Confederation of Indian Industry

Building a National Research Quad

(Fostering Industry-Academia-Research Lab-Start-up Collaboration)

Report under the aegis of CII National Mission on Technology, Innovation and Research

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1. INTRODUCTION

For any country to be able to use innovation to further growth, competitiveness and the welfare of its citizens, it is well established that it needs a vibrant and dynamic innovation ecosystem. It is only through synergistic efforts of the government, industry, academia and research institutions that the entire cycle of innovation from idea to market and beneficial outcomes can be successfully completed (Nelson, 1993; Lundvall, et.al., 2002).

As part of its deliberations for the year 2022-23, the CII National Panel on Technology, Innovation and Intellectual Property decided to take up "Building a National Quad" as an important sub-theme. A sub-group of members of the panel (see Annexure 1) focused their attention on understanding what it takes to build the quad, and to make recommendations to government, industry and academia on how to make this a reality.

2. THE CONTEXT

The Indian innovation system has both strengths and areas for improvement. While India's strengths include (1) a large reservoir of technically trained individuals; (2) high quality science, engineering and research institutions; (3) government support through policy initiatives, budgetary allocations and tax concessions; (4) sectors such as pharma and transportation where industry makes significant investments in R&D and innovation; and (5) a dynamic set of start-ups, there are challenges such as (1) overall low level of investment in R&D and innovation [0.6-0.7% of GDP]; (2) relatively low share of industry in total R&D spend; (3) an education system that has historically not been conducive to building creative skills; and (4) limited collaboration between academia, research institutions and industry (Krishnan, 2010a; Krishnan & Prashantham, 2019).

However, during Covid-19, it was observed that industry and academia came together in a mission mode with coordination by the government to solve many of the immediate challenges such as shortage of ventilators and personal protective equipment. There have also been earlier successful case studies of industry-academia interaction, though these may be limited in number. These historical bright spots suggest that building a National Quad is possible.

The Importance and Nature of Industry-Academia Collaboration

At a basic level, collaboration between industry and academia is focused on talent. Graduating students need jobs, and companies need competent people to undertake the myriad tasks involved in running their business. It is widely accepted that superior talent is an important source of competitive advantage.

But there is more, much more, to industry-academia collaboration than jobs and employment. Academia could potentially contribute basic research and do open exploration to build a knowledge pool to support industry's innovation efforts, do problem-solving and consulting, provide continuing education and training, and test and validate industry's ideas. Academia can create technologies upto the pre-competitive stage, and occasionally even develop ready-to-use technologies and products.

Industry can help identify promising streams of research for academia to work on, support academic research programmes in areas of mutual interest, build on research ideas already developed by academia and commercialize product, technologies and intellectual property created through academic research. The synergistic relationship between academia and industry is shown in Figure 1 below.

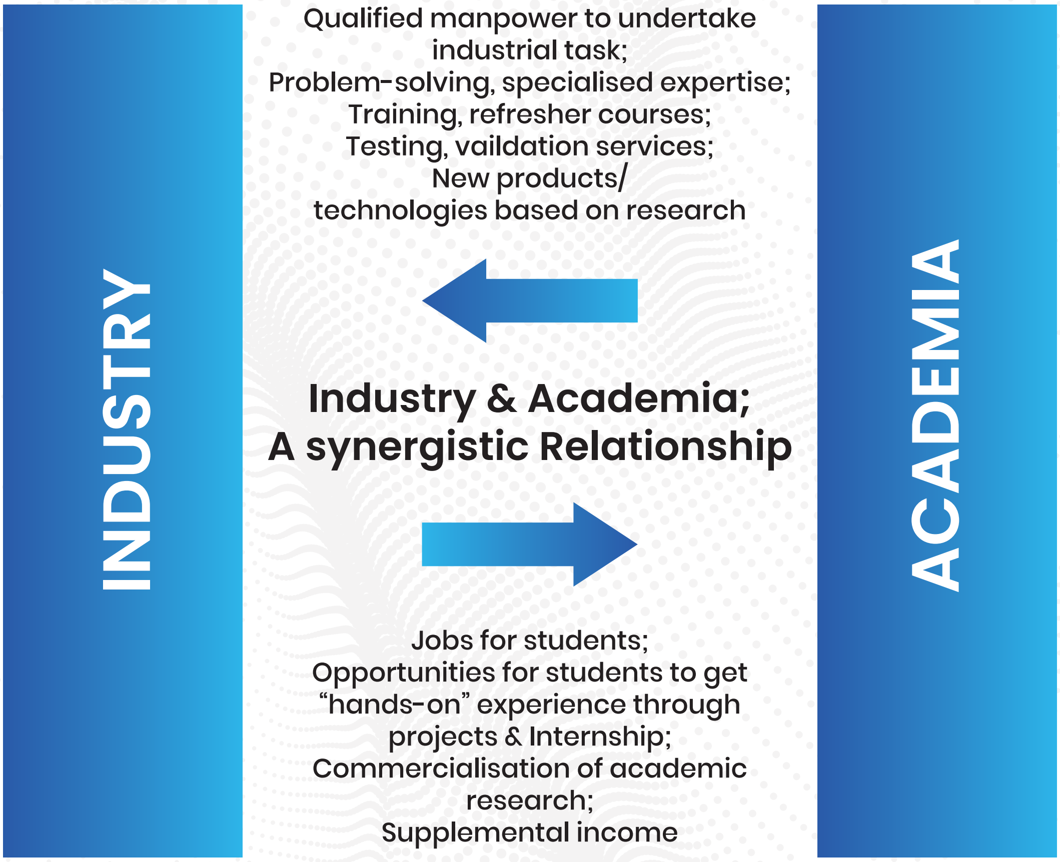


Figure 1: Industry & Academia: A Synergistic Relationship

In some industries like biotechnology, academic research is the principal source of key advancements whether it be mRNA vaccines or the CRISPR method for gene splicing. Globally, the concept of "open innovation" (Chesbrough, 2003) has become popular with large corporations, and academic institutions being important players in open innovation networks.

In the United States of America, the potential of academia-industry collaboration became evident during the Second World War when academic researchers developed technologies ranging from atom bombs to jet engines to radar and these were manufactured by a range of enterprises. After the Second World War, the USA worked towards institutionalising this arrangement through government-sponsored R&D programmes piloted by agencies like the National Science Foundation and the Department of Energy (NSF, 2020).

Industry – academia collaboration happens through diverse mechanisms. A useful categorization by D'Este and Patel (2007) suggests five categories of interactions – meetings and conferences, consultancy and contract research, creation of physical facilities, training and joint research. Some of these interactions (meetings and conferences, consultancy and contract research, training) are arms-length in nature while others (creation of physical facilities and joint research) signify a long-term commitment. According to Perkmann and Walsh (2007), these interactions fall on a continuum between research services and research partnerships. As we move along the continuum from research services to research partnerships, the knowledge flow becomes bi-directional and the intensity of engagement increases.

Pertuze, Calder, Greitzer & Lucas (2010) studied industry-university research to understand practices that enhance the impact for companies from joint research projects beyond the immediate project outcome. The seven best practices for Industry-University Collaboration identified by them are: (1) Define the Project's Strategic Context as Part of the Selection Process; (2) Select Boundary-Spanning Project Managers; (3) Share with the University Research Team the Vision of How the Collaboration can Help the Company; (4) Invest in Long-term Relationships; (5) Establish Strong Communication Linkages with the University Team; (6) Build Broad Awareness of the Project within the Company; and (7) Support the Work Internally Both During the Contract and After, Until the Research can be Exploited.

3. INDUSTRY-ACADEMIA COLLABORATION IN INDIA: STATUS & CHALLENGES

Industry-academia collaboration in India has historically been centered on talent. Besides companies providing internships and hiring graduates, academic institutions have provided continuing education programmes for corporate employees or facilitated external registration of company employees in Masters and PhD programmes. Some institutions like BITS Pilani intensified this engagement and worked closely with companies to get "Practice School" (extended semester-long internship) opportunities for their students and in turn ran intensive skill upgradation programmes for their corporate partners.

The quality of interaction in the talent sphere has shown significant improvement over time. Many professional colleges now teach soft skills such as communication and teamwork that help fresh graduates move smoothly into a corporate environment. Companies have shared their own resources (such as curricula and teaching material created for internal training) with colleges so that graduates are "industry-ready". Some of these programmes, such as Infosys's CampusConnect, cover hundreds of colleges across the country.

Industry is represented on Boards of Studies of the All India Council of Technical Education (AICTE) and universities so that the curriculum incorporates industry needs. Companies across the country offer internships and other short-term projects to students to give them an opportunity to learn what industry is about. Internships give companies a chance to evaluate students first-hand and offer employment to students with the right attitude and skills.

An early extension beyond training and employment was in the space of characterization and testing. Well-endowed institutions that had good laboratory infrastructure had the ability to use these facilities to provide testing services to companies.

Reflecting the above, a study of academia-industry collaboration in the Indian automobile industry by Krishnan and Jha (2012) found that:

- Industry-academia interaction for competency development and training in companies appears to be the most significant form of interaction.
- The second most prevalent form of interaction is for analytical studies, testing, etc. i.e., companies are contracting with academic institutions to provide research services.
- Industry University collaboration is clustered around a handful of IITs and the Indian Institute of Science.
- Investment by companies in research partnerships outside the umbrella of government-supported collaboration programmes is rare.

The same study found that the relative absence of research partnerships is not due to intellectual property ownership issues, but because (a) the cost and complexity involved in commercializing academic research that is science and engineering research oriented is high and (b) companies, driven by solving immediate or near-term problems, are focusing on assimilating and building on known technology from international vendors rather than creating new technology in-house or with academic partnerships.

What are the other reasons for a relatively low level of academia-industry collaboration in India?

- On the demand side, a major problem is a lack of emphasis on research and development (R&D) within companies. Research collaborations with academia are generally a complement to in-house R&D, so if R&D spend is low, the likelihood of research partnerships is also low. According to the R&D Statistics published by the Government of India's Department of Science & Technology (DST, 2020), more than 40% of Indian industry's expenditure on R&D is concentrated in just two sectors – pharmaceuticals and transportation. Given that the total expenditure on R&D is also small (India spends only 0.6-0.7% of its GDP on R&D compared to close to 3% in Korea or Japan!), this points to very low spends in the rest of the economy.
- It appears that a good part of industry isn't convinced that Indian academic institutions are the best partners. In fact, many top Indian companies have in recent years forged relationships with leading foreign universities rather than collaborating with Indian academic institutions.
- On the supply side, academia can contribute effectively to the knowledge needs of industry only when it emphasizes the importance of deep expertise in specific areas. Specialization and deep drilling down leads to the insights that would create new knowledge. Yet, except for the top institutions, Indian institutions of higher learning rarely facilitate specialization by their faculty. They feel no disquiet in asking a professor to teach a completely unrelated subject just to ensure that

the curriculum is completed on time. Colleges keep faculty so busy teaching that they have little time to think and reflect, let alone devote time to research and knowledge creation. The infrastructure needed for research in terms of laboratories and equipment is often inadequate. And performance measurement, incentive and compensation systems are poorly designed (or often non-existent) to support the development of such deep expertise.

- This problem is compounded by the absence of strong postgraduate programmes in Indian higher education (particularly in engineering). The world over, scaling up of research efforts in universities happens thanks to an army of graduate students doing master's and doctoral research. Yet, in India, only the Indian Institute of Science and the IITs offer postgraduate engineering programmes of any stature. And, with the large number of jobs available today, few students wish to delay their earning by going into postgraduate programmes.

- Complicating this scenario is the fact that industry and academia don't understand each other well and often don't speak the same language. When industry gives an academic institution a problem to solve, they often don't define it adequately, or give too large a problem that the academic institution can't wrap its hands around.

- Academia has its blind spots too. Academic researchers are sometimes not up-to-date with the latest industrial practices and infrastructure. The solutions they propose may not be practical enough for implementation. Academic institutions sometimes sees industry as the golden goose, and try to squeeze as much as they can from the engagement. Their researchers don't spend enough time and effort to understand the context of the company's problem.

4. BRIGHT SPOTS & BEST PRACTICES

Notwithstanding the above challenges, there have been bright spots of industry-academia interaction in India. Some of the prominent examples are summarized below.

Building the Indian Generic Pharma Industry

Historically, the most successful collaboration between industry and academia in India was arguably in the pharma industry. This reached its peak in the 1980s and 1990s when Indian pharma companies were taking advantage of Indian patent laws to grow aggressively. Since India did not award product patents in pharma at that time, the main challenge for Indian pharma companies was to identify alternate process routes that did not infringe any process patent that the molecule owner had in India. India's strength in chemical synthesis came to the fore as scientists from the Institute of Chemical Technology (then UDCT) and the Bombay College of Pharmacy besides from CSIR labs like NCL and IICT worked closely with pharma companies to identify such process routes. The fact that many of the promoters of pharma companies had studied in these institutions and had close personal links with the faculty/scientists helped this process.

Light Combat Aircraft Programme

One of India's most successful technology development projects has been the Light Combat Aircraft (LCA), now named as Tejas. When the LCA project started in the mid-1980s, India faced serious handicaps in composite materials, avionics and a host of other technologies. Dr. Kota Harinarayana who headed the Aeronautical Development Agency (ADA) that was created for the LCA project realized that it would not be possible to create all the needed expertise within ADA or HAL.

He therefore visited all the leading engineering schools in the country, made an assessment of the expertise available, and created a large collaborative platform to rope in this expertise. Very soon he realized that these individual faculty members lacked either the managerial expertise or the interest to manage complex research projects. So, ADA worked with the professors to break down the problems into more manageable pieces, each of which could be tackled as a Ph.D. or M. Tech. project. ADA funded the creation of physical infrastructure wherever necessary and did the overall programme management and coordination.

Collaborative Automotive Research (CAR) Programme

Following a positive interest shown by the automotive industry, The Principal Scientific Adviser (PSA) to the Government of India mooted a programme for support of consortium-based R&D in the Indian automotive sector called CAR in 2003. The automotive sector was chosen because the PSA believed that in a growing industry, there was a greater likelihood of technology getting commercialized.

Six panels of industry and academic experts were formed, resulting in a 2005 Road Map covering 30 areas. The consensus was that the government should support the industry by bringing in academia and research institutions to undertake pre-competitive research through a consortium approach.

A total of about Rs. 0.35 Billion was spent on 10 consortium projects from inception of the CAR programme till December 2010. All government financial support was given as grants to the institutions involved. The institution could in turn commission work at the companies and pay for this e.g. prototypes, machinery, etc.

The 10 consortium projects funded were as follows:

List of Collaborative R&D Projects under CAR Programme		
S. No.	Project Title	Partners
1	Engine Management System Petrol Powered Small Vehicles	IIT Bombay, IIT Madras, TVS Motor for Company, Ucal Car Fuel Systems
2	Vehicle Tracking and Control Systems using GPS/GSM Technologies	IIIT Bangalore, Ashok Leyland, Lattice Bridge, Bharat Electronics, Pallavan Transport Corporation Consultancy Services
3	Wi-Fi Based Vehicle Tracking	Amrita Vishwa Vidyapeeth
4	Development of Tailor Welded Blank Hydroforming Technology for Automotive Weight Reduction	ARCI Hyderabad, IIT Bombay, Tata Motors, Mahindra & Mahindra, Tata Steel, ProSim
5	Acoustic Diagnostics for 2-wheeler Engine Assembly Line	IIT Kanpur, IIT Delhi, IIIT Allahabad, Kritikal, Knowledge Online and TVS Motor Company
6	Low cost Flexible Automation using Robotic Arms	IIT Madras, Systemantics, IIT Bombay, Magstorq, TVS Motor Company, Mahindra & Mahindra, Sona Koyo Steering Systems, TVS Lucas, Bosch
7	Process Development in Semisolid Forming and Squeeze Casting of Alloy Components for Automobiles	IISc Bangalore, Sundaram Clayton, TVS Motor Company, Mahindra & Mahindra
8	Use of Straight Vegetable Oils in IC Engines	ICAT/NATRIP, IISc Bangalore, IIT Madras
9	Ultracapacitor for Electric & Hybrid Vehicles	IISc Bangalore, IIT Kharagpur, NCL Pune, CECRI Karaikudi, Kaptrinics, NED Energy
10	Development of Automobile Components through Electro-magnetic Forming Process	Bhabha Atomic Research Centre, Advanced Materials and Processes Research Institute, IIT Bombay, IIT Delhi, Fleur-de-lis Technologies, + Automotive Companies

Krishnan and Jha (2012) found that the government has played an important role in moving the academia and industry closer through collaborative programmes such as CAR described above.

Samtel Display Technology Centre

Another important initiative was the Samtel Display Technology Centre set up within the IIT Kanpur campus in 2006. By physically locating the Centre on campus, Samtel was able to draw on the institute faculty as well as students across disciplines to do projects of mutual interest. Professor K.R. Sarma, a senior professor of Electrical Engineering at IIT Kanpur, joined Samtel soon after his retirement as Adviser (Technology). Prof. Sarma played a crucial boundary-spanning and translation role. He was able to calibrate expectations on both sides and structure the interaction for mutual benefit by starting with small projects and then moving on to more complex ones.

Indian Institute of Technology, Madras

IIT Madras (IITM) has created what is arguably the most successful innovation ecosystem in Indian academia. The key elements of this system are (1) the IITM Incubation Activities, (2) the IITM Research Park, and (3) The Centre for Industrial Consultancy and Sponsored Research.

• *IITM Incubation Activities*

The IITM Incubation Cell provides a nurturing environment to nascent start-ups by providing support that helps them focus on working on their venture rather than get hassled by compliance and other requirements. The ecosystem nurtures interactions with like-minded people and more importantly supports risk taking. IIT Madras launches more than twenty start-up companies in a year.

The Centre For Innovation (CFI), the pre-incubator NIRMAAN, the Entrepreneurship-Cell (E-Cell) and Gopalakrishnan-Deshpande Centre (GDC) are important components of the innovation ecosystem of IIT Madras. CFI, India's largest student-run innovation lab, is the entry point to the ecosystem for students. At CFI, students generate interesting ideas, form teams, implement and test them. These are further nurtured, considering the technical and commercial aspects, at NIRMAAN before being supported and guided at E-Cell and GDC in their journey to become a product.

Pravartak, a recent addition to the innovation ecosystem, provides a holistic ecosystem for I&E in technology areas of national importance – comprising components for conducting translational research, product development, international collaboration, and then supporting entrepreneurship.

• *IIT Madras Research Park (IITMRP):*

IITMRP is India's first university-based research park modelled on the lines of the famous Stanford Research Park. Spread across 11.42 acres, IITMRP provides over 1.2 million square feet of workspace. The IITMRP campus houses over 3,000 professionals including those from R&D units of Indian corporates, MNC R&D subsidiaries, public sector, government research labs, start-ups and IIT Madras faculty.

The success stories of industry-academia engagement from IITMRP showcases both the breadth and depth of the engagement.

- Titan Industries Innovation Hub's partnership with IITMRP on material characterisation and coating, etc., has resulted in 5 patents.
- Saint Gobain Research India has undertaken 22 R&D projects with IITMRP. 20 of these have translated as profitable products and solutions in the market.
- Pfizer has set up its first R&D Asia R&D centre in IITMRP.
- Trivitron Healthcare's collaborative engagement with IITMRP has resulted in shaping three innovative solutions – Diabetic Retinopathy Software Analysis Kit, Android-based Wireless ECG and a Slow Infusion Syringe Pump.
- Centre for Automotive, Energy Materials of International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) and DST lab has set up and commissioned India's first pilot plant for Lithium-ion battery line for EVs/HEVs.

IIT Madras has a unique credit point system which measures and monitors the engagement of companies in the research park with the Institute:

IIT Madras Credit Point System for Sustained Measurable Collaboration with IIT Madras

Credit point system ensures that the necessary levels of engagement continue on a sustained basis enabling clients to realise value out of the IITMRP ecosystem. Credit points are earned through the following engagement models:

Motivating and retaining employees by sponsoring them as students at IITM	Interaction with IITM R&D Centres and Incubatees
R&D and Consultancy Projects	Engaging IITM faculty in projects
Work and internship opportunities for IITM students	Teaching / guiding / sponsoring IITM for IITM students
Receiving mentorship and guidance from IITM faculty	Supporting technical events

• *Centre for Industrial Consultancy and Sponsored Research (IC&SR), IIT Madras:*

IC&SR, established in the early 1970s is in the forefront of industry-academia relations in IIT Madras. Companies reach out to IC&SR to solve their problems. IC&SR engages with these companies in one of the following models:

- Institutional Consultancy: These are specific assignments that leverage the professional knowledge and expertise of the faculty and facilities of IIT Madras.
- Retainer Consultancy: IIT Madras faculty are engaged as consultants to the company for a mutually agreed duration.
- Research Based Industrial Projects: Applied research fall under this category. A company sponsors a project of interest to them. The company and IITM agree to share the know-how generated. The project duration typically ranges from six months to three years.

Some of the companies that have engaged with IC&SR include Exxon Mobil Research and Engineering Company, Qualcomm Technologies, Saint Gobain – India, Thales Research and Technology, KLA-Tencor Corporation, Texas Instruments - India, Mazagon Dock Shipbuilders, Engineers India, RITES, etc.

Some of the projects completed by IC&SR include:

- Glass surface treatment to render them dust-repelling for Saint Gobain - India.
- Post-mortem analysis of batteries for Mahindra Electric Mobility
- Combustion modelling of coal tar oil burner in induration furnace for Tata Steel
- Development of Structural Integrity Management System for existing offshore platforms in western offshore, India for ONGC.

IC&SR works in close collaboration with the different departments and centres of excellence in IIT Madras to bring their combined expertise to industry engagements.

• *Outcomes*

IIT Madras was ranked No. 1 in the Overall and Engineering categories of the 2022 NIRF ranking. They had a high score of 12.5 on 15 in the Footprint of Projects, Professional Practice and Executive Development Programs under the Research and Professional Practice bucket in the NIRF rankings.

IIT Madras was adjudged 'The Most Innovative Institute of the Year' in CII's Industrial Innovation Awards, 2020. IIT Madras was previously adjudged as the 'Top innovative Institution' in the country in Atal Ranking of Institutions on Innovation Achievements (ARIIA) by the Innovation Cell of Ministry of Education in 2019 and 2020.

Industry-academia engagement has been on an upswing in IIT Madras.

- Faculty members involved in sponsored research in 2020-21: 75%
- Faculty members in engineering departments involved in consultancy in 2020-21: 60%
- Value of sponsored research projects in 2020-21: About INR 484 crores per year (up by 2.6 times in 9 years)
- Professors of practice in 2020-21: 22 (up from 9 in 2016-17)

5. RECOMMENDATIONS: HOW TO BUILD A NATIONAL QUAD FOR INDIA

Moving to the next level of academia-industry collaboration in India is an important priority for India. Based on the challenges identified, and the bright spots and best practices listed above, after extensive consultation with industry experts, policy-makers and academic leaders, we propose the following recommendations that will help us build a national quad:

5.1 FOR ACADEMIA

Industry-academia collaboration is enhanced when there is better mutual understanding of the needs, strengths and weaknesses of both sides. To enhance this understanding, academic institutions should:

- Provide easy-to-avail options for faculty to take sabbaticals in industry
- Use "Professor of Practice" and adjunct faculty positions to bring industry experts into their institutions.

Academic organizations need to nurture people (scientists, managers) who can speak the same language as industry, build a rapport, facilitate project definition and closure, show some urgency for speed and clarity in decision making etc. To complement the above, there is a need for high-quality, branded training programs designed and offered by credible organizations like the top management institutions to train scientists/ tech managers. Role models for such programmes could include the Chevening-Rolls Royce Innovation and Science Policy Fellowship (CRISP Fellowship) at the University of Oxford and CSIR's TechnoEntrepreneurship Program for PhD students which was offered by IIM Bangalore.

Further, in order to facilitate transfer of technology and knowhow from projects undertaken in academic institutions to industry, institutions need to strengthen their technology management and industrial outreach capabilities:

- Academic institutions should have dedicated departments for translational research / technology transfer and technology-driven entrepreneurship with the following major capabilities :
    - o Carry out thorough assessment of ongoing R & D programmes , identify gaps in research projects on case-to-case basis and forging required partnerships with stakeholders of innovation ecosystem in view of the identified gaps
    - o Competence to create flexible business models at different levels of technology readiness and to strengthen the chain from ideation to technology transfer
    - o The process of preparing technology upscaling roadmaps
    - o IP valuation
    - o Skill of identifying the best possible uses / monetization possibilities of available IP
- Academic institutions should create dedicated set-ups, if not already having one, to create a facilitative environment towards outreach or build relationships with industry along various avenues - sponsored research, turnkey assignments, technology licensing, start-up incubators etc. (E.g. FITT at IIT Delhi)

Academic organizations will do better with very simple and predictable legal, IP and financial terms and agreements with industry and start-ups. Negotiations and subjectivity should be minimised to speed up things. This will help reduce dependence on slow institutional processes. Standardised agreements could greatly hasten this process. (E.g. Express agreements put out by many US Universities: These are standardized agreements with minimum discussions). Standard format agreements for academia-industry interaction are proposed in Annexure 2.

Academic institutions can facilitate collaboration and joint working with industry by creating high quality infrastructure like the IIT Madras Research Park which can be used to host R&D facilities and laboratories of industry partners.

To avoid the research park becoming just a real estate option for companies, a mechanism to both monitor and incentivize collaboration like the IIT Madras Research Park Credit points scheme would be useful.

Internally, academic institutions should periodically review and align their curricula and research activities with industry needs in partnership with R&D / industry experts.

The performance metrics of an academic should factor in, amongst others, industry outreach with clearly defined outcomes / impact. An appropriate incentive structure will augment participation. Encouragement is necessary for those outstanding in industrial or collaborative research. Sometimes there is an assumption that since the researcher is earning from industry collaboration, there is no need to recognize them in alternate ways. But the researcher needs recognition in the academic system as well. One possible recognition is alumni-sponsored chairs for those with high levels of industrial collaboration as done at IIT Madras.

At a minimum, credit must be given to faculty for their engagement in applied research, industrial R&D and collaborative projects. Specific recognition for patents obtained with greater weightage to patents licensed to industry would be helpful.

Industry problems don't come wrapped in neat disciplinary packages. So another priority for academia if it wants to work well with industry is to undertake more inter-disciplinary research. Setting up thematic centres of excellence should help academic institutions build these inter-disciplinary skills. They also need to develop performance indicators that encourage and motivate inter-disciplinary research work.
Generally, in academia, faculty select their own research problems. Often, the problems they choose are an extension of the earlier research work they have done, sometimes going back to their PhD work. Not surprisingly, these problems are driven more by developments in the academic field and publication opportunities. Institutions may consider helping faculty and research scholars identify problems that have both potential for research rigour resulting in publishable findings and industrial application. There are global role models like Prof. Bob Langer at MIT. We have seen similar capabilities in Indian scientists like Paul Ratnasamy and S. Sivaram at NCL and A.V. Rama Rao at NCL and IICT.

Academic institutions should encourage and allow flexibility in project execution. Many institutions are now building innovation ecosystems that include encouraging Professors to create start-ups. The Institutions should allow or even actively encourage porous boundaries between research laboratories and professor-driven start-ups. Some things can be done well in the academic institution setting, others may work better in a start-up setup. Of course, such arrangements should be with the consent of the industry sponsor and there should be appropriate mechanisms in place to avoid conflict of interest.

Industry associateship or membership schemes are also a good platform to enhance industry-academia collaboration. For example, at IIM Bangalore's Supply Chain Management Centre, industry members are actively involved in setting the centre agenda and commit to giving application projects to students every year.

5.2 FOR INDUSTRY – INDIVIDUAL CORPORATE ORGANISATIONS

Companies need to make serious engagement with academia as part of their strategic plan to augment capacity and capability building. That helps to enhance their competitive position. Short-term consulting assignments should give way to relationships from a mid to long term perspective. For instance, building a pipeline of IP / technologies is greatly enhanced if a company leverages the expertise of academic institutions. Some of the outstanding innovations in global companies have strong University linkages. A good Indian example of a home-grown network is TCS's Co-Innovation Network (COIN Model).

Companies need to build partnerships with academic and R&D institutions as relationships and not as one-time transactions. This involves nurturing deep expertise and experts over time. In the research institution context, Reliance's collaboration with NCL on polyolefins is a good example of such a long-term relationship.

A company should ideally have serious and senior level engagement with University leadership.

Large companies / industrial groups can create multi-year, multi-million-dollar funding opportunities for academic research. E.g. the Tata Group was able to build such programmes with IIT Kharagpur, and IIT Madras apart from Harvard Engineering and MIT.

Companies could involve researchers/scientists from academics/ research institutes on their scientific and advisory boards.

Companies can create a cadre of "boundary spanners" who can bridge industry and academia, and whose role is to build strong relationships with academic institutions. These boundary spanners should be individuals in executive and operating roles in addition to the academic interface coordinators or university relations managers that some companies already have.

Companies could also invest in capacity building by training their key executives in the nuances of technology scouting, ways of forging effective / efficient research collaborations, technology roadmapping, technology absorption, technology commercialization and IP management.

Companies should actively consider setting up a technology office within a technology park in universities as co-location is a first step to frequent dialogue and collaboration (E.g. Saint Gobain in IIT Madras Tech Park). In a significant push toward bringing critical research and development capabilities under one roof, industries should plan to create/develop in-house R&D centres in academic / research institutes. Through this, students, scientists & leading industry plus start-ups will foster collaboration between industry & academia. For example, last year Pfizer invested ₹150 crore in a 61,000 sq ft research and technology centre at the IIT Madras Research Park. It is the first and only one at present being set up by Pfizer in Asia.

Adopting an Open Innovation philosophy and following this up with an Open Innovation department with appropriately skilled human resources (especially in Indian companies), should help the companies. While companies often know their business needs, they fail to link to the research capabilities of academic institutions and publicly-funded labs with their business needs. This gap is more common in MSMEs / start-ups.

Adoption of the open innovation philosophy needs to be accompanied by mechanisms to encourage/ incentivize company team members to champion induction of new technology / research capabilities licensed/ acquired from academic and R&D institutions. This may help in reducing resistance to the “Not Invented Here” tendencies. For example, companies like Reckitt & Benckiser and P&G have clear internal messaging on the importance of ideas and technology from outside their company. P&G has a target of sourcing 50% of its ideas from outside the company.

Industry has an opportunity to use its CSR funds to facilitate creation of research infrastructure and collaboration. For example, on 6th February 2023, Science Gallery Bengaluru (SGB) received a corporate social responsibility grant of Rs 5 crore from TTK Prestige Limited, which will go into the development of SGB's Public Lab Complex that aims to foster public engagement and learning through research and experimentation.

Industry Research Clusters: Sometimes the best investment isn't in any single project, but in the cultivation of a research community that addresses the challenges of an industry in an innovative way. The Industry Research Cluster program helps those companies that want to take the lead in research-driven innovation in their respective industries and help secure teams of researchers to address big/small challenges being faced in companies. The industry research cluster approach helps in:

- Technology Transfer
- Contracting Research
- Material Testing
- Joint R&D Projects
- Industrial Solutions

Industry should adopt the cluster approach for solutions, a successful example of which is the Delhi S&T Cluster – Delhi Research Implementation and Innovation (DRIIV), which has Tata Power, Mahindra, BSES-Rajdhani Power Ltd., BSES-Yamuna Power Ltd., Google, and PhonePe as cluster members along with renowned Academic organizations, Government labs and Government agencies.

For a detailed note on geographical clusters, see Annexure 3.

Companies should encourage their own employees to take sabbaticals in academia and create structured programmes to welcome academic professionals to take sabbaticals and assignments in their organizations. Cross – sabbaticals would be even better. An industry expert may be invited to spend some time in an academic group and immerses himself in ongoing research or technology development work. An academic expert comes to the same company (chooses a product development or manufacturing function) and immerses herself in ongoing projects. The sabbatical can be implemented in a phased manner – the first phase can typically be one or two weeks. The second phase can be separated from first phase by a month or two. The second phase will be longer and can vary from one to two months. The duration of phase 1 and phase 2 are intentionally kept small so that it is easy for the experts to explore the sabbatical without going through a complex process of organizational approvals. E.g. Mahindra Research Valley (MRV) experimented with Micro (1-2 weeks) and mini (4-8 weeks) sabbaticals and found then useful. Even a structured virtual interaction between academia and industry can work (E.g. Thermax Sampark programme).

Companies would also benefit by creating interesting innovation opportunities for graduating PhD students and postdocs in industry so that they can facilitate knowledge exchange and not leave the country.

Companies could sponsor PhD and Masters projects in academic institutions to give an impetus to applied research projects. At the same time, they should appreciate that PhD theses would be placed in the public domain, though there could be some embargo to allow for filing patents before publication.

Collaborations work in an environment of trust and mutual respect; and at least one party has to initiate the process of building trust and respect.

5.3 FOR ECOSYSTEM PLAYERS

Industry bodies should create awards and recognitions for academics working effectively with industry that are comparable to the Bhatnagar Awards or Infosys Awards.

Currently almost all recognitions are heavily tilted towards academic/research achievements. For example, the Dutch Polymer Institute is a industry funded research consortium that recognizes researchers. https://www.polymers.eu/news/archief/dpi-invention-award-granted-to-dr-rob-duchateau)

There is a need to strengthen collaborative and consultative forums and professional societies. It would help if there is a good mix of both academia and industry in bodies like the Indian Institute of Metals, Institute of Chemical Engineers, IEEE, Computer Society of India, ACM, etc.

There is a good opportunity to make use of existing vehicles and to create new ones. E.g. CII organizes industrial best practice visits, primarily targeted at its industry members. It will be good to encourage academia visit industry in a similar context.

Roadmapping and matching funding models need to be collaboratively developed across the ecosystem with involvement of academia, industry, research institutions, standards bodies, professional associations and the government. Technology roadmapping is a very important strategic exercise that assesses the current status and the desired future status of a technology and creates a trajectory to go from here to there. The semiconductor industry used technology roadmaps to successfully achieve the doubling of computing power every 18 months over many decades (the Moore's law) – as a result, our smartphone today has more computing power than a supercomputing center of the 70s and 80s. Shell is famous for analysing and visualising future scenarios and using it to drive business growth. Nations like Singapore use long-term technology roadmaps to direct R&D funding from the Government into strategic sectors of research.

Today many technology roadmaps have been co-created with participation from various stakeholders with strong representation from academia. The challenge is around funding the mid-term topics. Near-term topics (1-3 years) are best suited for industry to take the lead and there is usually no issue with financial support. Mid-term topic (3 – 5 years) areas are perfect for academia to lead. Long-term topics (> 10 years) require a consortium approach that brings multiple players from industry, academia and Government to build on each other's strengths and share their resources. Focused collaboration has become the key for the success of such Consortia.

However, the inability to secure funding for the mid-term topics is a challenge. Collaborative approaches across the industry catalysed by industry associations and the government are required to secure funding for these higher risk, longer term initiatives. Also, a strong governance mechanism to monitor these projects is essential. These roadmaps are created with an India centric perspective in areas of national importance- energy security, climate change, electric mobility for India etc. Therefore, it is also important for the funding agency to only support deep tech research in areas that are aligned with these roadmaps.

The Indian National Academy of Engineers (INAE) led an initiative recently to build technology roadmaps in strategic growth areas. One of our CII Committee members led the technology roadmapping for automotive lightweighting wherein a cross functional team (CFT) of experts (industry, academia and Government) set ambitious target of 15% weighting reduction by 2025 and 30% reduction by 2030. CFT built tech roadmaps for material, design and manufacturing technologies and synchronized the three maps to achieve the 2025 and 2030 goals. Strategic growth areas like clean energy, clean mobility, affordable healthcare etc will greatly benefit from the intense focus brought by the tech roadmaps.

It is also possible to have different parties fund the research in the near and medium term versus the long term. The DST SERB has a funding model for industry relevant research (IRR) where industry and academia write a joint proposal for technology development – the Government funds the basic research component (long term) while the industry funds the applied research component (near and medium term).

It is important that the various research groups that receive funding are pursuing goals along the tech roadmap so that the outcome of their research can be stitched together and the end goal can be achieved through collaboration.

5.4 FOR GOVERNMENT

Government has an important role to play in multiple capacities. It is the biggest spender on R&D and S&T in India. It formulates and implements policies for industrial and economic development, and is also a regulator. It conceives and executes national missions such as Make in India and Atmanirbhar Bharat. Through the National Education Policy and its historical role as the founder and funder of India's top educational institutions, Government has a major influence on academia.

Specifically, there are many important ways in which the Government can contribute towards the development of the National Quad:

The Government, when funding an academic or research institution could insist on involving an industry partner in the project wherever relevant. Or, it could alternately prioritize proposals for funding that have an industry partner on board.

The government funding for R&D funding to industry should be conditional to involving an academic/ research institution. The European Union funding involves such conditionalities of involving partners from other domains to encourage partnerships/collaborations.

Government can offer more attractive tax rebates for collaborative research projects and programs.

Government can create an enabling policy to mandate/facilitate academic institutions to set up dedicated offices / affiliate organisations for managing industry alliances, outreach activities etc. If possible, budgetary support or seed grants towards the creation of a secretariat / cadre for technology outreach and transfer activities would provide a useful trigger.

The Government ranking frameworks (NIRF and ARIA) are today widely accepted by students and the academic community. Suitably tweaking of the inputs (or weightage) towards building working partnerships with industry in the institutional ranking framework can incentivise efforts by academic institutions.

Government should give greater autonomy to academic and research institutions to operate as independent, non-profits with their own rules of governance and engagement with industry. More specifically, the modes of engagement with industry should be flexible and heads of institutions should be empowered to act fast confidently and without fear to set terms of engagement with industry. Govt should fund research institutions with accountability assigned only at the Board level for outcomes and not set detailed guidelines for operations. Specifically, government institutions may be allowed to develop their own guidelines for finance and procurement in industry projects outside the General Financial Rules (GFR).

Industry likes to engage with specific people in academic institutions who they can trust and respect and work seamlessly with. Industry looks for relatively unique and specialized talents and does not look for skilled labour in R&D institutions while giving research projects (not to be confused with hiring of students etc by industry). This means that academic and R&D institutions need to have flexibility in hiring talent and procedural nimbleness in recruitment processes and freedom to incentivize people who work with industry.

The government should work towards the creation of transparent support mechanisms for nurturing industry consortiums on pre-competitive research done with R&D organizations. (Examples: https://www.polymers.eu/; https://cmac.ac.uk/about)

Government may consider initiatives to enhance the support system:

- To incentivise the research projects , which have high commercialization potential and can enhance competitiveness of Indian industry with substantial impact in terms of socio-economic indicators (for example : employment generation, import substitution, affordable products / services for large population)
- To carry out repeated validation / field trials of working prototypes in user segments, which can provide larger markets for commercialization.

In recent years, the largest growth in higher education has happened in the private university system. Government should facilitate the emergence of privately funded centres of excellence in Private Universities by giving generous tax incentives for philanthropy for such initiatives.

Government can play a coordinating role in identifying future needs that academia can work on. For example, during the Covid pandemic, Government catalysed the creation of a National Biomedical Resources Indigenization Consortium and a Consortium for Affordable and Rapid Diagnostics as Public-Private partnerships to meet national needs. Similar consortia can be created across sectors with the objective of identifying products and technologies that are likely to be needed in the future. Carrying this a step further the Government can launch programmes like the Collaborative Automotive Research programme to enable joint working between industry and academia on futuristic technologies with a domestic application focus.

Government support programmes to enhance the core research infrastructure in both public and private institutions will also be helpful as many institutions lack state-of-the-art technological infrastructure to do contemporary research. Such programmes have been run in the past in the form of TEQUIP and TIFAC CORE (Centre of Relevance and Excellence). The latter was based on joint investment by TIFAC and an industry partner.

6. ANNEXURE 1: CONTRIBUTORS

Members of the Sub-committee for the Report on Building a National Quad

1. Prof. Rishikesha T. Krishnan, Director, IIM Bangalore
2. Dr Gopichand Katragadda, Founder, Myelin Foundry
3. Dr Shankar Venugopal, Vice President, Mahindra & Mahindra
4. Dr Bhanu Manjunath Narayan, Whole Time Director, Syngenta
5. Mr Ravi Madipadaga, Technology Head, Siemens
6. Mr Avnish Sabharwal, Managing Director, Accenture Ventures and Open Innovation
7. Mr Subhrajit De, Co-founder and Technology leader - Energy and Carbon Management, Shell
8. Mr Tito Kishan Vemuri, Founder & CEO, ProInn Consultancy
9. Mr Mahesh Murthy, Chief Technology Officer, Thermax Limited
10. Mr Sridhar Rajam, Senior Principal Scientist, CavinKare
11. Dr Piyush Mishra, Tata Sons Ltd.
12. Prof. Sai Ramudu Meka, Associate Dean Corporate Interaction, IIT Roorkee

CII Team

1. Dr Ashish Mohan, Executive Director, CII
2. Ms Namita Bahl, Director, Technology, Innovation and R&D, CII
3. Ms Divya Arya, Deputy Director, Technology, Innovation and R&D, CII

7. ANNEXURE 2: STANDARD AGREEMENTS

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding ("MoU") is made this __________ day of __________, XXXX (Year)

BETWEEN

__________________, an established __________________, having its headquarters at ____________________ (hereinafter referred to as "____________________", which expression shall include its representatives, successors and permitted assigns), being represented by ____________________ , of the **FIRST PART.**

AND

____________________, a company incorporated under ________________, having its principal place of business at ____________________, herein referred to as "____________________" (which expression shall include its successors & permitted assigns), of the **SECOND PART.**

Hereinafter, ________________________ and ________________________ shall be individually referred to as a "**Party**" and collectively as the "**Parties**".

WHEREAS

A. __________ is a __________ (Business of the Company).

B. __________ is a __________ (Business of the Company).

C. The purpose of this MoU is to ____________________.

NOW THEREFORE THE PARTIES SET FORTH THEIR PRELIMINARY UNDERSTANDING AS FOLLOWS:

1. Scope & Objective of the MoU

1.1 Industry Lab:

____________________ shall support ____________________ to establish a Machine Learning Operations Lab. This lab may support learning and knowledge creation activities for association AI domains & applications. Supervision and guidance shall be facilitated by ____________________ along with ____________________ faculty members.

1.2 Curriculum Review and Enhancements:

____________________ shall support ____________________ with respect to framing of syllabi of certain courses and suggest necessary enhancements which would enable _____________ to enhance the technical skills of its students.

1.3 Student Interaction / Guest Lecture Programmes:

Wherever feasible and as agreed upon by the Parties, ____________________ shall provide speakers to participate and deliver technical presentations and discussions on topics that would be relevant to technologies in _______________.

1.4 Projects to UG, PG Students and PhD Scholars:

__________ shall explore the possibility of offering project internships for students from the undergraduate, postgraduate courses and PhD Scholars depending on its need for and availability of such projects in __________.

1.5 Sponsorship of Technical Events and Symposia at__________:

__________shall sponsor and participate in technical events and symposia at __________, the decisions for which will be taken on the case to case basis after review and discussion between the Parties.

1.6 Sponsoring of Research Projects:

__________ shall, wherever feasible, sponsor research project(s) in __________to be executed jointly or severally. Such research projects may be finalised under separate agreement.

1.7 Using ____________________ premises by ____________________:

__________ with prior approval of __________ authorities may use the premises of __________, its classrooms or auditorium for any of its recruitment events, or campus connect programs, scheduled on mutually agreed basis.

1.8 Faculty Training:

__________ shall support __________ to ensure that the faculty members of __________ are trained to teach the students the latest developments in the technologies used by __________ and relevant to its operations. Under this "Train the Trainer" program, __________ may conduct workshops/guest lectures/seminars at__________ to support the delivery of the relevant subjects.

1.9 Campus recruitment slot for ____________________:

__________shall provide slot for __________ to conduct its campus recruitment (placement / internship) events and select eligible students of UG and PG for employment.

2. Co-ordination

2.1 __________ and __________ will setup a "Joint Working Group" for coordination. Both Parties shall ensure that the Joint Working Group comprises of appropriate personnel to discuss and implement the measures mentioned in this MoU. Both sides will also designate a Single Point of Contact (SPOC) for coordinating various academic activities and for administration purpose.

2.2 In addition to above, __________ shall be represented by its designated members as and when necessary. Also, __________ shall be represented by its designated members as and when necessary.

2.3 The Parties hereby acknowledge and agree that they shall take all reasonable steps to co-operate and ensure successful implementation of all measures mutually agreed to in the areas mentioned in this MoU.

3. __________ confirms, it has full capacity, power and authority to enter into this MoU; and during the continuance of this MoU, will continue to have full capacity, power and to act as partner under this MoU and to carry out and perform all its duties and obligations as contemplated herein and has already taken and will continue to take all necessary actions to authorize; the execution, delivery and performance of this MoU.

4. In addition, both the parties agree to undertake activities for the joint objectives as and when necessitated and agreed upon by both the parties.

5. Terms and Termination

5.1 This MoU shall remain in effect for a period of __________ **(____) Years**, unless terminated earlier by the Parties. Any amendment to this MoU, pursuant to mutually agreed revisions of the terms, by the Parties, shall be in writing and signed by both the Parties.

5.2 Either Party shall have the right to terminate this MoU by giving sixty (60) days prior written notice to the other Party.

5.3 __________ and __________ agree that the disclosure of research findings and outcome to a third party, including publications, will be subject to mutual discussion and agreement.

5.4 The agreement may be revised at any point of time by mutual discussions.

6. Confidentiality

6.1 Neither Party shall, without the prior written consent of the other Party disclose to any third party the contents of this MoU or any information obtained by either Party in performance of or in connection with this MoU. The Parties agree to take all reasonable measures to maintain the confidentiality of all such Confidential Information which in no event will be less than the measures it uses to maintain the confidentiality of its own information of similar importance.

6.2 The obligations of confidentiality shall come into effect upon the signing of this MoU and shall survive for One (1) year even after the termination of this MoU.

6.3 __________ and __________ agree to respect each other's rights to intellectual property. The intellectual property rights (IPR) that arise out of the collaborative activity under this MoU will be jointly owned by __________ and __________. Any prior owned IP by either party shall continue to be owned by that party and will not transfer/fall under any joint IP ownership. Transfer of IP/Royalty, etc if any arising out of any joint project may be finalised by both parties on case to case basis.

7. Liability

Neither party shall be liable for any direct, indirect or consequential loss, damage, cost or expense of any kind whatever and however caused whether arising under statute, contract and tort or otherwise this MoU.

8. Arbitration

In the event of any dispute or differences arising at any time between the Parties hereto as to the construction, meaning or effect of this Agreement or any clause or thing contained herein or the rights, duties, liabilities and obligations of the Parties hereto or breach thereof, the parties shall in good faith endeavor to resolve the dispute by mutual discussion. In the event, the parties are unable to do so, the matter will be settled by arbitration subject to the provision of the Arbitration and Conciliation Act, 1996 and as amended from time to time. The Parties agree shall mutually endeavor to appoint a single arbitrator, within a period of thirty (30) days upon being called upon to do so. In the event, the Parties fail to appoint a single arbitrator, by mutual agreement, each Party will appoint one arbitrator and the two arbitrators so appointed will appoint a third arbitrator to whom the dispute will be referred for resolution. The arbitration proceedings shall be in English and held in Bangalore and in accordance with the Arbitration and Conciliation Act 1996 and as amended from time to time.

9. Governing Law and Jurisdiction

This MoU shall be governed by the laws of Republic of India. Any dispute arising in connection shall be submitted only to the Courts in India.

10. Non-Solicitation

________ shall not directly or indirectly solicit, or cause to be solicited the employment of any employee of ________, who is involved in the performance of its obligations under this MoU.

11. Binding

11.1 This MoU shall be binding on the Parties.

11.2 The Parties hereby acknowledges that this MoU is confined to the general terms agreed between the Parties for mutual co-operation.

12. Entire Understanding

This MoU contains the entire understanding of the Parties with respect to the subject matter addressed herein and supersede, replace and merge all prior understandings, promises, representations and agreements, whether written or oral, relating thereto.

For and on behalf of ___________	For and on behalf of ___________
Name:	**Name:**
Designation:	Designation:

In the presence of witnesses:

Name:	Name:
Designation:	Designation:

MUTUAL NON-DISCLOSURE AGREEMENT

THIS MUTUAL NON DISCLOSURE AGREEMENT (this "Agreement") is made on __________, XXXX (Year) ("Effective Date")

BETWEEN

_________________, an established __________,, having its headquarters at _________________ (hereinafter referred to as "________", which expression shall include its representatives, successors and permitted assigns), being represented by _________________, of the FIRST PART.

AND

_________________, a company incorporated under________, having its principal place of business at _____________________________, herein referred to as "________" (which expression shall include its successors & permitted assigns), of the SECOND PART.

Hereinafter, ________ and ________ shall be individually referred to as a "Party" and collectively as the "Parties".

1. *Purpose.* The parties wish to explore a business opportunity of mutual interest (the "Opportunity"), and in connection with the Opportunity, each party may disclose to the other confidential technical and business information that the disclosing party desires the receiving party to treat as confidential.

2. *"Confidential Information"* means (a) any information disclosed by either party to the other party, either directly or indirectly, in writing, orally or by inspection of tangible objects, including, without limitation, algorithms, business plans, customer data, customer lists, customer names, designs documents, drawings, engineering information, financial analysis, forecasts, formulas, hardware configuration information, know-how, ideas, inventions, market information, marketing plans, processes, products, product plans, research, specifications, software, source code, trade secrets or any other information which is designated as "confidential," "proprietary" or some similar designation (collectively, the "Disclosed Materials") and (b) any information otherwise obtained, directly or indirectly, by a receiving party through inspection, review or analysis of the Disclosed Materials. Information disclosed orally shall be considered Confidential Information only if such information is confirmed in writing as being Confidential Information within a reasonable time after the initial disclosure. Confidential Information may also include information of a third party that is in the possession of one of the parties and is disclosed to the other party under this Agreement. Confidential Information shall not, however, include any information that (i) was publicly known and made generally available in the public domain prior to the time of disclosure by the disclosing party; (ii) becomes publicly known and made generally available after disclosure by the disclosing party to the receiving party through no action or inaction of the receiving party; (iii) is already in the possession of the receiving party at the time of disclosure by the disclosing party as shown by the receiving party's files and records immediately prior to the time of disclosure; (iv) is obtained by the receiving party from a third party lawfully in possession of such information and without a breach of such third party's obligations of confidentiality; or (v) is independently developed by the receiving party without use of or reference to the disclosing party's Confidential Information, as shown by documents and other competent evidence in the receiving party's possession.

3. *Non-use and Non-disclosure.* Each party agrees not to use any Confidential Information of the other party for any purpose except to evaluate and engage in discussions concerning the Opportunity. Each party agrees not to disclose any Confidential Information of the other party, except that, subject to Section 4 below, a receiving party may disclose the other party's Confidential Information to those employees or authorized consultants of the receiving party who are required to have the information in order to evaluate or engage in discussions concerning the Opportunity. If a receiving party is required by law to make any disclosure that is prohibited or otherwise constrained by this Agreement, the receiving party will provide the disclosing party with prompt written notice of such requirement so that the disclosing party may seek a protective order or other appropriate relief. Subject to the foregoing sentence, such receiving party may furnish that portion (and only that portion) of the Confidential Information that the receiving party is legally compelled or is otherwise legally required to disclose; provided, however, that the receiving party provides such assistance as the disclosing party may reasonably request in obtaining such order or other relief. Neither party shall reverse engineer, disassemble or decompile any prototypes, software or other tangible objects that embody the other party's Confidential Information and that are provided to the party under this Agreement.

4. *Maintenance of Confidentiality.* Each party agrees that it shall take reasonable measures to protect the secrecy of and avoid disclosure and unauthorized use of the Confidential Information of the other party. Without limiting the foregoing, each party shall take at least those measures that it takes to protect its own confidential information of a similar nature, but in no case less than reasonable care (including, without limitation, all precautions the receiving party employs with respect to its confidential materials). Each party shall ensure that its employees or authorized consultants who have access to the other party's Confidential Information have signed a non-use and non-disclosure agreement in content similar to the provisions of this Agreement or are otherwise legally obligated not to disclose such Confidential Information, prior to any disclosure of Confidential Information to such employees or authorized consultants. No party shall make any copies of the other party's Confidential Information except upon the other party's prior written approval. Each party shall reproduce the other party's proprietary rights notices on any such authorized copies, in the same manner in which such notices were set forth in or on the original. A party receiving Confidential Information shall promptly notify the party disclosing such Confidential Information of any use or disclosure of such Confidential Information in violation of this Agreement of which the receiving party becomes aware.

5. *No Obligation.* Nothing in this Agreement shall obligate either party to proceed with any transaction between them, and each party reserves the right, in its sole discretion, to terminate the discussions contemplated by this Agreement concerning the Opportunity.

6. *No Warranty.* ALL CONFIDENTIAL INFORMATION IS PROVIDED "AS IS." EACH PARTY MAKES NO WARRANTIES, EXPRESS, IMPLIED OR OTHERWISE, REGARDING THE ACCURACY AND COMPLETENESS OF THE CONFIDENTIAL INFORMATION.

7. *Return of Materials.* All documents and other tangible objects containing or representing Confidential Information that have been disclosed by either party to the other party, and all copies or extracts thereof that are in the possession of the other party, shall be and remain the property of the disclosing party and shall be promptly returned to the disclosing party upon the disclosing party's written request. Notwithstanding the foregoing, a receiving party may retain in the offices of its legal advisor a single archival copy of any written or photographic Confidential Information provided by the other party under this Agreement, which copy shall only be used by the receiving party and its legal advisors in connection with the review of its obligations under this Agreement.

8. *No License.* Nothing in this Agreement is intended to grant any rights to either party under any patent, mask work right, copyright, trade secret or other intellectual property right of the other party, nor shall this Agreement grant any party any rights in or to the other party's Confidential Information.

9. *Term.* The obligations of each receiving party under this Agreement shall survive until such time as all Confidential Information of the other party disclosed hereunder becomes publicly known and made

generally available through no action or inaction of the receiving party but in no event more than 5 years after the last disclosure of Confidential Information under this Agreement.

10. Severability. If any provision of this Agreement is found to be illegal or unenforceable, the other provisions shall remain effective and enforceable to the greatest extent permitted by law.

11. Counterparts and Facsimiles. The parties may execute this Agreement in counterparts, each of which is deemed an original, but all of which together constitute one and the same agreement. This Agreement may be delivered by facsimile transmission, and facsimile copies of executed signature pages shall be binding as originals.

12. Miscellaneous. This Agreement shall benefit and bind the parties and their respective successors, heirs, legal representatives and permitted assigns. This Agreement shall be governed by the laws of India. This Agreement constitutes the entire agreement between the parties with respect to the Opportunity and supersedes all prior written and oral agreements between the parties regarding the subject matter of this Agreement, and neither party shall have any obligation, express or implied by law, with respect to trade secret or proprietary information of the other party except as set forth in this Agreement. No provision of this Agreement may be waived except by a writing executed by the party against whom the waiver is to be effective. A party's failure to enforce any provision of this Agreement shall neither be construed as a waiver of the provision nor prevent the party from enforcing any other provision of this Agreement. No part of this Agreement may be amended or otherwise modified except by a writing signed by the parties' provision to this Agreement.

Sign	Sign
Name	Name
Title	Title

8. ANNEXURE 3: HOW TO BUILD & STRENGTHEN INNOVATION CLUSTERS

Opportunity Statement: This chapter focuses on creation of a network of Innovation Clusters across India by integrating capabilities and leveraging inter-dependencies to enhance delivery impact and catalyze national growth through accelerated innovation, accounting for local demography, ecology, resources (human capital and infrastructure), technology and supply-chain.

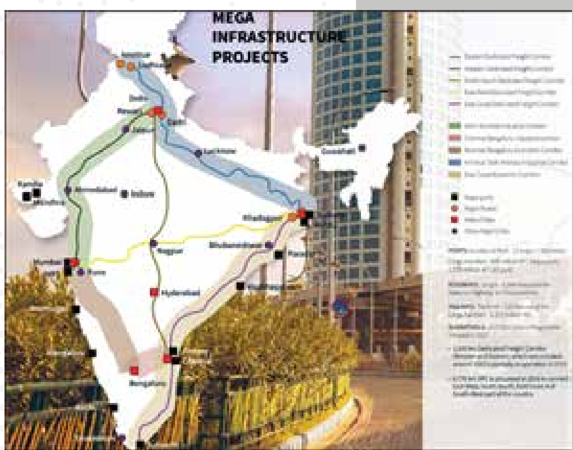
Clusters are areas of intensive, targeted business activities made up of enterprises, academic institutions, research laboratories, vendors, supply-chains, start-ups, government agencies, not-for-profit organizations and other institutions that provide specialized support etc., to boost innovation and growth in a particular industry and/ or theme of development. Silicon Valley in the US west coast is an example of a well-known cluster, and there are many more around the world today, viz. Israel, Bangalore, Taiwan etc. A cluster may be broadly described as a zonal, regional and/ or ecological concentration of related industries, academia, national and specialized laboratories, natural and human resources in a particular location. In several developed economies, clusters are a definitive feature of economies, making regions uniquely competitive for jobs, investments and generation of niche products and services. Clusters also function as an effective instrument for public policy and industry-academia collaboration by building the capacity to define, develop and harness ecological and demographic resources on several types and scales of programs directed at economic development. While many of the benefits of clusters arise spontaneously, active collaboration and intervention within a targeted cluster enhances the probabilities of success and additive returns. Cluster initiatives strengthen the linkages between various members and entities within a cluster and serve as a platform, viz. consortium, joint taskforce etc., for collective action. When the economic activities in a set of related industries, in a specific location, reach critical mass is when the local linkages within a cluster begin to have a meaningful impact on the performance of companies and that important opportunities for local collaboration among firms and other organizations in the relevant fields arise. While clusters can emerge naturally, there are sufficient examples of targeted interventions leading to drawing out specific innovation clusters, with broad mandates, ambitions and targets. Increasing competitiveness through cluster initiatives has become a basic element for a vast majority of countries' development strategies. Analysis of more than 500 cluster initiatives implemented over the last 10 years in 20 countries shows that the high competitiveness of these countries is based on the strong positions of individual clusters ("The Benefits of Clusters, Factors and Problems," 2014). It is noteworthy to mention that the US Silicon Valley was the foundation of innovation clusters – there are about 87 thousand companies, 40 research centers and a dozen universities. Over time, this zone has attracted about 33% of US venture capital companies (180 companies), 47 investments and 700 commercial banks, which finance the activities of companies.

Clusters help by:

- Connecting hundreds of partners and collaborators to solve industry-level challenges that affect them all, such as developing strong supply chains or managing data
- Attracting talent, research, capital and new companies by helping to establish India as a world-leader
- Innovating in the global marketplace with new products, processes & technology, R&D
- Growing more productive industries, healthier ecosystems, more jobs and success for firms across industries

- Empowering small & medium sized companies and Start-ups to grow faster, tap into expertise (Best Practices), find new markets and access Intellectual Property

Zonal clustering: Like most nations around the world, the Indian sub-continent can also be naturally divided into four zones corresponding to the 4 directions viz. North, East, West and South. however, for better geographical reach, coverage, other strategic partnerships & synergies, India has been categorized into 6 primary zones, as observed by most major industries, government bodies & academic institutions. in addition to the obvious mark-ups of North, South, East and West, the additional zones include Central & North-East. Each of these zones have their own characteristics and offer their unique set of resources towards developing and sustaining a local ecosystem and contributing to the broader national development. The adjoining figure presents the spread of the mentioned zones and has been adapted from <mention reference>. Zonal innovation networks and growth economies can become effective building blocks of sustained development, providing an opportunity towards contained, efficient and incisive interventions and cross pollination. The ability to produce innovative and competitive products and services shall depend on the creation and strengthening of these zonal clusters of industries that become hubs of innovation, most often topical and thematic. These zonal clusters, by themselves or in synergistic cooperation, enhance productivity and catalyze innovation by bringing together technology, resources, industries, academic institutions and other organizations, viz. start-ups, incubators, national and specialized laboratories, local regulations etc., proximity and the accompanying tight linkages help to develop more refined research agendas, directly access pools of specialized and targeted resources and faster deployment of new and contained insights. The following paragraphs dive into 4 zones – North, South, East and West – in greater details, as an illustration, to highlight their history, unique resources and offerings, zonal ecology and infrastructure, along with the spread and presence of industries & academic institutions within each of them. The adjoining figure, adapted from <mention reference> additionally illustrates the interconnectivity of the North, South, East and West zones through mega infrastructure projects around freight corridors, ports, nodal and metro cities and the 6 mega economic corridors. The below paragraphs illustrate primary characteristics of the North, West and South zones for creation of potential innovation clusters that are thematic and



topical nature. These are illustrative in nature, not exhaustive and similar thinking and characterization can be extended to the East, Central and North-East zones as well.

1. North Zone: The North Zone comprises of Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Chandigarh, Delhi, and Rajasthan. While Jammu and Kashmir, Ladakh, Himachal Pradesh and Uttarakhand are primarily mountainous regions with presence of the Himalayan ranges with its splendor of biodiversity, Punjab and Haryana boast of access to the foothills and vast stretches of fertile plains developed over centuries from the silt of the Himalayan rivers, making them suitable for perennial cultivation. Rajasthan, in sharp contrast, is primarily a desert land with its arid climate and unique vegetations. The North Zone also harbors several key academic and research institutions that will play a major role in the innovation and development – examples include Indian Institute of Technology Delhi, CSIR – Indian Institute of Petroleum, Indian Institute of Technology Mandi, Indian Institute of Technology Rajasthan, CSIR – Central Building Research Institute, CSIR – Central Scientific Instruments Organization, CSIR-CEERI's Incubation-cum Innovation Hub, Jaipur Centre etc.

A closer look into this zone would reveal the following primary themes, restricted to 3 for ease of reference and summary:

Cement & Minerals Industries: India is the 2nd largest cement producer in the world, expecting to witness further growth in production in the future decades due to the ongoing development and growth. This is also evident from the significant increase in investments by the domestic & foreign investors. Cement is a low margin and a highly localized product. Most cement plants are in and around the limestone and dolomite mines and with access to coal. Some of the best deposits are available in Rajasthan at Jodhpur, Mahendragarh, Pali, Chittorgarh etc. Following Madhya Pradesh (23 plants) and Gujarat (19 plants), Rajasthan is ranked 3rd amongst the Indian states having 15 cement manufacturing plants. It is to be noted that while the zonal segregation doesn’t include Madhya Pradesh and Gujarat in the North Zone, they are adjacent states to Rajasthan and demographically, this can further develop into an innovation cluster for cement manufacturing as well as adjacent non-metallic mineral-based industries, with rich deposits of mica, asbestos, kaolin, gypsum etc. For an example, innovation in the cement industry shall require focus on significant reduction in the carbon intensity of its production, achieved through carbon capture utilization and sequestration or switching to greener power (the zone has access to significant amount of solar and hydro power) or moving away from the conventional thermo-chemical process to other processes.

Automotive Cluster: Traditionally, Gurgaon & Manesar in Haryana have been the supply hub for automotive manufacturing units and OEMs (Original Equipment Manufacturer) such as Maruti Suzuki India (erstwhile MUL), Hero MotoCorp, Honda Motor, etc. The aluminum supply & die-cast industries are also spread around its periphery to meet the growing demands from these auto manufacturers. While the adjacent states of Gujarat and Madhya Pradesh provide easy access to significant deposits of bauxite, the states in North zone as classified here, esp. Rajasthan, boasts of rich deposits in lead, copper and mica. With access to such resources and to green power through solar and hydroelectricity, this zone is poised to pivot with agility to meet India’s aspiration to convert 30% of all car sales to EV by 2030. Access to the national highways quadrilateral also provides an attractive catalyst to the growth of EV industry by establishing solar parks and charging infrastructure along and adjacent to the highways.

Biodiversity and Tourism: This zone harbors a rich and varied (possibly the most) biodiversity of India. The northern plains are known as the 'Food Bowl of India' because plenty of food crops are grown here due to the alluvial soil and abundant, perennial availability of water. Wheat, rice, sugarcane, millets, jute & maize are the main crops grown here and they, in turn, contribute to soil remediation and beneficiation. Punjab, Haryana & Rajasthan form the wheat producing belt for India. Jammu and Kashmir, Himachal Pradesh & Uttarakhand nestle diverse flora & fauna. Kashmir & Himachal Pradesh contribute significantly to make India the 2nd highest saffron producer in the world. Srinagar has the largest Tulip Garden in Asia. The pine needles in the Himalayan region of Uttarakhand are being explored as an alternate source to generate electricity in the region.

Tourism sector is the largest service industry in India contributing to approximately 5% of the national Gross Domestic Product (GDP). Kashmir has been traditionally referred to as the 'Paradise on Earth'. Rajasthan has a rich heritage of royal palaces & forts. Uttarakhand draws millions of tourists every year to its temples & places of religious significance like Haridwar & Hrishikesh.

2. West Zone: West Zone comprises of Gujarat, Maharashtra, Goa, Dadra & Nagar Haveli and Daman & Diu. It is the Coastal belt with a tepid climate and has a major portion also covered by ghats. The Western Ghats, also known as the Sahyadri Hills, runs through the states of Gujarat, Maharashtra and Goa. Western Ghats is a UNESCO World Heritage Site & is one of the 8 'hottest hot-spots' of biological diversity in the world. The Gir National Park in Junagadh, Gujarat is the only National Park in India that nurtures the Asiatic lions & is spread across 258 sq kms. Mumbai, the capital of Maharashtra, recognized as the 'City that Never Sleeps', is also the largest city in India in terms of population. Mumbai is also known as the Financial and Commercial capital of India with the presence of The Bombay Stock Exchange, the National Stock Exchange and all major banks and financial institutions. For a deeper understanding, West Zone can be further classified to offer 2 major types of activities viz. Heavy Industries (H) and Service Industries (S).

Petrochem Industry (H) – From the time Reliance has forayed into the Petrochemical sector and post acquisition of IPCL, Jamnagar in Gujarat is the largest Petrochemical industrial center of India, followed by Mumbai High. Reliance Industries Limited (RIL) is the largest producer of petrochemicals in the country & amongst the top 10 in the world. With a refining capacity of over 33 million tons & paraxylene production of 1.5 million tons per year, Reliance Jamnagar is the world's largest grassroots refinery & aromatics complex. This creates a natural platform for large employment opportunity and synergies for R&D and technology engagements. Some of the relevant, major academic institutions are Indian Institute of Technology Bombay, Institute of Chemical Technology & Maharaja Sayaji Rao University of Baroda.

Textile Industry (H) – Traditionally Mumbai, Ahmedabad, Surat and Vapi have been identified as the textile hub of India. Mumbai and Gujarat are recognized as the textile capital of India. Ahmedabad in Gujarat state has emerged as a prominent cotton textile industrial center and is referred to as the 'Manchester of India'. The West zone has a presence of major textile & garment companies like Arvind Ltd, which is also the largest textile company in India. Other key players are Bombay Dyeing, Raymond Ltd, Welspun, etc., which fulfill their need for skilled manpower requirements through academia like National Institute of Fashion Technology Mumbai and Gandhinagar, National Institute of Design Ahmedabad, Sasmira College Mumbai and Veermata Jijabai Technological Institute Mumbai.

Automotive Industry (H) – Mumbai, Nashik & Chakan (Pune) contribute to about 33% of the total share of the automobile market in India. Pune alone houses about 4000 OEMs that aid the supply chain for Auto & Ancillary Spare Manufacturers in the country. It has the presence of major global players like Bajaj Auto, Tata Motors, Mahindra & Mahindra Ltd, Volkswagen India, Mercedes, etc. With the advent of new energies and alternate fuels like LNG, Hydrogen and green energy like Solar power, etc. there is a further potential to synergize and leverage key partnerships between auto manufacturers & energy companies like Shell, Adani Power, etc. Key academic institutes catering to the industrial needs of the zone are Institute of Technology Bombay, Veermata Jijabai Technological Institute, Mumbai, K. J. Somaiya College of Engineering and Management Mumbai, College of Engineering Pune, AISSMS College of Engineering Pune etc.

Banking & Insurance Industry (S) – Mumbai dominates the business & economics sector as the financial capital of India and is the wealthiest city in India. It houses the Head Offices of all major banks, NBFCs and financial institutions of the world, including the headquarter of Reserve Bank of India which is the central bank & chief finance regulatory authority of India. Bombay Stock Exchange (BSE) under Ministry of Finance is the oldest stock exchange in Asia & the 8th largest stock exchange in the world. Similarly, National Stock Exchange (NSE) is the world's largest derivative exchange by the number of contracts traded in 2021 & the 9th largest in the world after BSE. Most insurance companies and major banks are present in Bandra-Kurla Complex, Nariman Point or Lower Parel in Mumbai. GIFT City, Gandhinagar is also gaining prominence as India's first International Financial Services Center. Due to all these factors some of the best academic institutes offering financial management courses and talent base in Mumbai are Jamnalal Bajaj Institute of Management Studies, S. P. Jain Institute of Management and Research, Narsee Monjee Institute of Management Studies, Tata Institute of Social Sciences etcs.

IT & ITES (S) – The Information Technology (IT) industry contributes to almost 10% of India's GDP. Presence of major IT players like Tech Mahindra, Infosys, Tata Consultancy Services, IBM, etc. have made Pune, Mumbai and Thane the IT hub of Western India. They have significantly contributed towards developing and progressing digital infrastructure, automation, Artificial Intelligence, high performance and supercomputing infrastructure etc. After Bangalore, the twin cities of Mumbai and Pune employs the maximum number of software engineers and IT professionals in the country, furthering the digital development and revolution in India and globally.

3. South Zone: The South Zone comprises of Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Kerala and Puducherry. This zone is one of the greenest belts in the country and witnesses more of moderate or temperate climatic conditions. It has a mixed terrain with a combination of sea and land parcels with a good infrastructure setup that equally support heavy industries like the automotive sector, the IT sector as well as the Eco-Tourism in the country. Some of the major hubs in the south zone are Bangalore which is known as the Silicon Plateau, Chennai which is known as the Detroit of Asia and Hyderabad.

IT & ITES: As mentioned above, the IT industry contributes to about 10% of India's GDP and Bangalore and Mysore in Karnataka have established themselves as the biggest IT hubs of India. With the presence of major IT companies like Infosys, Wipro, Cisco, IBM, Microsoft, etc., it also houses the highest number of R&D centers in the country such as Indian Space Research Organization, General Electric, Boeing, Mercedes, Rolls Royce, Hindustan Aeronautics Limited, Amazon, Shell, etc. Bangalore is recognized as the Silicon Valley of Asia as it is home to the highest number of IT & ITES companies and thereby the highest number of software professionals & IT engineers in the country as well. Some key institutes that address the growing demand are Indian Institute of Science Bangalore, Indian Institute of Technology Madras, Manipal Institute of Technology Manipal, Indian Institute of Management Bangalore, Indian Statistical Institute Bangalore, Dayanand Sagar College of Engineering, M. S. Ramaiah Institute, Reva University, etc.

Automotive Sector: India is the 4th largest producer of automotives in the world. Chennai in Tamil Nadu has been nick named as the 'Detroit of Asia' due to the presence of major automobile manufacturing units and allied industries around the city. The 4-wheel vehicle manufacturers in Chennai are the base for 30% of India's automobile industry and 35% of its automobile component industry. Some of the key players that have contributed to make Chennai the largest auto hub in the country are Ashok Leyland, TVS Motors, Ford Motors, BMW, Daimler, Hyundai, Mahindra & Mahindra Ltd, etc. Some of the key academic Institutes are Indian Institute of Technology Madras, SRM University Chennai, Vellore Institute of Technology, Mahindra University etc

Start-ups & Unicorns: Bangalore is India's Unicorn capital with the largest number of Indian unicorns and start-ups headquartered in the city. There are more than 13000 start-ups and more than 27 Unicorns in Bangalore alone with their combined value estimated at $343 Bn. Some of the names that have made it to Unicorn status are Flipkart, Ola Cabs, PayTM, Oyo, Byju's, Swiggy, etc. These start-ups have significantly contributed to the overall employment growth and techno-commercial innovation in India and is continuously on the rise as more start-ups get added year on year. Many of the founders have graduated from Indian School of Business Hyderabad, Indian Institute of Management Bangalore, Indian Institute of Technology Madras etc.

Pisciculture & Tourism: India is home to more than 10% of the global fish biodiversity. Andhra Pradesh is the largest fish & sea food producer in the country and contributed about 35 lakh metric tons of fish in FY 2020-21. The state has a 974 km coastline and has rivers, canals, reservoirs, lakes & other water bodies suitable for fishing & setting up of fish tanks. As per estimates, Andhra Pradesh produces over 42 lakh tons of fish per year and exports it to various parts in the country & abroad. South zone is also active in tourism. Tamil Nadu attracted the highest number of tourists in 2021, due to its temple towns, marvelous heritage sites and stunning hill stations like.

Challenges: Cluster initiatives are becoming increasingly important in today's world of rapid innovation and deployments. A vast majority of nations and regions have adopted the philosophy of Innovation Clusters successfully, though the origination of the principle owes its roots to The Silicon Valley in the United States. A deeper study of several such innovation clusters clearly indicates a robust correlation of accelerated innovation. While such cluster structures meaningfully integrate interests of government bodies, enterprises, market, academic and research institutions, some of the challenges to keep in mind would be (Ref. Int'l J. of Economics and Financial Issues, 2016, 6(S1) 270-274):

The excessive concentration of enterprises in domestic and local relationships and cross-cluster environmental may lead to technology obsolescence and erosion of competitiveness in the markets.

The contained and bound nature of a cluster may cause the elasticity reduction of participating entities and thus, needs proactive interventions to balance breadth versus depth.

A cluster, by how it is designed and operated, runs the risk of isolation that may reduce the competitiveness necessary for sustained market growth and differentiated innovation.

The uniqueness of each cluster leads to considerable complication of efficiency assessment of its functioning because there is no opportunity for comparison with other clusters and thus suffers from lack of standardization.

It is complex to develop and measure a correlation between the entire cluster performance and that of its participating members. Appropriate allocation of funds and a clear, auditable set of metrics and key performance indicators shall continue to remain a challenge.

NOTES

i. This section draws extensively on Krishnan, Rishikesha T. (2010) "Taking a Fresh Look at Academia-Industry Collaboration," Edu Tech, March, 38-39.

ii. This example is drawn from Krishnan, Rishikesha T. (2010) "Taking a Fresh Look at Academia-Industry Collaboration," Edu Tech, March, 38-39.

iii. This example is drawn from Krishnan & Jha (2012).

iv. This section is based on inputs from Dr. N. Dayasindhu, Itihasa Research.

v. Adapted from "Bringing Unlike Minds Together: IITM Research Park, the perfect destination for research and innovation" IIT Madras Research Park Brochure.

vi. The sub-committee benefited greatly from the inputs of Dr. Sanjay Bhardwaj (ARCI), Dr. N. Dayasindhu (Itihasa Research), Dr. Anuradda Ganesh (Cummins), Dr. Nagesh Kumar (ISID), Mr. Mudit Narain (FAST), Dr V. Premnath (Venture Centre, Pune), Dr. V. Ramgopal Rao (IIT Delhi), Dr. D. Yogeswara Rao, Mr. Vipin Sondhi, Dr. Swami Subramaniam (IGNITE), Prof. K. VijayRaghavan (Former PSA) and Dr. Anil Wali (FITT, IIT Delhi). However, the conclusions reached and the recommendations made in this report are those of the committee.

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Confederation of Indian Industry
The Mantosh Sondhi Centre
23, Institutional Area, Lodi Road, New Delhi - 110 003 (India)
T: 91 11 45771000 / 24629994-7
E: info@cii.in * **W**: www.cii.in