once convinced. It has a strong commitment towards quality. It would not hesitate to enter into difficult areas.

- The university is uniquely placed to field multi-disciplinary teams to work on specific projects involving development/commercialization of products and processes. Qualified professional staff can always be hired to capture the technological know-how.

- The university offers an extremely peaceful atmosphere for work. The law and order is visible and durable, and ensures security.

- The university has a fairly well developed infrastructure in terms of services.

- It has a strong Information Resource Network comprising its own Internet Facility, Library service with global outreach, and a vast body of alumni spread throughout the world.
• It has in stock reasonable amount of tools for engineering design, modeling and simulation and a centre for this purpose having a parallel processing facility.

• The conduct of business of development leading to commercialization will be insulated by the university boundaries and will be protected from encroachment and interference by a variety of parasitic government departments, thus conserving valuable resources and time.

**Weakness**

• There has been too much emphasis on black-board teaching rather than on the development of learning, particularly learning by doing.

• There are wide gaps in the knowledge-base as far as the faculty is concerned.

• There is no experience of commercialization and marketing.

• Appropriate mechanisms for collaborative work and joint development activity are not in place.

• Organizational/financial support is contingent to track record.
Opportunities

- Since none of the universities in Pakistan has any worthwhile linkage with the industry, there is a unique opportunity available to the NEDUET to play a leading role in the acquisition and transfer of technology.

- Appropriate mechanism could imaginatively be designed in consultation with all the stakeholders to manage the business of joint/collaborative development work.

- Large engineering industries in the public sector do not have well manned and equipped design offices or bureaus. The SMEs cannot afford to engage qualified design engineers. Excellent opportunities, therefore, exist to outsource design services.

- Prospecting and harvesting the results of innovation by the university will have a strong invigorating effect on its future health.

Threats

- Generally there are invisible threats to the innovative approaches from the shaky, un-qualified and parasitic member of the staff. Disinformation is the main tool used by these retrogressive elements, which can be quite damaging to the hardworking and competent people.
- Discontinuities in the university policies and programmes could occur as a result of abrupt changes in the top management.

- Management of innovation needs skill, which of not demonstrated by the university top management will be obstructive to the aims and objectives of the university-industry linkage.
8. **Essential Attributes of the Management System**

- It is more than obvious that the existing system of the universities can hardly promote sustainable university industry linkage and the objective **will continue to remain elusive**. What is exactly required in the management arm of the university to look after its interest in the university industry linkage? If it does not exist, then it has to be created as an effective instrument. The following attributes will be essentially needed in the organization in order to enable it deliver the goods:

  — Autonomy to conduct business
  — Business acumen
  — Prompt decision making
  — Flexibility & readiness to learn
  — Mobility
  — Capacity to mobilize resources
  — Innovative thinking
  — Experience in development activities

- These attributes can only be realized in a private limited company. The last one, however, is not to be expected readily, as similar activities are non-existent in the country. It will be eventually acquired through a learning curve. The company is to wholly owned by the university and its CEO to be appointed by the university.
• Specific development projects will be managed by Project Management Teams, comprising the representatives of the stakeholders viz. University Company, Small & Medium Enterprise Bank, MoST, HEC, Utility Organizations, Industries and Entrepreneurs.

• Once the University Company is on the ground, it will develop systems and procedures to conduct its business.

• The University Company will take necessary initiative to take the following measures:

  — Develop in-house agenda for development work.

  — Make a thorough assessment of technology and its transfer in respect of the development goals.

  — Prepare feasibility of the development projects estimating the costs and time frame.

  — Market the project to the prospective stake-holders.

  — Mobilize the resources.

  — Constitute a project management team for each specific development project.
9. ANNEXURES

[9.1] University – Industry Council

[9.2] Millennium Development Goals

[9.3] Missing Opportunities

[9.4] University Industry Technology Support Programmes (UITSP)

[9.5] Firms Cooperating with Universities & Research Institutes

[9.6] Engineering Research Centers

[9.7] Incubator Characteristics

[9.8] Solar PV Cell Manufacturing Cost

[9.9] Yissum
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