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# Towards An Integrated Model for Academia-Industry Interface in India

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***Abstract*—**Academia-industry relationship is not like that of technology donator-acceptor, but is of interactive and collaborative nature, acknowledging and ensuring mutual respect for each other's role and contributions with an eye to attaining the true purpose of such relationships, namely, bringing about research-outcome synergy. Indeed, academia-industry interactions are a system that requires active and collaborative participations of all the stakeholders.

This paper examines various issues associated with academic institutions and industry collaboration with special attention to the nature of resources and potentialities of stakeholders in the context of knowledge management. This paper also explores the barriers of academia-industry interaction. It identifies potential areas where industry's participation with academia would be most effective for synergism. Lastly, this paper proposes an integrated model of several new collaborative approaches that are possible, mainly in the Indian scenario to strengthen academia-industry interface.

***Keywords*—**academia-industry, interface, knowledge economy, technology transfer.



## I. Introduction

THE dawn of 21st century is witnessing the advent of a new knowledge-driven society and a quantum leap in higher education. Higher education refers to a level of education that is offered at academies, universities, colleges, seminaries, institutes of technology, and certain other collegiate-level institutions, such as vocational schools, trade schools, and career colleges, that confer academic degrees or professional certifications. There is a rapidly growing demand for a higher education in the today's world because it serves various important functions in our society, the foremost being creation of knowledgeable individuals who will provide service to the society. With globalization taking place, the job market has become even more competitive. Now, a person not only has to compete for a job with the people from his own community or country but also with the people who emigrate from other countries. So what is it that will distinguish one from all other competitors? Of course it is one's additional skills, knowledge and a college degree. Indeed, many of the Indian universities have failed to fulfil this purpose. The recurring demands of skilled and specialised manpower from the industrial sector are not being met as a large section of graduates lack the necessary critical thinking and analytical skills required by the industry. Nowadays, a vast majority of higher education planners and academics, throughout the globe, has been trying to link universities and other research institutions with industries. Universities can boost the value of products in the form of knowledge; industry can supplement the value of university in the form of funds. The National Policy on Education [19] in India has put great emphasis on the need for university-industry interaction. However, in spite of so many efforts undertaken by the Center and State governments, university-industry interaction has failed to prove a noticeable progress up till now. It still remains superficial and limited to a few premier institutions.

How can one define academia-industry interface? A good definition could be that academia-industry interface is characterised by the interactive and collaborative programme between academic institutions and industrial sector for the attainment of certain reciprocally beneficial purposes and missions. Interdependence between academia and industry should be intensified to fulfil necessity for sustenance and innovation in their own domains. Academia-industry interface can be set up at diverse levels with different degrees spanning from mere consultations or visits to meticulous researches. There is a need for paradigm shift in the attitude and approach of both the entities for obtaining mutually beneficial objectives and goals. Despite the different mechanisms of academia-industry interface, there is ambiguity whether the relationship is considerable or only partial in nature. It is unavoidable that the academic sphere, industrial sector, and government machinery should form synergy cooperating, collaborating, and facilitating with each other to combat the new challenges of the global economy. This universal strategy is a must for economic viability and all round development of the country.

## II. Resources and Potentiality of Stakeholders

To make academia-industry interface a grand success, all the stakeholders- academic institutions, industry, and government should collaborate and interact with their own resources and potentiality, as it can be a 'win-win' partnership.

### *A. Government*

A government is an organization through which a political unit exercises its authority in a territory, controls and administers public policy, and guides and controls the actions

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of its members or subjects. Both academics and industry associations are always in search of government funding for its advancement. Practically academias are run by government aid and academics are paid by government through university employment. Besides having the money, governments further have the capability to track and account for funding and its meaningful application. Moreover, government has also the ability to identify more societal needs across the globe. A very significant role for government lies in generating a "buffer" within which disadvantaged groups can be nourished and benefited accordingly. Usually government cuts across a wide swath of industries and is reasonably consistent with fewer annual ups and downs than often happens in business. Today, industry is a very important part of most societies and nations. Therefore, a government should have some kind of industrial policy, regulating industrial placement, industrial pollution, industrial labour, and financing.

### *B. Academia*

Academia is the collective term for the community of students, faculty, and scholars engaged in higher education and research. The word comes from the Greek referring to the greater body of knowledge, its development and transmission across generations. Academia in the context of universities definitely possesses the research ability and motivation, as well as experience, in delivering the essence of education through courses and workshops to large sections of a population. By "university" we understand a corporation of people entrusted professionally with the invention of knowledge – research, on one hand; and in the dissemination of knowledge – teaching, on the other [6], [9], [10], [16]. Academia is also in a position of offering a neutral environment to bring culturally and ethnically diverse people together. Moreover, academia has the capability to explore concepts which are too dodgy for business. In general, there are plenty of cheap smart workforces in academic settings as students always have thrust for learning and gaining experience. Finally, academia has a responsibility to upgrade the society through interaction with its diverse community.

### *C. Industry*

Industry refers to any type of economic activity producing goods or services. It is part of a chain – from raw materials to finished product, finished product to service sector, and service sector to research and development. Industries, the countries they exist in, and the economies of those countries are interconnected in a complex web of interdependence. There are four main industrial economic sectors: the primary sector, which islargely involed in raw material extraction industries such as farming, mining, and logging; the secondary sector, which is involved in processing products, refining, construction, and manufacturing; the tertiary sector, which deals with provision of services (e.g., law and medicine) and distribution of manufactured goods; and the quaternary sector, a relatively new type of knowledge industry which focus on technological research, design, and development such as computer programming, and biochemistry. Industry is the engine that generates the tax base for government revenues and strengthens the economic viability of a population, city and country. Industry can also provide the basis of the problems and opportunities for application of university borne new technology or innovations that can be the prime focus of academia-industry collaborations. Large scale industry has the required resources to invest in the initiatives of new technology development, but it often tends to depend on bought out technologies, generally from the foreign countries. Academic intervention may be needed only in minor technological innovation or modification focused at technology absorption or implementation. Medium and small scale enterprises are a special aspect of industry that comprises the vast majority of businesses across the globe but they do not have the required resources to explore concepts and remove uncertainties of survival. Therefore, they are the main clients for academia- government collaboration.

## III. Barriers of Interaction

Despite the fact that the principle of academia-industry interface has been adopted by concerned agencies in the past decade or more, its full potential is far from being utilised due to the basic 'attitudinal differences' and perception of technology development among the stakeholders.

### *A. From Government*

Government is often too sluggish and generally not flexible enough when dealing with academia-industry collaboration as it is often not entrepreneurial by nature and troubled by monster bureaucracies [25]. An extremely large amount of reporting requirements coupled with little ICT (Information and Communications Technology) domain knowledge further aggravate collaboration. Personnel are often devoid of desired quality and compassion, delays in funding are regular phenomena and instances of overly controlling are numerous.

### *B. From Academia*

Academicians have widespread apathy towards applied research and they are reluctant to leave the comfort zone of pure teaching. Academia as represented through universities is generally adamant when dealing with collaborative projects and typically present additional levels of restrictive internal policies and procedures that hinder innovation. Academia is largely unaware of the real industrial and national needs and unable to market its strengths to industry adequately. Other inhibiting factors are lack of appropriate incentive to faculty and specialized technical infrastructure (R&D Lab.), absence of proper recognition for practising faculty as compared with pure academics worshipper, bureaucratic hiccups in utilisation of consultancy funds, absence of exclusive university-industry interaction cell in campus, etc.

*C. From Industry*

Industry, by nature, is always interested in targeted development. During its interaction with the academia, industry's desired time frames are instant, and investment is guided by efforts that yield result-oriented solutions. The costing frames are typically directed by reluctance to invest in its internal R&D which has either long term or unclear output. The other factors which hinder its interaction with academia are insensitivity to, or lack of cognizance of, the tons of resource potential of the academia; much dependence on easily available foreign know-how; an unhealthy obsession with expensive, eminent professional consultants; earlier bitter experience of interactions with the academia; obligations of ongoing technical collaboration agreements; anxiety to keep secret information of failure or success, confidential for fear of losing the competitive edge etc.

## IV. Integrated Model of Academia-Industry Interface

Academia-industry collaboration has always been a topic of discussion in both the sides. And still there is no widely accepted model to be followed. Certainly, the collaboration, throughout the globe, is quite restricted. This just exhibits the difficulty of the problem. This is due to the fact that academia -industry collaboration is not something that can be well explained with some stipulated laws or by establishing a static model because it evolves progressively keeping pace with the continuous changes in the academic and industrial domains [23].“There is huge gap between the rapidly evolving skill need of Indian businesses and those provided by our higher education system, there is a growing realization amongst the government, academic institutions and the industry, of the urgent need to bridge these skill gaps”[11]. Reference [1] has pointed out that there is lack of substantial integration with industry and other stakeholders in India and urged for adoption of new and innovative strategies to face the mammoth global challenges. Reference [21] has advocated that industry should come forward to work hand in hand with universities providing support to laboratories and scholarships to students without suggesting the proper way and strategy of taking advantage of this collaboration and aligning it for the enrichment of both the academia and industry. “Regular University-Industry interaction, which is critical to raising funds from corporate sources as well as restructuring the curriculum in tandem with the changing needs of the industry is missing in India”[26]. In fact present-day endeavour on academia-industry interface in India is limited to a narrow range of activities. Therefore, in order to strengthen academia-industry interface, the different types of collaboration and interaction that are possible among the stakeholders (Fig.1), particularly in the Indian scenario, are discussed.

*A. Encouragement of Efficient Work Flow*

1) *Creation of “Chair”*

In order to pool resources of academic institutions special honourable “Chairs” in the name of renowned academicians or industrialists can be created in the institute. The holder of the “Chair” will get financial benefit that can be met by the institutional fund received from different companies and organizations in that respect.

2) *Provision of Incentives*

To encourage academia-industry collaboration tax exemption for all expenditure on R&D where industry and academia work together could be given and service tax for any royalty coming out of technology transferred by an academic research institution to an industry could be exempted.

3) Foundation of Center of Excellence and Relevance

The recurring demand of qualified skilled manpower catering to the industry requirements could be met through establishment of centers for excellence in specified areas of universities/institutions under science and technology (S&T). These centers should have direct relevance to industries, which in turn are the major stakeholder. The industries and the Government would shoulder the costs of infrastructure and the host institution would bear all the recurring expenditure like pay of staff, maintenance of instruments, and other organizational expenses for the centre. The participation of industry in the centre is to be extended from the commencement of evaluation process to the Steering Committee entrusted with changing the curricula according to modern trends in technology and also the proper recruitment of students. Moreover, the setting up of the centers in the areas in accordance with public sector’s interest may bring better revenues for the government.

4) Reformation of Students’ Internships

Students’ exposures to industrial practices through internships are to be made mandatory [27].The student internships are also to be made more meaningful with feed back mechanism and long term so that both students and industry are benefited. This would also facilitate the industry to plan and structure the internship programme keeping pace with the academic curriculum. “Exposing students to the world of work plays two related and essential roles. First, by helping them to understand the reality of different kinds of work, and those who perform this work, ranging from manual labour to intellectual tasks, it sensitizes them to the conditions of a universe of persons outside of their own. Second, it allows them to apply what they have learnt in the classroom to real-world situations, and in doing so not only makes them better prepared for their own entry into the world of employment or academic research, but also strengthens their understanding of the underlying concepts they are supposed to have learned”[29].

5) Celebration of Annual S&T Festival

In this progressively globalized world, we come across many challenges that need innovative solutions. The burning challenges among them are climate change, a peak in global

oil production, and the fight for scarce resources including energy and water etc. Advancements in science, technology, and engineering will help us to understand these problems and how best to deal with them. The harnessing of knowledge through research and innovation will lead to economic prosperity and social progress, finally improving our quality of life. The Science and Technology Festival is a very important event in this context. It will arouse the curiosity of students about S&T and open their youthful minds to new information By promoting an interest in science and learning among the students, it will open them to a wealth of opportunities in the future.This festival should be celebrated in all the academic institutions annually involving students, staff, and industrial community.The festival should also be considered as an intimate gathering featuring distinguished personalities from around the world who will come to discuss the past, present, and future of technology.

6) Diffusion of Knowledge through Interaction of Peers

The knowledge pool of students of academic institutions can not be underestimated in this knowledge- driven era of globalization. Students having expertise on different aspects like application of new software, installation technique of photovoltaic (PV) cell for trapping solar energy, and rain water harvesting technique etc., can conduct workshop for other students of their respective institutions.

7) Involvement of Alumni as Mentor of Students

Alumni with industrial background can act as mentor for Indian students to provide guidance on improving employability skills, placements, knowledge of global business trends, overseas opportunities in business, and information of technological advancement etc. delivering lectures in their respective institute. Alumni can also raise a fund to support the entrepreneur skill among the interested students with feed back mechanism under special terms and conditions.

8) Pulling Top-Notch Talents to the Faculty Pool

Eminent scientists /technocrats outside the university system, inland or settled abroad, should be encouraged to participate in teaching and research ventures in universities with required and feasible assistance like allowing to earn royalty on patents, offering extra incentives to promote industrial cooperation, providing full tax exemptions on earnings from industry–sponsored projects, and permitting them to work as part-timer in the industrial sector in order to get the right admixture of theory and practice and to increase their output.

### *B. Setting Up of Interface Structures*

1) Center of Applied Research & Interface

Within the academic institution research and interface centers are to be constructed that would function with a degree of autonomy, with paramount industrial partnership and government aid. A good example of interface center is Bureau of Industrial Consultancy Services (BICS) of JNTU (Jawaharlal Nehru Technological University), Hyderabad that functions as the university's interface with industry.

2) Academia-Industry-R&D Lab Consortia

For industry-oriented applied R&D and also to tackle scientific and technological targets Academia-Industry-R&D lab consortia could be a productive mechanism. The consortia should be aimed to generate new innovative solution for targets that would have considerable economic viability and social developmental value.

3) R&D Center for Common Facilities

This approach at the national level can be created with the involvement of Government funding that can be co-shared by a number of firms on a demand-driven basis. This public-private partnership can work in two ways - (1) co-locating an industrial R&D Centre, in primary stages to begin, within the campus of academic institution or National Laboratory and (2) co-sharing some of the select facilities of laboratory with industry. The very apt examples are UGC (University Grants Commission) created four Centers of National Facilities - Indian Institute of Advanced Studies, Shimla (Himachal Pradesh.); Western Regional Instrumentation Center, Mumbai (Maharashtra); Crystal Growth Center, Anna University, Chennai and mesosphere-stratosphere-troposphere (MST) Radar Center, Tirupati (Andhra Pradesh) [14].

4) Center for Continuing Education Programmes (CCE)

Academic institution is an educational institution dedicated to education and research, which grants degrees. Many such institutes have the proficiency to offer intensive training for highbrow manpower development. Many subjects in the coursework are of great importance to the corporate sector. Hence, there is ample scope of collaboration between academic institutions and industry to organize training in topics of industry's interest and benefit. Particularly, in this type of collaboration, continuing education programms can be arranged by the academic institute utilizing its faculty and infrastructure where curricula should be designed for the participants of industry. "Continuing education has in its nature some collaborative tendencies. First is the multi disciplinary nature of its activities, and the wide range of subjects involved. Second is the nature of its clientele who come with a variety of backgrounds and experiences. A third is the growing use of technology in carrying out continuing education activities, thus ensuring that new providers need to understand new ways of doing things"[8]. In this type of programme crash course may also be offered by the academic faculty to increase quickly the level of technology and competence in the industrial community. "Educational institutions can become more flexible with registration procedures and scheduling; customize and update curriculum; and offer on-site instruction. In exchange they will receive the opportunity to increase enrollments, and therefore revenue; have increased visibility and credibility within the community; and have the use of state-of-the-art technology and equipment while working directly in the business environment"[2].Thus

collaboration in the delivery of continuing education can maximize the effective use of the resources of both partners.

5) Cell for Entrepreneurship Development and Technology Incubation

Government should take initiative to open various entrepreneurship cells in academia and it should be included in the curriculum to enlighten the students about the requirements of society and industry as well as freedom, challenges, and sphere of entrepreneurship, so that they can be interested to emerge as an entrepreneur instead of being entangled in the conventional jobs. This will provide a creative thought, risk-taking capacity, and enthusiasm for accomplishing down-to-earth problems in the young minds of the students. In India educational entrepreneurship is primarily need based but to promote it at a large scale a structured mechanism should be framed encompassing easy availability of fund for the project, attractive incentives, considerable tax reduction, provision of counseling service, and streamlining of labour and company laws. Moreover, academia should also arrange the resources and infrastructure necessary for spin off and incubation of technological achievements of research carried out there. Typical entrepreneurial initiatives in India are Center for Innovation, Incubation, and Entrepreneurship (CIIE) – IIM (Indian Institute of Management) Ahmedabad; Society for Innovation and Entrepreneurship (SINE) – IIT (Indian Indian Institute of Technology) Bombay; Cell for Tech Innovation, Development, and entrepreneurship support- IIT Chennai and Technology Incubation and Entrepreneurial Training Society (TIETS) – IIT Kharagpur.

6) Formation of a National Knowledge Network to Connect Institutions

For strengthening, accelerating research activities, and dissemination of information all academic institutes should frame a common database for information and knowledge where all their research activities like ongoing projects, publications, and awarded thesis could be accessed easily by others. Academia and industry should also be aligned with a single internet connection for implementation of world class standard practices through online courses/tutorials/conferences etc. An encouraging example is “Vidyanidhi”, the database for Indian theses that has been raised by Department of Library and Information Science, University of Mysore [21].

7) Common Certification System

Common Certification System to check the skill level and technical proficiency of the workforce should be raised .This can save expenditure in connection with recruitment and training of employees as well as time of the company [26].A common agency/ institute approved by industry and recognized by government can be entrusted with testing and certification at a national level. Skill assessment is the core part of the common certificate system where the concerned institutions should arrange an objective measurement and assessment of employees’ level of theoretical technical knowledge and their practical aptitude. The skill assessment is to be conducted into two phases: knowledge test and practical test. The knowledge test is to be done by a written examination and the practical test by a practical assignment on the worksite. A candidate will have to score 60 out of a total 100 to qualify the test. The skill qualification examination should be conducted at an agreed time, place and manner of the applicant. Certificate issuing, the last step of the whole skill assessment process can be followed by certificate registration and management by a computerized network system.

### *C. Intensifying Collaboration in Research*

1) Convergence of Interests towards Applied Research

Now-a-days in the era of globalisation the Intellectual Property Rights (IPR) has opened the door of collaboration in the area of research. Research is a detailed study of a subject, especially in order to discover new information or reach a new understanding. It should be considered as a fuel for harvesting knowledge. It should not be taken as a business or a profit center but a long term investment, which helps industry to yield more revenue and profits. Although academicians in most of the premier institutes remain engaged in research, collaboration in this area with industry is possible only if the industry shows interest for research. Till today in India, there is no requirement of research in most companies because the knowledge that is present in the public domain is enough for the company to carry on the business. But now there is a transition of the state to a new scenario. A technology driven company whose business depends on the advancement of technology requires research simply to develop new technologies that can improve its products, lower cost, and bring more profit. Though there was not much technology driven companies in India before, there are a few that are now coming forward (e.g., TIFR-Tata institute of fundamental research).Only research can accelerate the ability of a company to cope with the changes in technology. It can also bring a company in a leadership position in leveraging the new technology for better business prospects. Research can be conducted on basic or applied aspect. Basic research is related to the investigation of some universal knowledge which may have impact on the research community across the globe, whereas the applied research is concerned with the application of established knowledge for commercial gains. By nature, companies usually remain interested in applied research for their own benefit. It is the general practice of academicians to carry out basic research to know the fundamental laws governing the every aspects of the planet. But today, they are also doing some applied research besides the basic ones owing to their survival in this highly competitive market. So there is a convergence of interests as the researchers of both the sides are engaged in applied research. Success of academic research depends on publications, whereas in a company it is measured on short and long term benefits resulted from research. Although publications are not the area of interest of a company, yet there are some companies who find it difficult to assess their own work without having reviewer’s comment and hence go for publication suppressing some key factors. So

there lies a common objective between the industry and academic researchers. Thus, because of the similarity of nature of research, there arises a strong possibility of collaboration between academic institutes and industry. A very recent notable example is "Shared University Research Grant: IBM (International Business Machines) comes up with two key research projects on green technologies with IIT Delhi and IIT Roorkee" [18].

2) Diffusion of Skill of Conceptualization

In most of the academic institutions research projects are designed with a focus to investigate and gather knowledge which may not have applied aspect. Gradually the academicians concentrate themselves into conceptualising the matter and they become unaware of the real problems faced by the industry. Finally the academicians come to the conclusion that their research work is not useful for the industry. Although the result of basic research conducted by the academicians is not always directly useful for the industry yet there is a common ground for common work. Academicians have the capability to take out real matter from a problem, and then conceptualise it, and resolve in a conceptual domain. The industry researcher and practitioner are devoid of this expertise as they usually remain involved in the immediate solution of a particular problem instead of developing the ability of conceptualisation which requires much devotion, endeavor, and time. Conceptualisation is the key of research that deals with a general problem to discover new information or to reach a new understanding Therefore, a natural synergy exists between the academic and the industry researcher– industry can borrow skill of conceptualisation and generalisation from the academicians in lieu of offering the practical reality in which the conceptualisation can be applied.

3) Acceleration of Research Interaction

Concerned people from both sides need to understand that bringing the two together necessitates a lot of meaningful interaction. A quantum leap for research interaction can be provided if academics and industry researchers can sit together and spend a considerable time in the discussion of industry's problems and ongoing exploratory projects. This can be materialised by inviting academics in the industry as and when required submitting requisition to the authority concerned. During the visit enough interaction should be ensured for the visitors to get a thorough knowledge of the problems and this may result in the formation of a joint research project of academics and industry researchers. The project may be conducted either in the academic institute or industry or partially in both the places depending on the availability of facility for research. The research work should be co-supervised by the academic as well as industry researcher and the entire possible outcome should go to their credit. The result of applied research carried out in academic institute may be launched for multilocational trial in different companies across the country with a feed back mechanism for its commercialization.

4) International Academic Cohesion and Industrial Collaboration

There is tremendous opportunity in promoting interactions among academia, industries, and governments through which India and collaborated countries can be enriched. The interconnection through research collaboration, consultancy service, and extension programme is very significant for both academic and industrial development as well as economic prosperity of the allied countries. The Indian sick industries should be assisted through government policies and investment to ensure a reasonable level of competence in cutting-edge technology. This can be achieved though collaboration with foreign counties and inviting foreign companies to venture in to India. At present India is in a position of having S&T cooperation treaty with 57 countries incorporating the G8 countries such as France, Germany, Italy, Japan, UK, and the USA.

*D. Bilateral Programme of Mobility of S&T Professionals*

1) From Academia to Industries

Refresher course and orientation programme of one month each can be arranged in the industry where academic faculty can participate. The lectures in the programme will be delivered by the professionals from industry to provide up-to-date technical know-how. The refresher course would be designed to provide knowledge in depth while the orientation course would be created to acquaint the participant with the interdisciplinary approach to the real problem. The participation of the faculty can be made mandatory maintaining a time period interval. The faculty could also be offered an internship programme of six months to one year at advanced level in industry of national and international level. This would enable them to enlighten the students with more practical knowledge, relevant to industry [4].

2) From Industry to Academia

Intensive programmes under Visiting Professorship scheme should be created for regular visits of resourceful persons from industry to address students, academic, and scientific staff and to involve them in teaching or research during their short stay in the premises of the institute. An expert from industry, with several years of job experience should be given the status of a Professor. He could be called as a Corporate Professor, so that the individual may also earn due recognition from all concerned. This type of programme should also be designed to share knowledge during an open interactive discussion. Industry practitioners should display the challenges of the industry in the form of workshop or seminar and give real time exposure to the students. This endeavour not only ensures feasibility to the companies but also can mould the workforce according to its need.

### *E. Facilitating Flow of Technology from Laboratory to Market Access*

#### 1) General Policy of Technology Transfer

There are various mechanisms for the technology transfer of research and technologies invented by local universities and research institutions. At the primary level this may just involve discussion of mutual benefit or getting integrated in an undergraduate research project or offering a placement for a student to get experience of job. This is followed by commencement of larger scale collaborations. This usually involves a contribution from the external stakeholder. The type of technology transfer mechanism to be followed in any particular research depends on several aspects. The mechanisms for the technology transfer of research are consultancy, outright sale of technology, licensing of technology, joint-venture, and start-up ventures. There are several other means in which industries can sponsor different research activity at the universities. The other ways of collaboration are jointly organized new technology trainings and seminars, scholarships, collaborative research, and internship or industrial attachment. Typical example includes the successful mechanism of technology transfer in the form of an IPR policy of IIT Delhi where FITT (Foundation for Innovation & Technology Transfer), the technology transfer office acts as industry interface of the institute and also as its marketing arm [20].

#### 2) Enhancement of Technology Transfer towards Commercialisation

With the object to focus on key and strategic areas of research and to provide adequate funding to research that keeps pace with market needs or market-driven R&D, several appropriate programmes are to be adopted. During the evaluation process the commercial viability of the research output should be given the prime importance for approval, besides technical feasibility. The rearrangement of the various R&D grant projects in India may also be orchestrated, tending to streamline the objectives and management of the present grant projects under one management body. The former grant projects may also be rearranged and clustered into cultivation of new knowledge and advancement of technology for commercialisation. Funding policies should also be reformed and enlarged to incorporate funding for incubation and pilot project. Here the main target is to create a steady flow in the Linear R&D&C Value Chain, from elementary R&D work to commercial feasibility followed by full industrial scale-up. Moreover, government should come forward with special package of tax exemptions for encouragement of industrial support of R&D, extended permissions for collaboration with foreign R&D supporting institutions, and the foundation of a strong research infrastructure.

#### 3) Creation of Research Park to Encourage Growth of Enterprise

Science and technology parks should be founded in the immediate vicinity of academic institutions[15], where companies would be interested to establish their R&D sector, with a view to have easy access to sources of high quality technology and skilled manpower. Government should extend its hand in the availability of land in close proximity to these institutions with several concessions like concessions in electricity tariffs, duty exemptions for imported equipments, and all possible benefits of SEZ (Special Economic Zone) etc. Successful example is Science and Technology Entrepreneurs Park (STEP) established in the year 1988 by University of Pune and promoted by National Science and Technology Entrepreneurship Development Board (NSTEDB) of Department of Science and Technology, Government of India.

#### 4) Setting up of Venture Funds to Support Innovative Entrepreneurship

In India the major shortcomings in the development of knowledge-driven entrepreneurship is the lack of seed and early stage funding for such ventures. If sufficient venture funds for seed funding and first stage funding are created an entrepreneurial dimension can be injected into the students, researchers, and teachers of the academic institutes. Government should ensure legal power for faculty entrepreneurship, in the service condition. Each academic institute may open a commercial enterprise which will offer support to its entrepreneurs by providing services that may range from business plan writing, seed funding, product championing, mentoring, and incubation to legal assistance with intellectual property protection and licensing. It will also provide an encouraging atmosphere that will permit researchers to capitalise on their research outcome and create innovative products and services for the common people.

#### 5) Handling Rural Issues and Reforms

Keeping in view the problem in integrating many different rural development and related programmes at various levels, there is an urgent requirement for constitutional amendments and reformation of administrative executions. A three-in-one programme involving academia-industry-government should be launched for identification, management, and eradication of local rural problems like drought, flood, earthquake or any other natural calamities causing damage to human welfare and our national property. The first step of this programme is the identification of local rural problems by the local universities and state govt. followed by industry invitation for technical support in commercial arena.

### *F. Fostering Public-Private Partnership*

### 1) Areas of Partnerships

Throughout almost all industrialised or developing countries, there has been a significant role of government in promoting R&D in small and medium enterprises. In India partnership with large enterprise is usually limited to some strategic sectors like space research, atomic energy, and defence etc. But a policy framework for public sector partnership with large enterprise is lacking in the remaining knowledge pool which can provide a lot of new intellectual property. For example, there is ample scope of development and business in the virgin field of stem cell research, nana technology, and advance materials etc. where public sector alone can not perform the dual functions concurrently – the enhancement of science and the leading of commercialized technology and its products. Therefore, to get maximum gain from public investment in these new fields, R&D in public as well as private sector should progress simultaneously. "The public private partnership model could be effectively developed by allowing greater participation of private sector, NGOs, industry etc., by facilitating incentives for achieving the planned target" [13].

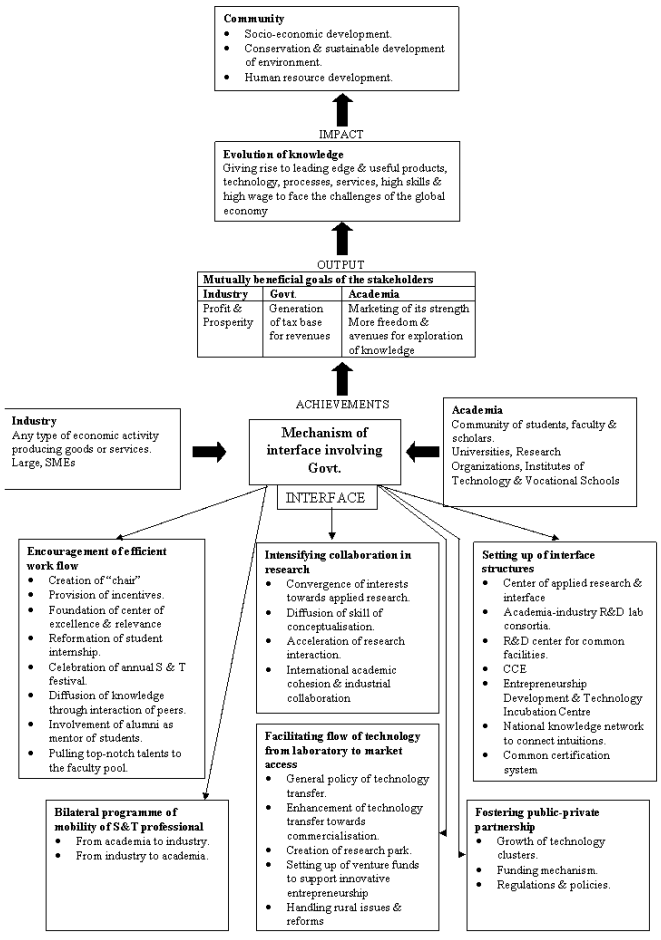


Fig.1 Integrated Model of Academia-Industry Interface

### 2) Growth of Technology Clusters

Knowledge- driven enterprise formation has gained a lot of success in countries where cluster building endeavour has been adopted. In this model there is a need of strategic co-location and funding of institutions, technological parks, innovation hub, business opportunities, technology transfer units etc. under one umbrella with shared goals and benefits of the entire cluster. Some of the components can be best privately funded, whereas others by public sector, but a common union should grow.

### 3) Funding Mechanism

Both public and private sector can co-invest equally in the R&D and the company will get the priority to a licence to cpmmercialize, whereas the government will get royalty and also have the right to give one more licence to another company. This system can raise competition and provide greater accessibility of the products to the consumers. Government can also get some emergency work done by a company providing public fund on contractual basis. The company concerned will have the first right to a licence to cpmmercialize the product and the government should give more licence to other companies to stop monopoly.

### 4) Regulations and Policies

Government should ensure a smooth transition of KPO (knowledge process outsourcing) between academia and industry through its regulatory bodies and policies laid down by the management. It can help with a clear stipulation, where it should prohibit so that the academic world may not be deceived by the industry.

## V. DISCUSSION

The world has moved from industrial revolution to knowledge revolution and from industrial economy towards knowledge economy. Global economies are gradually getting interconnected in this changed situation. Keeping pace with this change, R&D is crossing national boundary. India, with its enormous pool of technical graduates, is facing new challenges. They are actually the country's greatest resource and have brought opportunity for India to grasp the global economy. The quality of products of immeasurable economic value will hereafter be knowledge-based, requiring very limited capital unlike the traditionally manufactured industrial goods that need investment of vast capital. What is knowledge economy? A widely accepted definition could be that knowledge economy is characterized by the highest number of the well-trained, productive individuals. In other way it can be said that, much learned, research-minded human capital of the creative class is the bedrock of the knowledge economy. In the state-of-the-art era of knowledge driven economy, a productive interface between industry and academia is a critical requirement. In the proposed integrated model (Fig.1) an attempt has been made about knowledge sharing, knowledge transfer, and transfer of experience and technology between academia and industry. There is a prediction that,

probably before the middle of this century, BRICs (Brazil, Russia, India, and China) could emerge as a much larger force in the world economy and India's position could be the third largest economy. Indian companies in the software and automotive sectors have proved their capability in knowledge-based commercial operations and have earned recognition as potential world leaders. In the near future, new technologies in the domain of advanced materials and nano-technology, ICT, bio-technology and pharmaceuticals, etc. will presumably be the key drivers of growth. Therefore, in the cutting-edge era of S&T a glorious opportunity for India has emerged which can bring the leadership of the new technology-driven development and application of technology in varied fields.

The advent of technology-driven entrepreneurship in India at a galloping pace, demands the formation of a synergy with wider industry-academia interface [3]. Small and medium sized enterprises (SMEs), which are likely to be the major force in the new advancement of IT industry, could presumably be the accelerating agent in this emerging scenario. "While the thrust of this academia–industry interface initiative is from the perspective of large-scale research collaboration, the SME sector has common issues of concern which need to be addressed" [5]. IT companies may need an updated version of technology to cope with the rapidly changing IT industry in this highly competitive era. Therefore, it is imperative that IT companies should tie up with academia to ensure a steady inflow of IT professionals who are well aware of the most recent development in IT field [28].If academia, jointly with industry launch short-term, small-budgeted, targeted exploratory activity having commercial viability, it will provide confidence in industry for adopting long-term research oriented project. Besides teaching and research activities, academia's entrepreneurial activities are also likely to be very important for achieving enhanced academia-industry interaction.

In this era of globalization, to stay alive in the race for competitive excellence of global market, industries will have to restructure its R&D initiatives. This approach must be directed by a complete paradigmatic shift from a simple capital oriented business format to a technology driven entrepreneurial one. For conducting industry-oriented applied R&D, academia-Industry-R&D lab consortia could be a very fruitful mechanism [17]. Moreover, public-private partnership and industry involvement are really very important in connection with applied R&D, where there has to be a focus on market access of the research outcomes and technologies developed. While fundamental research is likely to continue to be largely promoted through public funds and conducted in academia, even in this, public-private partnership is imperative for setting up and maintaining the level of research infrastructure updated and upgraded to face the challenges of the changing world of global business and industry. Inclusion of industry practitioners in academia's research activities through academic programmes could be very important for achieving the desired outcomes in this direction. CCE has become a time tested window for academia-industry interaction, with active intervention from industrial sector. Establishment of technology incubation centers in the adjoining areas of academia could be yet another platform for interaction with industry. Finally it can be said that, in this era of knowledge-driven global economy, for promoting sustainable academia-industry interface multilevel collaboration is required. Reference [12] has put forward that academia-industry interface may be carried on "by a framework of representation from industry, society and professional organisations in the various levels of planning and management of engineering education as well as by a direct cooperation in actual course work". Reference [24] has advocated that "rather than opting for a particular model, we should explore different forms of partnership and settle with where we have comfortable levels of working with the industry, comfortable interaction scenarios and a corresponding comfortable sharing of the gains that we will have from the research of all types".Therefore, it is the foremost task to localise the areas where optimum collaboration is likely to be available. Moreover, to achieve the desired outcomes of this interface, there should be two-way academia-industry cooperation [22] and the two entities will have to be more sensitive with respect to each other's growth [7].

## V. Conclusion

With a goal to make India the global powerhouse in research and innovation, a new range of technology is required to meet the future challenges, and India has to head forward on innovative collaborations between industry and our universities through cooperative knowledge creation and exchange. Although cooperative research is the key word to fill the gaps existing in the present structure, there is a tremendous need to create other avenues that need to be intensified, stimulated, and above all integrated, for a close academia and industry interaction through all the stages of technology development, starting from conceptualization down to commercialization. Other avenues for tie ups are achievable and can be well explored. The most meaningful aspect is that such tie ups acknowledge and capitalize on the relative strengths of the academia and industry. Besides industry associations, the universities should also form linkages with government agencies which are entrusted with industrial development activities In spite of some shortcomings and inhibiting factors with respect to the academia-industry collaboration, government should put into place an integrated policy of academia-industry collaborative interaction encompassing a number of strategies enabling such an initiative to thrive in the country's quest for technological leadership.

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