## **International Conference**

# TOWARDS A BETTER INNOVATION ECOSYSTEM

(September 20-21, 2012, India International Centre, New Delhi - India)



Organized by



Indian National Academy of Engineering

In Collaboration with



National Innovation Council Government of India



International Council of Academies of Engineering and Technological Sciences, Inc.



**Confederation of Indian Industry** 

#### Supported by

Department of Science & Technology (DST)
Board of Research on Nuclear Sciences (BRNS)

**Conference Support & Knowledge Partner** 



# TABLE OF CONTENTS

Innovation: An Overview	1
Innovation Ecosystem: An Assessment	9
Creating and Nurturing Innovation Mindsets	59
Fostering International Collaboration for Innovation	85
Restructuring R&D	141
Inclusive Innovation	176
Funding Innovations	204
Building Innovative India	213
Annexures	251
Bibliography	258
About the Organizers	261
About the Knowledge Partner	262

#### **CONFERENCE SCHEDULE**

Welcome/About the Conference : Dr. MJ Zarabi

Conference Chair & Vice-President, INAE

Address : Dr. Baldev Raj

President, INAE

Keynote Address : Dr. RA Mashelkar

National Research Professor, National Chemical Laboratory &

President, Global Research Alliance

Inaugural Address : Dr. Sam Pitroda

Chairman, National Innovation Council & Adviser to the Prime Minister on Public Information Infrastructure & Innovations

Session 1: Innovation Ecosystem : An Assessment

Session Chair : Dr. K.V. Raghavan

Keynote Speakers

Dr. T Ramasami Prof. R Natarajan

Secretary, Department of Science Formerly Chairman, All India Council for

& Tech (DST), New Delhi

Topic: Nurturing an Ecosystem
for Innovations: Some Lessons
Topic: An Assessment Of The
Significant Ingredients Of

Innovation Ecosystem

Technical Education, New Delhi

**Session 2 : Creating and Nurturing Innovation Mindsets** 

Session Chair : Dr. A Ramakrishna

Formerly President (Operations) and Deputy Managing

Director, Larsen & Toubro Ltd., Chennai

Formerly President, Indian National Academy of Engineering

**Keynote Speakers:** 

Mr. Ashok Soota Prof. Dr. Otthein Herzog
Executive Chairman, Happiest acatech - National Academy of

Minds, Technologies Pvt. Ltd., Science and Engineering,

Bangalore Germany

Topic: Technology Innovation Topic: Bridging the Gap

and Innovation for the Market between Invention and Innovation

Session 3: Fostering International Collaboration for Innovation

Session Chair : Prof. Ashok Parthasarathi

Former Secretary to the Government of India

Former Science Adviser to late Prime Minister Mrs. Indira Gandhi

#### **Keynote Speakers**

Prof. Venkatesh Narayanamurti

Benjamin Peirce Professor of Technology and Public Policy &

Professor of Physics Harvard University

Topic: Innovation, Science and

Technology Policy, and

the Public Good

Dr. Xaver Edelmann

Member of the Board of Executive Directors, Swiss Federal Laboratories for Materials Science and Technology Gallen, Switzerland

Topic: Sustainable Resource Use - a

Global Challenge

Special Keynote Address : Dr. R Chidambaram

Principal Scientific Adviser to the Govt. of India & DAE

Homi Bhabha Chair Professor

Session 4: Restructuring R&D

Session Chair : Dr. V K Saraswat

Scientific Advisor, Defense Research & Development

Organization (DRDO), New Delhi

**Keynote Speakers:** 

Dr. Shiladitya Sengupta

Co-Chair, Center for Regenerative Medicine, Brigham & Women's Hospital, Harvard Medical School

Topic: Innovation at the Convergence of Science and

**Technology** 

Prof. Pankaj Jalote

Director, Indraprastha Institute of Information

Technology (IIIT), Delhi.

Topic: Strengthening the
Research Eco-System

**Session 5: Inclusive Innovation** 

Session Chair : Mr. Mehmood Khan

Former Global Leader of Innovation Process, Unilever, London

**Keynote Speakers:** 

Prof. Anil K Gupta Prof. Anil K Rajvanshi

Founder, Honey Bee Network Director, Nimbkar Agricultural Research

**Topic: Missing links in the** Institute (NARI)

inclusive innovation ecosystem Topic: Innovations for rural poor

**Session 6: Funding Innovation** 

Session Chair : Dr. Pronab Sen

Principal Adviser, Planning Commission, Govt. of India

Former Secretary, Govt. of India

**Keynote Speakers:** 

Mr. Saurabh Srivastava

Chairman, CA Technologies, India **Topic: Funding Innovation:** 

Driver for Creating Employment

& Wealth

Dr. HK Mittal

Adviser, Member Secretary, National Science & Technology Entrepreneurship Development Board (NSTEDB) Secretary, Technology Development Board (TDB) **Topic: Funding Innovation:** 

A Government Perspective

#### Session 7 : Building Innovative India

Special Keynote Address : Dr. Arun Maira

Member, Planning Commission

Govt. of India

**Topic: The Measurement Trap** 

Session Chair : Prof. Rishikesha T Krishnan

Professor of Corporate Strategy & Policy

Indian Institute of Management (IIM), Bangalore

#### **Keynote Speakers:**

Prof. Robin BatterhamProf. MS AnanthPresident, ATSE, AustraliaVisiting Professor

**Topic: Innovation –** Indian Institute of Sciences **Some Priorities for the Future** Former Director, IIT Madras

Topic: Innovation and the University

#### **PREFACE**

#### Dr. MJ Zarabi

Conference Chair & Vice-President, INAE



Innovation is engaging everybody's attention the world over. Given its importance, the Indian National Academy of Engineering (INAE) decided to hold an International Conference on "Towards a Better Innovation Ecosystem" as part of its Silver Jubilee Celebrations this year. More so, because the President of India has declared the decade of 2010 as the decade of innovation.

It was only natural as well as logical that INAE holds this Conference in collaboration with India's focal organization on innovation, the

National Innovation Council (NInC), of which Dr. Sam Pitroda is the Chairman, as well as with CII, premier Confederation of Indian Industry and, of course, International Council of Academies of Engineering and Technological Sciences (CAETS) in which INAE represents India.

A number of luminaries, both from within the country and overseas, participated in the Conference which was conducted in seven sessions over two days. Each session was addressed by two Keynote Speakers followed by a forty (40) minutes Discussion in which many key contributors and Discussants from among the audience participated freely.

This compendium includes presentations made and also captures salient observations and key recommendations made at the Conference.

A Poster Exhibition of recently commended innovations by young innovators was also organized on the sideline of the Conference as an expression of our appreciation for them which, I am sure, would also have proved to be informative as well as a source of inspiration for the young participants.

I would like to place on record my grateful thanks to all our collaborators and supporting organizations as well as all my colleagues in the Organizing Committee and in the INAE Secretariat, especially Ms Pratigya Laur, Brig Rajan Minocha and Brig SC Marwaha, for the hard work they have put in. I would also like to thank Dr. Baldev Raj, President, INAE for his help and support.

#### **Presidential Address**

**Dr Baldev Raj** President, INAE



On the occasion of 25<sup>th</sup> Anniversary of INAE, I congratulate Dr. Zarabi for doing a commendable job in organizing the Better Innovation Ecosystem Conference, and for bringing all the stakeholders from India and abroad together for this event. Let me also take this opportunity to congratulate Dr. Sam Pitroda for receiving the Policy Change Agent Award at the 2012 Economic Times Awards.

INAE has around 700 people in its organization and every year it chooses 30 people whom they consider as eminent contributors. Also, INAE selects young people below 35 years as Academia Associates. INAE also organizes awards that range from recognizing meritorious students, to the lifetime achievement awards. Dr. Sam Pitroda and Dr. Mashelkar are awardees of Life time achievement awards.

The 700 fellows are making remarkable contributions in their domains. INAE has provided a platform for these fellows to network in various groups in India and abroad. Many forums are being set up in the areas of energy, infrastructure, water, education, healthcare and other domains. INAE continuously comes out with reports that are later presented to the policy makers and young people for their future contributions. Interaction between all is very important for the proper implementation.

Galileo, Faraday and Edison are my greatest heroes. Faraday was a great 'discoverer', Edison was an 'innovator' and Galileo was a combination of 'discoverer & innovator'. Environmental factors or external environment is one of the prominent factors that drive innovation.

'Ecosystem' is a very common word but is very difficult to define. For building an 'Innovation Ecosystem', R&D spend, leadership and the student-academic community have to play a key role. These are considered as three major building blocks of a sound innovation ecosystem.

• Research & Development: Research & Development expenditure is one of most important pillars for building and developing a complete innovation ecosystem. Though, the amount to be spent on Research & Development activity is very crucial and significant, but the most important parameter to be considered is the quality of R&D output. Good quality of R&D will not only pay off the price of the expenditure incurred but will also enable new inventions and innovations. An R&D activity which

lacks quality will only waste time and money. A good innovation must be inclusive and ethical.

- **Leadership:** This is another major factor for building an innovation ecosystem. These are the leaders who define the outcome of any innovation. Leaders have the ability to visualize the need for future market needs.
- Student-Academic Community: The student-academic community is another major pillar that enables a country or society to build a sound innovation ecosystem. Here, the quality of education plays a very significant role. Sound academic practices along with good industry exposure can help to serve this purpose. Looking at the present scenario where competition is at a peak, we need students to emerge as innovators in ever larger numbers.

Innovation is a result of the flash tunneling effect of seniors coupled with the energy and talent of young minds. To foster an innovation culture, we need students as innovators to address the grand challenges facing humanity today. An intimate blend of academia and industrial interactions will help us achieve our goal of building a healthy innovation ecosystem. For building the innovation ecosystem of the future, India needs to produce more innovators like Vikram Sarabhai, Ratan Tata and so on.

The need of the hour is to encourage students to embrace experiential learning, and become entrepreneurial in their approach.

## **Keynote Address**

#### Dr RA Mashelkar

National Research Professor, National Chemical Laboratory & President, Global Research Alliance



It is a great honor and privilege to speak in this conference. First of all, I would like to congratulate Indian National Academy of Engineering on completion of 25 years. On its way to the Golden Jubilee down the line when India will be looked as a different country altogether as a potentially third most advanced country in the world, the engineers have big role to play in building the future of the nation. Engineer word itself comes from French word called "ingenuity" and it is that ingenuity which makes engineers

to see "hitherto unattainable". He spoke on the topic of "On Building an Inclusive Innovation Ecosystem". These words have come together for the first time – 'inclusive innovation', 'the ecosystem' and 'building the innovation ecosystem with inclusive innovation'. In my terms, inclusive innovation means it leads to inclusion of the excluded. That is the purpose of inclusive innovation. Now the question comes 'Why the people gets excluded at first place?' There are several reasons to it.

First is *poverty*. If you are poor, you are deprived of basic necessities of life including the education, health, financial services, sanitation, and whole range of things.

Second is *distance*. If you are in rural villages, you are again denied access, and then you have disability. It is unbelievable but in our country there are 2-3 crores people are disable out of 150 crores and they are deprived. Mitigation is huge. We cannot exclude the migrants, we have to include them.

As a foreign fellow of ATSE, Australia, I was honored for my talk. The topic of my talk was 'Indian Innovation from Gandhi to Gandhian Engineering'. What an Engineer can do? Engineers make more from less for more. It is not more profit but more people. More people is the term which Gandhiji implicit. This become popular as "MLM-More from Less for More" in Harvard and is used as one of the paper.

We are not talking about "less from less" which means that you are poor and so you will get less. We are rather talking about to give them more. In fact, MLM has actually current around the world and that World Economy Forum has special session on "More from Less for More". It communicates something that is extremely important for the world – More from Less- not just more profit but also for more and more people of the world; 2.6 million people whose income level are less than 2 dollars a day. What do we do for them? You might say why inclusive innovation? Why is it becoming a buzz word? It is for western interest because they want to see just not the economic growth but the inclusive economic growth. Social disharmony is something that they are worried about. Income inequalities came cause social

disharmony. A section of the society has certain benefits and the others don't enjoy them. Actually it is a key to achieve millennium development. As economic growth takes place and poor becomes lower middle class and lower middle class become middle class you are expanding your markets for the people who can buy things but who have aspirations and the market is close to billion. If you look at economic growth of China and look into the data of China from 1988 to 2007 which is 20 years, there average economic growth is 8.8%. But if u see what has also happened is the fact the gene coefficient has gone up during that time. The gene coefficient moved from 0.34 to 0.48. What does that mean? What does gene coefficient measure? It measures the inequality in incomes of top population and the bottom population. The statistical measure of today's China is that the top 10% has 34.6% of this share of economy and the bottom 10% has 2.4%. 34.6% versus 2.4% and it is increasing. That is why they are deeply concerned about the sort of social disharmony that is likely to come. Gap is widened between rural and urban incomes. For India, initially everyone was poor. As we started growing post liberalization, the gene coefficient increased. The same income disparity that is coming between top and bottom of the pyramid, Therefore, India has acted Mr. Sam Pitroda along with Prime Minister and then Finance Minister and now President of India His Excellency Mr. Pranab Mukherjee on 14th November 2012 is launching this Indian Inclusive Innovation Fund. Prime Minister has formed National Innovation Council spearheaded by Mr. Sam Pitroda has taken Inclusive Innovation as main agenda for the country. There are several Indian Inclusive Innovation Agendas that are being launched. One of its first kind of initiative to promote Inclusive Innovation is billion dollar funding phases of the support of enterprises for development of the bottom of the pyramid customers and profit entity for the social investment is the model that is being developed. I must proudly say this is first of its kind in the world. The big challenge now is access equality despite income inequality. Every one should have access to basic needs like health, education, water despite of income inequality. We can't wait to achieve income equality for access equality.

## **Inaugural Address**

#### Dr. Sam Pitroda

Chairman, National Innovation Council & Adviser to the Prime Minister on Public Information Infrastructure & Innovations



Innovation is becoming a buzz in India today. At present, information technology has changed the lives of every individual. The existence of the Internet has added value to whatever we do. Be it policy, industry or governance, everybody has been impacted.

To foster innovation at the national level, it is my proposal that each Member of Parliament recognize three best innovations in his / her constituency every year (making it close to 2,000 innovations

each year). Measures such as these would truly make 2010-2020 as the "Decade of Innovation", in which India has seized the opportunity to use science and technology to benefit millions of its disadvantaged citizens.

At the National Innovation Council of India (NIC), we have developed a roadmap for innovation as a platform, focusing on inclusive innovation and developing the right ecosystem. The factors that are needed to build right innovation ecosystem include, right government policies, incentives, availability of risk capital, venture capital funding and young talent. The situation demands that we need to build solutions that are affordable and highly scalable.

We are taking active steps towards delivering better, faster government services via the National e-Governance Plan (NeGP). At present close to 20,000 software professionals are working for the creation of diverse applications such as Global Information System (GIS) tags for railway and bus travel, cyber security and creation of data centres. The Unique Identification Number (UID) Program headed by Nandan Nilekani has already distributed Aadhar identity cards to 200 million people and the process to reach out to others continues.

Across various government institutions around 10,000 officers and staff are expected to get connected on a common platform in the coming years. Also, by end 2014, the much hated traditional, hard copy government file is set to be replaced by an electronic file system at the Centre that will hopefully improve collaboration and speed up decision making.

The biggest challenge that India currently faces is poverty. The main object of all government decision making must be to address this issue; if this is done, we can easily achieve an annual GDP growth rate of 8-10% year on year.

While India as a country has a definite road map to institutionalizing innovation and the creation of National Innovation Council (NIC) by the government is proof of that, we have to develop our student community in order to truly strengthen this ecosystem. Though everybody talks about innovation, yet enough results aren't there to be seen...India is a country of prototypes with people innovating only within their narrow disciplines. For taking the benefits of innovation to the wider population, we require a proper ecosystem. We must create a positive environment and encourage more young people to become self-employed and create new jobs. There is a lot of scope to do more in many sectors where the performance has been below average so far.

There is a need for new paradigm in the education sector. The need for quality mentorship is paramount in the education system. We require the creation of 15 million jobs each year and these jobs will not come from IT sector but a 100 areas such as agriculture, semiconductors, environment, nanotechnology, biotechnology and others.

The theme of the conference is inspiring, and for it to truly inspire institutional change towards innovation, we need to rise up. My team at the National Innovation Council will collaborate with the INAE to create sectoral councils to work on 50 new subjects for innovation, each with 5 domain experts from different institutions.

In conclusion, there are two ways of doing work in India:

- **Brahminical work style:** This work style includes, arranging conferences and seminars, writing reports and research papers etc. As Indians, we are very good at this type of work.
- Sudra work style: This is a more hands-on, solution-oriented work style, where the stress is to find practical solutions to day-to-day problems. Unfortunately, in India we are more inclined towards Brahminical work style.

The need of the hour is to adopt the Sudra work style to develop practical, innovative solutions to solve the most pressing issues (poverty alleviation, quality healthcare at affordable cost, education, water and sanitation, power etc.) facing the country.

#### CHAPTER 1

#### INNOVATION: AN OVERVIEW

#### Introduction

Innovation is indispensable for organizations to remain competitive and is indeed a major driver of progress of any nation. It is also an imperative for addressing the grand challenges in the realms of health, education, energy, environment that face us.

Innovation means different things to different people. Most often, people relate innovation with some common themes, ranging from creativity to unmet user needs [Hutch Carpenter, 2010]. Innovation, therefore, has a wide spectrum of definitions and a multidimensional nature, touching upon every aspect of modern life. Innovation can be defined as "the creation and delivery of new customer value in the marketplace with a sustainable value for the enterprise." (SRI, 2011).

**India's National Knowledge Commission (NKC)** defines Innovation as "a process by which varying degrees of measurable value enhancement is planned and achieved, in any commercial activity. This process may be breakthrough or incremental, and it may occur systematically in a company or sporadically; it may be achieved by:

- introducing new or improved goods or services and/or
- implementing new or improved operational processes and/or
- implementing new or improved organizational/ managerial processes

# Definitions of Innovation Unmet User Needs Applied Innovation Of Innovation Business Model Source: Hutch Carpenter, 2010]

in order to improve market share, competitiveness and quality, while reducing costs.' (NKC, 2009).

The **National Innovation Initiative** (NII) of the U.S.A. defines innovation as intersection invention and insight, leading to the creation of social and economic value where, insight provides the basis for application of the invention. Then. the solution must be tested and demonstrated to

be useful and viable, and finally, it must be commercially or socially produced. Only then is social and economic value created.'

Innovation results when a new approach is applied to an old problem that makes lasting and far-reaching changes in behavior, and can be defined as a new match between a need and a solution".

The GE Global Innovation Barometer (2011) provided the following five definitions for innovation:

- The implementation of new processes, products, organizational changes or marketing changes
- An environment/culture that embraces positive change, creativity and continuous improvement
- Research and development, new intellectual property (IP), and inventions
- Staying ahead in the market and being a market leader
- Solutions that benefit society and societal outcomes (including environmental outcomes)

According to the Royal Academy of Engineering, UK (2012), innovation can be of the following types:

- **Product innovation** changes in products or services that an organization offers.
- **Process innovation** changes in the way that products or services are created and delivered.
- **Position innovation** changes in the context in which products or services are introduced.
- **Paradigm innovation** changes in the underlying mental models and technology which frame organisations' activities, as exemplified in the development of online retailing, hybrid cars and wind turbines.

The institutional, local, national and cultural factors as well as technological advances and economic investment play a crucial role in advancing innovation. Innovation depends on the overall quality of institutional environment and interactions among stakeholders in the ecosystem.

#### A Historical Perspective to Innovation

When considering the history of innovation, it is important to consider how technological change came about, why and how technological change has changed, and how the changes have changed.

As elucidated by Joseph Schumpeter in his more recent theory of economic cycles (first published in 1939 in the USA, and later in 1961 through a German translation), a definition of the term *invention* emerged and evident in his theory of economic development.

Before Schumpeter's arrival, a sociological/socio-psychological theory of change was expounded by Gabriel Tarde (1890/1897). This theory was furthered by Schumpeter with regard to its evolutionary perspective.

Tarde was able to make a distinction between Invention and Imitation. Inventions are unique, generally unplanned events, but they themselves are "built upon elements of earlier imitation (...), and comprised of these compositions which in turn are imitated and become new elements of more complex structures" (Tarde 1890/2003: 69). While they are indeed decisive starting points for social change, they only arise through imitation (Manfred Moldaschl (2010)).

According to David Edgerton, in literature "there is a focus on the early history of selected technologies which later came into widespread use, or which appear self-evidently important. They are neither a history of technologies in use at a particular time, nor yet a history of invention or innovation at that time. It is the *conflation*, not the focus on invention or innovation, which is a crucial problem with the literature if one is interested in the place of technology in history, or indeed the history of invention or innovation."

#### Here are some examples:

- Thomas J. Misa's From Leonardo to the Internet, discussed the period between 1870–1930 as one where research and invention in electricity and chemicals took place; 1936–90 in terms of the wartime (World War II) history of the atomic bomb, electronics, and computing; 1970–2001 in terms of the fax, hamburgers, and the internet.
- According to Ruth Schwartz Cowan's textbook on U.S. technology "four technological systems have dominated twentieth-century history: automobiles, and their attendant roads and fuel sources; aircraft, spacecraft and also rockets; electronic communication devices, from wireless telegraphy to personal computers; and finally, biotechnologies, new foodstuffs, medications, and contraceptives".

India has a long legacy and unparalleled culture and tradition of being a pioneer in innovations in almost all the areas such as art, culture, music, architecture, performing arts, philosophy and scientific endeavors.

One of the earliest innovations known from India is the button. Buttons were used in the Indus Valley Civilization for ornamental purposes by 2000 BCE. It was originally used more as an ornament than as a fastening, and the earliest known button being found at Mohenjodaro in the Indus Valley.

In the 6<sup>th</sup> Century, India invented the zero and decimal system. India's innovation journey prospered through pioneering universities of Nalanda and Taxila.

Here are some of the key snapshots from India's innovation journey:

- Rich and innovative heritage -the Indus Valley Civilization, ancient cities such as Mohenjodaro, Harappa, Kalibangan and Lothal.
- Legendary universities such as Nalanda and Takshashila, which were reputed centres of learning. Also, India was also home to the innovative 'gurukul' system of education.
- **Medicine** -the ancient art of Ayurveda aimed at curing disease and preserving health.
- **Astronomy** Aryabhata outstanding contributions to including determination of the diameter of the earth and moon, the idea of the earth rotating on its own axis, value of pi and alphabetical representation of numbers.
- **Mathematics** significant contribution of the 'decimal system of enumeration', symbol for zero, first variant of Pascal's triangle.

After India's Independence, India went on to achieve some major innovative results such as "green revolution"-an agricultural independence - through which India is able not only to feed its populace but also in exporting its surplus stock. The next notable revolution is the "White revolution" which positioned India along with the top milk producing countries of the world. India joined the elite group of handful nations having capabilities in space science and technology, including design, and construction of launch vehicles. India's indigenous technological capabilities range from prospecting of raw materials to the design and construction of large nuclear reactors.

India has also moved towards displaying significant capabilities in business-model innovation. The most impressive achievements have been the growth of the **Indian software services industry**, **telecom**, **and pharmaceutical industry**. Providing low-cost mobile services, low cost vaccines, automobile etc, in the world by doing business-model innovations, combined with process improvements. A new and even more exciting phase of innovation is visible today. Following cases showcases successful business model innovation.

- By embracing innovation, **Tata Motors** has become India's third-largest car
  manufacturer and well ahead of top brands like Toyota, Honda and Ford in terms of
  volumes. It has created robust product platforms around the Indica, Indigo, and
  Nano brands, all specifically designed for the Indian market.
- A decade ago, **Bajaj Auto** was not a significant player in the motorcycle industry. Today, it is the second-largest motorcycle company in the country and a strong leader in more powerful and stylish sports bikes. The root of Bajaj's success was the development of the Pulsar, a bike that combined power, style and fuel economy based on its proprietary DTSi engine technology.

#### **Innovation Models**

How we understand innovation as a process has evolved gradually over a period of time. In the beginning, innovation was considered as a linear sequence of functional activities. This linear sequence comprised of either new research opportunities resulting in promising technological applications entering the market ('technology push'), or else a demand from the market for something new which then drew out new solutions to the problem ('technology pull').

Such a model has its limitations clearly, as sometimes the 'push' will dominate, sometimes the 'pull'. It is the interplay between 'push' and 'pull' that results in a successful innovation.

Innovations, and most of them, arise out of processes that involved false starts, or are messy, or improvised between stages, dead ended, and came out of sequence in a R&D process. A reading of innovation literature provides us with an understanding of how innovation processes have graduated from the historically simple linear models to the modern complex interactive models.

Roy Rothwell's five generations of innovation models

Generations Key Features			
First and Second	The linear models - need pull and technology push		
Third	Interaction between different elements and feedback loops between them – the coupling model		
Fourth	The parallel lines model, integration within the firm upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances		
Fifth	Systems integration and extensive networking, flexible and customized response, continuous innovation		

[Source: Imperial College, 2006]

Innovation usually occurs within a set of rules which are clearly understood, and involves players who try to innovate by doing what they do (product, process, position, etc.), but better. Some manage this more effectively than others, but the 'rules of the game' are widely accepted and do not change. But occasionally something happens which dislocates this framework and changes the rules of the game. By definition, these are not everyday events. [Tidd, 2006].

Clayton Christensen [1997] investigated why some innovations that were radical in nature reinforced the incumbent's position in a certain industry, contrary to what previous models

would predict. According to his research, sustaining innovation hardly results in the downfall of established companies because it improves the performance of existing products along the dimensions that mainstream customers value. On the other hand, disruptive innovation is characterized by elements or features that traditional customer segments may not want, at least initially. Such innovations will appear as cheaper, simpler and even with inferior quality if compared to existing products, but some marginal or new segment will value it.

Within the engineering profession, incremental innovation is continuous and gradual

change has a clear heritage. This type of innovation responsive to problems, opportunities or trends; maintains or enhances competitive position; is lower risk; the and is most common form. Such incremental innovation typifies the majority of development work within the automotive and aerospace sectors.

By contrast. with radical innovation, creative thinking challenges established paradigms, is higher risk, goes beyond competitive positioning, has the potential to impact fundamentally the way the world operates, and is less common. Radical innovation is responsible for the genesis hiah-

#### Difficulties arising from partial views of innovation

If innovation is only seen as	the result can be			
Strong R&D capability	Technology which fails to meet user needs and may not be accepted			
The province of specialists	Lack of involvement by others, and a lack of key knowledge and experience input from other perspectives in the R&D			
Understanding and meeting customer needs	Lack of technical progression, leading to inability to gain competitive edge			
Advances along the technology frontier	Producing products or services which the market does not want or designing processes which do not meet the needs of the user and whose implementation is resisted			
The province only of large firms	Weak small firms with too high a dependence on large customers.  Disruptive innovation as apparently insignificant small players seize new technical or market opportunities			
Only about 'breakthrough' changes	Neglect of the potential of incremental innovation: with an inability to secure and reinforce the gains from radical change because the incremental performance ratchet is not working well			
Only about strategically targeted projects	May miss out on lucky 'accidents' which open up new possibilities			
Only associated with key individuals	Pailure to utilize the creativity of the remainder of employees, and to secure their inputs and perspectives to improve innovation			
Only internally Generated	The 'not invented here' effect, where good ideas from outside are resisted or rejected			
Only externally generated	Innovation becomes simply a matter of filling a shopping list of needs from outside and there is little internal learning or development of technological competence.			
Only concerning single firms	Excludes the possibility of various forms of inter-organizational networking to create new products, streamline shared processes, etc.			

[Source: Imperial College, 2006]

technology industries such as ICT, telecommunications, biotechnology and sustainable energy (RAE, 2012).

When we consider the innovation process, we need to have a broad understanding and a map of the key processes. Our approach to managing innovation is also likely to be limited, if we have a limited view of the innovation process.

For instance, if we see innovation as a linear 'technology push' process (in which case all the attention goes into funding R&D with little input from the market and consumers) or one in which only the market is relied upon to pull through innovation

In case we view innovation only in terms of major 'breakthroughs', and do not consider the power and potential of incremental innovation, we would fail. For instance, the original Edison design of electric light bulbs remained almost unchanged in concept for a longtime. However, with some incremental product and process improvement from 1880 to 1896, there was a price reduction of the electric bulb by 80%, widening its reach and use.

Difficulties also arise when we view innovation as a single isolated change or as product or process only, without recognizing the interplay between the two [Tidd, 2006].

#### **Salient Observations**

- Innovation is a process and not an outcome by itself. The focus on innovation within enterprises enables an accurate assessment of the internal and external dimension of value created by innovation activities.
- Innovation processes bring together various stakeholders, including: individuals who aid in idea creation, groups that help in idea evaluation, organizations that focus on resource allocation and formalization of new activities, and the overarching context in which innovation happens, including external power structures or collaboration partners.
- Innovation is all pervasive across organizations, industries and international borders:
  - O Global value chains are connecting innovators internationally, through research, knowledge networks and trade. Increasingly, firms and entrepreneurs are globally mobile, with knowledge production across centers. They usually locate their knowledge assets in an innovation ecosystem that adapt to an interconnected world of rapid technological and economic change.
  - O Innovation involves interactions between a wide range of private and public actors, and is the result of continuous interactions and linkages between private sector, public sector, and universities and research labs that produce knowledge. In an innovation ecosystem, the knowledge infrastructure comprises of the science infrastructure as present in universities and research labs, and the supporting innovation information infrastructure.

O Public sector plays a major role in shaping the innovation environment, especially through producing essential intangible inputs in the form of skilled workforce; through the conceptualization and development of physical and knowledge infrastructures that are used by all industries. The public sector directly produces innovations related to its own activities, and can frequently foster new technologies and thereby tap into new sources of growth. Finally, the public sector creates new forms of innovative public service delivery, in critical domains of national importance, including health and education among others.

#### CHAPTER 2

#### **INNOVATION ECOSYSTEM: AN ASSESSMENT**

#### Introduction

A biological ecosystem is a complex set of relationships among the living resources, habitats, and residents of an area, whose functional goal is to maintain an equilibrium sustaining state. Similarly, an innovation ecosystem models the economic rather than the energy dynamics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation. (Deborah Jackson, NSF).

An innovation ecosystem comprises of multiple stakeholders including entrepreneurs, investors, talent, universities, working together in one geographic location, and interacting through multiple linkages.

As noted by Hwang and Horrowit(2011) through their interesting perspective to innovation ecosystem in their new book, *The Rainforest: The Secret to Building the Next Silicon Valley:* 

"Individual people are the atoms swimming in the complex biological system of human society. Innovation can be sparked to life by a particular combination of people who happen to have ideas, talent, and capital in the prebiotic soup of humanity. But those elements must be mixed in just the right way for them to find and connect with one another. When viewed from high above, humans are just particles moving around and bumping into each other. Rainforests – whether in Silicon Valley or elsewhere – are environments that encourage disconnected people to self-organize into greater forms of biological life."

In an innovation ecosystem, the key stakeholders are the research institutions engaged in basic research, and the commercial enterprises, that help in translating research ideas into the market. Complex relationships are formed between stakeholders in the process of enabling technology development and technology commercialization.

Metcalfe and Ramlogan (2008) define an innovation ecosystem as comprising of "a set of individuals who are repositories and generators of existing or new knowledge". Principle actors are commercial enterprises, research universities and other public and other stakeholders.

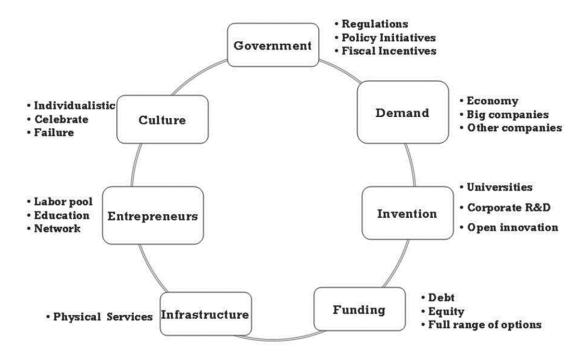
Innovation ecosystems evolve from national innovation systems models. Innovation systems can be governed by the policies that affect the institutions. Innovation ecosystems are dynamic structures, cannot be determinately governed by public policies, but they evolve according to changing market conditions.

#### **Elements of an Innovation Ecosystem**

Creating a strong and vibrant innovation ecosystem, this comprises of following components-

- A. An educational system which nurtures creativity and innovative mindset
- B. Universities and related institutions that provides advanced knowledge, environment and skills
- C. R&D that can supports technology development, basic and applied research
- D. Industry supporting new initiatives & which interacts with academia and which contribute towards development activities
- E. Government setting broad policy directions, funding basic scientific research, framework encouraging young people to enter into scientific career
- F. Bridging institutions like technology centre, incubation centres.
- G. Financial institutions, venture capital firms, angel brokers which provides the funding needs so as to commercialize innovative ideas.

#### Innovation Ecosystem: System Overview



[Source: Bill Aulet, MIT, 2012]

#### Role of elements in an Innovation Ecosystem

#### I. Role of Government

The role of Government is to create a conducive policy and regulatory environment for innovation, and to enable stakeholders within the innovation ecosystem to capitalize on that environment. Governments incentivize innovation through direct or indirect subsidies.

Governments may have several goals for innovation, ranging from encouraging the formation or growth of entrepreneurial ventures that create new technologies capable of competing on a global stage, to encouraging existing enterprises to take steps to modernize their business processes and technology infrastructures.

The role of the Government is to broaden and deepen its support for innovation in the private sector and the economy. To foster business and technological innovation, government need to focus on tax, legal, and fiscal considerations. Its major function is in facilitating the overall ecosystem and integrating the elements of ecosystem by providing supportive policies and regulation, proper funding mechanism, some R&D grants and tax relief's, IPR, support for higher education institutes, awards and recognitions etc. All such proactive initiatives, help in making the overall innovation ecosystem to work smoothly.

#### II. Role of educational institutions

Educational and research institutions of higher education play a key role in providing 21st century societies with skilled personnel possessing the knowledge to succeed in an increasingly complex world. Over the years, educational and research institutions have played an important role in serving as knowledge centers that attract private and non-profit sector enterprises interested in building research and enhancing innovation capacity.

University plays an increasingly important role in the Knowledge Society, with a stronger role in scientific research, and as an equal partner to Industry and Government, or in some instances, taking the lead role in the innovation pathway.

Quality education empowers students to ask the right questions, to develop the right insights and to apply the learning efficiently. Universities are playing crucial role in creating new knowledge through basic research, also supplying talent pool for R&D.

Present scenario demands bringing education to diverse groups, especially in rural or remote areas through more flexible curriculum and innovative learning system.

Academia holds the responsibility of capacity building, generating ideas and leading R&D. It is from these academic institutes, that the next generation of innovators, researchers, entrepreneurs, and business leaders come from.

#### III. Role of Financial institutions

Financial institutions play a very significant role in driving the overall innovation market. These institutions fund R&D centers/firms to effectively do research related activities. Banks and venture capital institutions are the key pillars of this segment. These institutes not only support business related activities of new start ups but also help to improve the functional activities of existing organizations.

Venture capital funding is much more of a partnership than the standard modes of institutional financing. Taking innovation to the market requires that those who have the technology concepts, those who have the entrepreneurial capacity to implement these concepts in the market and those who have the funds to finance this exercise come together. This interaction between the technologists, the entrepreneurs and the VC funds is what has been described as an ecosystem for innovation.

In addition to their obvious role as a promoter of business innovation, financial institutions can play a proactive role by acting as an institutional channel for financing innovation, by providing an incentives and awareness generation mechanism for entrepreneurs, and as a mediator for improving academia-industry interaction, and for technology commercialization.

#### IV. Role of Industry

Industry plays a vital role in facilitating innovation by translating and transferring research results from universities into the marketplace. Industry is engaged in accelerated transition to knowledge markets, with an enhanced search for external knowledge.

Through R&D alliances with universities, Industry focuses on increasing firm competitiveness, and bringing in new innovations to the marketplace through shared risk and costs.

There has been a significant change in management approach, with increasing stress on new alliances with academic and research institutions. This has taken the form of partnerships, co-operative programs, consortia with universities, government labs, other companies etc. at national and international level to identify external technology, knowledge, trained human resources, new partners and markets.

As facilitators of knowledge transfer, industry is focused on enhancing research results, and deal better with technology and market uncertainty

#### Gaps in the Indian Innovation Ecosystem

While considering the ideas to marketplace value chain within the innovation ecosystem, there exist several gaps and challenges that need to be addressed.

#### • Gaps in converting innovations into products

Academic and Research institutions have always been associated with giving rise to new promising technologies. In the innovation ecosystem today, academic and research institutions function as islands of excellence and are not well-connected within the innovation ecosystem.

There is a need to bridge the gap between research institutions and the marketplace, so that innovations are converted into products and businesses.

In India, the Government is the innovation champion, and is involved in spearheading innovation by providing adequate proof-of-concept funding through various initiatives that help ideas in crossing across the "valley of death" (the point where a new idea has strong commercial potential yet has not been proven enough for private investors). The Indian Government is involved in developing a strong nationwide system of technology incubation centres and technology transfer offices that help in accelerating innovation, and in the growth of new start-up businesses.

In the United States, the National Science Foundation (NSF) has spearheaded a new public-private effort, The Innovation Corps, aimed at strengthening the U.S. "innovation ecosystem" through leveraging promising technologies emerging from university labs into the marketplace.

#### • The need for Curiosity-driven research

Research comes with an uncertainty and requires an entrepreneurial mindset that is open to risk-taking, in investing in research, has top management commitment, and has the capability to manage the innovation process in a systematic way.

Today, while academic and research institutions focus on advancing the science through basic research in the form of research papers or patents, there is very little focus on *translational research*. In the current economic environment, industry is also not focused on investing in promising technology ventures, or in new research generation.

In India, scientists mostly focus on fundamental research and not on translational research. In many cases, the researchers do not realize the value of IP generation.

Therefore, one of the critical gaps that need to be addressed is the lack of curiosity in research.

#### • The Commercialization challenge

In India and in most developing countries, public R&D Institutes or university R&D labs lack the skilled resources, knowledge and training to move technologies through the commercialization pathway from ideas to market. There are multiple challenges that emanate from this situation.

Some of the critical challenges range from a lack of specialized training for scientists to assess the commercial potential of their innovations, to lack of technical knowledge of a licensor to understand the science, to fears of Intellectual Property theft by enterprises, to lack of risk-taking and risk-sharing abilities of Indian companies to invest in promising early-stage research. Lastly, only few research institutions invest in incentivizing their scientists, and in skilled personnel possessing technical and business skills. To combat these challenges, many research institutions in India have established technology incubation units, innovation centres, and in some instances, formal technology transfer offices to bridge the gap with industry.

#### **Salient Observations**

- Leaders can create their own innovation ecosystem. History is replete with examples of leaders who did not require an ecosystem, instead created one of their own. For instance, Srinivasa Ramanujan a magical genius; Sir C.V. Raman, who created the next generation of physicists; Homi Bhabha, who created a entirely new technology domain: Atomic Energy; J.N. Tata who developed the concept of 'Indigenous Manufacturing Industry'.
- Quite often, overlapping circles are used to depict how investors, academic researchers, private sector scientists, policymakers, and other stakeholders work together and help in fostering innovation. An innovation ecosystem mimics the nature's ecosystems. If one member in an innovation ecosystem is weak, it affects everyone.
- There are three pillars for fostering innovations, Research & Development resulting in innovations, Industry in generating wealth, while Academia creates knowledge. Scaling innovation is about conversion of risky ideas into innovations by taking them across the "valley of death". Out of 100 ideas, one is workable; out of 100 workable ideas, one works; and out of 100 working ideas, one profits.
- It may seem obvious to note the importance of having strong R&D institution framework and infrastructure, a thriving industrial base, a deep R&D talent pool and a business-friendly regulatory environment. A vibrant innovation ecosystem is one in which the barriers between organizations and individual entrepreneurs are broken down, where true collaboration occurs across industries, across disciplines,

- and where a risk taking culture truly thrives, tolerant of failure, and celebrating risk taking and success.
- DST has supported the formation and nurtured 64 STEPs/ TBIs so far in India that
  have spun off about 2600 companies which have created about 26,000 jobs. The
  incubated companies have a cumulative turnover estimated at INR 7,000 crores.
  They have served to connect academic and research systems to business
  incubation.
- For a successful innovation culture to exist in an innovation ecosystem, it is imperative that there is a successful synergy between new idea development and technology commercialization. A free flow of information and technology among people and organizations helps moving ideas across the innovation ecosystem.
- Lastly, a successful innovation ecosystem is one that involves all three entities present in it—government, universities, and the private sector—to engage and collaborate with each other.

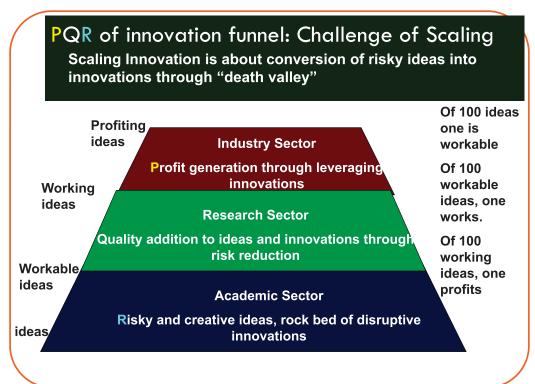
# Nurturing Ecosystem for Innovations: Some Lessons of DST, India

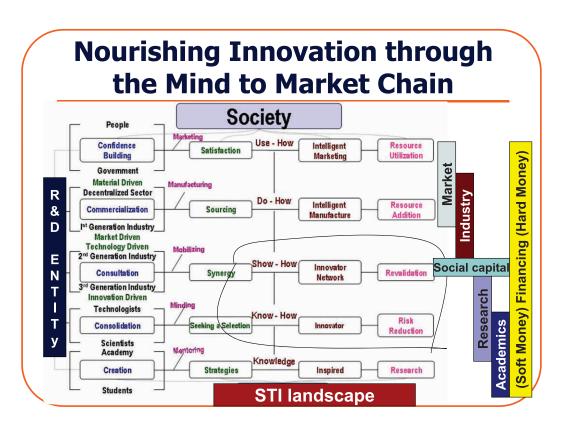
Dr T. Ramasami



15th Nov 2011

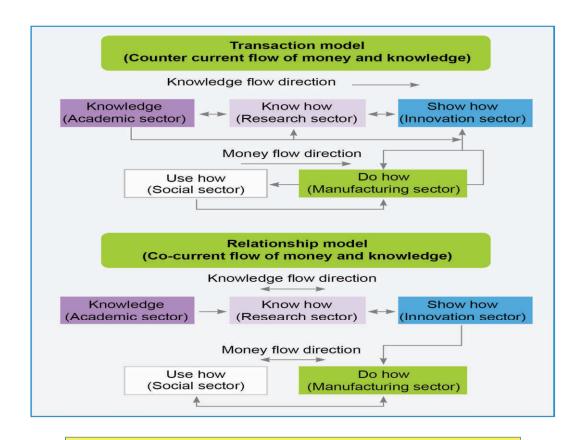
Innovation Round Table





A Challenge for scaling innovations:
Bridging Social capital based on
trust and risk preparedness

Fostering viable and sustainable Innovation partnerships within the Mind to Market Chain and Financing innovations



# PPP for Competition driven pursuit

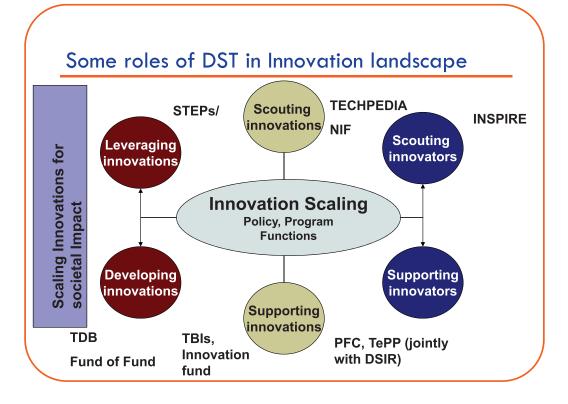


# **Next Generation Model for Innovation: For collaborative Excellence**

- Many global models based on large private sector investments exist and they support competitive excellence and protection of IPR tightly
- New Governance models may be required for promoting collaborative excellence in innovation
- Synergies and partnerships are essential elements of a rightly positioned research support system focused on affordable innovations and public and social good
- Next generation model for innovation support should address the needs of collaborative excellence
- India enjoys an advantage for cost optimization of innovations and this may well be a dying advantage.

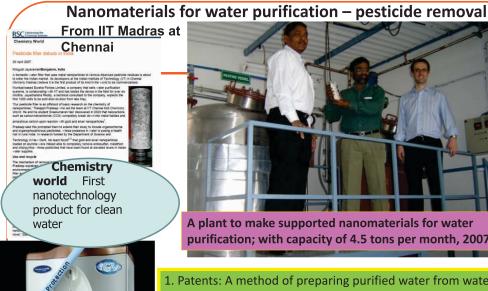
# Some Learning Experience

In Innovation Landscape



# Engagement of DST in the current Innovation Landscape

- Registration and support to Grass root and social Innovation
  - Through NIF and TePP in Partnership with DSIR
- Scouting and backing Innovations
  - DST-INTEL, DST-Lockheed Martin, DST-IIM(A)-ET, GITA with CII
- Incubation for Innovations
  - STEPs, TBI
- Revolving Fund in partnership with SIDBI
  - TIFAC action for supporting viability assessment and scaling
- Innovation Fund for Innovation clusters
  - Joint activity with NASSCOM
- Venture Financing support for Innovations
  - Technology Development Board through direct financing and Fund of Funds through equity in venture capitals
- Technology Acquisition Fund and National Innovation Fund
  - Efforts underway for deploying Technology Cess funds into Acquisition fund
- Developing indicators for innovation indexing
  - Partnership with OECD explored





A plant to make supported nanomaterials for water purification; with capacity of 4.5 tons per month, 2007

- 1. Patents: A method of preparing purified water from water containing pesticides, Indian patent 200767
- 2. Extraction of malatheon and chlorpiryhphos from drinking water by nanoparticles ..., PCT application, PCT/IN05/0002

Product is marketed now by a Eureka Forbes Ltd. Several new technologies are now available.

#### Innovation from Research Institutes

- Chitra valve Unique in design, materials of construction and fabrication. It is the most extensively researched, tested, and pre market clinically evaluated device in India. **ARCI**
- Based on accelerated durability tests, amply confirmed by measurement of wear of valves explanted after many years of animal implantation, the projected durability far exceeds the life span of even the youngest recipients. The valve commands 25% market share currently
- ARCI has developed a product based on nano silver for purification of water. Ceramic based filter candles have been developed and commercialized



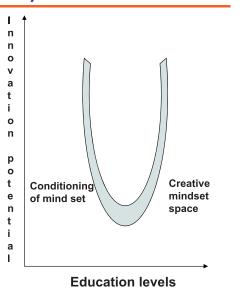
Chitra valve



Ceramic water filter

#### Grass root innovation system

- National Innovation Foundation Experience
  - Grass root innovators create affordable and social innovations; 160000 practices registered. A large untapped potential exists
  - Due diligence on marketing potentials and new mechanisms for leveraging grass root innovations may well be the next step forward



Incubating Enterprises within Academic system

Some lead examples

#### Incubator and Science and Technology Park Network



- IKP, Hyderabad ICRISAT, Hyderabad
- University of Hyderabad University of Delhi
- Sriram Inst. TBI, Delhi
- IAN-TBI. Delhi
- NID-NDBI, Ahmedabad
- Nirma Labs, Ahmedabad CIIE, IIM Ahmedabad
- 10 MICA, Ahmedabad 11 NSIC, Rajkot
- 12 NDRI, Karnal
- 13 MDI, Gurgaon
- 14 BITS, Meshra 15 Composites Tech. Park, Bangalore
- 16 E health-TBI, Bangalore
- 17 MIT, Manipal
- 18 JSS STEP, Mysore
- 19 NIT, Surathkal
- 20 BEC-STEP, Bagalkot
- 21 NIT, Calicut 22 Technopark-TBI, Trivandrum
- 23 Amrita TBI, Kollan
- 24 IIT-SINE, Mumbai
- 25 MITCON, Pune 26 NCL-VC, Pune
- 27 D.K.T.E. Textile Engg, Kolhapur
- 28 STP, Pune

- 29 MANIT, Bhopal
- 30 KIIT University, Bhubaneshwar
- 31 Thapar University, Patiala
- 32 GNEC-STEP, Ludhiana
- 33 BITS, Pilani
- 34 KEC, Perundurai 35 VIT -TBI, Vellore
- 36 Anna University TBI, Chennai 37 University of Madras, Chennai
- 38 IIT-RTBI, Chennai
- 39 BAIT, Sathvamangalam
- 40 Periyar TBI, Thanjavu 41 SPEC-TBI, Chennai
- 42 TREC-STEP, Tiruchirapalli
- 43 PSG-STEP Coimbatore
- 44 PSG-Nanotech TBI, Coi
- 45 TNAU, Coimbatore 46 Vel Tech, Chennai
- 47 JSSATE TBI, NOIDA 48 Amity TBI, NOIDA
- 49 KIET, Ghaziabad
- 50 IIT, Kanpur
- 51 IT-BHU, Varanasi
- 52 HBTI, Kanpur 53 IIT, Roorkee
- 54 Ekta-TBI, Kolkata
- 55 IIT, Kharagpur

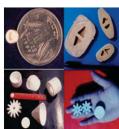


Ceeyes Metal Reclamalation Pvt. Ltd: A global company Led by S. Ananthakrishnan, alumni TREC, Trichy, incubated by TREC-STEP



Embedded Horns for cycles and Remote Light Controllers (RLC), Kongu engg. Coimbatore

Robokit developed by TRI Technosolutions REALTECH Pvt Ltd, a SINE company promoted by IIT Bombay alumnus



**ANTS Ceramics** Limited is an advanced materials manufacturing company started by graduates and faculty at IIT Kharagpur.



#### **Commercial products from** TBIs supported by DST



Science and Technology Entrepreneurship Parks (STEPs) and Technology Business Incubators (TBIs)

- DST has supported the formation and nurtured 64 STEPs/ TBIs so far in India
  - They has spun off about 2600 companies which have created about 26,000 jobs
  - The turn over of these companies is estimated @ 7,000 crores
  - They have served to connect academic and research systems to business incubation

There remains an open opportunity to nourish the Technology
Business Incubation systems in academic sector



The Power of Ideas is an entrepreneurial platform created by The Economic Times in association with the Department of Science and Technology to seek, reward, nurture and groom business ideas by connecting them with relevant evaluators, mentors and investors ......

Call for "Power of Ideas" received 16000 plus proposals; they were short-listed to 250 plus, connected venture capitalists, ~15 companies formed

#### Leveraging Innovations through formal sector

- Technology Development Board
  - TDB supports commercialization of innovations through venture fund support
  - Rs 585 crores claimed from the Government and released about ~Rs 890 crores sanctioning about Rs 1100 crores
  - Overall success rate is ~70%

- Vaccines
  - Shantha biotech, Bharath Biotech
- LCD Systems
  - Samtel
- Electric Mobility
  - REWA
- Civil Aviation
  - SARAS
- Home land Security
  - CEL

#### Some key products from TDB support







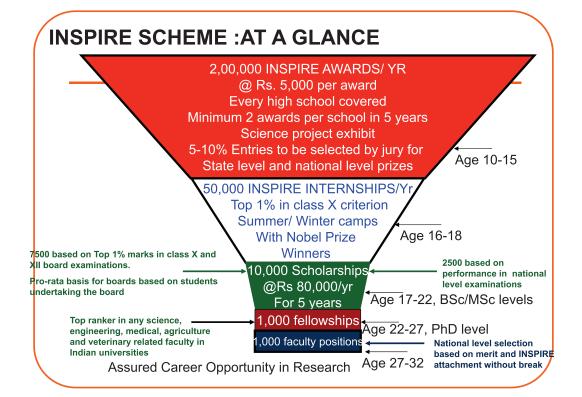
# Building innovators (Promoting innovative spirit among youth)

In the long Term horizon

- Talent attraction
- Mentorship building

15th Nov 2011

Innovation Round Table



#### INSPIRE IMPLEMENTATION STATUS

#### **INSPIRE AWARD**

6.5 lakh INSPIRE AWARDS released One national level Exhibition held Second Exhibition planned in Oct 12 Age group 10-15

#### **INSPIRE INTERNSHIP**

The programme has made a difference to 7500 CAMPS HELD. 30 NLs joined 1,20,000 INTERNS GAINED 3500 RESOURCE PERSONS ENROLLED Age 16-18 INSPIRE SCHOLAR

INSPIRE SCHOLAR
SHIPS ~15000
Age 17-22 BSc/MSc
INSPIRE FELLOWS
~1600 Age 22-27 PhD
74 awarded, 101 selected

Faculty Award for Assured Career under of age32

#### Attraction of Talent to Science

Science Awards

the science

sector

already

- From among 210,000 children in the age group of 10-15, 688 were selected for project competition at National levels
- National level competition revealed the innovation potentials of the youth. Some IPR worthy exhibits entered; 85 provisional applications made

Science Camps across the Country



#### Building Educators for Science Teaching: Scheme under development

- A new large scale motivational programme for teachers engaged in primary, secondary and tertiary education is being developed jointly by MHRD and MoST under a Grand Alliance Initiative
- The programme targets ~ 0.5 million teachers who are already in position.
- This target group could also be motivated to spread the cause of innovations in the educational system
- Whereas our traditional education system is focused on understanding Nature and not as much on solving problems, the programme could be used to the convey the cause of innovation ecosystem.

# Some generic lessons learnt for scaling innovations

- Innovation ecosystem would demand readjustments
  - In mind sets of educational system, financial institutions, R&D entities
  - In the governance systems for not treating genuine failures with negative mindset
  - In audit systems for financial discipline
  - Venture capital support system
  - Demand side management of innovation system
- Building Social capital
  - Migration away from
    - Defensive Decision Syndrome into trust based Decision logic
    - Risk averse to risk prepared social behavior
- Fair sized fund for Social Capital
  - National Innovation Fund

# Some lead ideas for promoting Innovation ecosystem

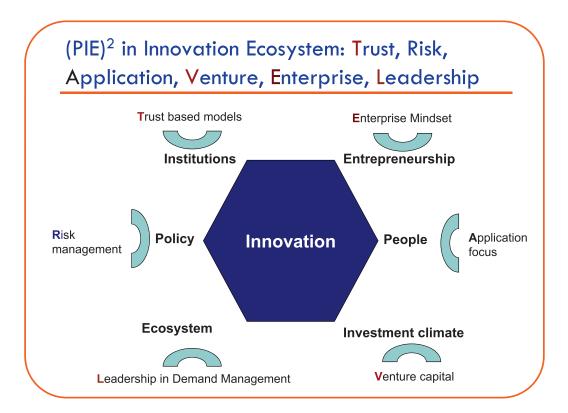
- Joint appointments
  - Academy, Research and Industry
    - Addressing conflicts of interest
- Transition from transaction to relationship model
  - New consortia models for R&D for public good
    - Addressing flaw of flows of knowledge and money
- Creation of PPP fund for R&D for public good
  - New easy to use operational methodologies
    - Built on the principle of "benefit to all" and trust
- New Audit system for innovation support
  - Transition from risk averse and risk promotion
    - Trust based review system with safety provisions

#### A Policy Paradigm for seeding an Innovation Ecosystem

- Engagement of Private Sector into R&D should be promoted soon and more aggressively
- In the intervening times, special policy guidelines for investing public funds into public-private partnerships into R&D for public and social goods may need to be considered.
  - Sub committee of PM's Council for Trade and Industry has
    - submitted a white paper for promoting PPP for R&D and Clean Energy
    - Proposed a PPP fund of Rs 5000 crores
    - Proposed a mission for affordable innovation for public good
    - Recommended the establishment of a Model Global Innovation Cluster
  - Implementation of key recommendations of the sub-committee would promote a desirable innovation system

#### Summary: What have we learnt?

- Innovation is a product of human urge for creation. India seems to enjoy sufficient strength
- Scouting processes for innovation demand many tools.
   Some tools seem to be delivering
- DST has played some limited roles and horizontal functions in demonstrating some untapped potentials
- Scaling innovations for national prosperity seem to require a new type of social capital and viable innovation partnerships. This is an area of gap.
- Innovation is required for fostering innovations for wealth creation





#### An Assessment of the Significant Ingredients of Innovation Ecosystem

by **Prof R. Natarajan** 

### AN ASSESSMENT OF THE SIGNIFICANT INGREDIENTS OF INNOVATION ECOSYSTEM

#### **CONTENTS OF PRESENTATION**

- ➤ Taxonomy Of Innovation:
  - ➤ Visible and Invisible Innovation
  - > Types of Innovation Wikipedia
  - ➤ Disruptive Innovation
- ➤ Indian Innovation:
  - **>**Jugaad
  - > Frugal Engineering
- > Innovation Metrics

- ➤Innovation Ecosystem
- ➤ Strategic Resources for Innovation
- Strategic University Research Policy
- ➤ Innovation-promoting Initiatives in the Academe
- ➤ Shortcomings of Present University Curricula
- ➤ Innovation Management

### INDIA INSIDE Nirmalya Kumar and Phanish Puranam

- ➤ If Indians are so smart, then where are the Indian Googles, iPads and Viagras? Where is the innovation?
- ➤ They were told to go to Silicon Valley, to the most creative companies like Microsoft, Intel, Google.
- ➤In each case they found that an Indian was the Head of the Innovation Center!

#### **INVISIBLE INNOVATION**

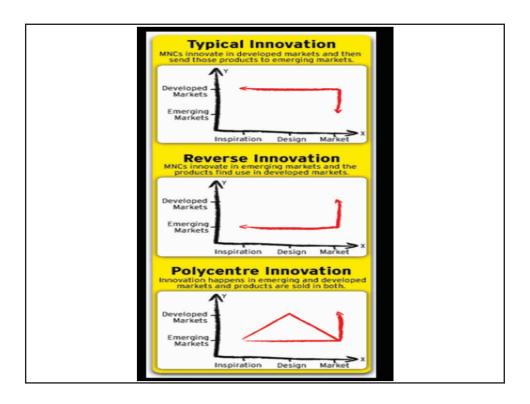
- Then they went to Bangalore, the Silicon Valley of India. And what they found was that the question is wrong.
- ➤ The Googles, iPods and Viagras are a certain kind of innovation -- the kind of innovation that the end user sees as a customer. B to C Innovation
- ➤ But there is a lot of other kinds of innovation that are happening in India that they call invisible innovation.
- ➤In almost every product that we are using today, some part of it was developed in India. It is just that it is not branded "India Inside".

#### **INVISIBLE INNOVATION**

- ➤ India is home to a number of multinational R&D facilities where small groups of scientists work on global products.
- > The way the work is divided, it becomes impossible to tell where the product was created.
- > "Yet global consumers rarely recognize India as the country of innovation because most of the innovation takes place in the B2B context."
- ➤ Case in point: The number of patents filed by Indian subsidiaries of U.S. multinationals rose from 35 in 2001 to 800 in 2007.

### VISIBLE AND INVISIBLE INNOVATION Nirmalya Kumar and Phanish Puranam

Visible Innovation	New products/services for end users	
Invisible Innovation	Globally segmented innovation: how MNCs leverage Indian Talent	
	Outsourcing innovation: R&D services on demand	
	Process Innovation: an injection of intelligence	
	Management Innovation: The global service delivery model	



#### **TYPES OF INNOVATION (Wikipedia)**

#### Sustaining (Incremental) Innovation

An innovation that does not affect existing markets.

#### **Evolutionary Innovation**

An innovation that improves a product in an existing market in ways that customers are expecting. (E.g., <u>fuel injection</u> in SI engines)

Revolutionary Innovation (discontinuous, radical)
An innovation that is unexpected, but nevertheless does not affect existing markets. (E.g., the <u>automobile</u> – hybrid vehicles, electric vehicles)

#### Disruptive Innovation

An innovation that creates a new market by applying a different set of values, which ultimately (and unexpectedly) overtakes an existing market. (E.g., the Ford Model T replacing horse carriages)

#### **INNOVATOR'S DILEMMA** – Clay Christensen, 1997.

- Why so many successful, well-run cos. find it so difficult to sustain their success over long periods.
- <u>Christensen:</u> The same factors that are responsible for their success can, and do, lead these cos. to be blindsided by new technology, that is simpler, cheaper and more versatile than the incumbent product, even though, at least initially, it cannot match performance.
  - disruptive innovations / technologies.

#### <u>DISRUPTIVE TECHNOLOGIES OBSOLETING</u> ESTABLISHED TECHNOLOGIES -- I

#### **ESTABLISHED TECHNOLOGY**

- Graduate Schools of Management
- Classroom and Campus-based instruction
- Standard textbooks
- Offset printing
- Microsoft Windows Operating Systems and Application Software written in C++

#### **DISRUPTIVE TECHNOLOGY**

- Corporate universities and in-house management training programs
- Distance education, typically enabled by the internet
- Custom-assembled modular digital textbooks
- Digital printing
- Internet protocols (IP), and Java software protocols

#### <u>DISRUPTIVE TECHNOLOGIES OBSOLETING</u> <u>ESTABLISHED TECHNOLOGIES -- III</u>

#### ESTABLISHED TECHNOLOGY

- Silver halide photographic film
- Wire line telephony
- Circuit-switched telecom networks
- Notebook computers
- Desktop personal computers
- New York and NASDAQ Stock Exchanges

#### **DISRUPTIVE TECHNOLOGY**

- Digital photography
- Mobile telephony
- Packet-switched communications networks
- Hand-held digital appliances
- Laptops, Tablet PCs, iPads,
- Electronic Communications Networks (ECNs)

#### <u>DISRUPTIVE TECHNOLOGIES OBSOLETING</u> ESTABLISHED TECHNOLOGIES -- IV

#### **ESTABLISHED TECHNOLOGY**

- . Bricks and mortar retailing
- Industrial materials distributors
- Printed greeting cards
- Electric Utility Companies

#### **DISRUPTIVE TECHNOLOGY**

- On-line retailing
- Internet-based sites such as Chemdex and e-Steel
- Free greeting cards, downloadable over the internet
- Distributed Power Generation (Gas Turbines, Micro-Turbines, Fuel Cells)

## INDIA RANKED SECOND IN GLOBAL INNOVATION EFFICIENCY INDEX [TOI JULY 3 2012]

- ➤ India has jumped to the second position in the Global Innovation Efficiency Index in 2012, from 9th position last year, according to INSEAD and the World Intellectual Property Organization.
- It is a metric to assess the innovation landscape in different countries.
- Countries which are strong in producing innovation outputs, despite a weaker innovation environment and inputs, are poised to rank high in the efficiency index.

#### **JUGAAD**

- ❖ A colloquial term to represent :
  - > "creative improvisation" or "making do"
  - " finding fixes " or " workarounds"
  - > creating solutions in the face of constraints
    - social, economic, technological
  - "signal resignation to current constraints"
- \* "Excessive dependence on the jugaad mindset may, in fact, impede the ability to fundamentally transform a situation through disciplined engineering"

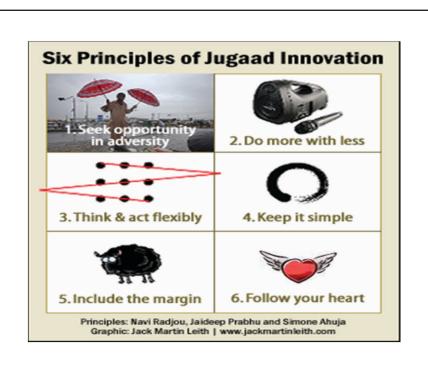
#### **WIKIPEDIA**

>" The term is still used for a type of vehicle, found in rural India, made by carpenters by fitting a diesel engine on a cart".









#### **FRUGAL ENGINEERING**

- ➤ A term coined by Carlos Ghoshn, Head of Renault-Nissan
- ➤ "Achieving more with fewer resources"
- > " Unlike Jugaad, Frugal Engineering is
  - " a systematic approach to making the constraints irrelevant, or at least less important "

#### **MEASURING INNOVATION**

"What we measure affects what we do.
We will never have perfect measures—
and we need different measures for different
purposes."

— Joseph Stiglitz

#### **INNOVATION METRICS**

Innovation That is Measured is Treasured

Like human health, there isn't any single measurement adequate to capture innovation's multiplicity of features.

- ❖ National measurement of innovation today is based on the old paradigm of an industrial economy, and for the most part measuring:
  - ➤ Inputs to innovation (R&D expenditures, education expenditures, capital investments); and
  - ➤ Intermediate outputs (publications, patents, workforce size and experience, innovative products).

- ❖ Services were conspicuously absent in traditional approaches.
- Accordingly, innovation measurement tended to be focussed on products and related production systems.
- More recently, there has been significant progress in delineating: The multiplicity of resources required for innovation

#### **USEFUL PROCESS METRICS**

- >R&D spending as a percentage of sales
- > Other process metrics include:
  - ❖Number of ideas in the pipeline
  - Number of ideas sourced from outside the organization

#### **SUMMARY INNOVATION INDEX**

- > Part of the European Innovation Scoreboard
- ➤ It measures innovation from an input/output perspective.

- ❖ Sample inputs include:
  - > tertiary education,
  - > ICT penetration,
  - > R&D and ICT expenditures, and
  - > Small and medium-sized firm policies.
- Sample outputs include:
  - > high-tech exports and employment,
  - > sales of new market products, and
  - > patents and trademarks

#### **GLOBAL INNOVATION INDEX**

❖Created by INSEAD in collaboration with the Confederation of Indian Industries, The Global Innovation Index groups over 90 indicators combining quantitative data with a large number of indicators drawn from the World Economic Forum's (WEF) Executive Opinion Survey

#### **GLOBAL INNOVATION INDEX**

- ➤ The Global Innovation Index 2011 (GII) is calculated as the simple average of:
  - > the Innovation Input Sub-Index, which captures the enabling environment for innovation; and
  - ➤ the Innovation Output Sub-Index, which captures the results of innovation.

#### **FIVE INPUT PILLARS AND TWO OUTPUT PILLARS**

#### **FIVE INPUT PILLARS**

- 1. Institutions,
- 2. Human capital and research,
- 3. Infrastructure,
- 4. Market sophistication,
- 5. Business sophistication

#### **TWO OUTPUT PILLARS:**

- 1. Scientific outputs, and
- 2. Creative outputs

#### **INDIA's RANKINGS**

#### **GLOBAL INNOVATION INDEX**

Switzerland	1st Rank	68.2 / 100
UK	5 <sup>th</sup> Rank	61.2
USA	10 <sup>th</sup> Rank	57.7
China	34 <sup>th</sup> Rank	45.4
India	65 <sup>th</sup> Rank	35.7

### UNCTAD's INNOVATION CAPABILITY INDEX Rishikesha T Krishnan

- UNCTAD'S World Innovation Report (WIR) 2005 proposed:
- ➤ Innovation Capability = f (Technological capability, and Human Capital)
- ➤ Technological Activity Index = f ( R&D manpower, patents, articles in scientific journals)
- ➤ Human Capital Index = f ( literacy, secondary enrolment and tertiary enrolments in the ratio of 1:2:3)
- ❖ India's Rank: 66 out of 117 countries on TAI
- ❖ China: 58 on TAI
- ❖ India's Rank: 92 on HCI
- China: 87

# EVOLUTION OF INNOVATION METRICS BY GENERATION (IBM)

I Generation Input Indicators (1950s-1960s)	II Generation Output Indicators (1970s-1980s)	III Generation Innovation Indicators (1990s)	IV Generation Process Indicators (2000+)
R&D Expenditures	Patents	Innovation surveys	Knowledge
S&T Personnel	Publications	Indexing	Intangibles
Capital	Products	Benchmarking Innovation Capacity	Networks
Tech Intensity	Quality Change		Demand
			Clusters
			Management Techniques
			Risk / Return
			System Dynamics

#### **SIEMENS AND 3M**

- ❖ According to Siemens, their measure of success is that '90 % of the products we sell are not older than two years'.
- ❖The 3M Co. is proud that '30 % of their products come from products less than 3 years old'.
- ❖ Both value Sustained and Continuous Innovation

#### <u>INNOVATION – PROMOTING ENVIRONMENTS</u>

- Innovation is more about creating environments that foster innovations than about brilliant individuals.
- It is often observed that the same creative individuals will be more creative in certain environments than others.

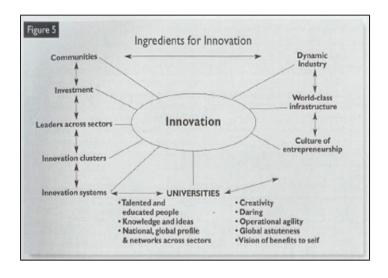
#### Wm. Wulf (Former President , NAE, USA):

- There is no simple formula for Innovation
- However, a "multi-component environment" appears collectively to encourage or discourage Innovation.

# SOME ESSENTIAL COMPONENTS OF THIS ENVIRONMENT:

- A vibrant research base
- An educated workforce
- A culture that permits, even encourages, risk-taking.
- A social climate that attracts the best and brightest from anywhere in the world to practise engineering.
- "patient capital" available to the entrepreneur.
- Tax laws that reward investment
- Appropriate protection for IP.

#### INGREDIENTS FOR INNOVATION



# DESIRABLE CHARACTERISTICS OF INNOVATORS AND ENTREPRENEURS

- ❖The 3M Co. looks for people with specific traits as indicators of their potential to be innovators:
  - Creative
  - · Broad interests
  - Problem-solver
  - · Self-motivated, energized
  - · Strong work ethic
  - Resourceful

#### STRATEGIC RESOURCES FOR S&T INNOVATION

- ❖ Research and Development.
- ☐ Universities and University R&D are the major suppliers of a nation's:
  - Knowledge
  - · Knowledge workforce; and
  - · Innovative technologies
- ❖ Talent:
- ☐ Talented people are at the heart of:
  - Innovation
  - · Sustainable growth of good jobs; and
  - The competitiveness of nations.

#### THE STRATEGIC ROLE OF UNIVERSITY RESEARCH

Report on "Growing Ontario's Innovation System":

Heather Munroe-Blum, James Duderstadt & Sir Graeme Davies – Dec. 1999

#### Recommendations in the Report:

- Create an optimal university research policy -environment for Innovation
- Grow Talent and University Research competitiveness
- Construct a world-class Infrastructure
- Expand the impact of university research
- Foster Entrepreneurship
- Foster local, national and global innovation networks and global profile
- Celebrate people, achievements and success.

# INNOVATION – PROMOTING INITIATIVES IN THE ACADEME

- I. Foundation for Innovation and Technology Transfer (FITT) at IIT Delhi
- Established as a Regd. Society in 1992, with the mission:

"To be an effective *interface* with the industry to foster, promote and sustain commercialization of S&T in the Institute for mutual benefits".

Among the key terms of reference:

"To add commercial value to academic knowledge and to market the intellectual and infrastructure resources of IIT Delhi for national development".

#### II Society for Innovation and Development (SID) at The Indian Institute Of Science (IISc), Bangalore

❖ Founded in 1999 with the mission:

"To enable India's innovations in S&T by creating a purposeful and effective channel to help and assist industries and business establishments to compete and prosper in the face of global competition, turbulent market conditions and fast-moving technologies".

SID has a symbiotic relationship with IISc in an industry-friendly as well as faculty-friendly way.

### **IIT MADRAS RESEARCH PARK**Bringing Unlike Minds Together

- ➤ The IIT Madras Research Park is modeled along the lines of successful research parks at Stanford and MIT.
- > The Golden Triad: Essential Elements:
  - ❖R&D personnel: bring in rich insights of the industry and market
  - ❖ Faculty : Encompassing a wealth of knowledge from multiple domains and departments
  - Students: Who work relentlessly, oblivious to the risk of failure

#### **CREDIT POINTS SYSTEM**

- ➤ IIT Madras Research Park has a proprietary CREDIT system to measure the extent of collaboration between a company and IIT Madras.
- CREDIT is an acronym for Collaboration in Research and Engagement with Departments in IIT Madras.
- ➤ The Research Park is *not* a real estate proposition. It is an *ecosystem* that facilitates R&D and innovation.

#### **INNOVATION UNIVERSITIES**

- ➤ Bill to be introduced shortly.
- ➤ Universities for Innovation:
  - ❖ "for making India the global knowledge hub, and
  - for promoting synergies between teaching and research to create institutions universally recognized for quality in teaching, learning and research"

# "ADVANCING INVENTIVE CREATIVITY THROUGH EDUCATION The Lemelson MIT Workshop - 2003

#### THE SHORTCOMINGS OF PRESENT CURRICULA

- ➤ An over-emphasis on deductive learning and an under-emphasis on experimental and inductive learning.
- ➤ Curricula providing insufficient support to individual initiative and self-discovery—specifying instead narrowly construed learning outcomes, with preconceived answers.

#### **INNOVATION AND INVENTION**

Ideas, Freedom and Diversity, not Rote Learning, will ensure India gets its place in the bold new world Kiran Karnik, Economic Times

- ➤ Of utmost importance is the creation of an ambience and ecosystem that stimulates and nurtures Innovation.
- ➤ Big Drivers of Innovation:
  - ❖ Diversity
  - Adversity

# CAN INNOVATION AND ENTREPRENEURSHIP BE TAUGHT?

#### Radcliffe:

"Innovation and Entrepreneurship are contextual, enacted and holistic activities", and consequently, attempts to extract their elemental parts via a reductionist paradigm for inclusion in a curriculum are likely to fail".

#### McKINSEY WISDOM

- ❖Innovation per se is not such a "good thing".
  The only universally "good thing" is Performance.
- "Who cares if a co. is great at Innovation, if it doesn't perform".
- McKinsey's talk about "earning the right to grow".
  If a co. is performing badly, growth will only drive it deeper into the hole.
- Sustainable and Sustained high performance is the true hallmark of corporate success.

# <u>USING WHAT GOES WRONG IN ENGINEERING</u> <u>TO LEARN HOW TO DO THINGS RIGHT --</u> <u>THE IMPORTANCE OF FAILURE</u>

#### AN EXAMPLE OF "SUCCESSFUL FAILURE" -- The Post-it-Note:

- The self-attaching removable bookmark.
- In trying to develop a new, stronger adhesive for tape, 3M Chemist Spence Silver, managed instead to create a weak one.
- He mentioned the results of his failed experiment to Arthur Frye who was having problem of keeping bookmarks in place in his church hymnal.
- His mind wandered during the dull sermon, and he had one of those 'flashes of insight'.
- A bookmark that would stick and remove without damaging the book.
- Later realized that what they had was not just a bookmark, but a new way to communicate or organize information.
- It is now one of 3M's best-selling products.

## PETER DRUCKER'S AND MASHELKAR'S RULES FOR R&D

- R&D should be business driven, not technologydriven.
- The starting points of the new R&D paradigm are the business goals and strategy of the firm.
- First-rate R&D labs need to be set up as freestanding businesses.
- The R&D function would be better managed by a "Technology Manager" than a "Research Director".
- Mashelkar had restructured the CSIR labs to reach *Lakshmi* through *Saraswathi*

#### CHAPTER 3

#### **CREATING AND NURTURING INNOVATIVE MINDSETS**

#### Introduction

Innovation demands creativity. In other words, all innovation begins with creative ideas.

When we consider innovation, there are essentially two key parts of innovation: creating and thinking newness and implementing the newness.

When considering an innovation mindset, the two critical components are *introducing an innovation culture* and *developing it in the ecosystem*, and it is for leaders in an enterprise to recognize, instill and nurture this mindset.

Creativity is the starting point for innovation. Almost every person is born with the basic physiological apparatus to innovate. Innovations can be broadly classified into three categories:

- Those innovations that are not socially "important" because they do not transcend the innovator's personal experience.
- Those innovations that are "important" because they have an influence beyond the innovator (e.g., creating a successful firm) and very few are "extremely important" because they have major economic or social impacts (e.g., developing an AIDS vaccine).

According to Vandervert (2003), "what makes an innovation an 'important' innovation or a deeply experienced 'insight' is a matter of its cultural or organizational context, and its degree of generalization".

An individual's ability to innovate results from the experiences that influence the how an individual sees, understands and interprets the environment in which he/she is immersed. Individual innovation is the sum product of the imagination of an individual and the representations that he/she creates.

Innovators understand and interpret their reality differently than others. Their representations are general, categorical, conceptually rich, complex and unique, all of which enables exceptional performance and achievements. According to Shavinina and Seeratan(2003), it is this unique representation that is the basis for "seeing" what other people do not see. The talent for innovation results from the interactions between three factors: the above average general and specific abilities, strong task commitment, and creativity (Shavinina and Seeratan (2003)).

Task commitment and creativity can be developed in some people if they are properly stimulated and trained in those activities in which they are talented, and if they develop appropriate links with the environment. But individual responses to the same stimuli are highly variable; even more, it is not possible to predict which individuals will respond favorably to specific stimuli. The nature of the training to develop innovative capabilities depends on the particular areas in which those capabilities will be applied, for example,

scientists receive a more formal training than artists. There is strong evidence, though, creative scientists benefit from being good artists and vice versa.

According to Andy Stefanovich (2011), the creative and innovative mindset is characterized by the five M's framework. The five M's include Mood, Mindset, Mechanisms, Measurement and Momentum.

The creative and innovative mindset is enhanced through four behaviors:

- Changing one's perspective
- Taking risks
- Finding one's passion
- Challenging assumptions and embracing ambiguity

According to Jeff Dyer, Hal Gregersen & Clayton Christensen (2011), there are five skills common in successful innovators:

- Associating Making "connections"
- Questioning Desire to fill gaps in understanding
- Observing Seeing things that others don't see in the things that everyone sees
- Networking Purposeful interactions with others having varied backgrounds and perspectives
- Experimenting The act of seeking answers to "what if"

#### Joy of Engineering, Design and Innovation (JEDI) Competition

A couple of years ago, Former Indian Institute of Science(IISc) professor and entrepreneur Swami Manohar started the Joy of Engineering, Design and Innovation (JED-i) competition that is based on final year projects done by engineering students as part of the engineering curriculum. The premise for organizing such a competition was that final year engineering projects represent a unique opportunity for students to demonstrate their real engineering skills.

The JED-i is organized by Bangalore-based engineering education company LimberLink Technologies Pvt. Ltd in partnership with the Indian Institute of Science and Mint. Prizes were given to final-year engineering projects in three categories—mechanical, electrical and computing, in addition to the overall best project award.

In 2012, the winner was Harshal Choudhari of IIT Madras for a standing wheelchair that allows a user to sit, stand or sleep. While standing wheelchairs exist in other parts of the world, this project aimed to reduce the cost and make them available in India.

A company with an innovation mindset is characterized by its workforce that has a high level of self-confidence and has a shared belief in their own capabilities and strengths.

According to Thomas Kuczmarski (1996), an innovation mindset is a positive and pervasive attitude that should be adopted throughout an organization by virtually every employee, from the CEO to hourly workers. Such a mindset can spread and be adopted and nurtured by others. This mindset stimulates and motivates individual employees, as well as teams, to holistically endorse a belief in creating newness.

Some of the key insights that build the foundation of an innovation mindset include the following:

- 1. Failure is an essential and intrinsic part of innovation. Successful companies understand this, and allow a innovation culture that allows risk-taking. The willingness to accept some failures inculcates confidence and helps in developing an innovative mindset, and in better financial results.
- 2. Using multi-functional teams with dedicated team members is a critical requirement for success. The opposing pulls of responsibilities between new products and the existing business will result in new products playing second fiddle. When people focus on, and have the time, concentration, and motivation, they develop an innovation mindset.
- 3. Financial incentives for stimulating an entrepreneurial environment are more apt to motivate the workforce on new product and innovation teams. By incentivizing people with prizes, an innovation mindset focused on solving big challenges can be developed.
- 4. **Commitment from top management** is crucial for successful innovation. Such commitment from top management is manifested with a perspective and mindset that allows for failures, mistakes and a long- term payback from the investments being made, coupled with a positive, proactive attitude.
- 5. **Identifying innovation values and new product team norms** to guide behavior and communications among team members is crucial. Companies that allow teams to invest adequate time upfront to share their perspectives and inputs, and are open to the inputs made, help to nurture new innovations.

"Breaking with the tradition of cumulative knowledge is a hugely risky step in the current academic world. To build a truly interdisciplinary field is already a revolution. To turn it into a "moving science" seems like a complete upheaval of recent traditions in economics. Yet, this way of producing theory would stimulate young scholars to see the dynamism of technologies and of ideas, locating them in their context and judging them and their policy implications in a truly evolutionary way. It would also vaccinate them against copying the recipes of the past and would move them to anticipate the opportunities of the future."

#### - Carlota Perez (2012)

Some of the key steps that can be taken by companies to create and nurture an innovation mindset include the following:

- **Support:** Enterprises can support their enthusiastic employees to work on their creative ideas, outside of their formal role and responsibilities, through formal processes to develop the ideas into workable innovations.
- **Engage:** Employees can be engaged and encouraged to share their ideas and inputs, and this will help in improving the overall innovation mindset and culture.

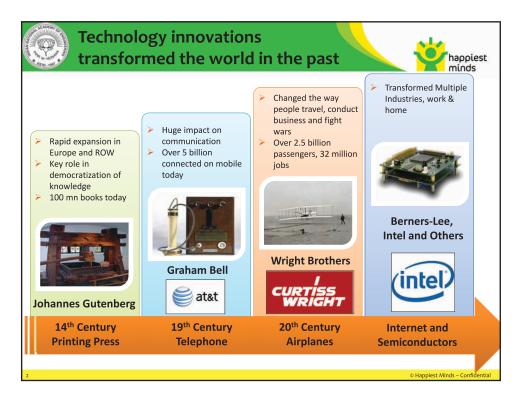
• **Be Bold:** Companies should be willing to take risks, and be prepared to deal with failures.

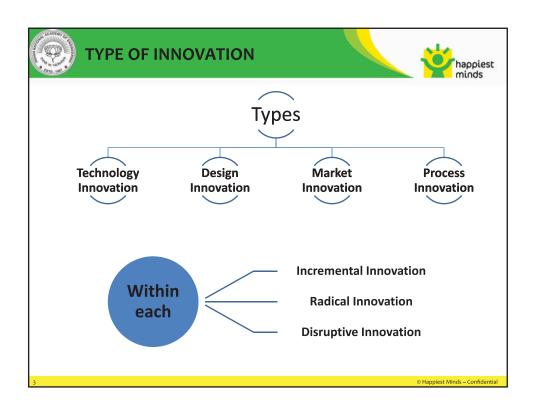
#### **Salient Observations**

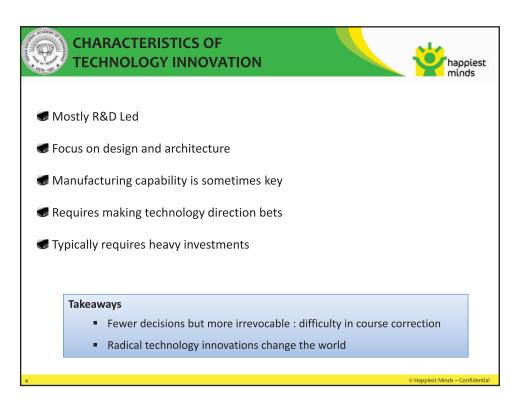
- Conventional engineering teaching is deductive, beginning with the basic theories and continues to the applications of those theories. The current paradigm for engineering education, e.g., an undergraduate degree in a particular engineering discipline, occasionally coupled with workplace training through internships and perhaps further graduate or professional studies, seems increasingly suspect in an era in which the shelf life of taught knowledge has declined to a few years.
- Employers prefer engineering graduates with both technical and non-technical abilities. To build an innovation ecosystem, the need of the hour is engineers who think and act as entrepreneurs. Some of the critical skills that a student needs to contribute in the system, include technical skills, a facilitative innovation environment, entrepreneurship skills, communication skills, knowledge & experience, and commitment to life long learning.
- One of the recent approaches that have been applied to engineering education is the experiential learning approach described as "learning by doing".
- The need of the hour is to redefine the nature of basic and applied engineering research, developing new research paradigms that better address compelling social priorities than those methods characterizing scientific research.
- There is a need to adopt a systemic, research-based approach to innovation and continuous improvement in engineering education, recognizing the importance of diverse approaches—albeit characterized by quality and rigor—to serve the highly diverse technology needs of our society.
- India has been responding to the innovation challenges through multiple approaches:
  - One of the critical issues facing the world today is attracting talented young people to make their careers in science and technology. INSPIRE program of Department of Science and Technology (DST) has taken the right step in this direction.
  - Techpedia is a portal of technology projects by students to link the needs of industry and grassroot innovators with young minds and to promote collaborative research. SRISTI has taken this initiative for promoting originality among young tech minds. The goal also is to link industry and informal sector with academia through the help of students volunteers from different parts of the country but mainly at SVNIT, Surat.

# Technology Innovation and Innovation for the Market

by
Ashok Soota
Executive Chairman
Happiest Minds Technologies









## CHARACTERISTICS OF MARKET INNOVATION



- Requires better contextual understanding:
  - Demographic shifts
  - Emerging markets
  - Global distribution of opportunities
  - Integrating technologies
- Taking bets on which market trends will take off
- Often leverages new emerging technologies e.g. cloud, mobility, social media, big data, analytics.
- Frequently creates new business models
- Market innovations can have multiplier effect with the right eco system creation

#### **Takeaways**

- The Internet has greatly reduced the cost of market innovation
- Increasingly taking place on the edge

Happiest Minds – Confidential



## Examples of Contextual Understanding for Market Innovation







"By 2016, the number of mobile devices is likely to outnumber the human beings on the planet"



"Cloud adoption is beyond the tipping point – the benefits of resource optimization, agility and cash flow management just cannot be ignored any longer."

"Data warehousing and reporting is not enough – the need today is to draw meaningful insights from information available via business analytics"







"Social Media is likely to become a primary means of customer communication over the next 5 years"





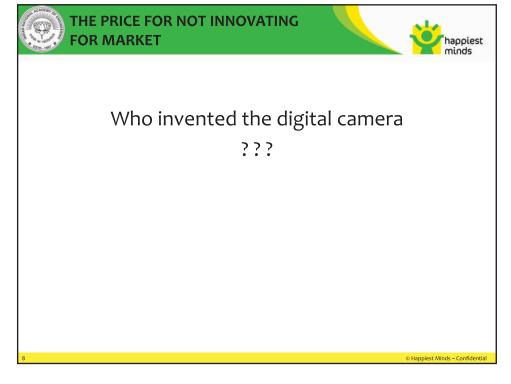


#### Takeaway:

Digital disruptions are driving the change

Happiest Minds – Confidential









#### Who invented the digital camera?

## **Kodak** 1975



#### Takeaways

- Technology innovations must be taken to market and monetized
- If you don't cannibalize your own product someone else will
- Be careful how you define your business e.g., Films v/s camera
- If you don't innovate, you are susceptible to disruption

Happiest Minds - Confidential



#### **DISRUPTIVE INNOVATION**



#### What is disruptive innovation

© Displacement of incumbents (sometimes an entire industry) by new entrants.

#### Means of disruption

- New technologies (digital cameras)
- New uses for existing products (the mobile phone is disrupting dozens of products e.g. GPS Systems, music players, cameras etc.
- © Globalization froces: e.g. Indian IT industry
- O New business models e.g., SaaS

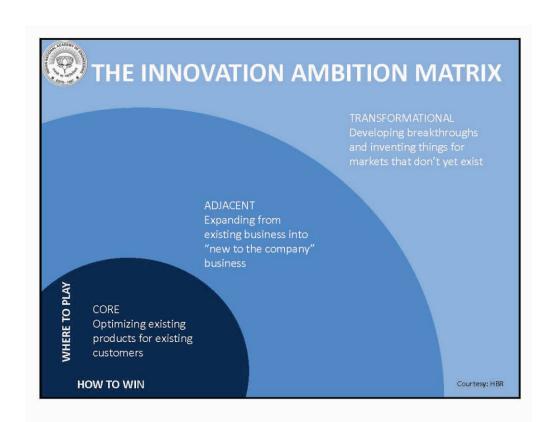
#### Why disruption occurs

© Many disruptive markets begin small and large players ignore

#### **Takeaways**

- For disruption don't market for the near term
- Today's disruptor can be disrupted tomorrow

Happiest Minds - Confidential





TYPICAL PROFILE FOR SUCCESSFUL

#### **Takeaways**

- Cannot afford to neglect the core and adjacent
- Excessive transformational investment can bet the company
- As a company/industry matures need to shift focus from Core to Transformational (relevance for Intel?)

Happiest Minds - Confidential



#### **SUMMARY OF TAKEAWAYS**



- Key differences in characteristics of Technology and Market innovation.
- 2. Technology decisions have higher lock in, higher investments and more difficult to course correct.
- Market innovations require better contextual understanding and frequently create new business models. Creation of an ecosystem creates a multiplier effect.
- 4. For market innovation rely on market research <u>and</u> focus group <u>and</u> observation <u>and</u> experience.
- 5. If you don't cannibalize your product (when technology makes it possible) someone else will.



#### **SUMMARY OF TAKEAWAYS**



- 6. Disruption surprises incumbents because new markets begin small. Today's disruptor can be disrupted tomorrow.
- 7. Every company must seek its own optimum mix of innovations for the core, adjacent markets to transformational innovation. This can change over time.
- 8. Today's world seems to notice and value market innovators more than technology innovators, though most of the important transformations in the world have come through Technology changes.
- 9. Innovation must deliver business value and organizations must measure their "Return on innovation".

© Happiest Minds – Confidential

# Bridging the Gap between Invention and Innovation

by

Prof. Dr. Otthein Herzog





#### Innovation - what is it??

The Indian National Knowledge Commission defined innovation as 1:

"Innovation is defined as a **process** by which varying degrees of **measurable value enhancement is planned and achieved**, in any commercial activity. This process may be breakthrough or incremental, and it may occur systematically in a company or sporadically; it may be achieved by:

- > introducing new or improved goods or services and/or
- > implementing new or improved operational processes and/or
- > implementing new or improved organizational/managerial processes

in order to improve market share, competitiveness and quality, while reducing costs."

1Dr. Ashok Kolaskar, Shriya Anand, Amlanjyoti Goswami, Innovation in India, National Knowledge Commission, 2007 acetech | August 2012





#### The Economic Crisis Underlines the Need for Substantial Innovations

- > Many national efforts have been started for "sustainable growth through innovation"
  - National innovation strategies must include the international and even global perspective – the grand challenges
  - Most new innovation challenges cannot be solved by one company or even one nation:
     New innovation platforms and instruments are required
  - Integrating the Knowledge Triangle education research business is key
  - Cooperation between different sectors is more important than ever: science, business, government, society
- > Academies can play a key role as independent and trusted advisors for society and politics.





#### acatech - Germany's Voice of Science and Technology

- > The institution:
  - acatech: independent and self-determined representative of science and technology in Germany and abroad
  - Partially funded by the Federal Government and the 16 Federal States as the National Academy of Science and Engineering
- > The acatech network (status: August 2012):
  - 390 members in Germany and abroad
  - 100 senators: business and society
- > The acatech vision:

"Sustainable growth through innovation"

> The acatech mission:

Driving the change, not just "talk and publish"



Head office in Munich



Office in Berlin



**Brussels Office** 





#### The Objectives: Providing knowledge, guidance and support



Scientific recommendations acatech advises policy makers and the public on technology issues



> Knowledge transfer acatech offers a platform for knowledge exchange fostering cooperation between science and businesses



> Promotion of young scientists and engineers acatech is committed to support young scientists and engineers



> Voice of science and engineering acatech represents the interests of German science and engineering on a national and international level









Biotechnology & Bioeconomy



**Energy & Resources** 



Healthcare Technologies



Information & Communication Technologies



Mobility, Logistics, Aerospace Engineering



Materials Science & Engineering



Nanotechnology



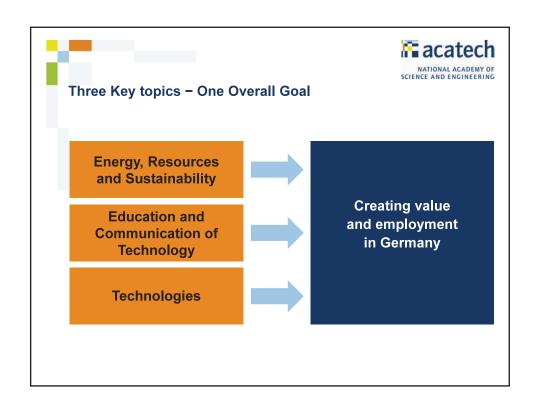
Product Development & Production

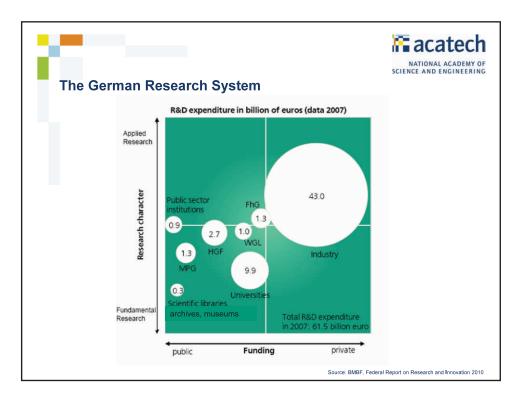


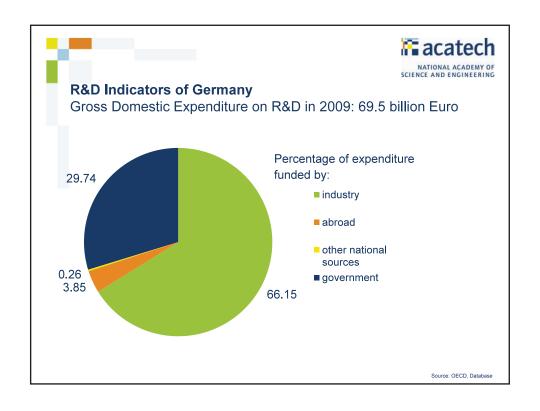
Safety and Security

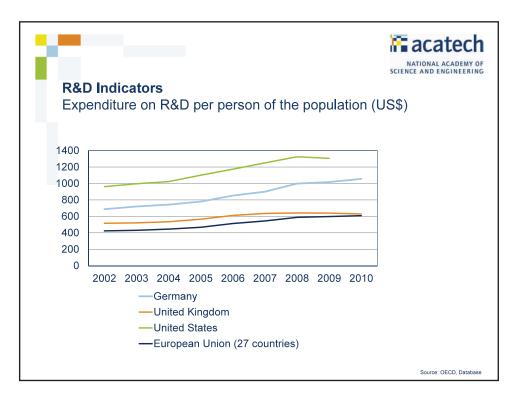


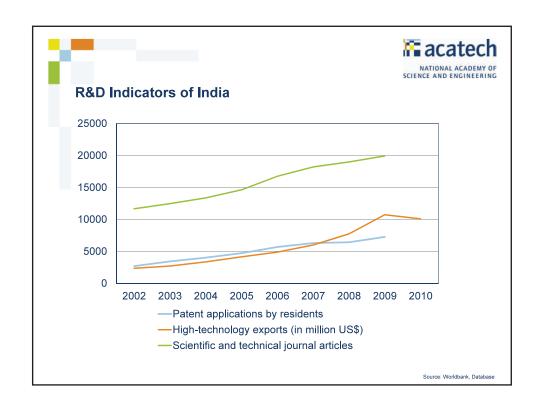
Society & Technology

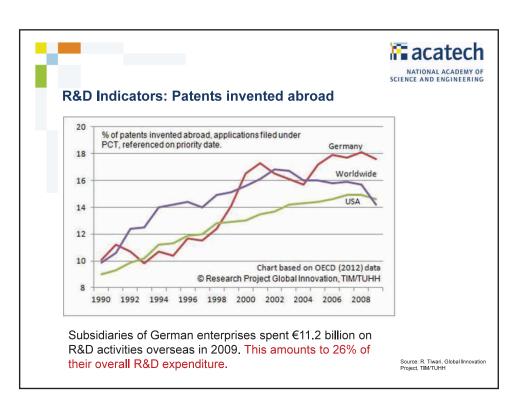
















#### Indo-German Collaboration on Innovation

- > India has an enormous potential for future R&D activities:
  - Talent resources
  - Growth in economic development
  - Market potential
- > Strong innovation efforts make India an attractive destination for research and development.
- India only lags behind China and the USA regarding its potential for future R&D activities. [UNCTAD (2005)]
- > R&D indicators for India regarding patent applications, hightechnology exports and scientific journal articles confirm this trend over the past years.

Source: Final Report: German and Indian Innovation Systems. Fraunhofer IAO





#### **INAE - acatech Collaboration for Innovation**

#### Joint Memorandum signed by INAE and acatech:

- > Study Visits
  - Exchanges of scientists, engineers, and technologists
- > Exploratory Missions
  - Facilitate joint ventures and collaboration in engineering, science, and technology.
- > Joint Seminars/Workshops
  - Joint seminars/workshops to improve the level of cooperation between scientists, engineers, and technologists of both sides.
- > Exchange of information and publications
- > Bi- or multi-lateral acitivities of mutual benefit
- → Sound basis for an Indian-German Innovation Platform
- → Sound basis for Indian-German innovation projects









### acatech Innovation Policy Advice to the German Government

Example: The Megacities Challenge – Smart Cities

#### Some Recommendations:

- > Smart technological innovations for Smart Cities are the result of problem-oriented and interactive processes between all stakeholders involved
- > The solutions depend on internationally recognised norms and technology standards
- > Pilot projects and reference cities are vital
- > Research funding and competition provide incentives for building up Smart Cities

#### **Key Technologies:**

- > Broadband across all city areas
- > Smart distribution grids
- > State-of-the-Art sensor networks
- > City data clouds and City Operating Systems
- > System integration technologies







#### acatech Smart City Project in Bangalore, India



- > Preparation by four workshops and four Symposia held in Bangalore
- > Identification of stakeholders: government, industry, science, NGOs



- Technology transfer and test in a real-life environment with a high solution potential
- Participation of government, industry, science and NGOs from India and Germany
- Visibility in India by two symposia during the German-Indian Year 2011/2012
- > Initial Projects are initiated in Bangalore



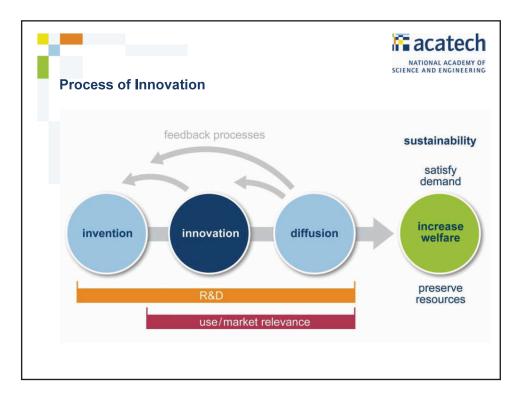


#### **Indo-German Collaboration in Innovation**

Opportunities and challenges

- India has positioned itself mainly as a service provider, especially in the ICT industry. There is a lower proportion of people working in research and development than in industrialized countries.
- > Industrial R&D expenditure is closely linked to the creation of new products and production techniques. They are considered to be an important driver of economic growth.
- > In Germany more than **two thirds of the annual funding** invested in research comes from the **private sector**. Focus of this research is mainly on applied and result-oriented science.
- > The experiences of Germany in the field of collaboration between public research and industrial R&D could open opportunities for India to move from global "service provider" to "innovation initiator".

Source: Final Report: German and Indian Innovation Systems. Fraunhofer IAO







#### **External Structures of Innovation Systems**

#### **Networks**

- Strategic enterprise networks and Cluster: Silicon Valley
- Heterogeneous networks: Business + Science + Politics + Governance/Judiciary

#### Informal Communities of Practice

- · Self-organised exchange, especially of implicit knowledge
- If Communities of Practice deviate from existing an technological paradigm → radical innovation possible

cf. Braun-Thürmann, Innovation, 2005





- > Public spending on innovation as a strategy in coping with the past financial and economic crisis
- > Innovation policy as a strategic approach in specific OECD and newly industrialised countries (e.g., BRICS)
- > Backlog of input factors in Germany:
  - human resources,
  - investment
- > Challenges by new developments in the global innovation system:
  - · Increasing relevance of non-technological, user-driven innovation (service sector)
  - Increasing competition from all over Asia

**Demand for** unbiased policy advice









#### Innovation through Technology Management?

- > Technology is part of the solution of India's innovation activities:
- > Innovation through new technologies is key for break-throughs, BUT:
- > Innovation through process improvements is key for continuous innovation
- > To bridge the gap between invention and innovation, processes must be managed:

from Jugaad to (systematic) frugal innovation (Rishikesha T. Krishnan)





#### Indo-German Collaboration in Innovation

Motivation

- > Several reasons for existing and further Indian German collaboration, for example:
- > R&D wage advantage
  - India has comparatively cheap labour which makes it a great destination for ICT offshoring
- > Tax advantage
  - India provides a generous and competitive tax environment for investment in R&D
- > Talent and skill pool
  - India produces the second largest annual output of scientists and engineers in the world (behind the USA) making the country an attractive destination for acquiring talent

27

Source: Final Report: German and Indian Innovation Systems. Fraunhofer IAO





#### Indian-German Collaboration in Innovation

Opportunities and challenges

India and Germany have very different innovation systems:

- In India the government plays an important role in the innovation system.
- > Therefore, the share of governmental R&D expenditures is high while industrial expenditures on R&D are still low.
- > The German research and innovation system has a broad and differentiated structure. Research is conducted in a variety of public and private institutions.
- > More than two thirds of the annual funding invested in research comes from the private sector. Focus of this research is mainly on applied and result-oriented science.

Source: Final Report: German and Indian Innovation Systems. Fraunhofer IAO

#### CHAPTER 4

# FOSTERING INTERNATIONAL COLLABORATIONS FOR INNOVATION

#### Introduction

The global population is expected to reach 9.3 billion by 2050. Population explosion poses unprecedented challenges to humankind. Some of the most innovative solutions to meeting human needs will arise from science-based answers to urgent challenges surrounding availability of food, energy and water; to prevent new disease epidemics and many other issues.

As translational research transcends national boundaries and becomes global in nature, it will lead to new innovations that benefit mankind.

For any single enterprise operating in the tough economic landscape of today, it is extremely difficult to keep itself updated of all the relevant advances in innovation, and innovation competencies. Global competition means drastically reduced product life cycles, while the growing technology convergence results in riskier and costlier innovation. As a result, companies focus on international collaborations for their knowledge-intensive corporate functions, including R&D, and also tap into external partners, including universities and customers. For competitiveness, it is increasingly important for enterprises to get integrated and work in international innovation networks.

Innovations are increasingly brought to the market by networks of firms, selected according to their comparative advantages, and operating in a coordinated manner. In this new model, organizations de-construct the innovation value chain and source pieces from partners that possess lower costs, better skills and/or access to knowledge that can provide a source of differentiation. The aim is to establish mutually beneficial relationships through which new products and services are developed. Thus integration in global innovation networks is becoming increasingly important for enterprise competitiveness.

It is through collaborative linkages that knowledge transfer happens, resulting in new knowledge and technology development. Such collaborations can span large distances.

#### **Key Drivers of International Collaborations in Innovation**

Some of the key drivers for international collaboration emanate from within the scientific community and are translated in science and research policy instruments. The goals include obtaining access the latest knowledge. For some of the developing countries with lesser R&D, the key objective driving international collaborations is to build up the innovation capacity.

Improving national competitiveness and tackling societal challenges globally are some of the key drivers for international collaboration in innovation.

• Global societal challenges, such as climate change and energy production require global consortiums for developing innovative solutions.

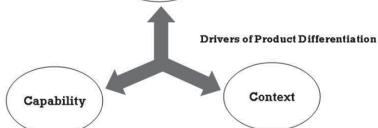
- Access to the state-of-the-art knowledge and building-up international relationships in similar domains also influences international collaborations. Sweden uses such a thematic approach to international collaborations in innovative R&D.
- With intent to improve R&D related Foreign Direct Investment (FDI), some countries, e.g. United Kingdom, focus on improving collaboration with countries having strong science and innovation culture.
- Individual researchers and research organizations (universities and other institutes)
  have the freedom and own responsibility to form international collaborations or to
  attract foreign talent, and the national R&D policies support and facilitate such
  collaborations through formal frameworks.

At the enterprise level, enterprises have developed an explicit strategy for international collaboration.

designed to support their business goals. Rather than focusing only on reducing cost, enterprises have focused on international collaborations for increased product differentiation leveraging the knowhow and local knowledge of their international partner. At the heart of any successful global collaboration strategy in innovation, these "3C's" will be seen.

# Cost

3C's of a Global Collaboration Strategy



[Source: Harvard Business School, 2007]

For instance, Boeing's approach to the development of its 787 Dreamliner aircraft involved massive global collaboration. As part of the project, Boeing tapped into the technological inputs and leveraged the advanced capabilities of over 50 partners from over 130 locations over a period of more than four years. In technologies like composite materials, which were used for the first time for large sections of the airplane, smaller more focused firms had developed expertise that was unique. Rather than replicate this expertise, the firm sought to tap into it, blending it with skills from other partners developing complementary technologies. As part of the project, Boeing gave its partners complete freedom to design the components they were manufacturing allowing for seamless integration with the outputs of other partners.

#### **Country Experiences in Innovation Collaboration**

The globalization of R&D innovation has been on the rise, with increase in international research collaboration in recent years due to the rise of India, Brazil and, particularly China as a country with a large R&D capacity with high international quality standards

In Europe, the changing demographics and the decreasing number of science and engineering graduates have resulted in the shortage of research talent available. International collaborations for innovation are increasingly sought after for attracting talent from partner countries.

For international collaborations in innovation to succeed, one of the key deciding factors is the state of the innovation ecosystem at the country level. This chapter discusses the innovation ecosystem in some select developed and developing countries:

#### **U.S. Innovation Ecosystem**

U.S. is regarded as one of the most innovative nation of the world. Government initiatives, funding & support have played a very significant role in driving the overall ecosystem of the country. Innovation exists in the system since cold war days, wherein government invested huge amount of money in the areas of defense, life sciences, aerospace, semiconductors, computers, and computer software. The developments in the above areas also attracted private investments to build a very strong innovation ecosystem.

Establishment of Defense Advanced Research Projects Agency (DARPA) in 1958 is regarded as major event in the history of U.S. innovation, which completely changed the outlook of the market. To build the ecosystem for the future market in late 1980's programmes such as the National Center for Manufacturing Sciences (NCMS), the semiconductor research consortium SEMATECH, the Advanced Technology Program (ATP) of the Department of Commerce, and the National Science Foundation's Engineering Research Centers, Small Business Innovation Research Programme (SBIR), etc, were introduced in the system.

In today's scenario, U.S. has adopted an integrated approach, wherein, different government departments are aligned with both public & private sector organizations to develop new innovative products & services. Apart from it, regular funding is seen in the market to nurture, support & convert concepts into reality. Funding public and university research base by various government bodies like National Science Foundation and National Institute of Health has also catalyzed innovation mindset in the country.

U.S. is now home for many MNC companies which are operating in the areas of aerospace, defense, ICT, etc, have established there high tech R&D centers across the nation. U.S. has dynamic entrepreneurial culture along with availability of venture capital, business angels, and other forms of public and private investment alongside strong mentoring programmes, facilitate business start-up and rapid growth to large scale in high-technology sectors.

Recently, government has introduced a sponsored program for small businesses, where for every \$1 raised from a private investor, the Government provides \$2 of debt capital, subject to a cap of \$150 million.

#### **Japan Innovation Ecosystem**

Japan in the recent times has passed through one of the worst phases of its time, negative growth rates, aging population, natural disasters, etc, were seen in the Japanese market. In-spite of these major hurdles Japan has one of the most strong innovation systems of the world. Till 1970s, Japan was major importer of different technologies but later after 1980s Japanese started capitalizing on their own expertise.

Strong bond between central government and the role of the Ministry of Economy, Trade and Industry (METI), large conglomerates and social and education institutions has helped Japan to remain as one of the most competitive markets.

Research, development and innovation is ranked in top strategic priorities by the Japanese government as well as by industry. The capacity to mobilize very large resources in pursuit of strategic priorities is a feature of the Japanese innovation system. Japanese government invests 4% of their GDP in R&D activities. METI supports innovative investment through research and funding agencies such as the National Institute of Advanced Industrial Science and Technology and the New Energy and Industrial Technology Development Organization. However large corporations provide about 80% of the national research expenditure.

Many companies in Japan have come out with rotational policy under which engineers are rotated from R&D departments to shop floor and back again to align themselves with customers requirement.

Apart from these, Japan is home for highly skilled labor wherein many individuals go for courses related technology & engineering. Also, companies in Japan prefer on-site training for the formation of technical skills in the individuals.

#### German Innovation Ecosystem

High value added engineering and heavy industries are the two main pillars in German innovation market. Decentralized approach, strong SME network, national technology and infrastructure priorities are considered as backbone of German innovation ecosystem. Investment & funding in educational & research sector has remained the top priority for German government. Every year around of 3% of the total GDP is invested in R&D activities by the German government.

Germany has rich & well diverse research expertise in today's scenario. Around 70 Max Planck institutes specializes in basic research, while about 60 Fraunhofer institutes conduct applied research, collaborating closely with industry. About 80 Leibniz institutes and 17

Helmholtz large science centres engage in basic, strategic and applied research. Energy, healthcare, mobility, security, automobile, chemicals, biotechnology, electrical and communication are some of the areas of their expertise.

To develop strong SME network SME Innovation Programme was launched by the German government in 2008 where €300 million are expected to be invested between SMEs and research institutes.

In 2010, second phase of High-Tech Strategy was introduced with aim to streamline knowledge transfer, commercialization, and strategic science-industry partnerships. The High-Tech Strategy has created long-term public-private partnerships in emerging technology areas. Industry is involved in roadmap development and priority setting. Leading companies such as BASF, Bosch, Daimler, Deutsche Telekom, Siemens and Deutsche Post DHL contribute to Germany's High-Tech Startup Funds launched in 2005 and 2011, providing over €500 million for start-ups. So far 250 start-ups have been supported, leveraging over €300 million in private-sector follow-on finance.

#### China Innovation Ecosystem

China is one of the fastest growing nations in the world economy. Inflow of FDI and opened economy corresponds for its rapid growth. Chinese government has allowed many foreign companies to set up their own R&D centers at Chinese territory. If we compare FDI inflows for R&D activities, around \$2 billion was invested last year which was only \$198 million in 2002. MNC's are able to shift less sensitive activities to China to take advantage of cost saving, while leaving core capabilities in developed nations with stronger intellectual property rights.

Though, R&D activities in the country have increased significantly, but quality and efforts to innovate new products has remained a major concerned in the country. In universities, for example, the continued emphasis on publication quantity results in repetitive papers with little added value. These are mainly considered as copy paste rather than true innovation.

One of the major challenges that China faces is the shortage of talent. Just like in India, most of the scientists and engineers who have graduated from Chinese universities are technically capable but unaccustomed to thinking creatively about problems. Another major issue which is seen in Chinese market is that majority of top university graduates in the field of physics seek to enroll in a graduate program abroad. Thus, China's top students emigrate abroad to study and then stay to work, depriving domestic companies of their talent. Key technological deficiencies in Chinese market include lack of access to foreign technology and poor intellectual property protection. However, intellectual property rights are slowly improving in China, but they still have to go long way to match OECD norms.

We can notice foreign investments in the market but lack of an established venture capital community constrains the ability of entrepreneurs to bring ideas to market.

#### **Brazil Innovation Ecosystem**

Brazil is another fastest growing nation in the global economy which has seen rapid development in the areas of defense, IT, aerospace, energy, etc. Brazil has developed an innovation ecosystem in aerospace with the growth of Embraer and its existing space program. At present, there are about 350 aerospace companies in Brazil which are doing immense R&D activities in the same segment.

As part of a Plan of Action on Science, Technology, and Innovation 2011-2014, the Ministry of Science, Technology and Innovation increased the resources of Financiadora de Estudos e Projetos (Research and Projects Financing), by around 50%.

In life sciences sector there are more than 250 life sciences companies in Brazil and many of them are founded in last five years. More than 1,200 products are under R&D and 610 are awaiting approval by regulatory agencies. The government plays an important role in supporting R&D inside those companies. The key strategy adopted for innovation in Brazilian market is to collaborate with universities and public institutes—73% of Brazilian life science enterprises reported interacting with a university or research center.

Brazil is a global leader in the area of bioenergy, including both biofuels and biomass; it has been ranked as number 6th in global clean energy investments, with 2010 investments being \$7.6 billion.

#### **Israel Innovation Ecosystem**

In last one decade innovation ecosystem in Israel has seen significant changes in its market landscape. The changing mindset has helped the coming up of many new startups in the country especially in the areas of healthcare, IT, semiconductors, etc. These new startups have created new dimensions in Jewish market, and have created new ways of building Jewish community.

Over the period of last 10 years, investments of more than \$500 million are seen in the country on account of liberalization & government allowing foreign companies to start their operations in domestic market.

The business sectors that have seen remarkable innovations & growth includes, life sciences, water technologies, communication, homeland security, semiconductor, chemicals, agro-technology, automotive, etc.

Recently, Infosys has signed a MoU with the Israeli government, according to this MoU, Infosys would be closely working with Israeli government to establish and enhance cooperation in industrial research and development. This MoU was signed by the government to align its Global Enterprise Collaboration Program to intensify innovation through a global ecosystem. Infosys would be working in the areas of emerging technologies such as cloud, information security, sensors, analytics, and sustainability.

#### **Reverse Innovation**

Underpinning the increasing international collaborations is the emerging innovation model of reverse innovation. Reverse innovation is driven by the income gap that exists between developing and the developed countries. To compete in the new flat world, global corporations must focus on the emerging markets, and be just as nimble for innovating locally as opposed to a one-size-fits-all approach globally. Enterprises must develop a deeper understanding of local geographies, local customer problems and work on a shift in the current organizational mindset. Reverse innovation requires a decentralized, local-market focus, with dedicated people and resources available locally with decision-making authority to choose which products to develop, how to make, sell and service them. Once tested and proven locally, such products involving potentially pioneering new technologies at lower price points can be introduced in the western markets and globally. In the new world, enterprise success in developing countries is imperative for continued success and growth in developed markets.

#### **Open Innovation**

In order to match the growing demand for innovation and globalization challenges, companies are increasingly tapping into "ecosystems of innovation" across countries, and sometimes involving external R&D. Companies link into these global innovation networks with people, institutions (universities, government agencies, etc.) and other companies in their own or different countries to solve problems, source knowledge and generate ideas. These global innovation networks include own R&D facilities abroad as well as collaborative arrangements with external partners and suppliers, in which firms depend in various ways on the expertise of the different partners.

While open innovation is not totally new, the organization of innovative activities (technological as well as non-technological) across firm boundaries is clearly on the increase, with more balance between internal and external sources of innovation.

In industries characterized by rather short technology life cycles, e.g. the ICT, electronics and telecommunications industry, companies have sought external partners in order to keep up with new developments in and around their industry. In industries characterized by rather long technology life cycles and strong protection of intellectual property rights (IPR) (e.g. pharmaceutical, chemical and materials industries), companies mainly look outside the firm to keep up with research.

#### Open Source Drug Discovery (OSDD)

Government of India has launched the Open Source Drug Discovery (OSDD) initiative, led by Council of Scientific and Industrial Research (CSIR), as an initiative for affordable healthcare. OSDD

is a novel open source platform, computational and experimental, to discover drugs for tuberculosis, affordable to the people of developing world

OSDD encourages and supports ideas and scientific projects from the scientists, researchers and even students in an open source mode. In addition, OSDD has developed a micro-attribution system through which credit points will be given to contributors based on the value of their contributions.

The involvement of universities with a good source of talent pool will be secured. The involvement of private sector is secured to participate in "open source" initiative under Private-Public partnership mode. The combined effort of all these players is likely to significantly optimize the cost and time of drug discovery significantly.

So far, the network has crowd-pulled some 5,500 participants in 130 countries, 80 percent of whom are in India. From the "healthy-looking front end", two anti-TB molecules are in advance stages of research, though they are still two to three years away from clinical study.

#### **Salient Observations**

- The policy attention for international research collaboration is growing rapidly in all countries. Globally the value of creating shared pools of knowledge for collective solution building is being recognized.
- Platforms for collaboration and networking can have a significant impact on driving innovation in the innovation ecosystem. These platforms enable sharing of ideas for needs-based solution building, leveraging existing knowledge, sharing of real time information and cross-fertilization of thinking. In an increasingly globalized world, these mechanisms of collaboration become even more significant to leverage the most innovative thinking from around the world to create global networks for research, cooperation and co-creation.
- International collaboration in innovation leads to improved research quality, in building the research capabilities and skill-sets. Such collaborations ultimately benefits society, through the many spill-over benefits of research and development that enhance the quality of life, health, and national competitiveness.
- Open Innovation offers strong principles for structuring participation, tapping people's intrinsic motivation, distributing accountability, and harnessing local knowledge, allowing for experimentation, and thus failure, without causing too much damage. This is because the costs are not all borne by a single entity. Open innovation requires discipline and has some core values at work. It is important to remember that adopting an open source mindset does not involving eschewing teams and strategy.

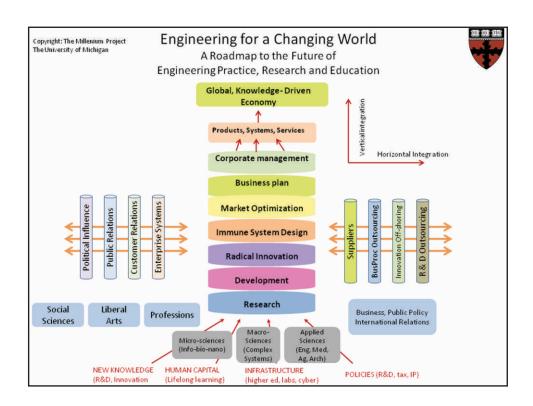
# Innovation, Science and Technology and the Public Good

by

Prof. Venkatesh "Venky" Narayanamurti
Professor of Technology and Public Policy
Professor of Physics
Harvard University

#### I want to address three questions:

- What does it mean to be a <u>leading and societally-</u> relevant university in an increasingly globalized world?
- What does it mean to be a broadly educated person in the 21st century?
- What should R&D institutions look like?



#### **Creating Engineering Innovators**

#### Definitions:

#### Creativity

• Process of having original ideas and insights

#### Inventiveness

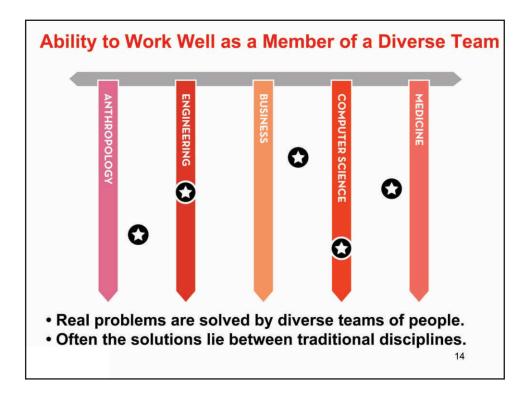
• Process of having original ideas and insights that have value

#### Innovation

 Process of having original ideas and insights that have value, then implementing them so they touch many lives and make a positive difference in the world

#### **Engineering Innovators:**

Creative engineers who think and act as entrepreneurs



#### **Educating Engineers For The 21st Century**

#### What are the critical skills our students need?

- Technical depth in a particular field
- Creativity and innovation
- Entrepreneurial outlook
- Communication skills
- Ability to work well as a member of diverse team
- Global knowledge and experience
- Commitment to life-long learning

# **Renaissance Engineers**

We want to educate engineers not only in how things work but also on how the world works!

#### Global Engineering Deans Council (GEDC)

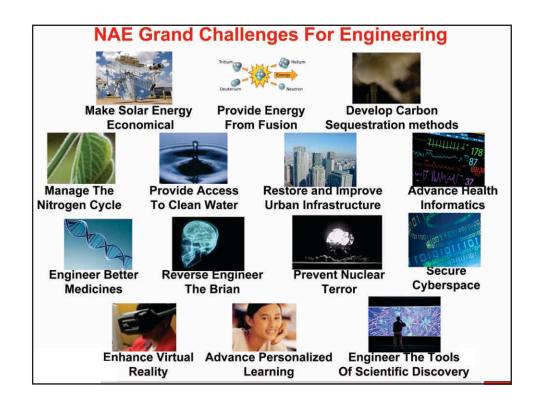
#### Vision

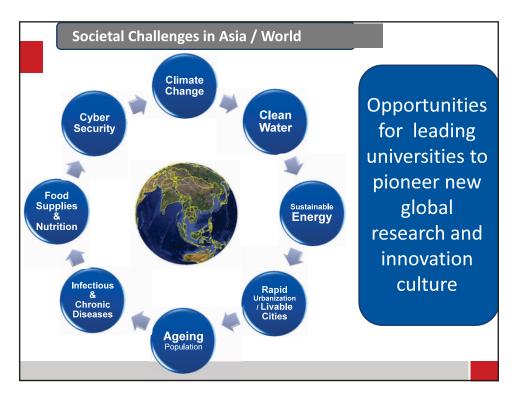
To enhance the capabilities of engineering deans to transform their schools in support of their societies in a globalized world

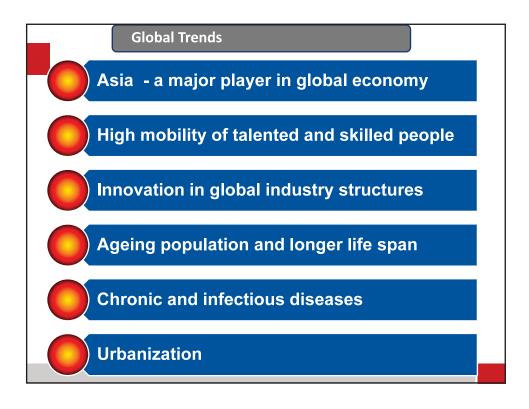
#### Mission

To serve as a global network of engineering deans and to leverage on the collective strengths for the advancement of engineering education and research









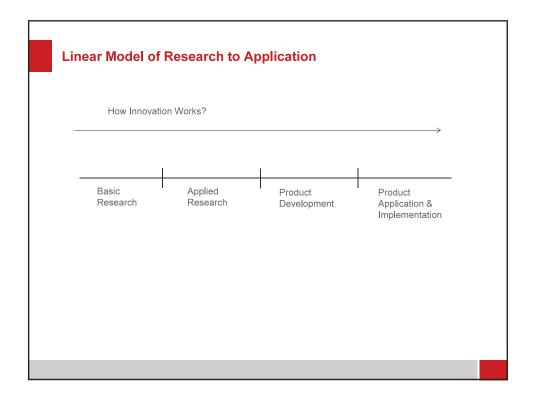
Fostering Institutions that Innovate

#### OR

Bridging the Basic-Applied Dichotomy and

Engineering, Discovering and Inventing the Future

FACTORY
Bell Labs
and the
Great Age
of American
Innovation
Jon Gertner

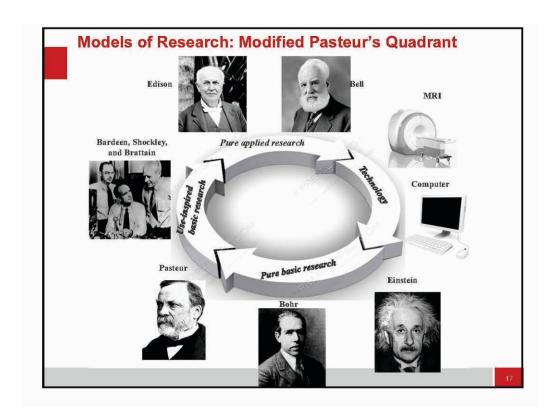


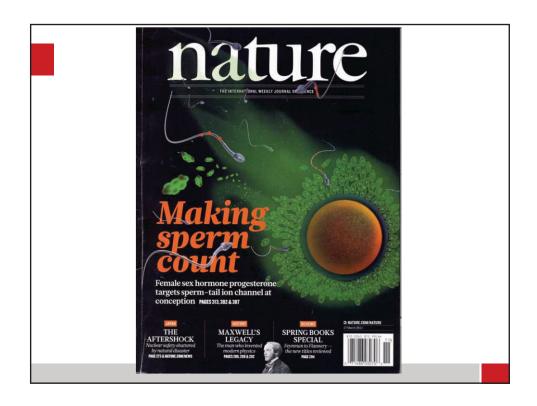
# Alternative View of Relationship between Basic and Applied Science

Science is about "what is", and engineering is about "will be"

- Many prominent examples of technology coming before science or "understanding"
  - Steam engine came before our understanding of thermodynamics
  - Aeroplane came before we had wind tunnels
- Use-inspired science: transistor, microbiology, nitrogen fixation, etc.

16











# The laird of physics James Clerk Maxwell's 1861 work on electromagnetism, which unified sei was driven as much by technology as by abstract theorizing, argues Simo

"But a 2010 report from Britain's Royal Society title The Scientific Century notes that 'the linear model of basic research through to innovation bears little relation to reality'. It adds that the model's long-lasting appeal is partly explained by historical assumptions and familiar myths that are rarely challenged. Rather than a stately progression from abstract theory to solid application, it was the product of a web of markets, technologies, labs and calculators in the workshop of the world."

Yet as a bright teenager in Galloway, in southwest Scotland, Maxwell had been unusually keen on turning classroom principles into practical devices, including homebuilt electric telegraphs. With his father's earnest backing, Maxwell studied engines on show in the manufacturing towns and at the Great Exhibition of the Works of Industry of all Nations at the Crystal Palace in London in 1851. His ingenuity attracted the attention of William Thomson (later Lord Kelvin) - the two met in 1850. The young professor at the University of Glasgow encouraged Maxwell to manufacture magnetically sensitive crystals at home in Galloway.



### **Bridging the Basic – Applied Dichotomy**

#### The transistor was both a "Discovery" and an "Invention"

#### INDUSTRIAL STRENGTH SCIENCE 59

vidual electrons—how they behave in electric and magnetic fields—which he had learned under Millikan's tutelage, came in handy. Use of a higher vacuum eliminated the blue haze; an oxide-coated filament and more exacting placement of the grid substantially improved the tube's output. A year later Arnold's "high-vacuum thermionic tube" finally solved the repeater problem. In October 1931 it was successfully installed on a telephone line from New York to Baltimore.

The true test came with the installation of the transcontinental line stretching over 3,400 miles from coast to coast—AT&T's goal for years. In July 1914 Vall was the first to speak over this line, which had repeaters in Pittsburgh, Omaha, and Salt Lake City to boost the electrical signals. On January 25, 1915, diginarias celebrated this great achievement during the opening ceremonies of the Panama-Pacific International Exposition in San Francisco. "It appeals to the imagination to speak across the continent," President Woodrow Wilson told Caldiornia listeners from the White House. And from New York, Alexander Graham Bell repeated his famous command, "Mr. Watson, come

Ceremony inaugurating the transcontinental selephone line on January 25, 1915, at the Pacific Telephone and Telepaph Company in San Francisco. Thomas Watson (front rous bind from left) speaks to Alexander Grabam Bell in New York as other dignitaries listen. Pormaits on the wall are of Bell (left) and AT&T president Theodore Vall (right).



60 CRYSTAL FIRE

here. I want you." Sitting in San Francisco, Watson bellowed back, "It will take me five days to get there now!"

The unqualified success in developing repeaters for the transcontinental line convinced AT&T officials that paying Ph.D. physicists to do industrial research was good business. And during the Great War the company continued hiring physicists, Davisson among them, to work on topics such as adapting the vacuum tube and related circuitry for wireless communications. Using improved, high-power vacuum tubes in late 1915, AT&T transmitted the first transoceanic telephone conversations between Arlington, Virginia, and the Eiffel Tower in Paris, putting the company a major step closer to Vail's ambitious goal.

This nucleus of a research department continued to expand after the war ended. On January 1, 1925, it was incorporated as a separate entity called the Bell Telephone Laboratories; with over 3,500 employees, it occupied almost the entire West Street building. The first president of Bell Labs was Frank Jewett, a physicist from the University of Chicago who had been with AT&T for over twenty years. Arnold, whom he had hired to work for him on the repeater problem, became Bell's first research director.

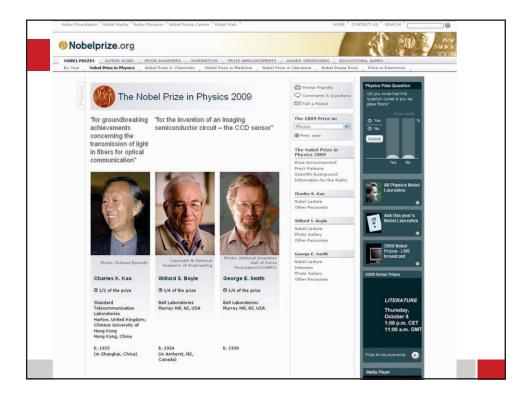
That same year Davisson and Germer began their investigations of electron scattering from nickel surfaces, work that began due to a patent dispute between AT&T and General Electric. With the help of the skilled engineers and technicians at the labs, who were now familiar with all aspects of vacuum tubes, they designed and built an intricate, high-vacuum apparatus that proved to be ideal for their experiments. Their serendipitous discovery of electron diffraction, confirming the wave nature of matter, led to the 1937 Nobel prize for Davisson—the first ever awarded to a scientist from Bell

#### Some Bell Labs Science

- Electron Diffraction (Davisson and Germer)
- Information Theory (Shanon)
- Surface States (Bardeen)
- Molecular Beam Epitaxy (Cho and Arthur)
- Theory of disordered materials (Anderson)
- 3K Microwave Background Radiation (Penzias, Wilson)
- Laser trapping of Atoms (Chu, Ashkin)
- Fractional Quantum Hall Effect (Tsui, Störmer, and Gossard)

#### **Some Bell Labs Inventions**

- Transistor (Bardeen, Brattain, Shockley)
- Laser (Townes, Schawlow)
- Solar Cell (Chapin, Fuller)
- CCD's (Boyle, Smith)
- Communication Satellites (Pierce)
- UNIX (Ritchie and Thompson)
- C Language
- Speech recognition
- National Medal of Technology



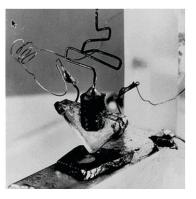
#### **Classes of Innovation**

- Innovation [is not] a single mechanism, instead there are four more or less separate ones.
- Innovation consists in novel solutions being arrived at in standard engineering – the thousands of small advancements and fixes that cumulate to move practice forward.
- It consists in radically novel technologies being brought into being by the process of invention.
- It consists in these novel technologies developing by changing their internal parts or adding to them in the process of structural deepening.
- And it consists in whole bodies of technology emerging, building out over time, and creatively transforming the industries that encounter them.

W. Brian Arthur The Nature of Technology (2009)

#### **Transistor Action**

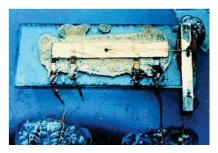
Discovery and Invention: 1940s



The world's first transistor, developed in 1947. It was a point-contact device roughly one centimeter across.

# **Invention and Innovation**

IC 1958



**Texas Instruments** 

# Tools and Technology Tools and Technology Tools and Technology Tools and Technology And Technology Tools and Technology And Technology

Bell Labs as a model for innovation institutions

What were the key ingredients?

Can we learn something from the example of Bell Labs?

Is there a need today?

# THE DELICATE BALANCE OF FREEDOM, FOCUS AND FUNDING: The Culture of the Great Industrial Laboratories

#### Meritocratic

- Recruited the best and the brightest
- Leadership was scientifically/technologically distinguished
- Fostered a culture of excellence through periodic performance reviews and mentoring

#### Stable funding

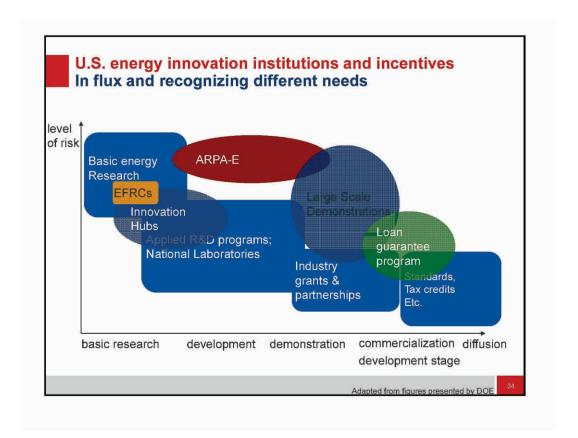
- Allocation of a steady funding stream with long-term interests in mind; insulation from short-term drivers
- Size of staff was determined by the need of having a critical mass in selected areas and with adequate funding to support each researcher

#### Balance Between Freedom and Focus

- Research insulated but not isolated from goals of the corporation
- Vertical integration from research to development to application
- Free flow across disciplinary boundaries thereby allowing for collaboration to address the most challenging problems

#### Some other characteristics

- Outstanding infrastructure and technical support
- Open "doors"
- Healthy regard for the "doers," "growers," and "tool makers"
- Kelley favorite question:
  - "Not what you know but what you don't know"



## Innovation in an International Perspective -How Important is Sustainable Management of Natural Resources?

by **Xaver Edelmann** 

#### Content of Presentation



- Innovation Rankings and Success Factors for Innovation
- Sustainable Use of Natural Resources
- World Resources Forum
- Decoupling Resource Use from Economic Growth
- Examples of Sustainable Business Approaches
- Roadmap for Resource Efficient Europe
- Sustainable Management of Resources as a Key Success Factor in the Future



SATW
Schweiterische Äkademin der Technischen Wissanschaften Academin suisse des sciences techniques Academin suisse des sciences techniques
Saiss Academin signere della seismat scienche
Saiss Academy of Engineering Sciences

# Sustainability in Innovation and Competitivity Reports



- World Economic Forum WEF
   The Global Competitiveness Report 2011/2012
   Sustainability not mentioned in part innovation
- INSEAD
   The Global Innovation Index 2012 Stronger Innovation Linkages for Global Growth
   Sustainability not an indicator
- INNOVATION UNION SCOREBOARD 2011
   The Innovation Union's performance scoreboard for Research and Innovation
   European Innovation Scoreboard indicators
  - share of innovators where innovation has significantly reduced the use of materials and energy





#### European Innovation Scoreboard Indicators



#### **ENABLERS**

- Human resources
- Finance and support

#### FIRM ACTIVITIES

- Firm investments
- Linkages & entrepreneurship
- Throughputs

#### **OUTPUTS**

Innovators

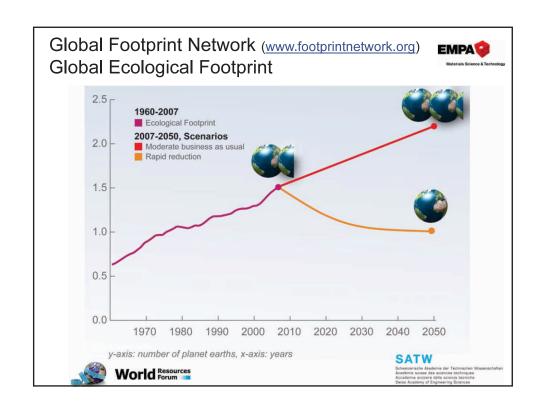
.....the share of innovators where innovation has significantly reduced the use of materials and energy.

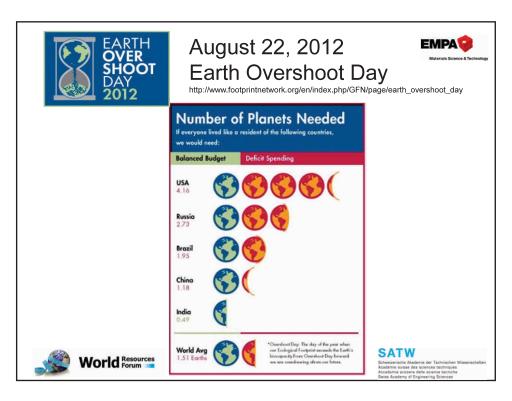
■ Economic effects

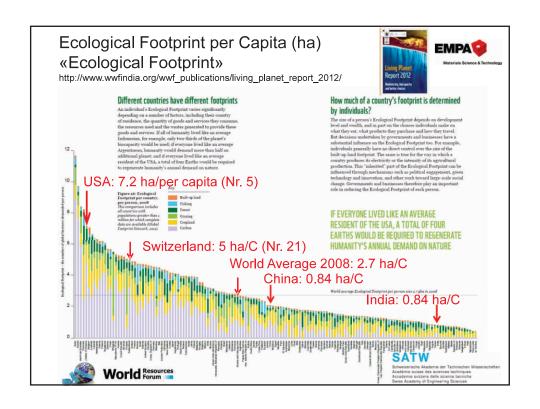


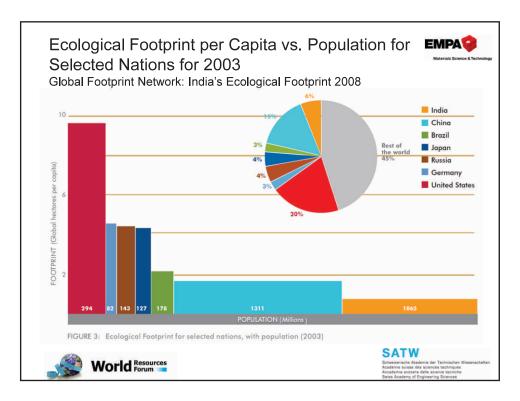


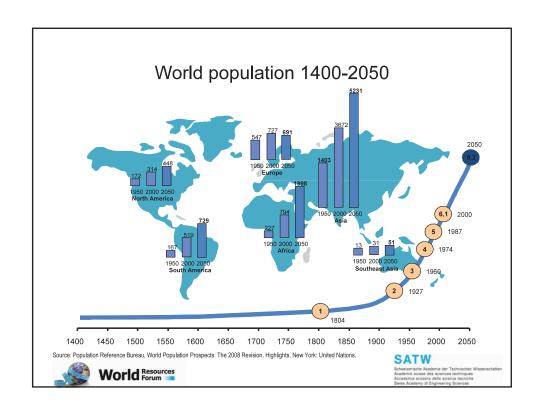
Innovation **Union** Scoreboard
2011

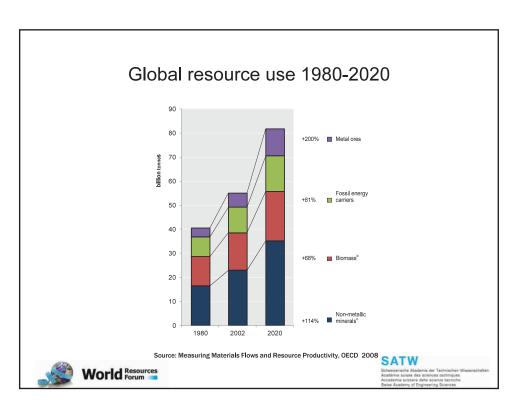


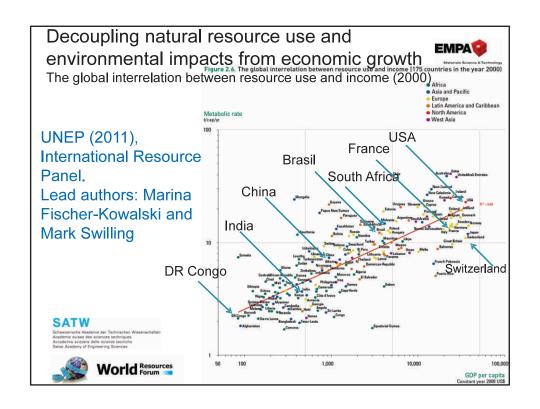


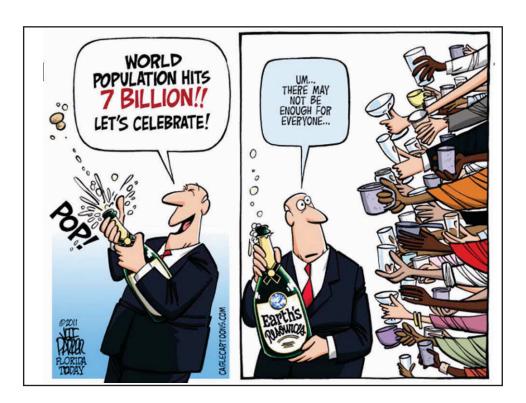












#### Resources are getting scarce

- Physical limits
- Political risks
- Prices

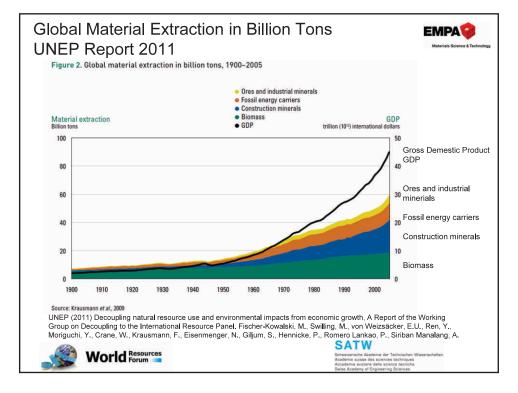


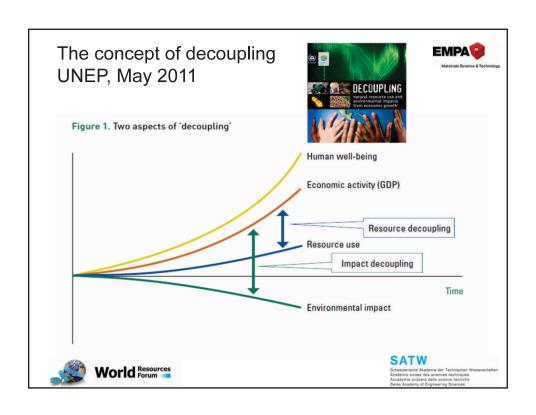
- Environmental and health challenges
- Social limits

See Resource Snapshots at <a href="http://www.worldresourcesforum.org/resource-snapshots">http://www.worldresourcesforum.org/resource-snapshots</a>



Bas de Leeuw www.worldresourcesforum.org SATW
Sohweiserische Alademie der Tachnischen Wissenschaften
Academie suisse des sciences techniques
Academie sinizere Selle scienze tecnnche
Seines Academy of Englisering Sciences











#### Questions dealt with at WRF2011

- What Do We Need to Achieve?
- Should We Limit the Use of Resources?
- How Can International and National Policies Establish a Resource Efficient Green Economy?
- What Are Industry Solutions to Achieve a Resource Efficient Green Economy?
- Where Do We All Go from Here?



#### Chairman's statement WRF 2011



# Tax resources and pollution in stead of labour

Input of Ernst Ulrich von Weizsäcker







#### Chairman's statement WRF 2011



Governments to create a framework for innovation. Partnerships with business and NGO's. Measurement of performance. Transparency.

Green Economy, not Greenwashing

Input of Jacqueline Aloisi de Larderell

World Resources





#### Chairman's statement WRF 2011



Not everything that can be counted counts, not everything that counts can be counted



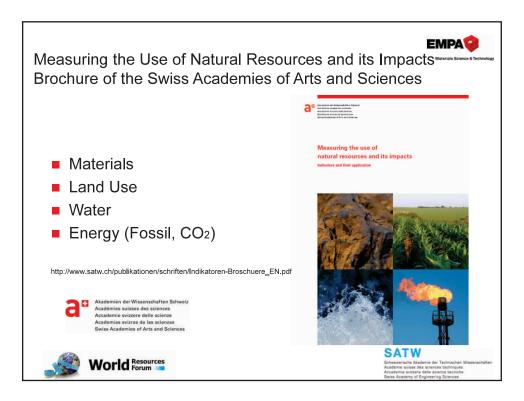
Explore values, emotions, underlying driving forces for consumption, involve youth

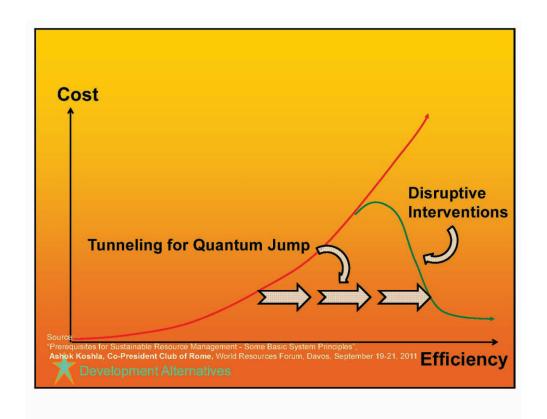
Input of Students (Young Generation)

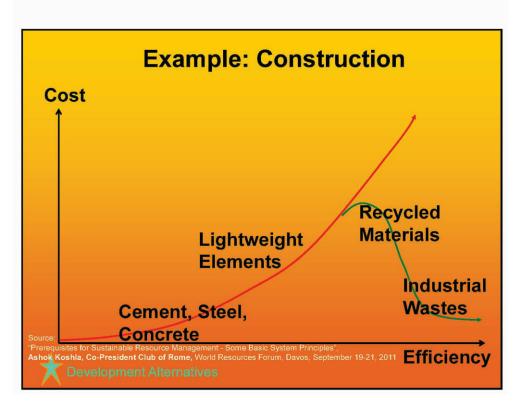












World Class Energy Efficiency in the Cement Industry India's Ecological Footprint – A Business Perspective 2008



Major initiatives taken up by the cement industry towards minimizing the industry 's Ecological Footprint include:

- Adoption of energy-efficient technologies
- Use of alternative fuels
- Installation of waste heat recovery system







Why Sustainability is a Key Driver of Innovation Ram Nidumolu, C.K. Prahalad, M.R. Rangaswami Harvard Business Review September 2009



#### Five Stages

- Stage 1: Viewing Compliance as Opportunity
- Stage 2: Making Value Chains Sustainable
- Stage 3: Designing Sustainable Products and Sevices
- Stage 4: Developing New Business Models
- Stage 5: Creating Next-Practice Platforms





# European Union Roadmap for a Resource Efficient Europe



- 1. Challenges and opportunities for Europe
- 2. Making Europe resource efficient
- 3. Transforming the Economy
- 3.1. Sustainable consumption and production
- 3.2. Turning waste into a resource
- 3.3. Supporting research and innovation
- 3.4. Environmentally harmful subsidies and getting the prices right
- 4. Natural Capital and Ecosystem Services
- 4.1. Ecosystem services
- 4.2. Biodiversity
- 4.3. Minerals and metals
- 4.4. Water
- 4.5. Air
- 4.6. Land and soils
- 4.7. Marine resources





# European Union



#### Roadmap for a Resource Efficient Europe (cont)

- 5. Key sectors
- 5.1. Addressing food
- 5.2. Improving buildings
- 5.3. Ensuring efficient mobility
- 6. Governance and monitoring
- 6.1. New pathways to action on resource efficiency
- 6.2. Supporting resource efficiency internationally
- 6.3. Improving the delivery of benefits from EU environmental measures
- Conclusion

Annex: Resource efficiency – the interlinks between sectors and resources, and EU policy initiatives

Head EU Directorate Environment:

Janez Potocnik (Plenary Speaker at WRF 2011)



SATW
Scheeuerische Akademie der Technischen Wissenschaften
Academie ausse des sciences techniques.
Accademie sizzere delle scienze techniques.
Bales Academy of Engineering Sciences





# WRF and Sustainable Innovation in India

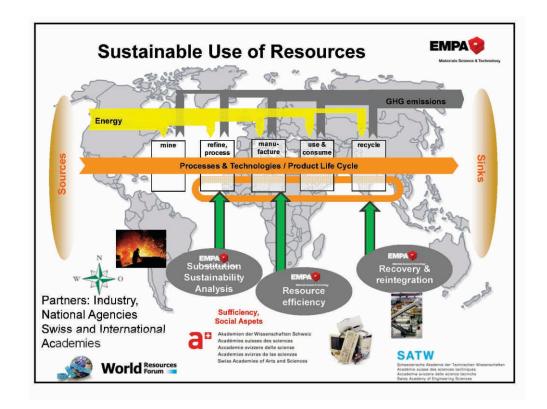


- January 2012: Events with Indira Gandhi Institute, Air India, and YES bank in Mumbai
- 15 October 2012: WRF/United Nations COP 11 Urban Eco-efficiency Lab in Hyderabad
- Planned for 2013: WRF India events in Bangalore, with India Competence Center, University of St. Gallen, Swissnex Bangalore, Indian Institute of Management, Bangalore, Indian Institute of Management, Udaipur, Indian National Academy of Engineering (INAE), Development Alternatives New Delhi (Ashok Khosla). Other partners welcome to join!









#### Doing more with less

Consuming and producing more efficiently and differently ...





... and providing opportunities for the poor.



Bas de Leeuw www.worldresourcesforum.org



#### **Final Remarks**



- Sustainability not yet a strong indicator for innovation.
- Demand for natural resources increasing steadily.
- True prices for natural resources needed.
- Sustainable use of natural resources a key success factor.
- «Green Economy» means sustainability along the whole value chain.
- Disruptive technologies for processes and products needed.
- New business models necessary.
- Great opportunities for emerging economies.

Thanks to INAE for the Invitation!
Thank you for your attention!





# **Special Keynote Address**

#### Dr. R Chidambaram

Principal Scientific Adviser to the Govt. of India & DAE Homi Bhabha Chair Professor

#### **Special Keynote Address**

 $\mathbf{b}\mathbf{v}$ 

#### Dr R Chidambaram

On

#### Improving the Research & Innovation Ecosystem

Dr Chidambaram mentioned that instead of speaking about the innovation ecosystem, he would rather focus on the research and innovation ecosystem because they are closely linked particularly in the areas of high technology. Innovations are either breakthrough innovations or incremental innovations and many of the incremental innovations can generate income for companies particularly when they do defensive patenting. Innovation is a word used by many people in different ways as in innovative business concept or innovative management system; but in the case of science and technology it has to be used in a different way. Research is generating knowledge as basic research or applied research. Through technology foresight analysis, one can decide the technologies which are important for India in areas of strategic interest for societal benefit. Then it becomes directed basic research. In applied research, you can have pre-competitive or propriety product or process development. A mix of innovative product or process or design innovation is more effective but when you look at the entire gamut of definition, the border between research and innovation begins to get fuzzy. Scientists create ideas, engineers create products and innovation creates wealth.

In biology, an ecosystem is a community of organisms interacting with one another and with the environment. The functional aspects of the system are energy flows within the system, utilization of the natural resources in the system and its sustainability. All these aspects need to be paraphrased in the context of research and innovation ecosystem. The innermost layer in a national research and innovation ecosystem is school education followed by higher education system. The einfrastructure is developing and the National Knowledge network which has been set up is connecting all institutes, labs and universities. In the R&D system we need leaders in innovation. Not individual innovators, but groups which can innovate for which leaders are required. Further international cooperation is becoming more prevalent as countries are connected through electronic connectivity. Innovative leaders should have government support to promote the efforts of academics. The components of an innovative ecosystem are talented young people, adequate funds and strong infrastructure. There should be an appetite for risk taking and leaders are required. The output of a laboratory is directly proportional to the number and quality of the graduate students. At the Class 10 +2 stage, there are talented people in science but they would rather opt for a professional course than taking up pure sciences as the former assures them better job prospects. The INSPIRE programme of DST is a step in the right direction to motivate young students to take up science as a career option. At the B.Tech level, the best students who have shown talent for engineering research, applied research and technology development either go abroad or take up management jobs in industry. During a brainstorming session it was suggested that during the placement interviews, the creamy layer of students from IITs be encouraged to do research at an educational institution but the salary be paid by the industry. The research should be in a broad area of interest to the company and not just problem solving. After obtaining PhD degree the scholar may join the industry and be engaged in research and development activities.

If one wants to become a global innovation leader, one must have a mix of fundamental science, applied research and manufacturing skills. A strong manufacturing base is necessary. Leaders create their own ecosystems. Further success is achieved only if one is working on an important problem. Any problem should be important to science and society. Relevance and excellence are both required. Many institutions in India have high brand equity like IISc, IITs and BARC. Multiple leaders converging to the same point create excellent institutional ecosystems. The old paradigm is to "put innovation into the product" whereas the new paradigm is "innovation is the product". There are some companies who do not manufacture, they just create intellectual property and earn money. Process innovation can trump product innovation whereas innovation in process plus design can trump process alone.

Collaborative innovation is based on the idea of "swam creativity". "Collaborative Innovation" was the theme of the 2008 Davos meeting of World Economic Forum. We should also think of altruistic collaborative innovation while tackling the problems of pandemic diseases, climate change threat and cyber security without worrying about IPR issues. Borders between disciplines and the way to classify people are also changing. In all mega science and technology projects there has to be international collaboration.

India has enormous capabilities for research. Synergy is an important facet of ecosystems. However, one must establish "Coherent Synergy". The mechanisms for establishing "Coherent Synergy" in to ecosystem for technology development and delivery are innovative academia-industry interaction interfaces for "precompetitive and applied research" and "directed basic research" for industrial development. The National Knowledge Network aims to connect all knowledge institutions in India through a high-speed optical fibre low-latency network. Regional and international research collaboration can be enhanced by connecting such knowledge networks. India can become an innovation leader provided we create an excellent research and innovation ecosystem and have proper "technology foresight" to make the right technology choices in a national perspective and introduce "Coherent Synergy" in our S&T related activities.

### Improving the Research & Innovation Ecosystem

by

R. Chidambaram
Principal Scientific Adviser to Govt. of India
&

INAE-Homi Bhabha Professor Bhabha Atomic Research Centre, Mumbai, India

### **Research & Innovation Ecosystem**

An *Ecosystem*, in biology, is a community of organisms interacting with one another and with the environment. And there are functional aspects of the system – energy flows within the system; utilization of the natural resources in the system; its sustainability; etc.

We have to paraphrase these aspects in the context of the *Research and Innovation Ecosystem*.

### The Layers in a national Research & Innovation Ecosystem

(Research, Development and Innovation are all inter-linked)

- ❖ Innermost layer School Education System
- Higher Education System
- Research & Development System Many Dimensions
- Innovation System Many Sub-layers
- Leadership
- e-science infrastructure
- **❖** International Cooperation
- **❖** Government Policy

### The Components of an Excellent Ecosystem

- ❖ Talented young people
- **❖** Adequate Funds
- Strong Infrastructure
- **♦** Appetite for Risk-Taking
- Leaders

Support for both Basic Research and Applied Research and establishment of a strong manufacturing base (the services sector alone is not enough) are essential for developing an excellent National R&I Ecosystem

### **The Leaders**

(They create their own Ecosystems)

❖ Srinivasa Ramanujan : The 'magical genius': SOLOIST

C.V. Raman : Created the next generation

of physicists

Homi Bhabha : Created a whole field: 'Atomic

Energy' - it was actually a

'leader swarm' backing Bhabha

J.N. Tata : Created the concept of

'Indigenous Manufacturing

Industry'.

### "Advice to a Young Scientist"

Always work on "Important" Problems.

···Peter Medawar

(Nobel Prize - winning Biologist)

- Important to Science or to Society! This advice is useful for everybody, Scientist or otherwise!

My motto when I was Director BARC: "Relevance or Excellence, preferably both".

### RESEARCH & INNOVATION ECOSYSTEM

- Many S&T institutions in India have a high brand equity - IISc, IITs, BARC, etc.
- ❖ Multiple leaders converging to the same point create excellent institutional ecosystems e.g. Gôttingen University in Germany (associated with 45 Nobel Laureates): Gauss, Riemann in the 19<sup>th</sup> Century; achieved its academic peak in the beginning of the 20<sup>th</sup> Century Hilbert, Klein, Born, Sommerfeld.

### Paradigm Shifts in Interpreting Innovation "Put Innovation into the Product" From: To: "Innovation is the Product" ... Kevin Rivette (Boston Consulting Group) "Innovation in Process trumps Innovation in Product" .. Lester Thurlow [...processes of manufacturing and distribution; "on-site and offshore business model of the IT Industry (Kiran Karnik)";...] "Innovation in Process + Design trumps Innovation in Process alone" ...William Buxton [... extracting value from creative insights e..g., - Indian textiles: design-inspired innovation...] We must examine India's strengths in all these approaches. from my address in TIFAC-National Academies(US) meet, Delhi, 18, Dec. 2007

### "The Many Dimensions of Indian Innovation"

'Because India is so large and so diverse and because change is occurring at such a rapid pace, it is impossible to talk about a single innovation policy. Conditions vary widely among technologies, among industries and among regions. For example, India is on par with global leaders in some technologies (nuclear power, space), well behind in other sectors (productivity of small and medium enterprises), and in a position to leapfrog into global leadership in some areas (tools for rural development)'.

from Chidambaram, "Indian Innovation: Action on Many Fronts", In "Issues in Science and Technology" Special Issue on 'Global Tour of Innovation Policy', National Academy(US), Volume XXIV, No. 1 Fall 2007, pp.59-62.

### **Collaborative Innovation**

The concept of collaborative Innovation – we normally associate innovative concept creation with individuals – is based on the idea of "swarm creativity" and transcends International borders. Collaborative Innovation Networks (COINS) are cyberteams enabled by the Web to share knowledge "directly and not through hierarchies."

"Collaborative Innovation" was the theme of the January 2008 Davos meeting of the World Economic Forum which I attended as a member of the Faculty. But I would like to suggest that we should also think of <u>altruistic Collaborative Innovation</u> while tackling the problems of pandemic diseases Climate Change threat and Cyber security, without worrying about IPR issues.

from my address in the Science and Technology in Society Forum Kyoto, October, 2009

### The Large Hadron Collider Model

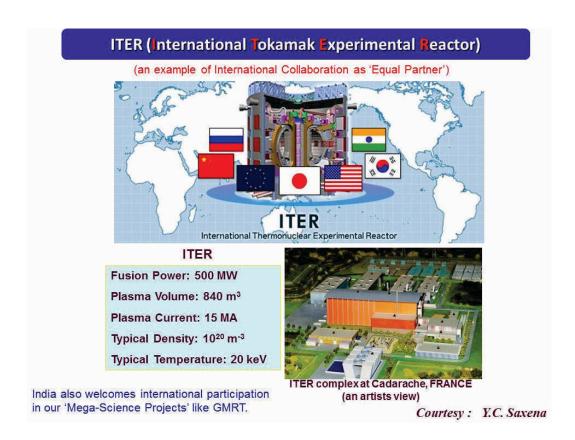
(Knowledge Diffusion through International R&D Collaboration)

The world's largest accelerator has been built in the Centre for European Nuclear Research(CERN) in Geneva - a more than 4 Billion U.S. Dollars machine. Under an agreement signed in 1996 when I was Chairman AEC, India contributed 40 Million U.S. Dollars - worth hitech equipment like a thousand superconducting sextuple magnets, etc. and advanced 'grid' software. Half of this contribution has been put into an 'India Fund' which will support Indian scientists who will work with the Accelerator. Indian scientist groups are also participating in the construction and experimentation with two giant Detector systems - CMS and Alice - TIFR and VECC/SINP lead the Indian teams for these two experiments (post-script: CMS was one of the 2 detectors involved in providing the recent experimental evidence on the Higgs Boson).

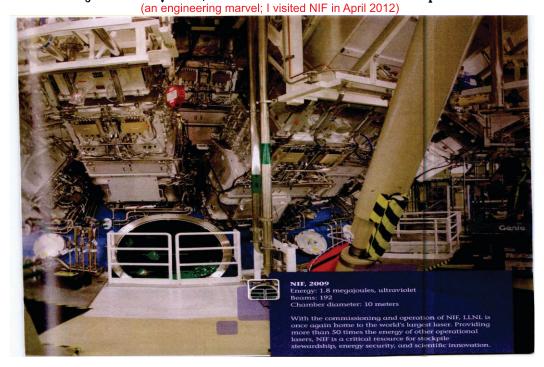
Collaboration with CERN has helped in nucleating the presently fast growing e-Research Infrastructure in India.

### Raman Effect and the Higgs Boson

- ❖ For discovering the *Raman Effect*, a physicist was enough, with a few students.
- ❖ To look for the <u>Higgs Boson</u>, we have the multibillion dollar precision - engineered Large Hadron Collider and teams involving hundreds of scientists, across international borders — studying the data from various detectors. And we need an e-science infrastructure.
- So the way we do science has changed and the ecosystem must adjust to this fact



### National Ignition Facility (NIF), Livermore & Laser-Induced Fusion Experiment (LIFE) (an engineering marvel; I visited NIF in April 2012)



### Advanced Ultra Super-Critical Thermal Plant

(an example of synergising exceptional component capabilities)

For the next 2 or 3 decades, most of our capacity addition may come from coal-burning. Need for Advanced USC coal-based plants, where the steam temperature is 700-750 deg.C.

While the main R&D project is aimed towards the full development of a 800 Mwe A-USC plant, my Office has supported two projects, which can be called preprojects, one for the development of boiler tubes and the other for blade material. Consortium of IGCAR, BHEL and NTPC - Dr. Baldev Raj spear-headed the initial effort, now Shri S.C. Chetal.

Two new indigenous materials have been developed by IGCAR for boiler tubes, with the help of MIDHANI and NFC:

### 304HCu SS Tubes

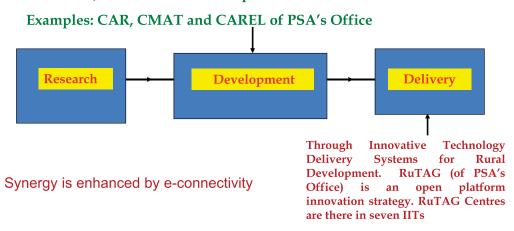
### Alloy 617 M tubes

Today, for advanced technology projects, fragmented capabilities have to be synergised. Such synergism should be considered an important component of the ecosystem.

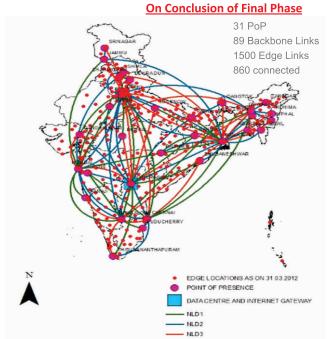
### Mechanisms for establishing 'Coherent Synergy' in the Ecosystem for Technology Development and Delivery

(Industrial Development vs Rural Development)

Through innovative Academia-Industry Interaction Interfaces for 'Pre-competitive Applied Research' and through 'Directed Basic Research', for Industrial Development



### **National Knowledge Network**



Aims to connect all Knowledge Institutions in India through a high-speed all-optical fibre low-latency network

Regional and International Research Collaboration can be enhanced by connecting such Knowledge Networks

Courtesy: R.S. Mani, NIC

Here is a huge opportunity to indigenise the manufacture of high-speed network products

### 'Developing' & 'Developed' Countries: A Basic Difference

Thermodynamic Equilibrium between Knowledge in the Academic System & Knowledge created in or transferred to Industry (in Developed Countries)

Lack of such Equilibrium (in Developing Countries)

That is why the R&I Ecosystems are different in India at present and, say, the U.S.A.

**But** Things are changing rapidly in India

R. Chidambaram

### CAN INDIA BECOME A RESEARCH & INNOVATION LEADER?

I think so, provided we create an excellent research & innovation ecosystem; provided we have proper 'technology foresight' to make the right technology choices, in a national perspective; and provided we introduce 'Coherent Synergy' (a phrase coined by me some years back) in our S&T related activities.

Without 'Coherent Synergy' among its various components, establishing an excellent R&I Ecosystem is not possible.

### **CHAPTER 5**

### RESTRUCTURING R&D

### Introduction

Basic research results in many promising ideas and innovations that are barely able to move through the product development pathway to the marketplace. Many fascinating creative thoughts and research insights often get lost in translation because of lack of funding, incentives, and technical R&D and market expertise to advance it any further through the product development pathway. Many promising innovations get clogged in an ever-widening gap in funding and support for the kind of research that moves basic science into products and applications for the market. This "Valley of Death" is one of the most important barriers for furthering innovations.

### **Private Equity Debt Financing** Venture Capital Proof R&D Maturity Commercialization of Demonstration Concept **Technological** Commercialization Valley of Death Valley of Death INDUSTRY UNIVERSITY

The Innovation Pathway and Bridging the Valley of Death

[Source: Adapted from Breakthrough Institute, 2011]

Private sector financing is typically unavailable to bring new promising innovations from early-stage laboratory research to proof-of-concept prototype and into the marketplace because of pervasive market barriers. Such a development leads to two market gaps that result in the deaths of many promising innovations at the early-stage. These gaps are known as the early-stage "Technological Valley of Death" and the later-stage "Commercialization Valley of Death." Both the barriers prevent in most innovative technologies from making it to the marketplace.

Thus, the ability and speed to hasten technology commercialization and bring promising innovations into the marketplace requires a restructuring of the way research and development is carried out today.

Crossing the "Valley of Death" requires innovative thinking, involving passing promising innovations through three successive phases:

- At the "Technological Research" stage, ideas arising from basic research need to be *translated* into proofs of concept and into products for the marketplace.
- At the "Technology Demonstration" stage, the prototype product should be validated at a real scale of the relevance in terms of user value and the competitiveness of new product prototypes.
- The third stage, called "Competitive manufacturing" should allow product prototypes duly validated during the demonstration phase into solutions to tackle grand societal challenges.

### Restructuring R&D

Improving innovation and making R&D more responsive to the societal benefits are two of the biggest priorities facing industry and universities alike. Across technology domains ranging from pharmaceuticals or electronics, to manufacturing sectors including automobiles, superior R&D performance is recognized as vital for competitive advantage.

As noted by Gary Pisano (2012), "the failure of many organizations to improve R&D performance is not due to lack of effort or commitment by the management or people involved. It is due to a misconception about the drivers of R&D performance. Too often, R&D performance is boiled down to a few simple universal practices. Unfortunately, there is no one best model for R&D that is universally superior. There is no "magic bullet.""

Typically, new promising innovations pass through the innovation value chain comprising of a series of five interlinked activities to the market. A set of public and private actors and institutions plays a critical role at each phase of the innovation chain in technology development, technology funding as well as technology graduation to the next technology stage.

The innovation value chain involves actions from multiple stakeholders including, researchers, entrepreneurs, venture capitalists and larger financial intermediaries, endusers, and local, state and federal governments.

### Public Research and Technology Uptake by Industry

Public research institutions and universities have been at the forefront of basic or fundamental research. The primary role for universities is to educate the next generation of talent. However, as the originator of new promising innovations, and to face today's grand challenges, universities need to make a concerted effort to become more creative and entrepreneurial.

Scientists conducting basic and translational research need further financial investment to take their innovations through a process of development, testing, and refinement to establish their market viability beyond the initial proof-of-concept. However, investors are shy of funding such early-stage R&D due to multiple risks pertaining to technical, market, and management execution related risks and long development timelines.

Historically, public research initiatives have often focused on technology push rather than industry pull, and have contributed more to accelerating the speed with which promising innovations pile-up on one side of the commercialization valley, without taking them across.

Public research institutions should be more open for partnerships and collaborations with other research institutions and industry to push promising innovations to the marketplace.

Such an enhanced public-private research interaction calls for new approaches toward creating a bridge over the "Valley of Death" that exists between basic research and commercialization. Academia management must develop a strategy for sustaining a culture of promoting collaborations and enhancing the status of applied R&D. Assessing the overall impact of research and inventions through the lens of social contribution, and developing adequate metrics to quantify it are also recommended.

The Commercialization Valley of Death affects promising innovations with established proof-of-concept that require large capital infusions to demonstrate that their design and manufacturing processes can be brought to full commercial scale. For technology commercialization, the central challenge is accumulating enough capital for the commercialization, production, and manufacturing processes associated with demonstration and market launch.

In India, Dr Vijay Chandru, former Professor at Indian Institute of Science (IISc), is one of the few academics who crossed the bridge to the industry with his successful venture, Strand Life Sciences.

As mentioned before, university-level education is geared towards incremental innovation and engineers need to be geared for radical innovation development through skill building or experiential learning.

When considering a shift towards restructuring R&D, some of the key steps that need to be taken include the following:

Closer engagement with Industry: One of the steps that public research
institutions should undertake is to allow small and medium enterprises (SMEs) to
consider some of the early stage research outputs arising from academic research
labs. This would allow industry to consider opportunities early and, allow academic
professors to gain an informed view of current market needs and technology
trends.

### • Inculcating Innovation in the Engineering Courses:

Human capital is the key for enhanced R&D success. Relooking the current educational tools and learning imparted to students in engineering courses is essential, and changes made to ensure that innovative pedagogy is deployed to boost innovative R&D.

Experiential learning and working on real-life projects will prime engineering students to prepare themselves better for radical innovation, instead of the current incremental innovations that engineers are adept at.

By working and learning in multi-disciplinary groups, students would be able to understand and appreciate new societal challenges and would be better prepared to develop and deliver new promising technology products and solutions.

Rather than consider innovation just as an extracurricular activity, it is imperative that pedagogy is geared towards radical innovation development.

Students can benefit from intensive boot camps wherein they could present their promising ideas, and build their capacity and understanding of innovation through regular innovation workshops.

Industry can play a key role in skill development, by providing final year engineering students with an opportunity to work on live innovation projects. Such projects should be tailored to the curriculum level and learning of the student. The projects should ideally involve working on futuristic technologies, and wherein the work of the students is relevant and helpful in pushing the innovation through the innovation pathway to the next stage.

Government should continue to invest in developing high-quality skills through innovative educational tools and radical innovation necessary for preparing the engineers and scientists of the future. Government should focus on engineering as a strategically important and vulnerable subject and aid institutions in quality staff intake and retention.

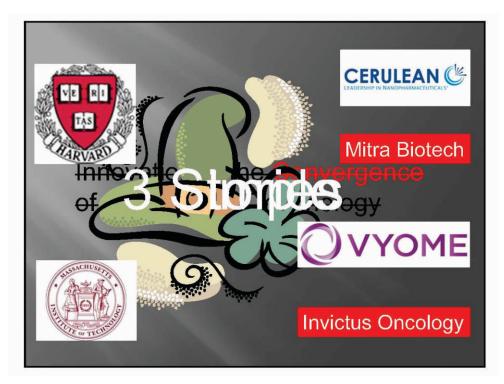
### **Salient Observations**

- The need of the hour for public research institutions today is to focus on applied or translational research.
  - o In a win-win partnership, academia brings credibility, cutting edge knowledge, new and interesting ideas, and intellectual and physical resources to the table. On the other hand, industry brings influence, training, technical know-how, significant research problems and financial resources.
  - Innovative R&D is fostered and new capabilities and competencies are builtup through greater technological collaboration between public research

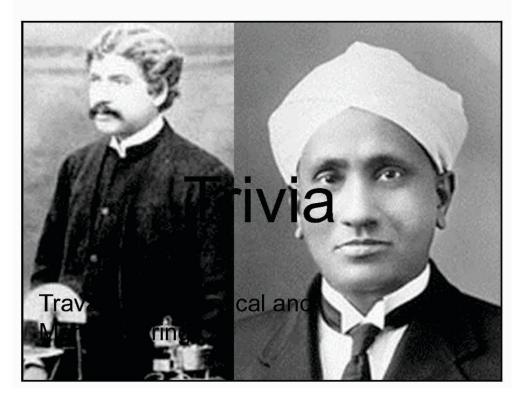
institutions and industry. Through greater academia-industry collaboration, new product and process innovations as well as new technologies can be fostered for public good.

- Risk-taking, failure-averse innovation culture in academic research institutions and universities would enable students to experiment and work on their own research ideas.
- Academia-industry partnerships need careful planning, design, implementation, and monitoring to meet the needs at the local, regional, and global level.
- o For its part, industry can benefit from working with the academic sector because they share visions that can help industry to be in "the frontline looking over the horizon." Industry also stands to benefit from such partnerships because research and development need multiple approaches, including fundamental research, to understand the phenomena behind the technology.
- To prepare engineering graduates for the new and complex challenges facing our world in the 21<sup>st</sup> century, it is essential that the undergraduate engineering education is reviewed and transformed. Successful educational change would involve an attitudinal shift in both faculty and students.
- Lastly, a culture of collective responsibility would enable the adoption of systemic and sustainable change in engineering education, helping prepare students for the future.

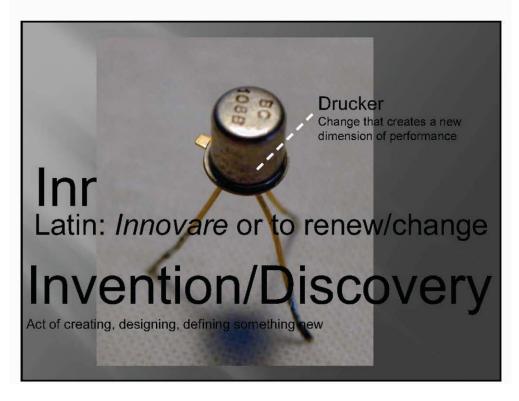
### Innovation Patents Frugal Innovation Jugaad Inclusive Innovation Reverse Innovation Academia vs Industry by Dr Shiladitya Sengupta

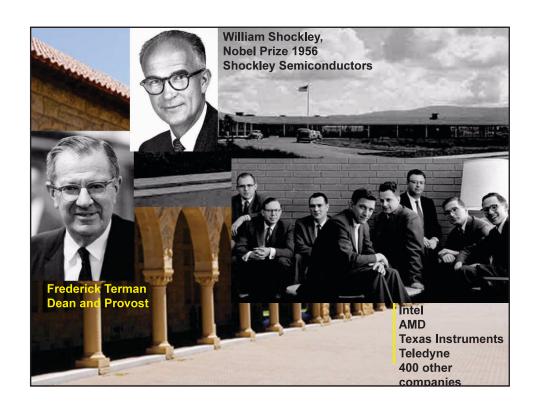


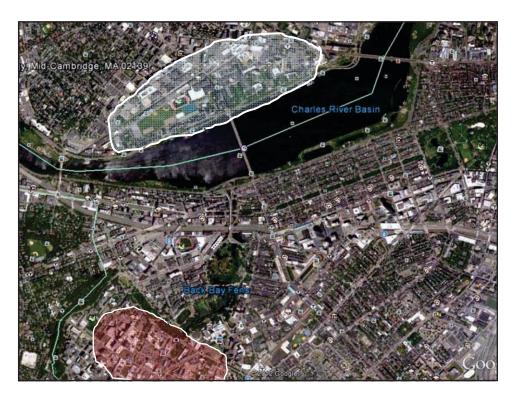


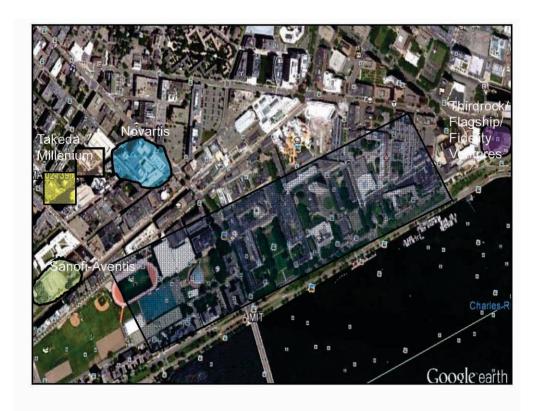


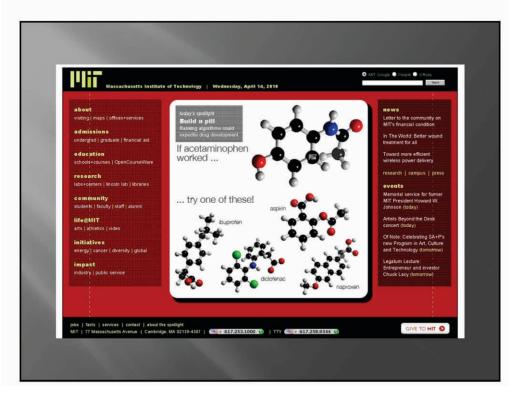
# Story 1. The ecosystem





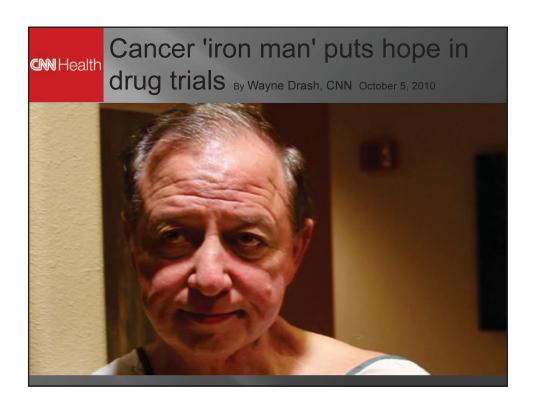


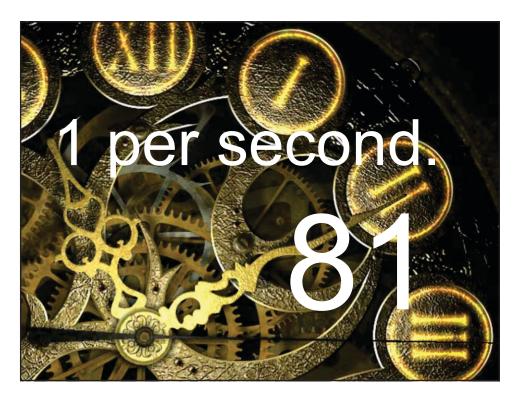




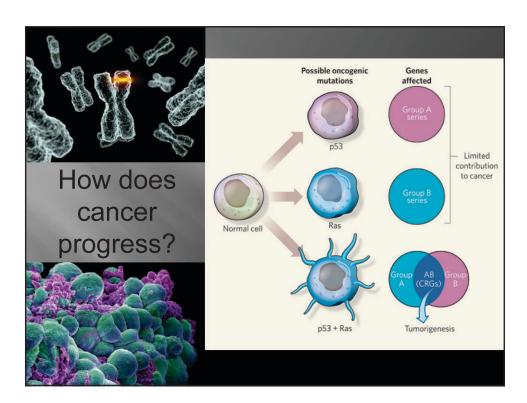


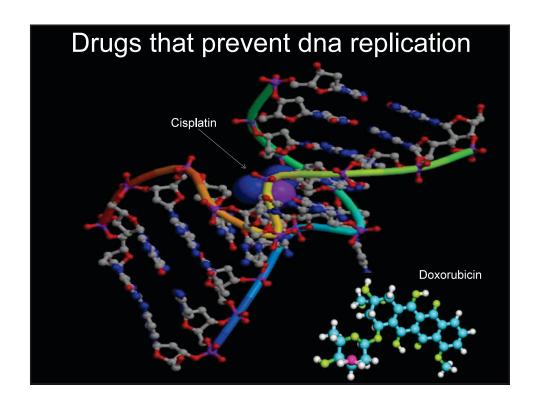
## Story 2. Why Innovate. The story of John Gossman

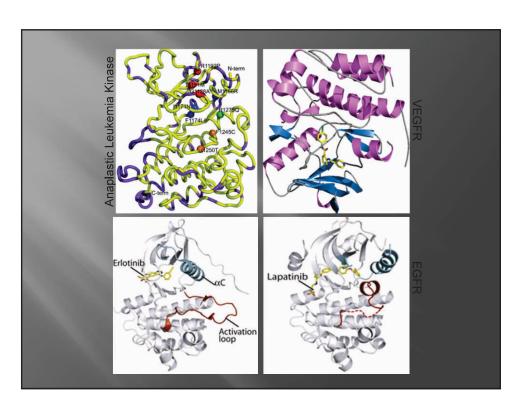
















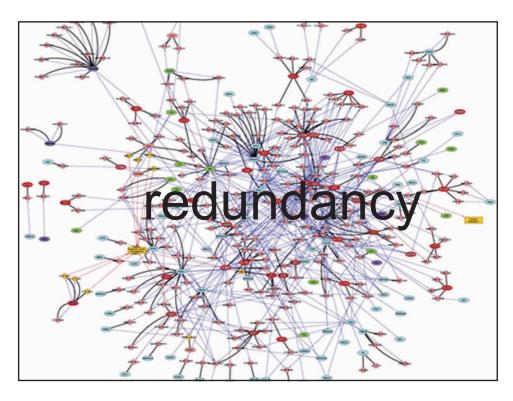


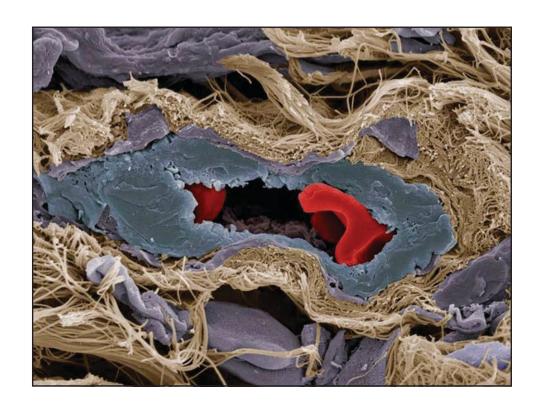


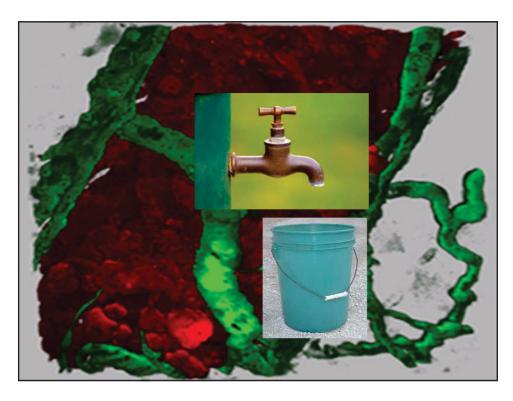


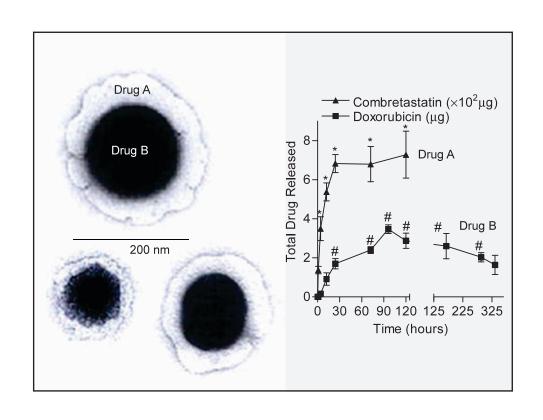


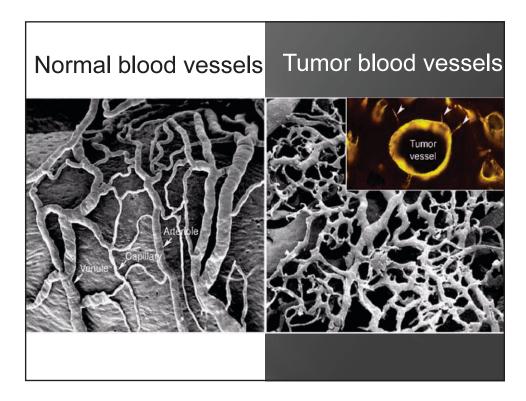


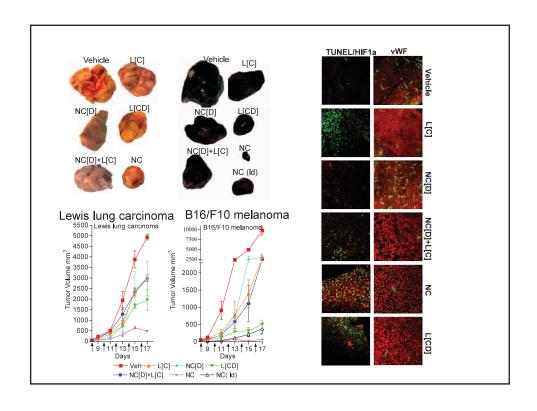


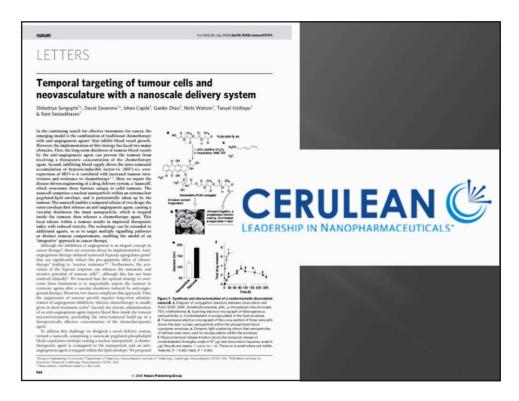


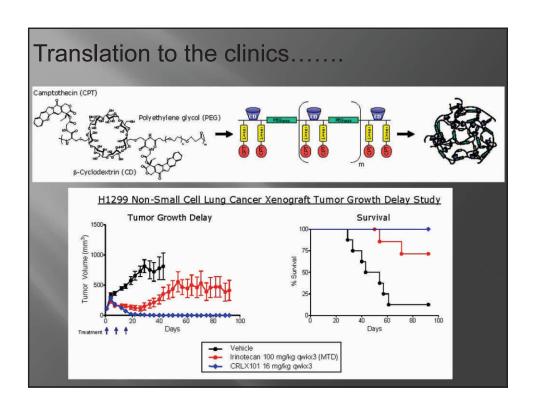


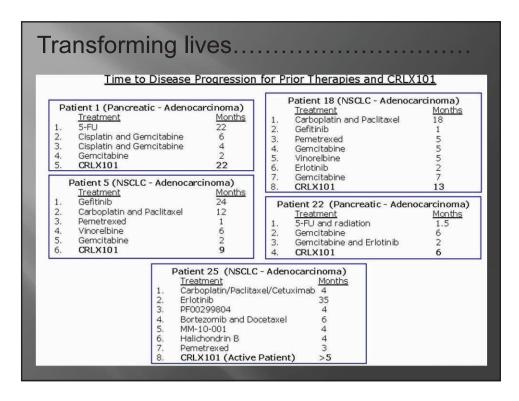




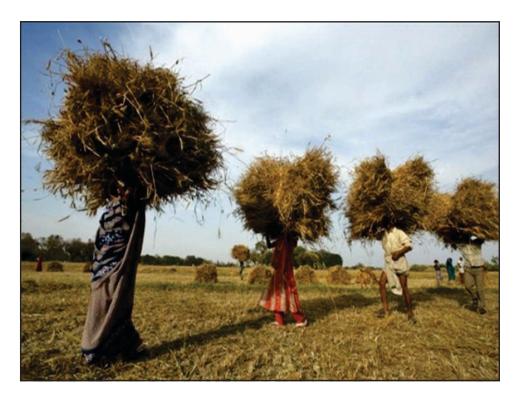












### **LETTERS**

nanotechnology

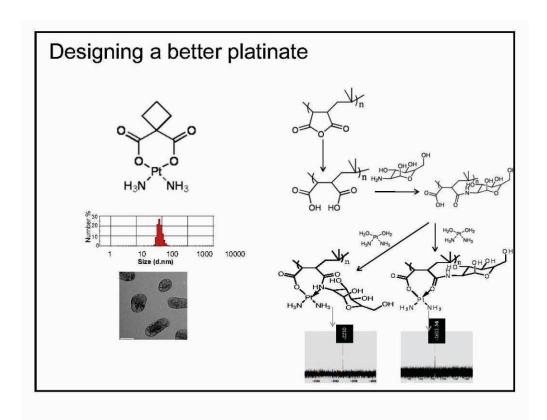
### Design considerations for tumour-targeted nanoparticles

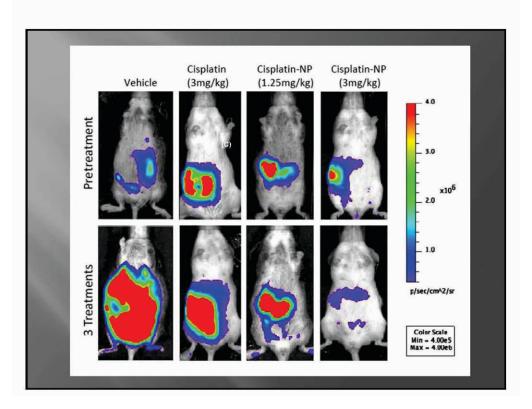
Hak Soo Choi<sup>1</sup>, Wenhao Liu<sup>2</sup>, Fangbing Liu<sup>1</sup>, Khaled Nasr<sup>1</sup>, Preeti Misra<sup>1</sup>, Moungi G. Bawendi<sup>2</sup> and John V. Frangioni<sup>L3\*</sup>

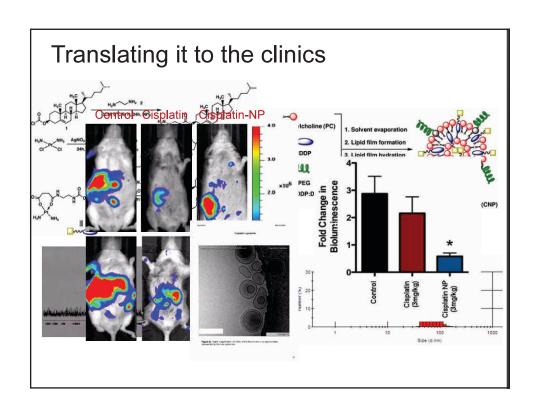
Inorganic/organic hybrid nanoparticles are potentially useful in biomedicine, but to avoid non-specific background fluorescence and long-term toxicity, they need to be cleared from the body within a reasonable timescale<sup>3</sup>. Previously, we have shown that rigid spherical nanoparticles such as quantum dots can be cleared by the kidness if they have a hydrodynamic diameter of approximatel<sup>3</sup>, 5.5 mm ind a rwitterionic surface charge<sup>3</sup>. Here, we show that quantum dots (antitionalized with high-affinity small-molecule ligands that target tumours can also be cleared by the kidness if their hydrodynamic diameter is less than this value, which sets an upper limit of 5-10 ligands per quantum dot for renal clearance. Animal models of prostate cancer and melanoma show receptor-specific imaging and renal clearance within 4 h post-injection. This study suggests a set of design rules for the clinical translation of targeted nanoparticles that can be eliminated though the kidneys.

Although many dates of histogramaticle intensity is provided in the care of histogramatic intensity is provided in the care of histogramatic intensity. In the case of the clinical translation is in the RES. Indeed, most tumour targeting of nanoparticles in a probably the result of enhanced permeability and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in a limitation<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in all most scapility and retention<sup>3</sup>, and not specific targeting in almost scapility and retention<sup>3</sup>, and not specific targeting

To demonstrate the generality of the technology, we developed two different types of QDs, one targeting prostate-specific mem-brane antigen (PSMA)-positive prostate cancer cells via the small malands linear CBI (sed. 35) and one transition intention = 9







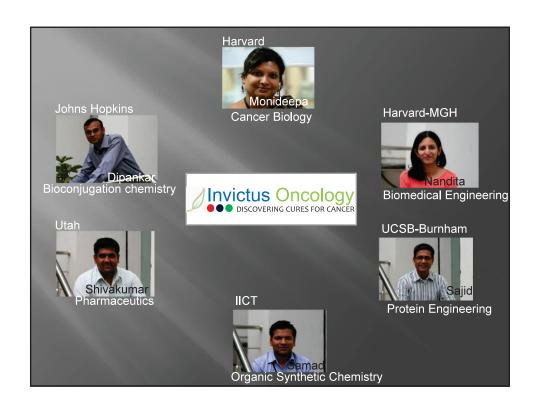


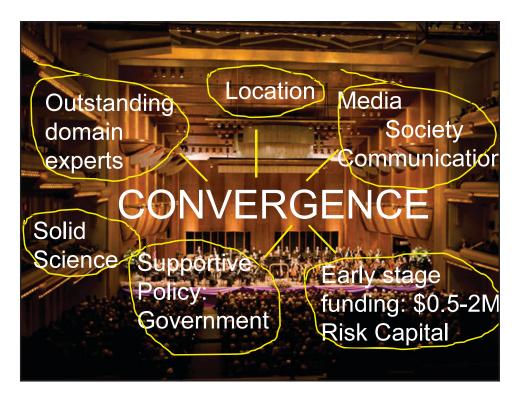


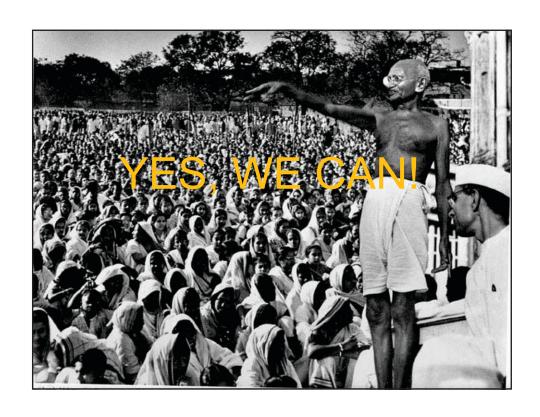












# Improving the Research Ecosystem by Pankaj Jalote



# Improving the Research Ecosystem

Pankaj Jalote Professor and Director Indraprastha Institute of Information Technology (IIIT), Delhi

### IIIT Delhi



Created by an Act of Govt of Delhi – fully autonomous, State University, managed by a Board of Governors

Vision: Be a world-class R&D-led institute of higher education in IT and allied areas

- § Globally respected for research **and** education
- § Thriving UG and PG programs
- § Socially relevant, Linked globally, Industry-facing

# Research - top of Pyramid

There is a pyramid in the engineering world
At the bottom we have the users of products
and services – that is a large numbers Engineers create products and services
Researchers – create knowledge and laws that
engineers use for creating products

It is a broad pyramid - top is very small





Is a community of living organisms interacting as a system
An ecosystem has producers and consumers in a healthy balance
And needs some nutrients to thrive

## Research Ecosystem



Main producer: Researchers •

Universities

- Government sponsored research labs
- Corporate labs

Main consumers of research output •

Researchers themselves

 Industry to create value (product, services,...) for society

Main nutrient: Funding through funding agencies, private funding



Without strong offtake / use of research output, strong research not easy In India, the consumer was very weak • No industry depending on R&D output

Weak research community

Now the consumption side is creating a demand for research – industry and government is asking for innovation and research to accelerate inclusion, growth,...

Much more needs to be done – to accelerate growth of R&D consumption

# Strengthening the Consumers )

Researchers as consumers requires things like •

- Conferences of repute
- Journals of high quality
- Peer review and recognition system

Most of these need strong doses



This is extremely important – without basic nutrients, ecosystem cannot thrive Funding is like sun/water Private funding is currently non existent Government funding is limited, often has many constraints

# Strengthening the funding

Further incentives for private sector funding Government sector funding •

Increase allocation substantially

- Relax the constraints in funding (travel, honorarium to Pls, etc.)
- Make them competitive



Critical mass - cannot have much without it; law of normal curve is at play Improving the research work environment - compensation, quality of work place, support, Creating icons - so best people go to research

Universities have to become the epicenter

- Our universities have become primarily "knowledge disseminators" (and examiners)
- This is a hard and tough journey

### **CHAPTER 6**

### **INCLUSIVE INNOVATION**

### Introduction

In developing countries, a majority of the 'Bottom of Pyramid' is often concentrated in rural areas and lacks the same level of access as most urban citizens.

The 'Bottom of the Pyramid' (BOP) includes 4 billion people earning less than US\$2/day. They lack access to basic necessities of life—safe water, sanitation services, housing, quality education, basic health care, electricity, phones, roads, financial services. In most instances, they have limited access to reliable markets to buy and sell their goods and services.

Population	n	Access to water Sou	improved rce	Access to Sanitation	_	Poverty	
Rural(%)	Urban(%)	Rural(%)	Urban(%)	Rural(%)	Urban(%)	Rural(%)	Urban(%)
70	30	84	96	21	54	30.2	24.7

[Source: World Bank, Human Development Report]

As per the World Bank, they represent an untapped market of US\$5 trillion.

These 4 billion people require 'ultra-low cost solutions' that are 'extremely affordable'.

It is when economically poor and disadvantaged people are enabled through capacity building to produce what they already know and do; or enable them to convert their innovations and outstanding traditional knowledge into products either on a stand-alone basis or by bundling it with knowledge of others. By developing such value-added products for delivery to the market through commercial or public delivery channels, inclusive development is promoted. Inclusive innovation has been recognized as a key goal for inclusive development in many developing countries, and in particular, India, China, Brazil and South Africa.

In 1989, Dr Anil Gupta started the Honey Bee Network. Since its inception, Honey Bee Network has mobilized thousands of grassroots green innovations and traditional knowledge examples from all over India and different parts of the world. The movement has spread to more than 75 countries, and interestingly China has taken keen interest and the lead. By identifying and tapping indigenous knowledge, Honey Bee Network encourages rural inventors and entrepreneurs to come up with products which can be used by industries, and leading to inclusive development.

Dr. Gupta set up the National Innovation Foundation (NIF) in 2000, a registered National body sponsored by Government of India that keeps track of innovations across India. NIF has mobilized more than 140,000 innovations and traditional knowledge products. NIF has created a fund to obtain the rights of technologies from innovators after compensating

them for the same. These engineering technologies and agricultural varieties will then be given to small scale entrepreneurs for manufacturing, marketing and distribution. In many cases, further research work will also be undertaken. By linking with the Future Group, some of the most interesting finds will soon reach a larger market.

Some of the innovations that NIF has discovered focus on agriculture: a more productive strain of peppers, a makeshift seat that lets coconut harvesters rest high up in trees, a hollow spear that pierces a hole in a field and drops in a seed. Some other interesting finds include the washing machine mounted on the back of a scooter and powered by its engine, and the amphibious bicycle.

### **Defining Inclusive Innovation**

According to RA Mashelkar, any innovation that leads to affordable access of quality goods and services for the excluded population, primarily at the base of the pyramid, and on a sustainable basis with a significant outreach can be termed as inclusive innovation.

The providers of such inclusive innovation could range from individuals to institutions to enterprises with motivation of achieving public good with simultaneous private good.

The providers of inclusive innovation could be individual grassroots innovators. This means innovation 'by the people for the people'. Inclusion innovation can arise through organized research done through the formal science, technology and innovation ecosystem of a country, including national laboratories, universities.

Inclusive innovation can be triggered and fostered by enterprises, whose strategies to tap the `next billion consumer market' that arises due to the economic growth in emerging economies. Such a growth gives rise to hundreds of millions of new customers with aspirations, who seek low cost but high quality products.

According to RA Mashelkar, any Inclusive innovation will have the following characteristics:

### 1. Affordability

The affordability will depend upon where exactly the individuals are placed in the economic pyramid. If 2.6 billion people in the world are earning less than \$2 a day, then one can imagine that the goods and services cannot be just 'low cost' but 'ultra low cost'. Such inclusive innovation will have to be aimed at 'extreme reduction' in both the costs of production as well as the distribution.

### 2. Sustainability

The Second characteristic is about the inclusive innovation being sustainable and affordable for the people, without having to depend on the government. Instead, it should work by retaining the market principles with which only the private sector.

### 3. Quality

The third characteristic pertains to quality. People at the base of the pyramid should be enjoying more or less the same level of quality of basic services as people at the top of the pyramid. As such, a truly inclusive type of innovation would be about getting 'more from less', meaning that technological advances would be leverage to invent, design, produce and disseminate quality products affordable for the majority of the people.

### 4. Bottom of the Pyramid

Access is a key characteristic for the excluded population, primarily at the base of the pyramid. For true inclusion, it is obvious that 2.6 billion people with income levels less than US\$2 per day should be the primary beneficiary of inclusive innovation.

### 5. Accessibility

For inclusive innovation to flourish, the benefits of inclusive innovation should reach a significant portion of population.

It must be emphasized that inclusive innovation forces us to measure the opportunity by the ends of innovation that is what people actually get to enjoy—as opposed to just an increase in their means. In important ways, this rationale invokes a return to the traditional case for innovation—its ability to produce break-through improvements in the quality of life—alongside the usual objective of competitiveness.

### **Spread of Inclusive Innovations**

Some examples of inclusive innovations are outlined below:

- **Embrace incubator** requires no electricity and is mobile, costing US\$25 or 800 times less than a traditional one.
- A **portable water filter** produces bacteria-free water using rice husks, costing US\$24 with a recurring expense of US\$4 every few months.
- **Jaipur Foot** a prosthetic with proven performance in harsh conditions, while costing US\$28 or more than 300 times less than a conventional one in the US.
- Computer-based functional literacy tool developed by the Tata Group that can train an illiterate individual to read a newspaper with only 40 hours of training and costs US\$2 per person.
- **Herbal Drug** developed by a Vietnamese firm to treat women's fibroids and men's prostate costing 70 times less than French drug (treated 300,000 persons).

• Low cost Refrigerator Chhotu Kool, which does away with the use of conventional technology involving a compressor and uses a cooling chip and a fan similar to that used in computers and is available for \$69. This is a good example of a disruptive technology innovation.

Inclusive innovation improves the quality of life as more people gain access to quality goods and services at affordable prices, by improving competitiveness as less resources drive down costs and open new markets.

Inclusive Innovation at work: Less for More

Products	Pricing Levels (in USD)			
	From	To		
Psoriasis Treatment	20000	100		
Hepatitis B Vaccine	18	0.4		
Cataract Surgery	3000	30		
Artificial Foot	12000	28		

[Source: CyberMedia Research]

### Narayana Hrudayalaya

Dr Devi Shetty pioneered one of the world's largest cardiac care facility providing heart surgery and other forms of cardiac care, including care for children through the Narayana Hrudayalaya Cardiac Care Centre.

At Narayana Hrudayalaya, patients are charged a flat \$1,500 compared with the US where an average heart surgery costs \$45,000. Despite helping so many poor patients, NH is known for being so efficient that it has a higher profit margin (7.7 per cent after tax) than most US private hospitals (6.9 per cent).

### 3Nethra

Another example of successful inclusive innovation is *3Nethra*. Started by experienced technologists in January 2010, 3Nethra helps in 'prescreening at doorstep' by detecting the onset of blindness at very early stage. It is a paradigm shift in moving "pre-screening" away from hospitals to the patient's doorstep. Also, it is a single, portable, intelligent, non-invasive, non-mydriatic eye pre-screening device which can take the image of the eye and with built in image processing algorithm can sort the eye images.

This single machine can detect diseases like Cataract, Glaucoma, Diabetic Retina, Refraction & Cornea problems. They plan to expand their services in 110 M cumulative lives in 5 years.

### **Jugaad or Frugal Innovation**

With an increasing acceptance as a management technique, Jugaad is now recognized globally as an acceptable form of frugal engineering pioneered in India

Jugaad is a Hindi term that translates as "an innovative fix; an improvised solution born from lack of resources, ingenuity and cleverness." Jugaad involves attaining any objective with the available resources at hand. The practitioners of Jugaad use the combination of present knowledge and innovation in utilizing whatever resources may be at hand without asking or waiting for additional resources.

There is a large and growing demand from the BOP in developing countries for affordable and good quality products that offer value for money. Interestingly, even customers in the West now seek similar technologies, products or solutions, instead of over-engineered, high price products. This trend can be attributed to the prolonged economic downturns or a greater focus on sustainability.

There are many examples of Jugaad from across India. These range from creating a truck by connecting a diesel engine onto a cart, to creating a seat for tree climbers.

As noted by NESTA in its recent report, *Our Frugal Future*[2012], Jugaad or frugal innovation involves the following characteristics:

- Jugaad or Frugal Innovation involves making better things, not just cheaper things.
- Frugal innovation extends to services, not just products.
- Frugal innovation is about remodelling, and not just de-featuring.
- Low cost does not mean low-tech: Quality is critical, and frugal innovation can require, or be combined with frontier science and technology.

There are some criticisms that have been leveled against Jugaad:

- It represents a quick fix and crudeness.
- Jugaad involves getting around the law, regulations and standards.
- It is used for making things that people want, and they do not meet quality standards.
- The innovations developed through Jugaad are not scalable.

Globally, financial austerity and environmental sustainability have created a greater interest in frugal innovation amongst customers. While there are many countries experimenting with frugal innovation, India has unique advantages:

- A vast, price-sensitive market;
- A culture of creative improvisation;
- A vibrant civil society;
- An emerging funding system for social innovation; and

• A Government keen to create an 'inclusive' model of innovation that aims to connect India's leading scientists with its greatest societal challenges.

### **Promoting Inclusive Innovations**

Some of the key challenges facing the BOP relate to accessibility and affordability. Often, they find themselves having to make difficult compromises: they have limited incomes, and they desire products and services that are suited to their needs; they require information, yet they have difficulty accessing it.

Inclusive Innovation could be enabled through:

- Creation of pilot technologies that target country-specific development challenges
- Generation of pilot technologies (solar appliances, herbal drugs, low-cost diagnostics)
- Commercialization of prototypes created by grassroots innovators (e.g., solar lamps, pedal-driven washing machine)
- Upgradation of technological capabilities of SME enterprises to enhance efficiency, competitiveness and new products and markets

Some of the key steps that need to be taken for promoting inclusive innovation are outlined below:

### 1. Government

- Government should support in the creation of an Inclusive Innovation Fund for promoting inclusive innovation. Such a Fund could support conducting of R&D to produce prototypes/ pilots; in demonstrating the technical feasibility of innovations; in incentivizing businesses to undertake mass production; and in providing grants for supporting innovation.
- Public Policy should provide a conducive framework, supported by policies, regulations and incentives that encourage the creation, adoption, commercialization and diffusion of inclusive innovations. Such policies should enable effective collaboration amongst various stakeholders in the innovation ecosystem.
- Government should invest in the business enablers to improve marketrelated infrastructure and policies, and provide essential services
- Information is critical for the BOP, and public policy should focus on educating and supporting the BOP in creating new innovations. This would

be through initiatives including, rural consumer forums and public education campaigns.

• Government should foster public-private partnerships by bringing in, aligning stakeholders around common priorities.

### The India Inclusive Innovation Fund (NIF)

The Indian Government has since indeed established an India Inclusive Innovation Fund (IIIF) with a corpus of \$1 billion that will drive and catalyze the creation of an ecosystem of enterprise, entrepreneurship, and venture capital, targeted at innovative solutions for the BOP.

The Fund will focus on providing risk capital funding to enterprises that create and deliver technologies and solutions aimed at enhancing the quality of life for the BOP; and will support investment at different stages of the enterprise development cycle – from early stages, through later phases of scaling-up of potentially successful solutions and business models.

The Fund proposes to seek capital from a range of sources: seed fund contributions from the government and its agencies; contributions from various Indian public sector enterprises, banks, and so forth; and contributions from private investors, corporates and investment firms.

[Source: National Innovation Council]

### 2. Businesses

- Enterprises need to understand the specific needs and constraints of the BOP, and invest in R&D and new product development for the BOP market
- They need to assess opportunities that would help integrate the BOP into value chains and reduce overall costs, while focusing on capacity building for BOP suppliers and distributors.
- Enterprises should partner or collaborate with others to align complementary investments, share supply and distribution costs, and improve the enabling environment, and should work through a business model that fosters collaboration amongst stakeholders.

### 3. Civil Society

- Civil Society should focus on strengthening the technical and commercial capabilities of the BOP to enable higher quality and efficiency of production.
- By creating enabling market infrastructure, Civil Society should embrace new non-traditional roles in business partnerships, for example, by

providing a distribution system to efficiently deliver products and services, as well as education and skills for the BOP

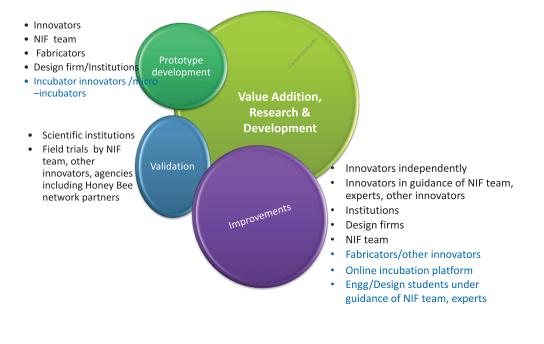
### 4. Research/Academic Institutions, International Organizations

- Research institutions should conduct research to identify business and market development opportunities that would benefit the BOP and communicate to stakeholders
- They should undertake or fund R&D for new product development targeted at the BOP, and aid in funding the start-up phase of new business models to enable experimentation
- They should identify public-sector policy and investment priorities to enable inclusive business models
- Awareness is a key for the BOP, and this can be achieved through specific campaigns, sharing of best practices and lessons learnt, and by an ongoing monitoring and evaluation of business models.

### **Salient Observations**

- Inclusive innovation model focuses on the needs of the deprived, and involves directing the best human and financial resources to solving more basic developmental needs.
- As argued by Prahalad (2004), large companies can use their considerable technological, organizational, and marketing capabilities to create and deliver products and services for people at the bottom of the economic pyramid—those with incomes of less than \$2 a day—and make a profit doing so.
- For those at the Bottom of Pyramid, the lack of recognition, understanding and appreciation of informal learning platforms and mechanisms are hurdles to innovation. Alternative modes of community engagement need to be encouraged that better facilitate learning and innovation among poor communities. A conscious integration effort to shift to pro-poor approaches to development, and on a bigger scale, a deliberate establishment of inclusive innovation systems should be facilitated by individuals and institutions and backed by policy action.
- The Indian tradition of Jugaad, involves developing alternatives, improvisations, and make-do to overcome a lack of resources and solve seemingly insoluble problems. However, Jugaad has a negative connotation, and implies compromising on quality. RA Mashelkar (2010) prefers to call it —Gandhian innovation, because at the core of this type of innovation lie two of Mahatma's tenets: Affordability and sustainability. Indian companies have recently discovered their power.

### Value Addition, Research & Development at National Innovation Foundation-India



### Low cost windmill

Innovator: Mohammad Mehtar Hussain and Mushtaq Ahmad, Darrang, Assam

- Looking for a low-cost alternative to pump water in the fields for the winter crops, the brothers devised the simple windmill made up of bamboo and tir sheets.
- Looking at its potential in Gujarat Grassroots Innovations Augmentation Network- West (GIAN -W) has improved the design considerably with the help of innovators and other experts.
- GIAN -W installed 50 units in the salt farming area of Gujarat for pumping up brine water and also for simple farm irrigation purposes.
- Challenge: Design of a power generating wind mill suitable for low wind regions (capacity 1 to 1.5 kW)
- Design of reliable low cost brake system, pump suitable for high speed reciprocating movement to get maximum output and minimize brake down of the pump assembly





New approaches



<u>Video</u>

### **Bamboo splint maker**

Innovator: Shri Paresh Bhai Panachal | 43 Years | Ahmedabad

- For the processing of bamboo, electricity operated high capacity machines are available, which are suitable for industries but not for poor people who make bamboo strips and sticks using knife for various purposes.
- These are two manual machines, one for slicing the bamboo pieces of definite size and length, while the other is for splinting.
- Capacity of producing 30 kg of sticks per day
- Blades are made of high carbon steel and needs to be replaced after producing 10,000 kg of splints.
- Cost of set of machine: Rs 40,000/-
- The innovator has sold 80 machine
- The innovator is selling this machine since 2011.
- Sixty machines have been sold to tribal communities through DFO Udaipur and 20 machine through NGO in Siligudi,(WB)

Challenge: Dissemination in different parts of country



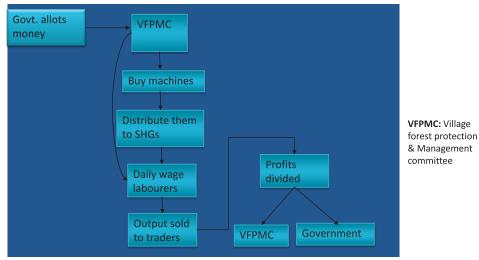






### Bamboo splint maker

• Model being adopted by Udaipur District Forest Office -Udaipur

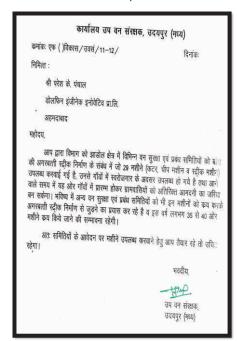


Activity -> Sticks making Only Chips making Only Sticks making Kulfi sticks making

Rates /kg-> Rs. 19 Rs. 4 Rs. 15 Rs. 8

### Bamboo splint maker

### Feedback from DFOP- Udaipur



### **Bamboo processor**

Innovator : Mr. Lalbiakzuala Ralte and L Sailo, Aizwal, Mizoram

- Conventionally the splitting and slicing of the bamboo is done manually by hand which is a tedious process and needs expertise.
- Manual machine for slicing and making bamboo splints
- Can make 50 splints at a time
- Splint thickness:1.2 mm, width: 1.2 mm
- 2 kg bamboo slices (250 mm wide) yields about 5000 splints/hour
- Price: Rs.5000 /-
- Weight: 5 kg
- Size 550 x 400 x 175 (mm)
- Innovator himself is manufacturing and selling from Aizwal, Mizoram.
- Over 1800 units have been sold locally

Challenge: Dissemination in different parts of country





Video

### **Bamboo splint maker**

Innovator : Mr. Ushman Shekhani, Chhatisgarh

- A cost effective manually operated device that helps reduces drudgery.
- This is specifically designed to increase the efficiency of bamboo workers, who prepare bamboo splint for incense sticks, tooth picks, ice cream sticks and is a good livelihood generation product.

Dimension : 4" x 2" x 3"

Splint Width : 0.5 mm

Splint Thickness: 0.5-2.5 mm

Weight : 100 gm

Capacity : 2000 splints or 1.3 kg/ h Material : Wood, Carbon steel

- Innovator himself is manufacturing and selling locally at small scale
- Innovator is selling since 2002 and sold over 10000 units
- Price: Rs. 350/-
- Innovator can manufacture 200 units per month



**Challenge:** Mass dissemination in different parts of country

Video

### **Incense Sticks Making Machine**

Innovator : Shri Manihar Sharma, Manipur

- This manual device has two blade arrangements, one for making small bamboo splints and the other for making small sticks.
- For stick making it has a multi-bladed arrangement for different stick sizes.
- Both the blades are fixed on two sides of a small wooden bloke.
- It can make sticks from both green and dry bamboo.



**Challenge:** Mass dissemination in different parts of country

### Hand operated water lifting device

Innovator : Shri N Shakthimainthan, Thiruvarur, Tamil Nadu

- Consists of 2 pairs of chain and sprocket (gear ratio 1:2), impeller pump and pipes.
- Discharge, irrigation capacity and delivery head of this device are 20-22,000 1/h, 0.03 ha/h and 0.5 m, respectively.
- It can be used for low head (upto 1 m) and high discharge application, for transferring water from canal to field, from one field to other field . And can also be used for draining out excess water from field
- CMERI Durgapur worked on the technology. Came up with improved design, has easy and standard manufacturing, majority of standard components and ergonomic design for reduction in effort for the same discharge.





Satisfactory user feedback; Need of mass manufacturing for reduction in cost.

Video

### Adjustable walker

Innovator: Miss Shalini Kumari, Patna, Bihar

- It is quite difficult for old, physically challenged or person recuperating from lower limb problems to climb up or down stairs using conventional four leg walkers.
- Shalini gave an idea to mechanically alter the height of the legs of the walker so that they can be adjusted as per the height of the stairs.
- NIF team developed prototype of his idea





NIF engaged design firm (M/s Lumium Innovations Pvt Ltd, Ahmedabad) to develop improved reliable prototype.



Product with good aesthetics and reliable functionality is developed. Further improvements based on feedback of potential users are being incorporated.

### **Improved metal cutter**

Innovator: Abdul Rahman Sheikh, Anantnag, Jammu & Kashmir

- Can cut MS sections (pipe, rods, angles, flats, etc) and sheets, precisely
- Cutting range: One inch to eight inch (pipe, guarder etc) and it can cut flat sheets of any length.
- It can be adjusted to cut in any angle (the cutting blade can be rotated from 0 to 180 degree).
- NIF engaged design firm (M/s Lumium Innovations Pvt Ltd, Ahmedabad) to improve aesthetics, functionality, safety, etc.





Prototype with good aesthetics, improved and reliable functionality, reduced adjustments needed at low cost is developed. Further improvements based on feedback of potential users are being incorporated.

Video

### **Ceiling Air Cooler**

Innovator: Shri Gopal Kumar Saluja, Ambala, Haryana

- It comprises a ceiling fan, a submersible water-pump with motor, a water container having arrangement for continuous water drip, as used in desert coolers.
- Ceiling mounted hence saves space



 NIF engaged Srishti School of Design Bangalore for improvements in the design. The new design has provision of wall mounted water reservoir, uses cotton strips clad in aluminum mesh for misting. As the fan is turned on, air comes through the strips which are always kept moist by capillary suction.



Under trials for assessing effectiveness; other ideas in mechanism are welcome

### Motorcycle driven multifunctional farming implement

Innovator: Shri Mansukhbhai Jagani, Amreli, Gujarat

- It has self designed chassis cum tool bar attached to rear of motorcycle after removal of its rear wheel
- It can do shallow ploughing, sowing and inter culturing. And can also be used for haulage/transport.
- CMERI Durgapur worked on the technology. Came up with new design of chassis which can be fitted to motorcycle without removal of rear wheel and in short duration of 30-35 min.







It has high turning radius hence difficult to maneuver, more loss of time in turning hence less field efficiency; farmers didn't accept the design.

### **Travel bag with folding seats**

Innovator

: Ms Nisha Chaube, Noida, Uttar Pradesh

Considering the problem commuters have to face while waiting for buses/trains at stations, Nisha has incorporated light-weight folding seats in traveling bags so that the same can be used when needed.



NIF engaged a designer cum fabricator M/s Senzo Consultancy, Mumbai for developing marketable product (Travel bag with seat and attachable seat for existing bag)







• The developed prototype has problem in balancing, has lack of user friendly way of folding and unfolding the seat, aesthetic design, etc.

### **Solar Laminator**

### Innovator: Shri Amandeep Singh, Hanumangadh Rajasthan

- · Low cost solution for lamination in the places where electricity is not available/ is erratic
- The paper to be laminated is kept between the lamination sheet and then passed between the rollers for lamination
- No bubbling or wrinkling is observed during the process.
- On a sunny and clear day, it takes 15-20 min to laminate first document. Once the laminator gets heated to the optimum, the time taken for one lamination is comparable to that taken by an electricity operated one.
- It also has provision of using electricity in case the work needs to be done in absence of sun light
- NIF involved an design firm to optimize the design and convert it into marketable product







- Cost effective and easy to manufacture design
- Needs locking system for keeping reflectors at some position
- Further weight and size reduction were possible for laminating A-4 documents

### Pomegranate deseeding machine

### Innovator: Shri Uddhab Bharali, North Lakhimpur, Assam

- Conventional method of separating the arils from the peel is a very tedious and time consuming process.
- Pomegranate fruits cut into half are fed into the deseeding machine. After the operation time of 5 min, the grains get collected in the seed collection tray located at the bottom of the machine.
- Leftover and other membranous part remain in the upper casing of the machine.
- Capacity 5 kg/h
- NIF involved Design Dept, IIT Guwahati in improvement of the technology





Need of making further compact and efficient unit

### Pomegranate deseeding machine

Innovator: Shri Uddhab Bharali, North Lakhimpur, Assam



Deseeding efficiency < 50 % Capacity: 50-60 kg/h Power requirement: 0.4 units/h

### Design student MsMrinal, MIT Pune worked with NIF team



Deseeding efficiency > 70 %, in two passes >85%

Capacity: 50-60 kg/h

Power requirement: 0.4 units/h

Safety , operators comfort and cleaning issues

resolved

Video

### **Auto compression sprayer**

Innovator Shri Arvind Patel, Ahmedabad, Gujarat

- It uses the force generated by the body movement for spraying application. It has dead weights reciprocating the piston to pressurize the fluid inside the chamber
- CMERI Durgapur worked on the technology. They came up with compact design using small tension spring and a new lever mechanism; and good aesthetics views.









CMERI-Proto 2

It could not produce sufficient pressure while normal walking

<u>Video</u>

# Some More Challenges

### **Manual Paddy Transplanter**

Millions of women have to bend their backs for hours standing naked feet in the water to transplant paddy in the fields. The challenge is to develop a manual paddy transplanter, which should

- Be easy to operate, clean and maintain
- Light in weight so that it can be carried easily
- Be atleast three times in capacity (output: area transplanted/unit time) as compared to human effort
- Be able to be used in different kinds of soils and across different agroclimatic regions of the country with minor modifications to suit local needs
- Be cost effective so that small and marginal farmers may afford it
- Be useful for small land holdings and may be scaled up for larger farms
- The construction materials should be such which are easily available across the country







Prototypes developed by Photo Singh & Ranjeet Mirig

### Developing a fuel efficient wood/bio mass stove

The challenge is to develop a stove, which could satisfy the following conditions

- Fuel efficient with efficiency greater than 50 % at least
- Able to use different kinds of fuel woods, bio mass available/used in different parts of the country
- Low in smoke/emissions
- Can be made/assembled easily using locally available materials (throughout the country)
- Should be compact so that a small household can also use it
- Cost effective



### Developing a tea plucking device

Women comprise over fifty percent of the total work force in tea gardens in India. Plucking of tea leaves manually involves a lot of drudgery. The challenge is to develop a tea leaf plucking device, which satisfies the following conditions

- Ergonomic, manual/semi-automatic so that the labour does not get replaced and mainly the drudgery is reduced
- Be easy to operate, clean and maintain
- Less in weight so that it can be used easily, tea collection bag may also be incorporated in the same so that women do not need to carry it on their back
- Be atleast three times in capacity (output: tea leaves plucked/unit time) as compared to human effort
- The construction materials should be such which are easily available across the country
- Provision of height adjustment should be there
- Should be able to move easily between the rows of tea plants
- Cost effective so that it is not a burden for tea plantation owners or welfare committees to purchase them



### Variable input power generator

- The variable speed of wind, water affects performance of the windmill and hydropower turbine. The existing power generating windmills/hydropower turbines don't function below the critical wind/water speed.
- •In biomass gasifier the output of generator is many times pulsating due to difference in combustion efficiency of fuel, calorific value, moisture content and feed rate; resulting variation in flow rate of producer gas.

There is need of developing variable input (constantoutput) power generatorsystemfor all three types of applications. There may be mechanism similar to flywheel in engines for constantaverageoutput)

### Auto power adjusting engine

It has become trend of using high horsepower engines for different applications irrespective of loading (Eg. while purchasing tractor the farmers compete with their neighbours and purchase high horse power tractors, but uses them with conventional implements designed for lower size tractors. In many cases the engine is very poorly loaded, however the fuel consumption remains at much higher side due to its idle requirements.



There is need of developing engine, which can be used as variable power engine by turning on/off some cylinders as per the need. The fuel consumption at idle running can be reduced

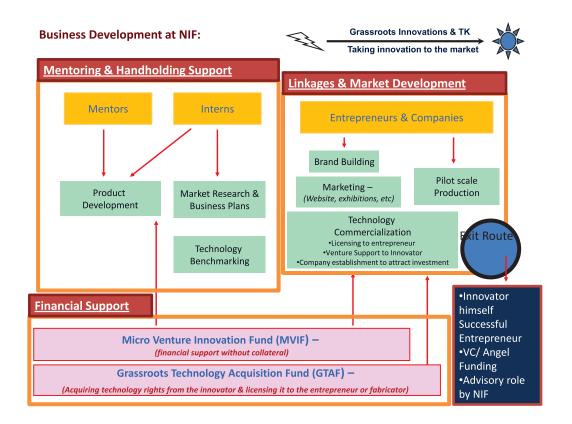
<u>Reference:</u> Raheman, H., Maheshwari, R. K. and Sahu, R. K. A decision support system for matching and field performance prediction of tractor-implement system, 19th convention of Institution of Engineers (Agricultural Engineering), Bangalore, January 2006.

### Decision support systems and automization in farming

- The existing techniques in farm implements don't tell the farmers, "how many hours the machine/implement has been used".. can the farmer answer precisely ??.. Then how can they maintain and do periodic service....
- The existing techniques in farm implements don't tell the farmers whether the seeds are being sown at equal depth? Whether plant to plant spacing is maintained properly?? Whether the ploughing depth is controlled properly in the age of using automatic depth and draft control system and if there is variation in depth of ploughing. What is the pattern??
- The existing agro processing machines don't give feedback whether the output is having consistency
- There is need of developing embedded electronic systems (suiting the
  environmental condition in Indian context) for precision farming which can
  help the farmers in taking the decisions and also can regulate the preset
  performance parameters automatically.

### Mobile phone based applications

- To design a water quality scanner that uses mobile phone camera or any
  mobile based sensor attachment that uses the data processing power of a
  mobile.
- To design a mobile phone based ultraviolet LED properly encased for safety reasons that can be used to disinfect water, or even food.
- To design a mobile phone based application that helps user in self grading tutorials for english, math, basic science etc. The application will have a question bank with varying level of difficulty. The user can select or the application can set the difficulty level according to the user needs.



### **Innovations for Rural Poor**

### **ANIL K. RAJVANSHI**

Director, Nimbkar Agricultural Research Institute (NARI), P.O. Box 44, PHALTAN-415523, Maharashtra, INDIA E-mail: anilrajvanshi@gmail.com

Good morning ladies and gentlemen,

I am delighted and deeply honored to give this keynote at <u>INAE-organized International Conference on Innovation</u>. I must thank Dr. Mashelkar for suggesting my name and Dr. Zarabi and his colleagues at INAE for inviting me.

Since yesterday we all have heard many speakers talking about innovation in various fields. My talk will focus on innovations for rural poor. But for us to do so we must first understand the problems of rural poor.

### Consider the following:

- 1. Sixty five percent of our population is rural-based. And 60% of this population (~ 400 million) has nearly non-existent electricity. Nearly 50,000 villages have never seen electricity. It is a sad state of affairs even 65 years after independence.
- 2. In poor rural households they mostly use kerosene in polluting lanterns for lighting and use 180-200 million tons/year of biomass in inefficient, primitive and smoky stoves. Besides there is no provision of clean drinking water.
- 3. In rural India around 300,000 deaths/year take place because of indoor air pollution and another 1.5 million deaths due to diarrhea-related cases.
- 4. Around 400 million people in rural areas survive on less than Rs. 40/day. With increased electronic mass media exposure (cell phones, T.V. etc.) they aspire to a better quality of life. This aspiration is the driving force for urban migration and rise of Maoism in the country.
- 5. Energy is the basis of life. Lack of it produces economic stagnation and social upheavals. Energy situation in rural areas is really alarming with per capita electricity consumption of just 96 kWhr/year. Even average per capita consumption of Indians is only 18 GJ/year as compared to 350 GJ/person-year for U.S. citizens.
- 6. Human Development Index (HDI) is directly proportional to the energy consumption. In India it is 0.55 with per capita energy consumption of 18 GJ/year. With energy consumption of 50-60 GJ/year HDI can be raised to 0.8 (equivalent to European lifestyle of 1970s) and is a doable goal.

I feel most of these problems have come because of non-governance. In a corrupt society which unfortunately India is, the first casualty is governance and we are seeing the effects. Part of this non-governance has been a very poor energy infrastructure which has resulted in unavailability of adequate energy in rural areas.

### Strategy for Rural Development

The rural population has the same aspirations as you and I have. With increased exposure to mass media, their desire to improve their lot has also increased. Thus technology intervention is required in using local resources to provide products and services to these people. Filtering-down approach of urban goods to rural areas will not work in the long run because of lack of infrastructure, resources and different local situations.

This is a technological age. Whatever we do is governed by technology and thus technology plays an extremely important role in our lives.

Most of the technological efforts in the past for providing basic facilities to rural areas have been based on a 'tinkering' approach, meaning a small adjustment here and there, and using 'low' or appropriate technology. This approach, which has been used by various agencies, normally resulted in incremental changes like development of improved chulhas (cook stoves) or better bullock carts. Tinkering, however, has barely made a dent in the quality of life of the poor people.

I therefore believe that innovations in technology are needed and that sophisticated technology is needed to convert efficiently the locally available resources and materials into useful products. These innovations are also called frugal innovations in which one can achieve much more from fewer resources and materials. This is the hallmark of evolution, where natural systems evolve into very efficient materials and energy converters. In this process, size reduction and increased complexity of the system take place. Some of our designs and technologies are following this route. For example, computer chips, cellphones, power plants, etc. have reduced in size, increased in complexity and become more efficient. Technology developers should follow this strategy in developing rural technologies. In fact, much more sophisticated thought and 'high' technology are required for solving rural problems since the materials and energy resources available are limited and often in 'dilute forms'.

I also believe that the Mantra for rural development should be "Improve quality of life for rural poor – one household at a time".

Thus the major effort should be for providing basic amenities for rural households. This includes excellent light, very clean and easy to use fuel for cooking and clean potable water. Besides innovation is needed in providing a very energy-efficient fan (maximizing air flow; m3/W) for comfort cooling and a tiny refrigerator for keeping small amount of milk and vegetables. With provision of these amenities the quality of life of rural poor can make a quantum jump.

We will show with few examples how some of these innovations can take place.

### Lanstove™

A good example of a frugal innovation (achieve more with less) is the concept of <u>Lanstove developed by our Institute</u>. It simultaneously provides excellent light (equivalent to that from 250-300 W electric bulb), cooks a complete meal for a family of 4-5 people and boils 10 liters of water. In one shot it provides a very high quality end-product of lighting, cooking and clean potable water. For an unelectrified household this is a unique invention. Lanstove has been tested in about 50 huts and 25 units have been distributed to the rural households which had never seen electricity.

The Lanstove™ runs on kerosene and is clean and as easy to light and run as LPG. Tests reveal that the CO levels are less than 4 ppm even after 4 hours of use and the particulate levels are also within WHO

standards. Efforts are on to put a small thermoelectric element in the Lanstove for charging cell phones. Similarly R&D has also started on using the heat from Lanstove to drive an absorption chilling unit for a very small refrigerator.



In working with the rural poor it also became evident that just with better cooking technology their diet will not improve and improved nutrition needs a different effort. Most of the rural poor are landless laborers who come home in the evening very tired after working in the fields and farms and have to cook on most primitive and polluting cook stoves. They cook and eat whatever is available from Public Distribution Shops (PDS)-which most of the times do not have adequate rations.

Hence a concept of <u>rural restaurants</u> has been developed. These restaurants will be similar to regular ones but for people below poverty line (BPL) they will provide meals at subsidized rates. These citizens will pay only Rs. 10 per meal and the rest, which is expected to be quite small, will come as a part of Government subsidy. The buying of meals could be facilitated by the use of UID (Aadhar) card by rural poor.

The rural poor will get more nutritive and tasty food by eating in these restaurants. Besides the time saved can be used for resting and other gainful activities like teaching children. Since the food will not be cooked in huts, this strategy will result in less pollution in rural households. This will be beneficial for their health. Besides, women's chores will be reduced drastically.

Cooking food in these restaurants will also result in much more efficient use of energy since energy/kg of food cooked in households is greater than that in restaurants.

Large-scale employment generation in rural areas may result because of this activity. With an average norm of 30 people employed/a 100-chair restaurant, this program has the potential of generating about 20 million jobs permanently in rural areas. Besides the infrastructure development in setting up restaurants and establishing the food chain etc will help the local farmers and will generate huge amount of wealth in these areas.

In the long run this strategy may provide better food security for rural poor than the existing one which is based on cheap food availability in PDS – a system which is prone to corruption and leakage.

Besides the above innovations another major innovation needed is in increasing the productive employment and purchasing power of rural poor. NREGA has given money to them without increasing their or the nation's productivity. I think energy from agriculture can provide it.

### Energy from Agriculture

India produces close to 800-1000 million tons of agricultural residues per year. Most of these residues are burnt in the fields to solve the waste disposal problem though a part of them also go as fertilizer and animal feed. Burning of residues not only creates tremendous air pollution but is a waste of an important energy source. There is enough scientific data available that shows that the biomass residue burning in Indian sub-continent is creating a huge brown cloud which is modifying the weather over India.

These agricultural residues can theoretically produce about 150 billion liters of ethanol per year via lignocellulosic conversion. This can take care of about 50% of India's oil demand. Similarly if we take the pyrolysis oil route then these residues can provide around 80% of India's diesel demand. Pyrolysis oil is produced by rapid heating of biomass to 600-7000C and quenching the smoke rapidly to produce oil. This oil with suitable modifications is very close to diesel in characteristics. Both these technologies are near maturation and quite a number of plants are being set up the world over for pyrolysis oil and ethanol production from agricultural residues.

Alternatively if these residues are burnt in the biomass-based power plants they can produce close to 80,000 MW of electricity which is nearly 50% of India's total installed capacity. Biomass power plant technology is very well developed and produces around 60,000 MW of electric power around the world. In India there are close to 91 plants with capacities of 6-10 MW each and total installed capacity of about 500 MW. Our Institute was the principal author of this policy which was initiated by DNES (now MNRE) in 1996.

Besides producing energy these residues (with enough R&D) can also contribute to the organic fertilizer industry. Thus the use of residues from present agriculture can substantially ease India's present energy crisis and can be a Rs. 2 lakh crore/year industry. At the same time this can also produce <u>about 50 million jobs in rural areas</u>. With increasing crop production to feed our burgeoning population more agricultural residues will be produced which can further help in energy and fertilizer production.

Farming for energy therefore can create huge wealth in rural areas and lead to prosperous India.

However, for this to happen two things are necessary. Firstly farmers need to be compensated properly for the agricultural residues.

It is a peculiar aspect of farming that only 25-40% of its produce fetches money and the rest 60-75% are agricultural residues which have to be discarded. No industry can run on such norms where 3/4th of its produce is not sold and in fact discarded. Yet for farming we accept these norms.

When agricultural residues are capable of producing very high quality energy like liquid fuels and electricity, they should be given a very good price. Our estimates show that with proper pricing of these residues (Rs. 3000/ton) a farmer can easily earn between Rs. 5000 to Rs. 7000/acre/season by selling them for energy production.

Any marginal farmer can produce agricultural residues even if the main crop fails. The income from these residues can give him benefits even in the case of distress sale of his crop and this is the best

hedge against farmers' suicides. I also feel that unless and until the farmer gets remuneration from his entire produce, farming will never become economically viable. This is an aspect of farming which should be understood by policy planners.

The second aspect of farming is the need for sophisticated science and technology inputs in it. Presently most of the agriculture in India still exists in stone ages. There is very little mechanization and ancient agronomic practices are used. The problem has also been compounded by the fact that because of land reforms in India the land holdings have reduced thereby restricting the use of existing large farm machines. In fact this farm size reduction could be a boon in disguise since it can fuel innovations in precision agriculture and small farm machinery. This can reduce inputs and increase productivity of farms.

### Other issues

Recently some very innovative technologies like 3D printing — where a computer design can be made into a three dimensional product layer by layer using a special printer, are being developed. This technology is presently very costly and is mostly used to make plastic goods. Nevertheless the technology is progressing so rapidly that it is a matter of time before small objects made of any material could be produced using 3D printers.

This technology has far reaching consequences for rural areas where it can be envisaged that small manufacturing shops will manufacture items of use economically and on as-and-when-needed basis from the locally available raw materials. This perhaps could be a forerunner of self-sufficient dream villages that Mahatma Gandhi always talked about.

However more than these technologies the most important innovation needed for improving the life of rural population should be in governance. All the good efforts by technologists, planners and government are of no use if the benefits do not reach the bottom of pyramid population.

The poor have waited long enough for 65 years! The numbers are on their side and the rise of Maoism, strife and general unrest in the country is caused by the chasm between expectations and reality.

I think one of the solutions could be to sensitize the bright young scientists, engineers and managers to the plight of rural people. This can happen if they spend some time in rural areas and work with rural NGOs. Observing the poverty first hand can fire the bright minds to come up with innovative ideas. Besides this exposure to rural poverty will also help these youngsters to become frugal and nudge them to live a more sustainable lifestyle!

Finally I will end this talk by telling you a story, a tale from our ancient scriptures, the Puranas. It is the typical Indian story of a sage and his disciples.

The sage asks his disciples, "When does the night end?" And the disciples say, "At dawn, of course." The sage says, "I know that. But when does the night end and the dawn begin?"

The first disciple, who is from the tropical south of India replies, "When the first glimmer of light across the sky reveals the fronds of the coconut trees swaying in the breeze, that is when the night ends and the dawn begins". The sage says "no".

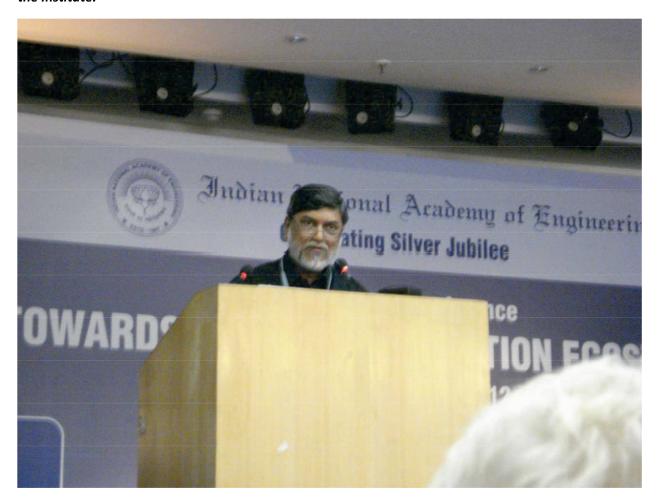
So the second disciple, who is from the cold north, ventures: "When the first streaks of sunshine make the snow gleam white on the mountaintops of the Himalayas, that is when the night ends and the dawn begins".

The sage says, "No, my sons, when two travelers from opposite ends of our land meet and embrace each other as brothers, and when they realize they sleep under the same sky, see the same stars and dream the same dreams – that is when the night ends and the dawn begins".

I feel that when we scientists, technologists and planners help light up the lives of rural population through technology and resources, then it will bring in the dawn of a new and prosperous India.

Thank you.

The material from this article can be used only after giving proper acknowledgment to the author and the Institute.



Dr. Anil K Rajvanshi delivering his talk at INAE, 21<sup>st</sup> September 2012

The Video of this talk is at this site.

### CHAPTER 7

### **FUNDING INNOVATION**

### Introduction

Innovation is as an important driver of economic growth. It has been extensively established through empirical research and surveys that innovation leads to new and improved products and services, higher productivity, and lower prices.

Financing is one of the significant difficulties in innovation. Although access to finance does not pose as big a challenge for large and even medium firms, it is a severe constraint for smaller enterprises, start-ups, and innovative grassroots projects.

Funding innovation comprises of a cycle beginning with research universities generating ideas which are incubated to proof of concept through public funding (government sponsored seed and incubation funding) into the marketplace through business enterprises backed by private funding (capital).

Funding innovation helps in covering innovation costs, supporting incubation, and financing commercialization and delivery to the market.

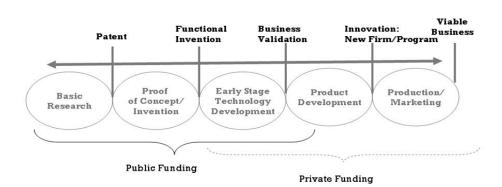
According to Mark Dutz (2007), constraints in funding innovation include the following:

- Actual and perceived risks arising from the higher failure rates of innovative micro, small, and medium enterprises (MSMEs), and unproven products and business models
- Lack of management and operational capabilities among technopreneurs and scarce mentoring resources
- Information asymmetries—given that entrepreneurs and innovators are more comfortable with innovation than are financiers, partly because of lack of technical expertise among financiers
- High transaction costs of dealing with start-ups and MSMEs given the small size of seed and early-stage investment relative to investment efforts (due diligence) and the time required in hand-holding and mentoring start-up management teams.
- Difficulties in attracting experienced investment professionals as fund managers in seed and early-stage funds as a result of the long gestation period for returns on such investment and the lower remuneration—the 2.0–2.5 percent management fee from managing small funds (\$10 million–\$30 million) is less than that from managing larger, later-stage, and private equity funds.

In India, Government funding has played an important role in India's early-stage technology development but has not achieved the desired scale and quality of research and development (R&D) investment and commercialization.

### A. Public Funding

Although pathways of innovation can be unpredictable, governments are supportive of innovation policies that support knowledge development and dissemination. The Government creates various strategies including direct and indirect investments in basic and applied R&D and human capital development to incentivize innovation. Supporting policy frameworks are developed by Government that foster innovation by facilitating government/academic/non-profit and industry collaborations, promoting technology transfer (Alic, Mowery and Rubin, 2003).



**Funding Options for Early-Stage Technologies** 

[Source: Adapted from NSB, 2010]

Public funding of innovation is most needed during the early-stage research and development as it is difficult for private funding sources to fully realize returns on any investment in research. As such, basic research is not funded by the private sector to the level that is considered optimal for societal benefits. At the early-stage research and development, the cost of capital cannot be easily estimated, leading to difficulties for entrepreneurs in obtaining external financing.

Through public funding, technologies for public good are developed, and help in risk mitigation associated with putting knowledge to commercial use.

According to official statistics, around three-quarters of R&D funding in India comes from government. The government is the dominant player and is very supportive of early-stage research. In fact, government is the largest source of funding for early-stage funding of companies.

When compared with other developing and developed countries, India's innovation spend stacks-up reasonably efficiently by producing more patents per dollar of R&D spend than China, and more scientific publications per dollar of R&D spend than United States (NESTA, 2012).

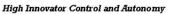
The Indian Government supports Indian innovation through various policy tools. In India, government programs have played a larger role in funding early-stage finance than have angel investors and university-funded incubators. University-funded incubators have played an important role in giving initial support, but venture capital is not always available through these incubators. Moreover, many of these incubators are not adequately funded and lack facilities to support a large number of entrepreneurs. Government support for early-stage technology development has mainly been in the form of grants, soft loans, and government-funded incubators.

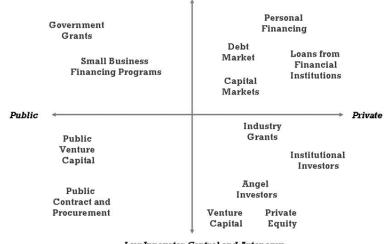
Mariana Mazzucato (2011) has examined the role of Government in the early stageresearch, and has successfully illustrated the importance of the public support for innovation, by analyzing the origination and fostering of innovation in numerous industries in the United States and Great Britain.

### **B.** Private Funding

Private companies are interested in activities that enhance returns to shareholders. Thus. investments innovation are one of the alternative uses for current revenues Private financing of innovation traditionally does not come until research and development has advanced sufficiently provide private investors a reasonable assurance of their realizing a financial return. Thus, private financing concentrates

### Sources for Public and Private Funding of Innovation





Low Innovator Control and Autonomy

[Source: Beth-Anne Schuelke-Leech, 2012]

on the demonstration and deployment components of innovation.

Private funding of innovation happens through multiple options. Two of the most special types of equity finance: angel and venture capital are discussed below:

### Angel Investment

One of the most likely revenue sources for early-stage start-ups is through angel investment. It is the high-tech, knowledge-intensive industries such as

medical devices, software, and biotechnology that benefits most from angel investment.

According to a recent study, firms that received angel funding are somewhat more likely to survive for at least four years. The study also pointed that angel funding is positively related to the likelihood of subsequent external investment (Kerr, Lerner and Schoar 2010).

### • Venture Capital Investment

Venture capital investment occurs at a later stage than angel investment, and venture capitalists seek to gain returns on their investment in the form of an initial public offering (i.e., sale of stock) or company sale (PrivCo 2011).

In India, private financing of innovation is on the rise, and venture capital investments have quadrupled since 2005.

### **Salient Observations**

- For innovation to succeed, funding is critical.
- Many innovations and entrepreneurs fail to bridge the valley of death because of insufficient or lack of funding. It is also true that innovation results in technologies that alter how financing is needed and available, leading to an evolution of financial instruments. As such, funding and innovation co-exist, and are necessary for the advancement of the other.
- In contemporary India, there exist several governmental schemes and mechanisms for funding innovation. The Government is the key driver of innovation, and there are many new out-of-the-box ideas aimed at promoting innovation, by making available the best funding opportunities.
- For instance, DST in collaboration with Economic Times launched the Power of Ideas initiative. This initiative has been extremely successful in generating 15000+ ideas. After a rigorous examination, close to 9000 ideas are identified and shortlisted, of which 800-1000 which are worth investing. In 2011, around 100 ideas got funded, a single platform we have so many ideas.
- Venture capitalists or Angel investors also offer funding to innovators, but its availability in India is very low compared to its demand.
- 95% of early stage finance available for entrepreneurs actually comes from abroad, with no domestic sources available. From a nation's perspective, this is a very serious issue involving a large chunk of the intellectual assets and its benefits draining out.

# **Funding Innovation: Driver for Creating Employment & Wealth**

Mr. Saurabh Srivastava

Chairman, CA Technologies, India

The theme of innovation is probably the most central theme that we as a country should focus on today. We have a lot of things to do that are incomplete. Half or more than half of our population lives below an acceptable poverty line and we don't have enough resources to fix this. So, whenever in the world, when you need to do "a lot-lot more with a lot-lot less", the only way you can do so is to INNOVATE. So, INNOVATION has to be a very central theme.

Encouraging this theme is important – no less than the PM has recognized it and created National Innovation Council (NIC) with the sole objective of how we, as a country, leverage innovation.

If you look around the world we can find out what encouraging innovation actually does. The prime example is the USA, one of the most innovative nations in the world. They have found a way of 'processizing' innovation and you can see the result coupled with entrepreneurship. America is a country which constantly continues to reinvent itself. Whenever there is a recession, wherein many other countries go into a deep dive for a while, America is the country which tends to recover. It has one of the world's lowest unemployment rates, but contrary to what most of us think it's not because of big industries, its not the IBMs, General Motors that do that...because for two decades 1980-2000 when the USA had fairly un-sustained economic growth, employment in the large scale sector declined by 7%. It's really entrepreneurs. More than half of exports from the USA are from companies with less than 100 employees. INNOVATION & ENTREPRENEURSHIP is actually the key.

Israel is another prime example, a country in a very difficult neighborhood; it doesn't have any real asset except the people; it's not lucky to have oil. Yet it is the only country in the region that's the part of the developed world and that's because they constantly innovate. And it's important because if you look around everywhere, what has happened to our quality of life – it has changed purely by virtue of innovation. Everything has changed for the better in our lives. For us in India, how important is this? By 2020, we need to create another 110 million jobs. So, we are looking for over 10 million jobs in a year. There is no country in the world that has done so. So it's very unlikely that we will be able to create such large numbers of jobs through normal mechanisms. China works reasonably well as a top down economy but even in China they have not managed to do this kind of work. While we can't create more than 10 million jobs every year, but if we can create a million entrepreneurs or half a million entrepreneurs they can create those many jobs. This is what happens in America, this is what happens in every country that manages to have high levels of economic growth, employment etc. So this approach of innovation + entrepreneurship has to be very-very fundamental for us. The theme I was asked to focus on was how we can fund innovation. Because at the end of the day any innovation, invention is of no value unless it can reach people, unless people use it.

So the challenge here is that most of the financing mechanism that we had till recently, were not mostly oriented towards innovation — most were oriented towards the old manufacturing system where you have land, plant & machinery and you can take loan against it because they were real assets; people who loaned you money had a way of recovering money. What has changed is that those are no longer the real assets in areas of innovation now, real assets are people and their ideas and now there is very little value for machinery, real assets etc. The popular saying is that all your real assets walk out of the door at 5 PM every day. To fund that kind of activity / innovation you are taking a risk. Because in innovation inherent is the issue of risk, not everything works. Innovation is hard, if you ask people who fund start-ups, they will tell you that out of 100 innovations you fund, it results in only 2-3 successes and that is considered very good.

So a mechanism to fund innovation did come around, which was developed in the USA. Maybe, in some way it was developed a bit earlier in the times of Shakespeare in England, called angel investors. But in real terms, venture capital started in the US two decades ago; it is the only financial construct known which can fund innovation because what it does is it invests in people who do innovative things.

And, as a venture capitalist, at the time of investment you know that for every 10 bets you fund, 5 of them would be worth zero, 2-3 might struggle a lot and only 1-2 will do really well. So you can tell people to invest with you;

even though the vast majority of investments fail, they will still get 20-30% annualized returns. That is the concept which is developed to fund investment in the West and has worked very well. What happens in this type of construct is if a company dies, ventures don't survive, all ideas don't make it but the society benefits.

If we look at the Internet, there was huge funding to do anything in internet ecommerce in the late 1990s. Then we had what was called the internet bust of 2000 and the telecom bust of 2000. You all remember the bust because a lot of venture capitalists lost money and lot of people lost their jobs. What happened in the process? The people who funded innovation, they funded a telecom infrastructure, which still exists, so that was real. Companies may have gone down but the internet was not a bubble in terms of the infrastructure it created. The internet infrastructure that was rolled out exists; we are all leveraging it today. The business model that they created did not work but the investments in the assets survived and that's how society moves forward.

If we look around that why it is important and what it can do for us. An example in Indian context – we had no IT industry about two decades ago. In 1988 when we formed NASSCOM the whole industry was about US\$ 15 million at that time, any company in the USA or Europe was bigger than our whole industry. That industry crossed US\$ 100 billion this year and our 2020 projection shows that software alone would be around US\$ 225 billion, if you add on the pieces we will come up to US\$ 300 billion. 20 million jobs have been created by this industry direct or indirect which actually did not exist two decades ago through pure innovation and entrepreneurship. Except for the Tatas, everybody else was a first generation middle-class entrepreneur by large. This wasn't done with a lot of money; most of us started a company with a lac of rupees, or Rupees 10 lac, that's all we had. There wasn't even venture capital at that time. This shows what can happen if you unleash the power of entrepreneurship and innovation. What was the innovation? Innovation was simple - we found we could provide world class service at a very different price point when we started. There was a good enough proposition, and as we went along we found we could improve on that and provide better than world class service. We could take the whole process through which software was developed and delivered; we could disaggregate the process; we could break up into subprocesses some of which were done in one country while some were done in another country, and we could strengthen those processes. We could get it done not by people with 20 years experience which was done in the USA, but by the fresh graduates that we had. All of that was innovation and that created an industry today that is the envy of the whole world. In China today, the government is investing 100s of millions of dollars to create new start-ups; they are inviting us to come there just to recreate the industry. But the software industry was created not top down but by innovation.

Recently we had a committee set up by the Planning Commission on how we could create a vibrant entrepreneurial ecosystem in India. One of the things that we came to a conclusion on running some analysis was that if we created the right driver, the right policy framework and right ecosystem in India then we could create more than one version of what we have done in the IT industry. We could create industries of the same kind, we could create industries that give employment to 10 million, 20 million and can generate revenues of US\$ 200 billion simply by letting innovation flourish.

Another challenge I would say is that there are many things that go into making innovation work, beyond funding. But funding is actually a key, because there is a symbiotic relationship between the numbers of people who are willing to follow their ideas and try to create something around it, those numbers of people are directly related to the amount of funding they receive. So, if the funding is available more and more people would try their genius, and if there are more and more innovative people, more of funding will come through. So, either you are on a vicious cycle or a virtuous cycle. Countries like the USA are on a virtuous cycle.

Israel had no venture capitalists; the government stepped in and told foreign VCs to come and invest and offered guarantees to underwrite their downside risk ("If you lose money, we will cover it and if you make money you can take it"). A lot of VCs found this a great idea as there was no loss of money and came into the country; nobody lost any money and the government didn't pay anything and in the process today Israel is home to one of the most active venture capital industries.

There are many things which we could do in India, which would encourage the flow of money to innovative ideas and solutions. There are many which we are already doing. What is missing is the gap between where an incubation centre helps and the next round of money which somebody lends. We do have a lot of venture capital firms, which lend companies Rupees 50 crore or Rupees 100 crore, but when a company needs Rupees 2-3 crore,

the next stage, which is often called a value stage, that is the place where we have a lag in funding in India. As a result, innovation in India has not flourished the way it could have.

We are one of the most entrepreneurial countries in the world and we have done some good work as a community. We need to look both within the private and government sectors and see how we can bridge the gap in funding innovation. There are several aspects to become an innovative country – we need to have a culture which accepts innovation, which accepts being an entrepreneur as a prized career as against working for a multinational, we need a society where failure is accepted because 9 out of 10 times you will fail.

We need to have much better interaction between academia and industry. If you look at Silicon Valley, what makes it Silicon Valley, a lot of it is Stanford University. Stanford University interacts with all the entrepreneurs. Professors at Stanford University have made so many good companies happen, Google being one of them. We need to have that interaction which is missing today. The interaction is improving and most of the leading colleges and institutes such as the IITs and IIMs have centres for entrepreneurship and incubation. A lot is improving but we need more such entrepreneurial courses which go into our curriculum.

I talked about having more favourable policy mechanism, also institutions. We have had a tendency in our bureaucracy to have a culture of lack of trust; we need to change this mindset because when you have innovation and entrepreneurship, you will have a lot of failures. So, if people in these institutions have a culture of not taking risk then they will not do the right thing by innovation because for that you need to take risk and many of them would fail.

Innovation, around the world, when coupled with entrepreneurship has been the biggest agent of change for society, but it has improved the quality of life largely for the middle class and higher social strata. The reason for that is that most of the changes have taken place in the West. And, the Western countries do not have a majority of their populations living below the poverty line, so poverty alleviation has not been the key focus of change through entrepreneurship.

We are involved in those innovation cycles where the target customers are affluent sections of society. This construct, which is leveraging entrepreneurship, innovation, getting the best brains in the world to look at improving quality of life, solving issues and problems has not been applied to the problems of the poor because it has not been anybody's priority. Naturally, the low hanging fruit where you make more money is where people have more money and when those numbers are large then why focus below. In India this is not an option, because if you solve the problems of the affluent you only solve the problems for 10-25% of the country. So the big challenge for us and also for NIC is how we leverage innovation, how do we leverage all the models that have worked for solving problems of the rich to solve the problems of the poor. What we are doing here is to use the same concept that is used to fund innovation and entrepreneurship for solving problems of the rich, to solve the problems of the poor. And the reason for this is that the 'bottom of the pyramid' is served today only by two classes of funding, one is philanthropy which in India is still a smaller source vis-à-vis the US. And then you have government funding and grants, half of the money doesn't even get to where it is needed, so this is an inefficient form of problem solving. When the money stops the work stops.

On the other hand we can create another class of funding; if you invest we will give you modest financial returns, not 30% but maybe 10-12%. Coupled with some measurable social returns we can create another class of capital which is looking for returns that are much-much bigger than either of these two. So the experiment we are trying is to create a venture fund to get the best brains to come and work and to run it, but it would only invest in ventures that serve the bottom of the pyramid; innovations that have high impact on the lives of the poor. So we are leveraging the same funding mechanism for innovation that is normally used for a different class. It's an experiment but India is the best place to try it. While there are challenges, we have all the means to solve it. We can do it because we have almost a billion people connected, world class entrepreneurs, so we are the ones who can try to create a model which others in the world can use.

[Disclaimer: This transcript does not purport to be a record of the actual proceedings of the Indian National Academy of Engineering International Conference "Towards a Better Innovation Ecosystem". The transcripts are meant to serve as a reference text for the benefit of readers (INAE members, students, academia, industry executives, policymakers et al) who may wish to understand and reflect upon the key thoughts shared by invited speakers and panel members. The transcripts have been edited for brevity and clarity, where necessary.]

# **Funding Innovation: A Government Perspective**

### Dr H K Mittal

Adviser and Member Secretary, National Science & Technology Entrepreneurship Development Board (NSTEDB)
Secretary, Technology Development Board (TDB)

Funding innovation is always exciting, on the upside as well as on the downside. On the downside we have legal cases, sleepless nights, bad debts. The first thing about innovation is that the innovator thinks that it is the best thing which could happen to the world, and with this perception he / she comes to us for funding support.

I would like to share a story about an innovator- an artificial flower maker which felt and had the same fragrance as that of a real flower. His innovation was chosen among 64 countries as winner. The message that comes out of this anecdote is that technology is not about only high-end products, a good solution can actually impact the poor in a big way. We don't have to create models exclusively for the poor; we can create models which can co-exist with both commercial intent as well as for the greater public good. Problem with these innovative products, nobody in government sector is willing to buy these innovative products because they cost more; they have an incremental cost attached to it. So the system doesn't actually encourage innovation in that sense.

The best source of funding of innovations is the Customer, nobody else because he is giving you double validation; not only he is giving you money but also accepting your product. And it's money well earned. The reason why Government must get involved in the innovation business is because innovation is risky. An additional amount of risk is assumed when entrepreneurs and / or investors try to promote such an innovative enterprise, so one has to actually take care of that additional amount of risk.

While funding innovations what are the considerations of an investing institution? There are only two main considerations; the first is "how big is the problem that we are trying to solve?" The second is "how good is the team?" If these two basic things are met, I think the rest of them are not that important. If I am trying to solve a very big problem, then well I have good market, I could achieve a good sales turnover; the institution which invests is sure to get desirable returns is the team managing the business is good.

At DST, we are taking steps to foster the entrepreneurial spirit by funding promising innovations. One of our recent success stories is a program that we run with The Economic Times called the "Power of Ideas". The program is open for just 1 month and every year in that 1 month we get 15,000+ ideas. While all of them are not excellent ideas, around 9,000 ideas are really good ideas. Of these, 800-1,000 are worth investing. In the end, we select 250 ideas which are funded. Last year around 100 got funded, and a single platform has been able to generate so many ideas.

There is a peculiar situation in India that while we have large number of innovators and inventors, our R&D outputs still need to be technologically sound and commercially viable. No doubt, we have good research but products coming from the formal R&D system are few and far between. So, we need to create an ecosystem that can leverage on what is created by our innovators and inventors.

In India, there is no early stage finance available for start-ups. Early stage finance refers to domestic capital. 95% of it actually comes from abroad. This is a very, very serious issue, and a large chunk of the benefit which India should have got is actually going out.

In India, the systems to accept failure do not exist. While the process is much simpler now to start a company, on an average to start a business in India it takes 6 months. In China it takes 15 days while in Singapore, it takes a single day. To close a business in our country, it takes 7 years. We are at the rock bottom in terms of ease of closing a business.

We think when a company closes; it is the end of an individual. We associate close with death. But in developed countries, you close a company and start another company so that's not the end of the individual entrepreneur. So, with this backdrop, it is far easier for individuals who have the right attitude, skills and knowledge to launch themselves into entrepreneurship.

Over the past years, various interesting models of financing and innovation that have evolved including **'crowd sourcing'**. You put your idea on the Internet, then you start receiving contributions from individuals. They can invest in your idea, and its kind of a grant. This has become very popular, especially in the IT-ITeS sector. Now the problem is as long as it is a grant there is no problem. The moment it is a investment you are governed by public limited company laws, you cannot have more than 50 people contributing as an investment and so on. Still, this system is gaining in popularity.

There is no concept of investing in knowledge-based, technology-based ventures because knowledge and technology do not offer a touch and feel factor, so the valuation is critical.

Funding of knowledge and technology is a completely different game. Our banks and financial institutions are more used to asset based financing. How do we change this mindset?

Funding a software project gives me the shivers because there are no hard assets, computers get depreciated, companies operate from rented buildings and in the name of security we have virtually nothing in case of technology and knowledge funding. The positive side is that there are institutions which have now come up, which actually guarantee your loan like the Credit Guarantee Scheme of SIDBI, but we want more of such institutions and mechanisms.

Let me conclude by sharing the story of Suhas Gopinath. He is the youngest entrepreneur of the world who started out at the age of 13 years. He wanted to work in the Internet space. He wanted to create a portal, Internet charges were Rs. 30 per hour that time. Today, Suhas has about 800 employees of which 500 are at Silicon Valley. He received many offers to sell his company but he refused. At age 25, he is enjoying his entrepreneurial success. A point to note is that when Suhas started out, he was not allowed to open a company in India since he was not yet 18 years.

We need to work towards an innovation ecosystem that awards risk taking, and accepts failure.

[Disclaimer: This transcript does not purport to be a record of the actual proceedings of the Indian National Academy of Engineering International Conference "Towards a Better Innovation Ecosystem". The transcripts are meant to serve as a reference text for the benefit of readers (INAE members, students, academia, industry executives, policymakers et al) who may wish to understand and reflect upon the key thoughts shared by invited speakers and panel members. The transcripts have been edited for brevity and clarity, where necessary.]

### **CHAPTER 8**

### BUILDING AN INNOVATIVE INDIA

### Introduction

Historically, India has always been at the forefront of innovation as manifested by its many path-breaking ideas and innovations in multiple industry domains. However, in the recent past, India has faltered in its quest for sustaining and leveraging innovation.

According to the National Innovation Council (NInC), given the unique and continuing challenges arising from unmet needs in critical areas like health, education, employment and economic and social wellbeing, India requires a new approach. In order to meet the most pressing challenges that India faces today, incremental approaches will not work. For India, innovation is the key, and is a real imperative for sharing the benefits of the knowledge economy with a nation of a billion people.

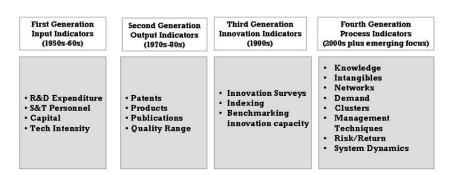
How innovative is India today? If one looks at recent reports on innovation metrics, India is not seen on the big stage.

For instance, the Global Innovation Index 2012 published by INSEAD and the World Intellectual Property Organization (WIPO) ranks 141 countries on the basis of their innovation capabilities. Though India ranked 2nd in the Global Innovation Efficiency Index, it lies at 62 position lagging behind 61 counties in terms of innovation. It is ranked way below all the other BRIC countries in the global innovation index.

Innovation indicators can be categorized into four generations from the input-based first generation to the gradual evolution into fourth generation process indicators.

One way of measuring innovation seeks measuring through it innovation inputs. for instance. with R&D intensity. Another stream of measuring innovation is innovation through outputs, such as patents and patent-related index. However, the linkage between such measures and organization innovativeness and economic growth vague. As pointed out by Gittleman(2008), at the micro level, the value of

### **Evolution of Innovation Metrics: By Generation**



[Source: Center of Accelerating Innovation, George Washington University, 2006]

using patents as an innovation indicator is very limited.

According to YS Rajan (2012) "...macro indicators—such as national investment in research and development (R&D) (also known as gross expenditure in R&D, or GERD), R&D expenditure by industry as a percentage of sales turnover, patent filings in a year, or frequency of research publications and number of PhDs in science and engineering for example—are inadequate to capture the realities of innovation system in India."

In 2012, the report from the UK's innovation foundation, the National Endowment for Science, Technology and the Arts (NESTA) was published that celebrated India's frugal innovation. According to the report as India's science budget has been rising by 25% a year, "combined with deepening scientific and technological capabilities", 'frugal innovation' could be an important source of competitive advantage for India, and a basis for strategic collaboration with Western countries.

According to Arun Maira (2012) "a new paradigm of innovation has been growing in India: with a focus on simplicity and frugality in the process of innovation itself in contrast to the dominant paradigm wherein innovation is expensive and requires large resources of highly qualified personnel and finance and facilities. In the dominant paradigm, the principal, or even only measures of the innovation capacity of a system were the amounts spent on R&D, the numbers of scientists engaged, and the numbers of patents produced. Whereas in the new paradigm of innovation that has emerged in India, the measures of a system's innovation capability lie in the production of solutions (products and services) that are affordable and accessible to people with very low incomes. In this paradigm, innovations are outside the laboratory mostly. They are in institutional and organizational innovations that enable co-creation and co-operation to create reach, reduce costs, and deliver solutions that are useful to masses of people at the 'bottom of the pyramid'. This paradigm of innovation is being acknowledged now as a legitimate and useful innovation."

Entrepreneurship and education are two opportunities that need to be leveraged and interconnected for developing the required human capital for building the future. On one hand, entrepreneurship is the engine that fuels innovation, generate employment and foster economic growth. To address the prevailing issues there is a need of creating an environment where entrepreneurship can prosper and where entrepreneurs can try new ideas and empower others. On the other hand, education helps in developing skills to generate an entrepreneurial mindset and prepare future leaders.

Education needs to be at the top of the government and the private sector agenda. India needs effective leaders and well-build educational systems that prepare the current and future generations of entrepreneurs, workers, teachers, managers and individuals. Higher education institutions have become increasingly important for nations economic and social development. Technical universities are the engines of scientific invention and technological development.

### Indian Government: Key Innovation Facilitator

Government of India declared 2010 to 2020 as the Decade of Innovation for preparing a road map for innovation in the country- to leverage of the potential for implementation of a model of inclusive innovation in the country across has unique challenges and

opportunities and across diverse areas such as health, education, skills, agriculture, urban and rural development, energy, water and climate change.

The National Innovation Council (NInC) of the Government of India is focused on encouraging and facilitating the creation of an Indian Model of Innovation.

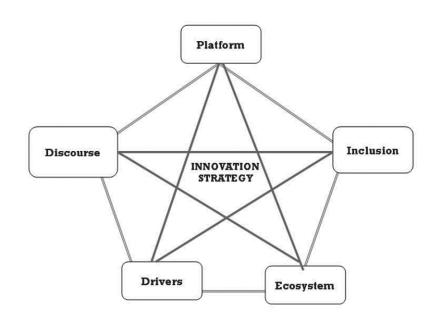
The NInC aims to look at innovations through a prism going beyond formal R&D

parameters and through five key parameters:

Platform, Inclusion,

Ecosystem, Drivers and Discourse. This will help in breaking sectoral silos and moves beyond a high-tech, product-based approach to include organizational, process and service innovation.

### Innovation Strategy of NInC



[Source: NInC, 2012]

The core idea is to innovate to produce affordable and qualitative solutions that address the needs of people at the Bottom of the Pyramid, eliminate disparity and focus on an inclusive growth model.

The Government of India is working on improving the overall innovation climate in India, with a focus on developing robust innovation frameworks, creating linkages, and capacity-building.

One of the key challenges facing universities in India is the absence of an enabling environment for innovation. Universities can play a role in developing innovation ecosystems in their local regions. Another challenge facing India is the need to overcome missing gaps, and create vibrant linkages between universities and industry, government and other stakeholders.

### Enabling Policy

There is a need for policies that enable a supportive environment for public and private innovation and encourages the development of innovations through universities.

Towards this end, one significant initiative by the Government is the National Innovation Act. The National Innovation Act will facilitate public or private initiatives and public-private partnerships to build an innovation support system. It will also develop a national integrated science and technology plan for India. Lastly, the Act aims to create favorable conditions for increased R&D investment and attractive for global industries, including IT, BioPharma and Engineering.

Another initiative of the Government aims to increase private investment in higher education through the Foreign Education Providers' Bill, pending in the Parliament.

### • Enabling education for new innovations

Government of India is also creating a legislative framework for supporting and facilitating the development of 14 Innovation Universities including PPP which would be embedded in ecosystems developed for promoting synergies among education, research and incubation centres or industry. Each of these 14 Innovation Universities will focus on one deep theme of innovation and will focus on one area or problem of global significance in general and India in particular, by building an ecosystem of research and teaching around related disciplines and fields and will search for solutions that are globally valid; some themes could be urbanization, public health, water security, environmental sustainability, digital literacy etc.

The Government is looking at setting-up New Greenfield Innovation Universities that would support an already existing University/Institution of repute to attain world class standards through innovation in specific core disciplines. In addition, Government is also engaged in identifying and setting-up educational hubs across India. In these hubs, a few institutions of excellence would be located.

The National Innovation Council(NInC) is working on creating the first Global Meta University. This Meta University will reinterpret the concept of a University as not just a traditional, physical space of learning, but as a repository of knowledge and information that can be delivered through multiple mediums with access from anywhere and at anytime.

Some of India's premier institutions such as Indian Institute of Technology-Delhi, Jawaharlal Nehru University, University of Delhi, Jamia-Millia Islamia have already initiated steps to constitute a Meta-university.

Central to the Meta University, there would be a focus on a pedagogy that leverages technology, and allows continuous learning from the environment.

The Government is also working on improving the interface between academia and industry, while providing a conducive environment for technology commercialization.

### ■ Innovation Clusters

With intent to catalyze innovation and to create linkages amongst stakeholders, Government is developing Cluster Innovation Centres for that will bring together the University and its partners on a single platform to forge linkages between various stakeholders from industry and academia.

Already, there exists an ecosystem of Technology Business Incubators and centres for Technology Entrepreneurship Promotion.

### At a Glance: Key Initiatives of the National Innovation Council (NInC)

- Developing a framework to finance innovation for the Bottom of the Pyramid through the creation of an India Inclusive Innovation Fund:
- Creating an eco-system for seeding innovations in regional industry with a focus on MSMEs, by facilitating the creation of Industry Innovation Clusters to drive job creation and productivity;
- Leveraging our demographic dividend for innovation by creating a connected India through the spread of rural broadband in two years time to all 250,000 panchayats;
- Nurturing innovation in the education system through action in schools and colleges
  by intervening in curriculum, talent-spotting of innovators among students and award
  of Innovation Fellowships, creation of a Meta University, as a global first, that rides on
  the National Knowledge Network to promote multi-disciplinary learning, and
  facilitating the creation of innovation ecosystems at Universities through University
  Innovation Clusters;
- Promoting an innovation culture through action in areas of communication and advocacy through an Innovation Portal and working through mass media organizations;
- Creating an institutional framework for innovations in Government by facilitating the setting up of State Innovation Councils in each State, and Sectoral Innovation Councils aligned to Union Government Ministries
- Promotion of projects that create an innovation dividend like the setting up of a Rabindranath Tagore Knowledge City in Kolkata, setting up twenty Innovation Design Centres co-located in existing institutes

- Setting challenges for the Indian imagination to come up with solutions, especially those that relate to inclusive innovation
- Promoting co-creation and sharing of knowledge through Global Knowledge Partnerships, beginning with a Global Roundtable on Innovations for sharing ideas

[Source: National Innovation Council]

### **Indian Industry: Moving-up the Innovation Ladder**

Across multiple emerging technology areas including cloud computing, big data, stem cells, Indian firms are slowly gearing up for developing and delivering new innovations.

Indian IT services firms have been at the forefront of many business model and process innovations. This trend towards innovation can be attributed partly to the innovation culture set forth by innovation centres established by multinational companies (MNCs) and strong growth of R&D-based innovation. Many Indian R&D centres of MNC firms have been pioneering product innovation in the Indian and global context. Indian R&D firms and startups are increasingly pursuing product innovation, a space traditionally dominated by MNCs.

### Focus on Rural India

There are many companies that are now focusing more on rural India, and are gearing-up with innovations directed towards the rural populace. For instance, Alcatel Lucent has developed a data server for areas with limited data networks. A large number of Indian and MNC firms are focused on delivering innovation through domestic IT transformation via e-Governance projects for improved government service delivery to its citizens. For example, MindTree's innovative biometric-enabled identity management software (ComputeCell) has made a significant impact in capturing an individual's identity on a real-time basis. Many start-ups are developing innovations for healthcare delivery through mhealth for rural India.

At the centre of the new innovation continuum is the emergence of India as a hotbed for next-generation technologies. An India success story would enable companies to introduce the products across other emerging countries as well as in developed countries.

### Indian R&D, Global Success

Indian R&D firms have leveraged engineering expertise to develop innovative product designs for their clients to drive lower costs and faster time to market. Several Indian firms have collaborated with global companies to produce breakthrough innovations. For instance, Infotech Enterprises Partnered with a global engineering conglomerate to create the world's most eco-friendly aircraft engine.

To face the grand challenges that India is fighting, incentivizing innovation through an enabling environment and investing in cutting-edge research and development is an imperative. To enhance India's industry competitiveness, and to compete in the fierce competitive global R&D ecosystem, India needs to take actions.

Some of the key transformative priorities that India needs to act include the following:

### I. ENABLING RESEARCH CAPABILITIES

India needs to build on its public research capabilities to cope with the challenges of the future. Simultaneously, it needs to take steps to invest in the R&D infrastructure, and to go forward with research funding that enables greater academia-industry linkages, and result in promising research outputs to enter the marketplace.

### ■ Combating Grand Challenges

Innovation-driven research is required to combat some of the most urgent issues such as climate change, biotechnology for health and food security and poverty as well as to boost competitiveness. Innovation is an imperative.

Advances in biotechnology can help address a broad range of challenges that face India today, ranging from anti-cancer therapeutics to next-generation capabilities in disease detection.

### Research Infrastructure

The research capacity at universities and public research institutions needs to be enhanced to tackle complex research challenges. Towards this end, India needs to invest in world-class robust research infrastructure that is supportive of new product development and provides access to new enabling technologies, finances and people.

There needs to be a focus on boosting translational research as well as basic research to enable a pipeline of next generation innovations to be ideated, evaluated and developed.

With a focus on technology commercialization, technology transfer offices should be created across the public research system and manned by trained people with scientific and technical skills. This would enable new discoveries to be moved through the innovation value chain.

As various research domains converge to give rise to new pathbreaking innovations, it is important that a culture of collaboration is established

between scientists working at research institutions and other institutions and industry. Multidisciplinary research must be encouraged to create new innovative products and solutions.

Lastly, Indian Government has been at the forefront of supporting early-stage research. It must intensify efforts to increase research funding that enables research institutions and universities to undertake translational research for creating next-generation innovations that underpin private sector innovations.

### II. INVESTING IN HUMAN CAPITAL

To build and sustain an innovation culture, developing a research-workforce strategy is crucial. Such a strategy would focus on early education as well as advanced training and capacity building for scientists and entrepreneurs.

### **■** Education

India needs to adopt innovative and interactive pedagogies that enable experiential learning among school children. This would enable the development of cognitive skills at an early age. Evidence-based early learning should be a focus for the Government.

Students must also be allowed to build an entrepreneurial mindset by allowing them to work on some live projects in various technology domains, suited for their learning level.

Skill development among teachers is another imperative. Online and interactive learning needs to be encouraged, and technology must be embraced. Teachers need to be empowered with access to the best tools and capacity building programs.

Lastly, global best practices and international standards must be deployed for training teachers.

### Skill Development

By building on the research fellowship and training programs of the Government, researchers should be provided access to build their research capacities. Career paths should be well-defined so that it boosts the morale of researchers and enables them to discover innovative solutions for the complex challenges.

Research institutions should be encouraged to allow their scientists to move beyond their silos and to work in large multidisciplinary teams across institutions, and in cooperation with industry. Such moves would help in ensuring that the research outputs of inventive public research are fully captured.

To prepare for the future, India must develop the skill-sets and creativity of the research workforce so that they embrace new ideas and concepts, new developments and build a risk-taking attitude.

### III. FOSTERING ENTERPRISE GROWTH

Innovation is about risk-taking and driving new products and services through to the market place.

### **■** Boosting Innovation-based Entrepreneurship

Government should encourage entrepreneurs through creation of enabling mechanisms including research infrastructure, access to finance, access to markets, and access to quality mentorship with well-defined commercialization pathways. Entrepreneurship thrives in innovation ecosystems wherein there is active stakeholder engagement, collaboration and technology linkages.

The Innovation ecosystem should foster entrepreneurship by enabling young start-ups to take promising research results through the innovation value chain to the marketplace.

### Access to Finance and Innovative R&D

Policy should focus on providing enterprises with an opportunity to uptake promising public research results by encouraging greater collaboration, and greater tax incentives. Steps should be taken by Government to encourage SMEs and all other stakeholders, including academia and industry to engage in new innovation partnership models that accelerate new technology commercialization and help in new venture creation.

### **Salient Observations**

- Since India's independence, institutional mechanisms have been established by the government to address India's scientific and technological development that has been instrumental in providing a platform for innovation to flourish.
- Support for both basic research and applied research and establishment of a strong manufacturing base are essential for developing an excellent national research and innovation ecosystem. Going forward, policy should focus on strengthening global innovation partnerships, and by enhancing public-private partnership mechanisms such as Global Innovation and Technology Alliance

(GITA), and earmarking of increased public funds for joint industrial R&D projects involving more countries.

- Measuring India's innovation through macro indicators—such as national investment in research and development (R&D) (also known as gross expenditure in R&D, or GERD), R&D expenditure by industry as a percentage of sales turnover, the patents filed in a year, or number of research papers and number of PhDs in science and engineering, are not sufficient to provide policy makers with the necessary evidence to take concrete actions to stimulate and accelerate innovation in academia and the industry, agriculture, and services sectors.
- When it comes to understanding Indian innovation, multiple elements need to be considered in totality in order to address the challenges of innovation. Considering a few specific elements—such as tax incentives, additional funds for R&D or excellence in education—regardless of how important they each are, in isolation will not be sufficient.
- According to Arun Maira, a global innovation index that compares countries performances attracts a lot of attention. However, such a model that classifies 94 factors into 8 categories and attracts equal weightage is flawed in that all the factors considered are totally different. For instance, 'culture to innovate', 'political stability' and 'personal computers per 100 people' are varied factors and cannot be given a precise numerical score. In India, the innovation policy focuses on developing innovations for the needs of people who have nothing.

### Recommendations

- A cohesive national strategy on innovation, focused on improve and efficient regulatory oversight and policy initiatives, should be developed that enables linkages and productive partnerships between private sector, public sector research institutions, academia and government to work on transformational technologies.
- Innovation should be supported through investments and incentives that help startups to build intellectual property, proof of concept and lead.
- The policy framework for innovation should reflect and incentivize international and multi-partner commitments.
- Transformational initiatives should focus on converting existing technology clusters in India into innovation hubs that allows for active and creative collaborations across networks and across technology domains, involving collaborations between academic researchers and private companies for fostering new technology development.
- There is a need to augment capacity for research and development to allow access to new knowledge, to build creative collaborations, and to act as a pipeline for new

innovation. By creating better linkages between researchers and private sector, access to transformational knowledge and new technologies can be fostered.

- New formal and informal innovations should be identified, validated, refined with appropriate commercialization pathways developed for them.
- An effective communication strategy needs to be put in place involving government and other stakeholders to promote the use and dissemination of new innovative technologies across regions and geographies.

# **Special Keynote Address**

### Dr. Arun Maira

Member, Planning Commission, Government of India

# The Measurement Trap

### **Innovation and Measurement**

(Refer to: Indo-US Conference on collaboration in innovation)

Reinventing the Wheel of Progress/Economic Growth

- Too much pressure of the wheel on the earth
- Not carrying everyone along

### A. Four questions:

- 1. Why Innovation?
  - What are we not getting enough of with prevalent approaches..requires new approaches/innovations
- 2. What is Innovation?
  - What does it look like? How would we recognize it?
- 3. How does Innovation happen?

# QUESTIONS 2 AND 3 POINT TO THE NEED FOR A MODEL OF THE PHENOMENON

4. Finally, What should be the Government agenda for creating conditions for more innovations?

# **B.** The Measurement Trap

The US Air Force has been unable to select a replacement for its aging fleet of air refueling tankers for almost a decade now. The selection process has been stalled several times by ethics scandals and legal challenges. Therefore the authorities have decided to remove all subjective elements in the evaluation. 373 mandatory requirements have been laid out, each of which must be met on a simple pass-fail basis. In this effort to avoid any bias, the water flow in the plane's toilets is rated as highly as the fuel offload rate!

One may laugh at this as an example of mindless bureaucracy. However a similar approach to evaluation pervades the world of academics and economists too.

A leading international business school has **developed a global innovation index to compare countries' performances**. Its model has **94 factors divided into eight categories**. The mathematical means of the variables in each category are calculated to give the score of the category, and then a simple mean of the categories is calculated to determine a country's rating. Mathematically very precise, but the **94 factors, though equally weighted, are very different**. For example, they include 'R&D expenditure as a % of GDP', 'Culture to innovate', 'Personal computers per 100 people', and 'Political stability'. One may wonder if personal computers count as much as culture? Or political stability as much as R&D expenditure? And how does one give a precise numerical score to 'culture to innovate', and 'political stability'?

Similar intellectual weaknesses pervade international comparisons of 'competitiveness' of countries. They list many factors which should matter and then conduct surveys of business executives' opinions about them. The opinions are converted into mathematical scores and, viola, one has an accurate assessment of the country!

International comparisons of countries attract a lot of attention because we love competitions. We want to know who is winning. Therefore we want a single number. However, policy-makers should take such international comparisons with a huge dollop of salt. Most evaluations are an incomplete, and perhaps even inaccurate representation of the phenomena that policy-makers wish to influence, whether innovativeness, competitiveness, or even development of countries.

((The size and growth of GDP as determinants of how well countries are doing is a glaring example of the weaknesses in the single number syndrome of measurement. While there is increasing dissatisfaction with GDP as an accurate measure of the overall health of a country, economists and policy-makers continue to be almost obsessive about it. They have little respect for alternatives such as Gross National Happiness, which Bhutan and France are examining, because these indices include 'subjective' matters that cannot be measured, they say. Nevertheless the same policy-makers seem to take other evaluations, such as those of competitiveness and innovativeness, quite seriously even though these too are riddled with subjectivity.))

Policy-makers need good models to produce good results. A model is a 'system of things and relations' that 'shows the construction of something'. Thus the model of the innovation eco-system must not only name and measure the various elements of the system but it should also explain the relationships between them. How do the elements within a model affect each other? What are the feedback loops amongst them? The size of the elements cannot be merely added up, as in effect they are when evaluations are made by adding the scores for each. And to leave elements out of a model merely because they cannot be quantified makes the model useless for predicting the behavior of a system.

((This is the limitation of almost all economic models. The feelings and emotions of people are left out because they are 'subjective'. However, when such mathematical models cannot explain the behavior of a system, such as gyrations in the stock market, then analysts talk about subjective 'moods' and 'sentiments' as explanations!))

# C. Returning to the Questions about Innovation: The Metaphor of the Wheel: The Rim, the Axle, the Spokes

The RIM: What is the Result we Want, the Effect on the Ground?

- 1. Innovation for what purpose? For Inclusion, and for Sustainability
  - Innovations to produce for the *needs of people who have nothing* or very little, not for *spurring the greed of people* who already have something
  - Not for tempting people who already have been through I-pods, I-phones, and I-pads with another I-to have; but to provide people with affordable and accessible health care, education, clean drinking water, low cost housing
  - Innovations in the *production* of energy, in the *consumption* of energy, and in the *architecture of energy networks* that combine low cost *scale* sources, renewal but *intermittent* generation sources, and *high flexibility* switch-on off sources

### 2. What is an innovation?

 Not only a patentable device or molecule, but also a business model, a new form of enterprise  Indeed most innovations to provide poorer people affordable and accessible services are innovations in processes, enterprises, and business models albeit with innovations in products in some cases

THE AXLE: The SOURCE OF POWER that Drives the System What motivates innovators?

- The challenge of creating a solution that has not been discovered or a pot of money?
- All studies of innovation—in science, in arts, in business models (Aarvind Eye, and Amul) A passion

THE SPOKES: The Enablers that take up the Power and enable desired action at the Rim

Innovations in how innovation is produced?

- 'Innovative' companies, eg in pharma sector, finding it very difficult and too costly to produce innovations for the poor
- Companies with largest R&D budgets not the most innovative
- Concept that Innovation must be synonymous with R&D and patents is limited
- Must reduce the cost of producing innovations to produce innovations for people who cannot pay much
- Collaborative models of innovation—open source, sharing of resources, combining knowledge

Co-creation and co-operative innovation will require innovative concepts for managing intellectual property rights

- More innovation will be stimulated by more Co-creation and more Competition, whereas prevalent IP regimes are swinging too far towards creating Monopolies
- Monopolies capture and 'strand' knowledge; they prevent its wider use; they reduce competition in the application of knowledge for wider benefit
- Need to find a better balance between the protection of property and the need for sharing to produce benefits for people

Arun Maira September 21, 2012

# <u>Innovation – some priorities for the future</u>

### **Robin Batterham**

### President, Australian Academy of Technological Sciences and Engineering

### **Summary**

Both India and Australia recognise the importance of innovation. As with most countries, it is seen that options to improve economic, social and environmental outcomes going forward into an ever more competitive world depend on a country's performance in innovation. In India, the coming 10 years are a declared Decade of (Office of Advisor to the Prime Minister of India 2011). In Australia, we have now had for a few years Innovation Priorities (and measurements reported against them) (Department of Innovation, Industry, Science and Research, Australian Government, 2011) as well as Research priorities of long standing.

Focussing on India and Australia, the performance in innovation is compared and contrasted. Interestingly, we can see that there are quite some similarities in the areas that need more attention, particularly that of collaboration. Collaboration between researchers and those in enterprises is an area where there is room for real improvement. From studies on collaboration and innovative capacity, we can conclude that more initiatives to encourage collaboration would be of great benefit, both in India and Australia.

### Introduction

Even a casual inspection of budgets for R&D and incentives for innovation around the globe would be enough to assert that virtually all countries have realised that innovation is essential if we are to feed ourselves, have adequate water, health care, live sustainably and of course enjoy the benefits of increasing prosperity. It is innovation that delivers on these basic requirements and aspirations.

By innovation we mean of course much more than creativity, or good ideas, or R&D. Innovation refers to the exploitation of a new idea or development. It requires that there is a change in end use, generally in the market place. The new idea can be new to the world, to the country, or merely to one small group of end users. Much of the discussion on innovation gets very confused because idea generation and all the creativity that sits behind it and the ongoing march of science is often billed as innovation. It is not. It might lead to innovation but until an enterprise (which can be an NGO or a not for profit or even a government) changes something in the market place, there is no innovation.

It is easy to overlook that much of the benefits we enjoy today from lower prices in real terms stems from innovation. Indeed, when one looks at the way commodity prices have fallen for at least two centuries, then it is fundamentally the succeeding waves of stepwise innovation and the ongoing continuous improvement in between that drives prices ever lower. There is no other explanation as demand at least for commodities keeps rising and in mineral and energy areas, grades or availability keeps falling, yet prices keep falling in real terms as in figure 1 for copper. Other commodities are similar.

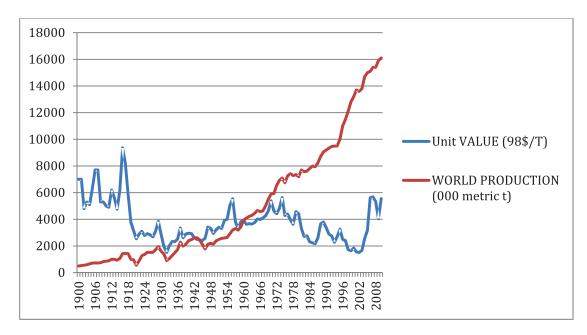


Figure 1 : Copper as an example of how innovation drives real prices down, despite ever increasing demand. (USGS 2012)

### Innovation in India and Australia

The OECD has for ten years published an annual scorecard on Science, Technology and Industry. The latest, (OECD 2011) indicates that there are many measures relevant to innovation with some surprising inter-country comparisons. That said, it is clear there is no single measure of innovation that tells the whole story.

There are currently marked differences between countries, both within the grouping of developed countries and within developing countries. The change in some developing countries over the last 10 years is truly remarkable. There are some who would argue that the developing countries have different ways of innovating. Yoslan Nur (2012) suggests that "the main factor in developing countries is poverty and the need to improve access to basic services such as food, water, health, housing and education. Current systems are often fragmented and poorly connected". One can argue that developing countries are different in that not only is there interaction between formal enterprises, universities, research institutes, governments and financial system, there is also interaction between NGOs, informal companies, grassroots inventors, local and indigenous knowledge.

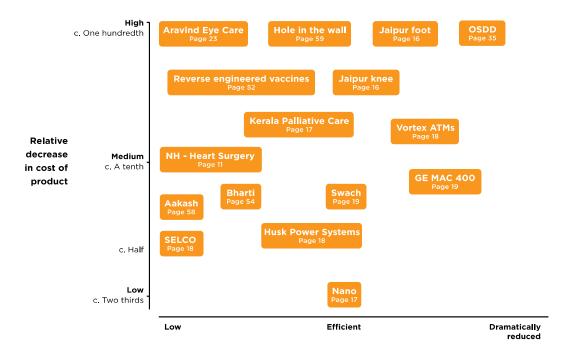
The recent report by Bound and Thornton (2012) is a good measure of how innovation in India compares with the rest of the world. The report highlights the advantages of "frugal innovation" – better, not just cheaper.

India is seen as producing products and services that are dramatically lower in cost and outperform alternatives and can be made available at large scale. This is in response to the large and increasingly aspirational middle class who are very price sensitive. It builds on a tradition of creative improvisation and fits well with a policy of "getting more for less".

The authors note the key characteristics that are somewhat unique to India, in particular they see frugal innovation as:

- making better things, not just cheaper things
- extending to services, not just products
- about remodeling
- not meaning low-tech: frugal innovation can require, or be combined with frontier science and technology.

Bound and Thornton refer to some significant successes in frugal innovation, as listed in Figure 2. It would appear that there is advantage and no obvious disadvantage in adopting the "frugal innovation" approach.



Relative decrease in cost of the innovation process

Figure 2 Achievements of frugal innovation in India (Bound and Thornton, 2012)

All this suggests that each country must tailor its innovation system to its own particular needs. This is indeed the case as it has long been noted that slavish copying of one country's apparent model (eg the co-location seen in California between research institutions and start-up companies) by other countries is rarely effective. India's encouragement for IT investment may be the leading example to the contrary compared with the number of "technology parks" around the world which struggle for profitable existence.

The OECD has also published a special report focussing on innovation strategy (OECD 2010). From that report one notes several points relevant to the special case of Australia, India and their opportunities to learn from each other and to collaborate in innovation.

Much is made or triadic patents or patent families in the OECD work. While patents are an output and not an outcome in terms of innovation, triadic patents<sup>1</sup> are costly and tend only to be taken out when there is higher value associated with an invention. They are therefore one of the better proxies for innovation. That India is two orders of magnitude below Australia in terms of triadic patents per capita (OECD 2010) is not surprising given the developing nature of India. What is not good and should be a wakeup call for Australia is that Australia sits in terms of triadic patents at one third the average performance of OECD countries. This is a sobering result and suggests, as many of us know, that Australians are good at doing R&D but poor indeed at showing connection between researchers and those in end user land who must make innovation happen.

Australia of course has some considerable success in innovations that have gone on to become global products, eg Cochlear and the bionic ear and Resmed in terms of the treatment of sleep apnoea. Australia's poor performance overall however cannot be explained away by the structure of our industries. As Pettigrew has recently pointed out, Australia has relatively low number of researchers working in industry and an above average number (on OECD standards) working in higher education and government (Pettigrew 2012). India also sits in a similar position in that the percentage of researchers in industry is low (28%) compared with many other countries (Bound and Thornton, 2012).

A deeper dive into the figures will in fact show some areas where India is ahead and Australia can learn from India and vice versa. For example, in terms of biotechnology patents filed at the European Patent Office India are well ahead of the OECD field and in fact leads the field (OECD 2010). Australia by comparison is well behind the OECD average. Similarly for ICT patents.

At a structural level it is interesting to note the different performance of India and Australia in terms of the private sector versus the public sector. In India, 23% of patents filed come from the public sector while the OECD average is 6% and in Australia we see 8%. It would be informative to find out how the uptake of this government led patenting activity. One notes however that of patents filed, the percentage actually granted after six years is much higher for India then for Australia (OECD 2010).

Other indicators also point to the significant structural differences between Australia and India, eg the number of newly registered enterprises per year as a percentage of all registered enterprises is some measure of the ease of setting up enterprises. India at 4% per year is clearly in a different space to Australia with one of the higher OECD rates, viz. 14%. One sees this also in the days needed to set up a business with India somewhat above the OECD average and Australia below – a consistent picture.

### Collaboration as an element of innovation

The lack of agreed, simple clear measures for innovation is an indication of the complexity of innovation systems. That said, there is general acceptance that public support for R&D is necessary, partly for the training of new researchers and partly because individual enterprises cannot capture enough of the benefits of the R&D to justify covering the full

<sup>&</sup>lt;sup>1</sup> Triadic patents are those patents applied for at the European Patent Office, the Japan Patent Office and the US Patent and trademark Office. They tend to represent higher value inventions and are an indicator of value that is somewhat removed from "home country" local market advantages.

cost of the work, let alone the difficulty of generating competitive advantage when the results of the R&D are published. India has a greater perceived need for more researchers than Australia and the recent move to allow the CSIR to award higher degrees in its own right is an interesting move. It has been considered in Australia from time to time (for CSIRO) but not seen as necessary. The move by the Queensland Government to attach their rural R&D researchers to the University of Queensland is an alternative which will facilitate more PhD's being available for primary industry research.

It has long been established that collaboration between researchers is beneficial. The broad statistics are compelling – whether at an enterprise level or even at a country level.

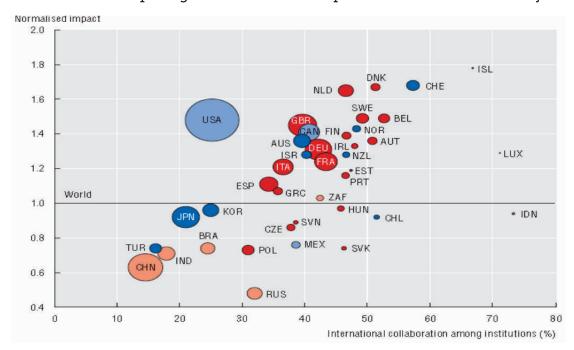


Figure 3: The impact of scientific production and the extent of international collaboration (OECD 2011)

What the figure on international collaboration shows is that at a country level, the more a country collaborates, the more the scientific impact of their R&D. Again, we come to the same conclusion as above, viz. it is in the interests of a country for a government to help fund and facilitate international collaboration in R&D.

The recent study by Bound and Thornton (2012) shows that collaboration between Australia and India is increasing, albeit from a relatively low base.

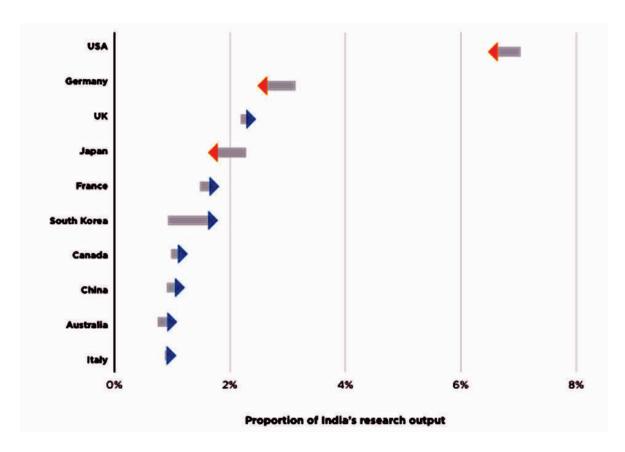


Figure 4: Research collaboration with India: relative changes between countries in the last 10 years

There is another side to collaboration however where both India and Australia are not faring as well. This is the extent that businesses collaborate with researchers in Universities and Government Institutions. From the Australian Government Innovation Report (2011), we note that Australia is under the OECD average. Anecdotal comments suggest India is also low in this regard. The realities are that companies do not source a significant amount of the ideas for innovation from Universities or Government Institutions, as noted in the figure from (Department of Innovation, Industry, Science and Research, Australian Government, 2011)

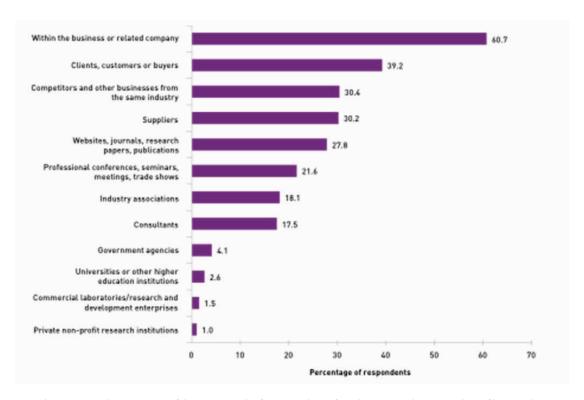


Figure 5: Sources of ideas or information for innovation-active firms in Australia 2008-2009 (Department of Innovation, Industry, Science and Research, Australian Government, 2011)

When one considers the extraordinarily low interaction between innovating firms and researchers in Universities and Government Institutions, it is clearly an area for improvement and facilitation by Government. In the UK, a survey of firms that collaborate with Universities (D'Este and Perkmann 2010) showed the fascinating result that the value to the firm was roughly one half in the actual research results and the other half was in the interaction and trading of ideas between the firm and the researchers. This is clearly a significant multiplier over and above the research results per se and is all the more reason to concentrate on improving the collaboration between firms and universities and government research organisations. D'Este and Perkmann go on to observe that "experience in collaborative research increases the probability of more frequent collaboration". This is of course intuitively obvious but nevertheless most significant: the more one collaborates, the easier it is in the future to be involved in collaboration.

In this regard it is pleasing to see that both the Indian and the Australian Governments recognise the importance of the collaborative plank of the innovation system, eg the Indian Governments strategy to "provide right mechanism for collaboration, training and support to drive innovation" (Office of Advisor to Prime Minister of India 2011) and the Australian Government's announcement of Industrial Transformation Research Hubs and Training Centres (announced in December 2011 but details still to be promulgated).

One can hope that in the future performance measures for universities and institutions will focus more on collaboration as an equal with the existing measures on research excellence, publications and student numbers. It is important that we see more robust and numerous

partnerships between enterprises and researchers in universities and government institutions with the intent of driving more innovation.

### The importance of innovative capacity

The OECD has undertaken a global study of the renewable energy area (Johnstone 2010). This is one of the few studies on innovation that looks at some of the inputs, such as the level of related R&D as well as the outputs, eg how much is invested in a country in an emerging area such as renewable energy. There is much controversy around the world on the drivers for the necessary investment to make innovation happen in this area. The Johnstone analysis focused on such drivers as the role of dedicated R&D, "market mechanisms" set in place by government such as feed in tariffs or mandated renewable energy targets or certificates and, finally, the general innovative capacity in a country rather than that especially associated with renewable energy.

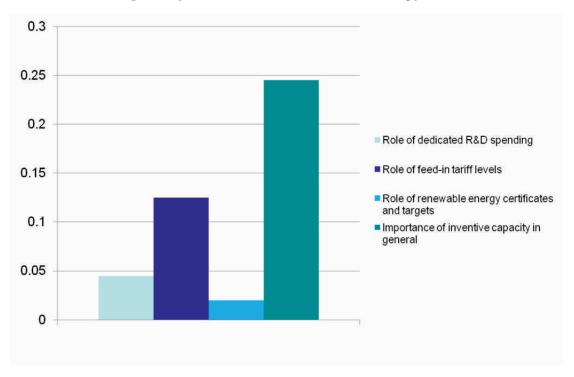


Figure 6 : Effect of different factors on innovation for renewable energy (Johnstone 2010)

Given the lack of agreed measures of the innovative capacity in a country, the Johnstone analysis used the total number of patent families (similar to Triadic patents) as the measure of general innovative capacity in a country. The results are shown in Figure 5 and are somewhat extraordinary in that general innovative capacity has far more influence than targeted measures. There is a lesson here that is fully consistent with the notion that to improve our innovation systems, innovative capacity should be targeted and as discussed in this short paper, encouraging more collaboration between researchers in universities and government institutions is an obvious target.

### Conclusions

Globally, innovation is recognized as critical for delivering the improvements needed for basic and aspirational requirements in an ever more competitive world. Government policies in most countries and in Australia and India reflect this recognition.

It can be argued that developing countries have features in their innovation systems that are outside of those in developed countries, yet there is much in common.

Using extensive data and analysis from the OECD, it is suggested that innovative capacity is a target for general improvement and that collaboration should be a particular target for both India and Australia.

### References

Bound, K, and Thornton, I, 2012. "Our frugal future: Lessons from India's innovation system" July 2012, NESTA, London. Available from

www.nesta.org.uk/homel/assets/features/our frugal future lessons from indias innovation system

Department of Innovation, Industry, Science and Research, Australian Government, 2011. Australian Innovation System Report, 2011, Commonwealth of Australia.

D'Este, P, and Perkmann, M, 2010. Why do academics engage with industry? The entrepreneurial university and individual motivations, Advanced Institute of Management Research Working Paper Series, May.

Johnstone, N, 2010. Climate policy and technological innovation and transfer. An overview of trends and recent empirical results, OECD 2010.

Nur, Y, 2012. Rethinking the innovation approach in developing countries, World Technopolis Association, 1(2): 107-117.

OECD, 2010. Measuring Innovation: A new perspective, OECD Publishing.

OECD, 2011. OECD Science Technology and Industry Scoreboard 2011: Innovation and Growth in Knowledge Economics, OECD Publishing.

Office of Advisor to the Prime Minister of India, 2011. Towards a more inclusive and innovative India – Creating roadmap for decade of innovation. Strategic Paper, New Delhi, India: Prime Minister's Office.

Pettigrew, AG, 2012. Australia's position in the world of science, technology and innovation, Occasional Paper Series, Australia's Chief Scientist, Issue 2, May.

United States Geological Survey (USGS), 2012. Copper statistics. Available from: <a href="http://minerals.usgs.gov/ds/2005/140/ds140-coppe.pdf">http://minerals.usgs.gov/ds/2005/140/ds140-coppe.pdf</a>

# Innovation and The University

by

Prof M.S. Ananth
Former Director, IIT Madras
Visiting Professor of Chemical Engineering
Indian Institute of Science, Bangalore

# OUTLINE OF TALK Semantics Creativity and the brain The Magic garden The Idea factory: Internationalisation Interdisciplinarity Research Parks The IIT Madras Research Park

# **CREATIVE PROCESSES**



- · Discovery, Invention and Innovation
- The first two pertain to the knowledge component, the third to the knowhow component; they are rarer and less predictable than the third
- Failed inventions, do not vanish; they accumulate and are a resource for innovation
- A single invention can trigger many innovations
   [Holmes]

### **INNOVATION**



- Extracting value from a creative understanding of what is already known
- Innovation has everything to do with commercial success. Innovation drives the economy.......The technical excellence of an invention matters far less than the economic willingness of the customer or client to explore it

[Schrage]

# CREATIVITY AND THE BRAIN



- The human brain has two parts: left and right
- The left is logical, good with language and good with step by step reasoning
- The right is intuitive, musical and thinks in pictures; it is illiterate!
- Synergy between left & right brain is the basis of creativity [Blakesley]

# THE SYNERGY



- Freedom from logic and structure of the right brain is the basis of idea-generation
- Ideas so generated are often wrong
- Logical verification by the left brain is therefore equally important in the creative process
- The left brain is dominant in some and the right in others; synergy can be between the left brain of one and the right brain of the collaborator!

# MANAGING CREATIVITY



- The Magic Garden aproach: hire brilliant minds, provide the atmosphere, leave them alone and ....pray for discoveries or inventions
- The Idea Factory approach: bring unlike
   (prepared) minds together and create opportunities
   for interaction; industrial labs keep an IPR
   specialist in circulation to spot market opportunities
   [Stewart]

# **UNLIKE MINDS**



Minds in the university can be unlike in different ways. For example they can differ in their

- A. Cultural background (eg. the US graduate school)
- B. Disciplinary training (eg. Bell Labs 1930s)
- C. Attitudes (eg. University based Research Parks)

# A. INTERNATIONALISATION



- Science is universal but scientists have a cultural identity and associated prejudices
- Need mix of cultures to overcome some
- Atleast 25% PG students/ 10% faculty from other cultures?
- Need a good mix of right and left brains!
- Need effective implementation mechanisms

# **B. INTERDISCIPLINARITY**



- Interdisciplinarity is inherent to all scientific work and problem-solving
- Fostered by societal need/ economic opportunity
- Interdisciplinary collaboration makes academia more sensitive to social demand
- Interdisciplinary frameworks take root only if problem addressed is of significant value to society

# INTERDISCIPLINARITY



- First used as a management tool to solve 'real' problems in specific sectors eg. Bell Labs in 1930s
- "Put mix of academic disciplines to action"
- Freedom at work but structured formal exchange of ideas
- IPR specialists hired to identify opportunities

# THE POST SCIENTIFIC SOCIETY

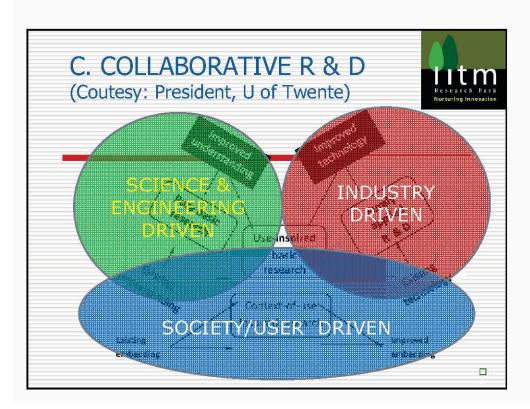


- Increased importance of social sciences & arts
- Specialized products and services: eg.1- Google,
   YouTube, eBay, Yahoo; eg.2- Wal-Mart, FedEx,
   Dell, Amazon, Cisco
- More translators and exploiters of new science
- Social & environmental awareness and concern
- Include constructive social activist groups too!
- IPR alone is not a measure of innovativeness

# INTERDISCIPLINARITY TODAY



- Long term social issues require interdisciplinary collaboration among the members of the society as a whole with its infinite variety of sensibilities and values
- Collaboration should include persons from the social sciences, ethics, law and the humanities
- Scientists cannot be the main contributors nor the only judges



# THE SILICON VALLEY



- Louis Pasteur: " ..... discovery is the result of chance meeting a prepared mind"
- During the 90s, large fraction of IPRs in Silicon
   Valley have Indian and in particular IIT-ian
   names
- IITs had been preparing minds for 50 years and chance was meeting them in Silicon Valley!
- Need to create "chances" in our backyards

### RESEARCH PARKS



- Entrepreneurship flourishes in the vicinity of high quality educational institutions
- Innovation needs local concentration of unlike minds:
  - Faculty: advanced domain knowledge
  - Industrial R&D personnel: keen on converting ideas into marketable products
  - Students: spirit to conquer the world/ ignorant of the "impossible"

# IIT MADRAS RESEARCH PARK

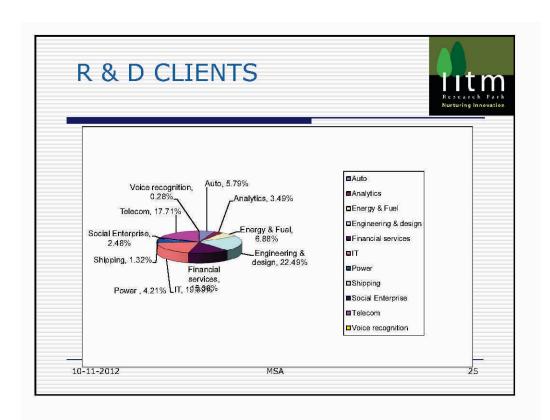


- State Government: 11.5 acres very close to campus/ tariff concessions
- Central Government: permission to form a Sec. 25 company/ interest-free part-funding
- Low rental / long term lease of space; 85% for R&D, 15% start-ups
- R&D interaction with IITM (quantified in terms of credits) for industry to continue in Park

# THE CREDIT SYSTEM!



- R&D projects in IITM (credits per Rs 1M)
- Consultancy to IIT Faculty (credits per Rs 1M)
- Royalty (credits per Rs 100K)
- Sponsored Ph.D / Masters Students (per year)
- Adjunct faculty (per year)
- Teaching by Industry personnel per hour
- Joint guidance PhD/ MS/B.Tech (per year)
- Part-time employment PhD/MS/BTech (per mo)
- Minimum credits/year/m<sup>2</sup> to stay in the Park!



# SOME INCUBATEES



- RTBI Rural Inclusive Technology
- Uniphore Voice Net and Biometric Systems
- DesiCrew Rural BPO
- ROPE Rural Products to Global Market
- Villgro Rural Innovations
- Dhvani Research Non-Destructive Testing
- Aaum Research and Analytics Analytics
- Myeasydocs Document Authentication

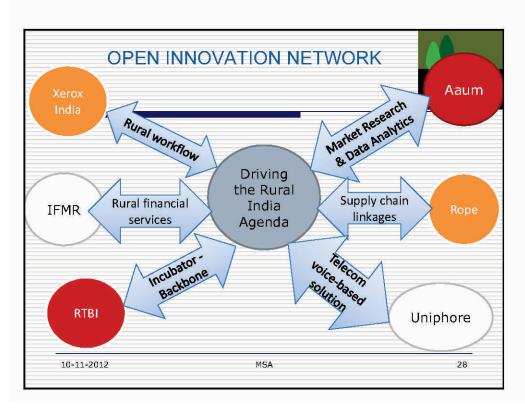
10-11-2012 MSA 26

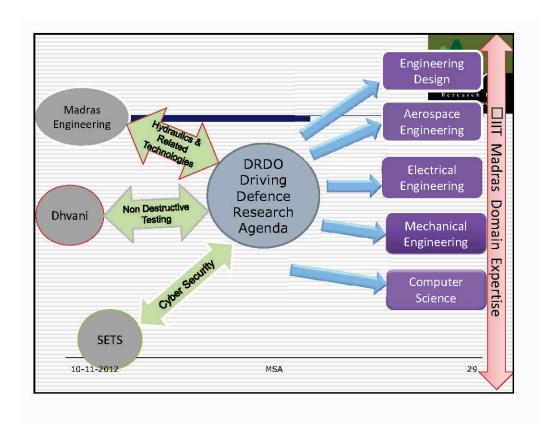
# THE FIRST YEAR

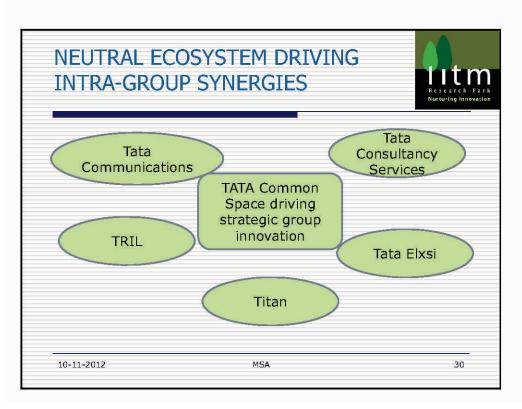


- About 40 companies/ 2500 people
- Strong portfolio of research across multiple sectors
- Over 4 dozen patents in the pipeline
- Incidental Advantages: Open innovation; intragroup synergies
- Over 100 student internships

MSA







# SUMMING UP



- Creativity Innovation, competitiveness & entrepreneurship - is the key factor for success in the global economy
- It is best managed by the 'idea factory' approach
- University based Research Parks (URPs) can take univ-ind-govt collaboration to higher level
- The IITMRP is the first URP in India
- India needs a 100 URPs making her a design house

10-11-2012 MSA 31

# REFERENCES



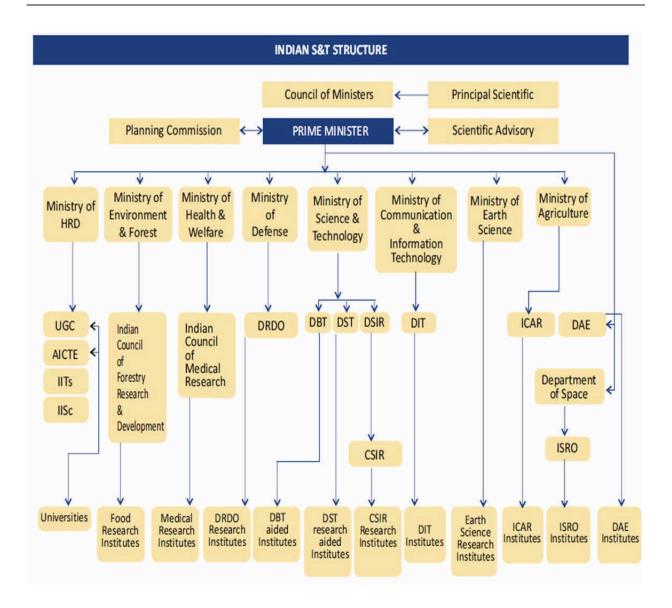
- 1. Blakeslee, T.R., "The Right Brain", Berkeley books, 1986
- 2. Holmes: <a href="http://metamorphicf.files.wordpress.com/">http://metamorphicf.files.wordpress.com/</a>
- 3. 2010/02/invention-and-innovation-mh-rev.pdf
- Schrage, M., quoted by Colby, S., in http:// <u>colbys.blogspot.com/ 2004/</u> 11/invention-orinnovation.html



# **REFERENCES**

- 4. Stewart, T.A., "The Wealth of Knowledge", Currency Doubleway, New York 2001.
- 5. Vest, C.M., Engineering Education in the 21st Century, Talk at IIT Madras, 20th January 2010
- Wessner, C., Understanding Research, Science and Technology Parks: Global Best Practices, National Academies Press, Washington DC, 2001.

Annexure: 1
Indian S&T Structure



[Source: CyberMedia Research]

National Science and Technology Entrepreneurship Development Board (NSTEDB) aims to foster technology based and knowledge driven entrepreneurship among S&T persons through its programmes and activities. The rate of incubator formation which was a trickle in the 80s and 90s has gained momentum in the current decade. During last three years new Incubators have been set up and now the number has grown to over 55.

List of TBI's		List of STEPs	
IT BHU, Varanasi	MICA, Ahmedabad	NDRI, Karnal	SJCE STEP, Mysore
CIIE IIM, Ahmedabad	MITCON, Pune	Krishna TBI, Ghaziabad	TREC STEP, Trichi
NIT, Calicut	TBI @ BITS, Pilani	Amrita TBI, Kollam	STEP IIT, Kharagpur
VIT-TBI, Vellore	ICICI KP, Hyderabad	SIDBI IIT, Kanpur	STP, Pune
TBI @ KEC, Erode	Technopark, Trivandrum	TBI University of Madras, Madras	NITK-STEP, Surathkal
TBI Composites, B'lore	Amity TBI, Noida	Ekta Incubation Centre, Kolkata	PSG-STEP, Coimbatore
ICRISAT, Hyderbad	Periyar TBI, Thanjavur	NCL, Pune	BEC STEP, Bagalkot
SIIE, Bombay	RTBI-IIT, Madras	TBI Univ. of Delhi	JSSATE STEP, Noida
NDBI, Ahmedabad	Bannari TBI, Sathyamangalam	Shriram Institute For Industrial Research, Delhi	STEP-TIET, Patiala

[Source: CyberMedia Research]

#### A. Innovation and Entrepreneurship Development Centres (IEDCs):

Innovation and Entrepreneurship Development Centres (IEDCs) have been promoted in education institutions to develop institutional mechanism to create entrepreneurial culture in academic institutions to foster growth of innovation and entrepreneurship amongst the faculty and students. The IEDCs aim to promote innovation amongst the students of S&T. The students are encouraged to take up innovative projects as a part of their curriculum and are supported to develop a working prototype. 15 IEDCs have been supported so far across the country.

#### B. Entrepreneurship Development Cell (EDC):

EDCs have been promoted by NSTEDB in educational institutions and institutions of higher learning to create entrepreneurial culture in the parent institution and other institutions in the region and to act as an institutional mechanism for providing information and assistance to budding S&T entrepreneurs. About 15 EDCs are currently operational.

#### C. Science & Technology Entrepreneurship Development (STED) Project:

STED project aims to bring socio-economic development in a region by promoting entrepreneurial temper and motivating unemployed youth for establishing micro enterprise based on innovative skills and technology. With the support to 48 STED Projects in the current financial year 2010-11, it is expected to establish more than 2500 micro-enterprises / units all over the country. Seven new projects were established in Kamrup (Assam), Gurdaspur (Punjab), Tiruvarur (Tamil Nadu), Pudukkottai (Tamil Nadu), Amravati (Maharastra), Nellore (Andhra Pradesh) and Tuticorin (Tamil Nadu). Skill Development Training through S&T (STST) aims at demonstrating the effectiveness of short term market oriented technical skill training in empowering unemployed youth to earn a sustainable livelihood. More than 8,400 youth are expected to be trained during 2010-11.

#### D. Technology Based Entrepreneurship Development Program (TEDP):

Technology Based Entrepreneurship Development Program (TEDP) is a program in which training is given on specific products/technologies/processes, which have commercial viability and which have been developed by R&D labs or other academic institutions. Besides the hands on training, the potential entrepreneurs are given entrepreneurial, motivational and managerial inputs. The duration of this program is 6 8 weeks depending upon the nature of technology and training needed. This program provides state-of-the-art inputs to the entrepreneurs about the technology to be employed and they can also develop their skills in application of the technology. The EDP conducting organization can concentrate in a specific discipline of technology and thus can have a more effective control over the program. The R&D institutions having commercially viable technologies get potential entrepreneurs as its takers and thus ideas/technologies get converted into wealth generating products and services. During 2010-11, 110 TEDPs were organized with the support from NSTEDB.

#### E. Entrepreneurship Development Program (EDP):

The Entrepreneurship Development Program (EDP) is an important innovative breakthrough in the strategy for developing human resources for promoting economic progress in India as well as in other under-developed countries. The EDP is an innovation in that those persons who possess certain identifiable qualities of entrepreneurship are counselled, motivated and trained to strengthen their self confidence, seize a business opportunity, initiate an enterprise and be the masters of their own i.e. to become 'entrepreneurs' instead passively waiting for a suitable employment.

The EDP is not just an extended version of (Business) management training program the primary aim of which is to provide theoretical and practical knowledge to manage production, finance, marketing and personnel of an existing enterprise with a view to minimize costs and maximize profits and/or growth of sales under given environment. In contrast, an EDP brings about a sound combination of techniques of behavioural psychology, tools of management science and available information on technology with a view to identify entrepreneurs, particularly 'first generation' entrepreneurs, strengthen their achievement motivation and train them in enterprise management so that they can confidently start and successfully run their own business ventures. Further, an EDP also ensures that on completion of the training, the potential entrepreneurs are helped in making loan application, securing available incentives, seeking government approvals, choice of location, etc.

#### F. Entrepreneurship Awareness Camps (EAC):

NSTEDB sponsors Entrepreneurship Awareness Camps of 2-3 days duration in educational institutions to inculcate spirit of entrepreneurship amongst students pursuing degree/diploma course in S&T streams and also amongst the faculty. During 2010-11, about 450 EACs have been supported for the benefit of students and faculty.

#### G. Faculty Development Program (FDP):

Faculty Development Program is designed to train and develop professionals in entrepreneurship development so that they can act as resource persons in guiding and motivating young S&T persons to take up entrepreneurship as a career. Through each FDP, 15-20 faculty members of Science and Engineering Colleges, Polytechnics and Entrepreneurship Development Organizations are trained for duration of two weeks. During the year 2010-11, 80 FDPs have been conducted all over the country.

#### **H.** Science Tech Entrepreneur:

A Monthly Publication of National Science & Technology Entrepreneurship Development Board (NSTEDB): The Science Tech Entrepreneur Magazine is brought out to disseminate information about various aspects of entrepreneurship technology finance and management to budding as well as established entrepreneurs which meets the objectives of NSTEDB. The Science Tech Entrepreneur magazine is published as E-magazine. This E- magazine is available on the NSTEDB

[Source: Department of Science & Technology (DST), Annual report 2010-11]

#### 1. Department of Science and Technology (DST)

#### Financing from the Technology Development Board (TDB)

The TDB primarily provides low–cost loans (up to 50 per cent of costs at 5 per cent interest) to companies to support commercialization. It also occasionally takes an equity stake (up to 25 per cent) or makes outright grants.

#### **Techno-entrepreneurs Promotion Program (TePP)**

The program provides small grants to individual (particularly 'grassroots') innovators. It helps the inventor to identify and network with an appropriate R&D/academic institution for guidance, assists in for filing and securing of intellectual property rights and then linking up with appropriate source of finances for commercialization of the product.

#### 2. Department of Scientific and Industrial Research (DSIR)

#### The Development and Demonstration Program (TDDP)

The TDDP also provides low-cost loans for the development and scaling of industrial technologies.

#### 3. Council of Scientific and Industrial Research (CSIR)

#### The New Millennium India Technology Leadership Initiative (NMTLI)

The NMTILI supports joint work between Indian companies and the government laboratory network to create technology leadership positions in industries/technologies where India has a potential competitive advantage in global markets.

The Government funds the entire project (in most cases) as a grant-in-aid for publicly funded R&D/academic partners and as a soft loan (3 per cent interest) to the industry partner and also underwrites the risk of failure.

#### 4. Department of Biotechnology (DBT)

#### The Biotechnology Ignition Grant (BIG)

This scheme is designed to stimulate commercialization of research discoveries by providing very early stage grants for the development and maturation of those discoveries into marketable product or intellectual property (IP), in particular to help bridge the gap between discovery and invention.

#### **Biotechnology Industry Partnership Program (BIPP)**

BIPP is a government partnership with Industries for support on a cost sharing basis for path-breaking research in frontier futuristic technology areas having major economic potential and making the Indian industry globally competitive. It is focused on IP creation with ownership retained by Indian industry and wherever relevant, by collaborating scientists.

#### **Small Business Innovation Research Initiative (SBIRI)**

The SBIRI, a scheme launched in September, 2005 aims to encourage small and medium scale industries to take up risk in innovative R&D in biotech sector. The main focus is on supporting proof of concept and early stage research in startups and SMEs.

#### **Bio-incubator Support Scheme (BISS)**

In order to foster techno entrepreneurship in biotechnology, BIRAC has initiated a scheme for Strengthening and Up-gradation of the existing Bio-incubators and also to establish New World Class Bio-incubators in certain strategic locations. These Bio incubators will provide the incubation space and other required services to start-up companies for their initial growth.

[Source: CyberMedia Research, 2012]

#### Tax incentives

India offers a variety of tax incentives to support R&D. These incentives can broadly be classified as input-based and output based. Offering fiscal incentives to stimulate business R&D has emerged as an increasingly popular policy tool over the past decade. The tax credits provide an indirect means of supporting R&D, in contrast to the direct government funding of business R&D through grants or contracts.

#### 1. Input based:

- A 200 per cent super deduction for in-house R&D expenditures, including capital expenditures (other than land and buildings). The super deduction is limited to taxpayers in bio-technology or manufacturing and producing products.
- A super deduction of 125 per cent to 200 per cent for payments to entities carrying out R&D in India.
- 100 per cent deduction for R&D expenses that do not otherwise qualify for the above super deductions.

#### 2. Output based:

 Waiver of excise duty for three years on goods produced, based on indigenouslydeveloped technologies and patented in any two of India, the EU, the USA or Japan.

[Source: NESTA, 2012]

National Innovation Foundation (NIF), is an autonomous body of the Department of Science and Technology, Government of India, it started functioning in March 2000 as India's national initiative to strengthen the grassroots technological innovations and outstanding traditional knowledge. NIF helps them get due reward for their innovations and ensure that such innovations diffuse widely through commercial and non-commercial channels generating incentives for them and others involved in the value chain. The NIF has a governing board chaired by Dr. R.A Mashelkar, Former director general CSIR and president Global Research Alliance. Professor Anil K.Gupta, President SRISTI and Professor IIM ahmedabad, is the executive vice chairperson of NIF.

With major contribution from the Honey Bee Network, NIF has been able to build up a database of more than 1, 60,000 ideas, innovations and traditional knowledge practices (not all unique) from over 545 districts of the country. NIF has filed over 550 patents on behalf of the innovators and outstanding traditional knowledge holders of which thirty five patents have been granted in India and four in USA. Micro Venture Innovation Fund at NIF has provided risk capital for 178 projects, which are at different stages of incubation.

There are four types awards given by NIF for innovation-

#### Grassroots Innovation award-

These awards are presented to grassroots innovators and outstanding traditional knowledge holders. NIF has so far conducted 6 award functions and given away hundreds of awards in various categories in its nationwide innovation movement.

#### **IGNITE-**

IGNITE is an annual national competition to harness the creative and innovative spirit of school children. Students are invited to send their original creative technological ideas and innovations for the same. The last IGNITE competition- IGNITE 11 saw submission of 4104 entries from 25 States and Union Territories of the country. IGNITE aims to promote originality, creativity and innovative spirit among our children so that when they become leaders of our society, they ensure an imaginative, inclusive and an innovative future for the country.

#### **Gandhian Inclusive Innovation Challenge-**

Through the Gandhian Inclusive Innovation Challenge Awards, NIF challenges the innovators in informal and formal sector to offer solutions to challenges that have been posed, all concerned with the drudgery that the women of India especially the resource poor women of India have. This challenge has been instituted this year and those challenges have been identified as follows: (a) Developing a manual paddy transplanter; (b) Developing a fuel efficient wood/bio mass stove; (c)Developing a tea plucking device

#### The Anjani Mashelkar Inclusive Innovation Award

It will be an annual award of Rs 1 lakh given to an Indian innovator (individual or organization). The award will be given from the benefits accrued from a corpus donated to the International Longevity Centre by Dr R A Mashelkar.

[Source: National Innovation Foundation (NIF)]

#### **BIBLIOGRAPHY**

Bill Aulet [2008]: 'How to Build a Successful Innovation Ecosystem', MIT Sloan and CRECE.

Biswas, P.K. & Pohit, S. [2012]: 'Private Sector Investment Opportunities in Indian R&D.', NISTADS.

Bramachari, S.[2011]" 'Connect to Decode – Innovative Crowdsourcing Model', in Sharma, L.K. and Ayra, S. (eds)(2011) 'The India Idea.' New Delhi: Wisdom Tree.

Cantwell, J., & Piscitello, L. [2000]: 'Accumulating Technological Competence: Its changing impact on Corporate Diversification and Internationalization.' Industrial and Corporate Change, 9(1), 21-51.

Christensen, Clayton M. [1997]: 'The Innovator's Dilemma: When New Technologies cause Great Firms to Fail', Boston, Massachusetts, USA: Harvard Business School Press

Cohan Ruth Schwartz [1997]: 'A Social History of American Technology'. Oxford University Press.

Dutz, M [2007]: 'Unleashing India's Innovation: Toward Sustainable and Inclusive Growth'. World Bank.

Edgerton D [2010]: 'Innovation, Technology or History: What Is the Historiography of Technology About?' Technology and Culture, Volume 51, Number 3, July 2010, pp.680-697

Hwang V & Horowitt G [2012]: 'The Rainforest: The Secret to Building the Next Silicon Valley', (Regenwald)

INSEAD [2012]: INSEAD- Global Innovation Index 2012.

http://www.wipo.int/export/sites/www/freepublications/en/economics/gii 2012.pdf (Accessed on 26 Aug, 2012).

Jackson D [2011]: 'What is an Innovation Ecosystem?' National Science Foundation <a href="http://www.erc-assoc.org/docs/innovation">http://www.erc-assoc.org/docs/innovation</a> ecosystem.pdf (Accessed on 26 Aug, 2012).

Jeff Dyer, Hal Gregersen, Clayton M. Christensen [2011]: 'The Innovator's DNA: Mastering the Five Skills of Disruptive Innovators', Harvard Business Review Press.

Kafouros, M. I., Buckley, P. J., & Clegg, J. [2012]: 'The effects of global knowledge reservoirs on the productivity of multinational enterprises: The role of international depth and breadth'. Research Policy, 41(5), 848-861.

Kerr, W., Lerner, J. & Schoar, A [2010]: The Consequences of Entrepreneurial Finance: A Regression Discontinuity Analysis', Harvard Business Review Press.

Kuczmarski, T [1996]: 'Innovation: Leadership Strategies for the Competitive Edge', McGraw-Hill.

Kumar, N. and Puranam, P. [2011]: 'India Inside. The emerging innovation challenge to the West.' Boston MA: Harvard Business Review Press.

MacCormack, A. [2007]: 'Innovation Through Global Collaboration: A New Source of Competitive Advantage', Harvard Business School, Boston, MA.

Mashelkar R: 'What will qualify as Inclusive Innovation?'

http://www.imcnet.org/pdf/What%20will%20qualify%20as%20Inclusvie%20Innovation%20(Bhavn a%20Doshi).pdf (Accessed on 29 August, 2012).

Mazzucato, M. [2011]: 'The Entrepreneurial State', Demos, London, UK.

Martha Lagace. "Entrepreneurial Hospital Pioneers New Model". Online webpage of Harvard Business school, at <a href="http://hbswk.hbs.edu/item/4585.html">http://hbswk.hbs.edu/item/4585.html</a> (Accessed on 21 August 2012).

Mercan B & Göktaş D [2011]: 'Components of Innovation Ecosystems: A Cross-Country Study' International Research Journal of Finance and Economics, 76 (2011)

Metcalfe and Ramlogan R [2008]: 'Innovation Systems and the Competitive Process in Developing Economies', The Quarterly Review of Economics and Finance, Vol.48, (in press).

Modaschl M [2010]: 'Why Innovation Theories Make no Sense', Department of Innovation Research and Sustainable Resource Management (BWL IX), Chemnitz University of Technology.

Misa Thomas[2011]: 'Leonardo to the Internet: Technology and Culture from the Renaissance to the Present', Johns Hopkins Studies in the History of Technology.

National Innovation Council. Report to the people. First Year. 2011, New Delhi

National Innovation Commission-Innovation in India 2007 report.

http://knowledgecommission.gov.in/downloads/documents/NKC Innovation.pdf (Accessed on 28 August, 2012)

NESTA [2012]: 'Our Frugal Future: Lessons from India's Innovation Ecosystem, NESTA, London.

Perez C[2012]: 'Innovation systems and policy: not only for the rich?', The other canon foundation, Norway and Tallinn University of Technology, Tallinn.

http://technologygovernance.eu/files/main/2012071005451212.pdf (Accessed on 1 Sept, 2012)

Pisano, G. [2012]: 'Creating an R&D Strategy', Harvard Business Review, Working Paper 12-095.

Prabhu Ram. [2008]: 'Managing Knowledge Transfer in the Life Sciences', BioSpectrum, CyberMedia, India, pp. 50-54.

Prabhu Ram [2008]: 'Technology Transfer in the Indian Public Research System', Research Global, Association of Commonwealth Universities (ACU), London, pp. 10-13

Prahalad, C.K.& Mashelkar, R.M. [2010]: 'Innovation's holy grail', Harvard Business Review.

Prahalad, C. K. [2004]: 'Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits'. Upper Saddle River, NJ: Wharton School Publishing.

Rajan, Y.S. [2012]: Shaping the National Innovation System: The Indian Perspective, The Global Innovation Index, WIPO.

http://www.wipo.int/econ stat/en/economics/gii/pdf/chapter7.pdf (Accessed on 21 August, 2012)

Radjou, N, Prabhu, J. and Ahuja, S. [2012] 'Jugaad Innovation: Think frugal, be flexible, generate breakthrough growth.' Hoboken NJ: Jossey-Bass.

Rishikesha T Krishnan [2010]: 'From Jugaad to Systematic Innovation: The Challenge for India', The Utpreraka Foundation

Stefanovich, Andy [2011]: 'Look at More: A Proven Approach to Innovation, Growth, and Change', Jossey-Bass.

Schuelke-Leech, Beth-Anne [2012]: 'Innovation Finance: A Synthesis of Public Funding and Private Financing of Innovation', Ohio State University.

Schumpeter, J.A. [1947]: 'The Creative Response in Economic History', Journal of Economic History vol. VII (1947), no. 2, pp. 149-159.

Shavinina, L. V., & Seeratan, K. L. [2004]: 'Extracognitive Phenomena in the Intellectual functioning of Creative and Talented individuals', In L.V. Shavinina (Ed.) The international handbook on innovation. (pp. 17-30). Oxford, England: Elsevier Science

Sibal, K. in Nayar, A. [2011]: 'Developing world: Educating India'. 'Nature.' 472, pp. 24-26.

Sinha R.K. [2011]: India's National Innovation System: Roadmap to 2020. ASCI Journal of Management 41(1), pp. 65–74.

Stefanovich, A [2011]: 'Look at More: A Proven Approach to Innovation, Growth, and Change' Jossey-Bass.

Tidd J [2006]: 'A Review of Innovation Models', Discussion Paper, Imperial College, London.

http://www.emotools.com/static/upload/files/innovation\_models.pdf (Accessed on 21 August, 2012)

Tiwari, R. and Herstatt, C. [2012]: 'Frugal Innovations for the 'Unserved' Customer: An Assessment of India's Attractiveness as a Lead Market for Cost-effective Products.' Working Paper. Hamburg: Hamburg University of Technology.

Vandervert, L. [2004]:'The neurophysiological basis of innovation'. In L.V. Shavinina (Ed.) The international handbook on innovation. (pp. 17-30). Oxford, England: Elsevier Science.

Wadhwa, V. et al. [2008]: 'How the Disciple became the Guru: Is it time for the US to learn workforce development from former disciple, India?' Kauffman Foundation.

http://www.kauffman.org/uploadedfiles/disciple became guru 080608.pdf (Accessed on 20 Aug, 2012)

#### **CONFERENCE ORGANIZERS**

#### About Indian National Academy of Engineering (INAE)

The Indian National Academy of Engineering (INAE), founded in 1987, elects most distinguished engineers, engineer-scientists and technologists covering the entire spectrum of engineering disciplines as Fellows from India and world. INAE functions as an apex body and promotes best practices in engineering & technology and the related sciences for their application to solving problems of national importance. The Academy provides a forum for futuristic planning for country's development requiring engineering and technological inputs and brings together specialists from such fields as may be necessary for comprehensive solutions to the needs of the country. INAE is an autonomous institution supported partly through grant-in-aid by Department of Science & Technology, Government of India. As the only engineering Academy of the country, INAE represents India at the International Council of Academies of Engineering and Technological Sciences (CAETS).

www.inae.in

#### National Innovation Council Government of India

Realizing that innovation is the engine for the growth of prosperity and national competitiveness in the 21st century, the President of India has declared 2010 as the 'Decade of Innovation'. To take this agenda forward, the Office of Adviser to the PM on Public Information Infrastructure and Innovations (PIII) is working on developing a national strategy on innovation with a focus on an Indian model of inclusive growth. The idea is to create an indigenous model of development suited to Indian needs and challenges. Towards this end, the Prime Minister has approved the setting up of a National Innovation Council (NIC) to discuss, analyze and help implement strategies for inclusive innovation in India and prepare a Roadmap for Innovation 2010-2020. NIC would be the first step in creating a crosscutting system which will provide mutually reinforcing policies, recommendations and methodologies to implement and boost innovation performance in the country.

www.innovationcouncil.gov.in

# International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS)

CAETS is an independent nonpolitical, non-governmental international organization of engineering and technological sciences academies, one member academy per country, with the following objectives:

- Prepared to advise governments and international organizations on technical and policy issue related to its areas of expertise;
- Contribute to the strengthening of engineering and technological activities to promote sustainable economic growth and social welfare throughout the world;
- Foster a balanced understanding of the applications of engineering and technology by the public;

- Provide an international forum for discussion and communication of engineering and technological issues of common concern;
- Foster cooperative international engineering and technological efforts through meaningful contacts for development of programs of bilateral and multilateral interest;
- Encourage improvement of engineering education and practice internationally; and
- Foster establishment of additional engineering academies in countries where none exist.

www.caets.org

#### Confederation of Indian Industry (CII)

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes. CII is a non-government, not-for-profit, industry led and industry managed organization, playing a proactive role in India's development process. Founded over 116 years ago, it is India's premier business association, with a direct membership of over 8100 organizations from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 90,000 companies from around 400 national and regional sectoral associations. CII catalyses change by working closely with government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialized services and global linkages. It also provides a platform for sectoral consensus building and networking. Major emphasis is laid on projecting a positive image of business, assisting industry to identify and execute corporate citizenship programmes. Partnerships with over 120 NGOs across the country carry forward our initiatives in integrated and inclusive development, which include health, education, livelihood, diversity management, skill development and water, to name a few.

www.cii.in

#### CONFERENCE SUPPORT-CUM-KNOWLEDGE PARTNER

#### About CyberMedia Research (CMR)

A part of CyberMedia, South Asia's largest specialty media and media services group, CyberMedia Research (CMR) has been a front runner in market research, consulting and advisory services since 1986.

CMR offers research-based insights and consulting services – market intelligence, market sizing, stakeholder satisfaction, growth opportunity identification, incubation advisory, and go-to-market services – covering the Lifesciences, Information Technology, Telecommunications, Semiconductor, Electronics & Smart Infrastructure, Government, Energy and Utilities sectors, as well as the large enterprise, SMB and consumer user segments.

Cyber Media Research Ltd., an ISO 9001: 2008 company, is a member of the Market Research Society of India (<a href="www.mrsi.in">www.mrsi.in</a>) and senior CMR analysts are enrolled with the European Society for Market Research (<a href="www.ESOMAR.org">www.ESOMAR.org</a>). CMR's core value proposition encompasses a rich portfolio of syndicated reports and custom research capabilities across multiple industries, markets and geographies. For more details, please visit <a href="http://www.cybermediaresearch.co.in">http://www.cybermediaresearch.co.in</a> or <a href="http://www.cybermediaresearch.co.in">http://www.cybermediaresearch.co.in</a> or <a href="http://www.cybermediaresearch.co.in">http://www.cybermediaresearch.co.in</a> or



# **Towards a Better Innovation Ecosystem**

The Indian National Academy of Engineering (INAE), founded in 1987, comprises India's most distinguished engineers, engineer-scientists and technologists covering the entire spectrum of engineering disciplines. INAE functions as an apex body and promotes the practice of engineering & technology and the related sciences for their application to solving problems of national importance. The Academy provides a forum for futuristic planning for country's development requiring engineering and technological inputs and brings together specialists from such fields as may be necessary for comprehensive solutions to the needs of the country. INAE is an autonomous institution supported partly through grant-in-aid by Department of Science & Technology, Government of India. It is the only engineering Academy of the country. INAE represents India at the International Council of Academies of Engineering and Technological Sciences (CAETS).

The Academy organizes Symposia/Seminars/Workshop/Conferences at national/international levels on topics of national importance. Based on the deliberations, INAE invariably brings out policy recommendations for suitable follow-up action by the concerned Ministry/Department/agency(ies). As part of the INAE silver jubilee year celebrations, the International Conference on "Towards a Better Innovation Ecosystem" was organized by INAE in collaboration with National Innovation Council (NIC), India; International Council of Academies of Engineering and Technological Sciences (CAETS) and Confederation of Indian Industry (CII) on Sep 20-21, 2012 at New Delhi.



# Indian National Academy of Engineering

6th Floor, Vishwakarma Bhawan, Shaheed Jeet Singh Marg
New Delhi-110 016; Phone: +91 11 26582635 Fax: +91 11 26856635
e-mail: inaehg@inae.in website: http://www.inae.in