Australia India Institute Task Force Report

Science Technology Innovation: Australia and India

A report produced in conjunction with The Australian Academy of Technological Sciences and Engineering (ATSE)

ATSE

Australia India Institute

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The Australia India Institute's

Task Force on Science Technology Innovation

This Task Force report, *Science Technology Innovation: Australia and India* was commissioned by the Australia India Institute (A.I.I.) in conjunction with the Australian Academy of Technological Sciences and Engineering (ATSE).

The Task Force was led by Professor Robin Batterham AO FREng FAA FTSE, from the Australian side, and Dr Ramesh Mashelkar FRS FTSE, from the Indian side. Professor John Webb OAM was the convenor.

The Report contains a set of commissioned articles on key aspects of this vitally important subject for our two nations, including the impact of globalisation, the international context, the challenge of inclusive innovation and of grass roots innovation, and the critical question of financing for innovation.

The Task Force also interviewed senior research figures to glean insights from their experiences in collaborating internationally on specific projects and participating in institutional partnerships.

The report also contains an analysis of the Australia India Strategic Research Fund, Australia's single largest bilateral project of its kind with any nation to date.

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Telling the India Story in the Asian Century

The Australia India Institute

The Australia India Institute is a centre for the study of contemporary India based at the University of Melbourne.

The A.I.I promotes dialogue, research and partnerships between India and Australia across a wide range of areas of common interest, including teaching and academic research, policy roundtables and debates, and diplomatic and cultural exchanges and dialogues.

The Institute's Task Forces bring together leaders in key areas from both nations to focus attention on important issues, opportunities and challenges. Previous Task Force reports have examined Australia-India Perceptions, Indian Ocean regional security, and Tobacco Control.

The Institute also maintains partnerships with the University of New South Wales, and La Trobe University.

We welcome your interest in this report, and invite you to become part of the India story in the Asian Century.

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Collaboration with India invests in innovation capacity

Executive summary

In the 21st century, wealth creation will increasingly depend on creativity and innovation-based new technology. The challenge for an economy like Australia's, underpinned by large but finite natural resource endowments, is to expand its knowledge base and sustain growth through smart innovation strategies.

Traditionally, the networks and pathways of international innovation have been dominated by activities in the USA and certain European nodes. Increasingly, however, the epicentre of world trade and influence is shifting from West to East as the power and influence of China and India grow in step with their expanding economies. Globalised innovation chains now include Indian cities such as Bangalore and Hyderabad, where many research centres are located, some sponsored by governments, others by privately-owned multinational or Indian corporations. In a globalised world, collaboration with Asian nations is increasingly recognised as an essential element in the success of other economies.

Australia and India have recognised the opportunities that exist, not only for trade and investment, but also in collaborative research.

The Australia–India Strategic Research Fund (AISRF), initiated in 2006 and extended and increased in 2009, is a prime example in which our two nations contribute equally to fund advanced research. Several Australian and Indian universities have established joint research facilities such as the Monash University–IIT Bombay Research Academy collaboration, leading to the awarding of joint PhD degrees. Support from industrial and corporate partners has also backed applied projects of mutual interest.

Not surprisingly, international collaborations between India and other countries are also growing strongly in recognition of India's untapped research and development capabilities, which have seen it described recently as a 'sleeping giant' in science and technology.

Collaboration with India can be seen as an investment in innovation capacity, with collaborative research and development projects raising the possibility of shared innovation, shared intellectual capital, and potentially substantial wealth generation for partner nations, including Australia.

Recommendations

Collaboration between Australia and India represents a unique opportunity. Both countries have high quality R&D and are well-focused strategically to address significant common challenges that require innovation.

The Task Force recommends:

- That funding for the Australia–India Strategic Research Fund be continued to further strengthen this component of the bilateral relationship. The AISRF has enabled scientific communities in India and Australia to engage in collaborative research, thus building an extensive set of connections involving thousands of established and younger researchers in each country.
- That an India–Australia Innovation Forum be held in both countries, bringing together researchers, institutions, financiers, entrepreneurs, industry and policy makers to raise the profile and importance of innovation in collaborative research. The current collaborations between Australia and India have concentrated on joint research and joint research outcomes. Projects focused on applying research outcomes have received less emphasis. Although the AISRF Grand Challenge program does anticipate innovative outcomes of value to the 'common man', more needs to be done to ensure that bilateral research collaboration has the widest possible impact. An India-Australia Innovation Forum would make an important contribution to achieving this goal.
- That a series of science missions to India and to Australia, comparable to the trade missions that are currently sponsored by state and national governments, be organised to help raise awareness among Indian and Australian science communities of the potential benefits of collaboration. The emphasis of the mission should be on innovation and commercialisation of knowledge-based inventions. The appropriate agency to manage these missions from the Australian side is Austrade. Particular attention should be paid to opportunities and challenges under the rubric of 'inclusive innovation'.
- That an award recognising joint Australia-India innovations developed through bilateral research collaborations be established with sponsorship from major business houses and research-dependent corporates. The new award would augment existing national prizes for innovation in both countries. Award winners in each country should also be invited to present their work at relevant meetings and forums in the other country.
- That both governments strengthen their diplomatic representation in the science technology and innovation portfolios. The appointment of a counsellor position at the Australian High Commission in New Delhi is recommended as well as a dedicated position in the Indian High Commission, Canberra. The appointees would be responsible for supporting the establishment of new institutional partnerships and initiatives around innovation collaboration.
- That alternate funding mechanisms be considered to progress science and technology collaborations between India and Australia. As well as governmental funding for various types and levels of collaboration, funding opportunities through NGOs should be well advertised to stakeholders. Variation to current funding models should be considered to allow for "Kick Start" funding to facilitate partnerships between major research institutions in Australia and India, attracting additional financial backing and forging new relationships with the corporate and business worlds of both nations.

An overview of innovation systems

India

In the global innovation index 2012, India ranked 64th. India's gross expenditure on R&D as a proportion of GDP in 2012 was 1 per cent. India anticipates increasing this to 2 per cent by 2017, split equally between government investment and private sector investment. India's share of global research output was 3.5 per cent in 2012. The Government of India announced their Decade of Innovation commencing in 2010, with a focus on inclusive growth. This includes creating a framework for encouraging and facilitating innovations across all sectors, and promoting state and sectoral innovation councils. The strategy of the Indian Government also includes the establishment of cluster innovation centres. Key stakeholders in the Indian innovation system include federal and state governments, governmental organisations, the Indian science community, industry associations, innovation organisations, non-governmental organisations, major industry and small to medium enterprises (SMEs).

Australia

In the global innovation index 2012, Australia ranked 23rd. Australia's gross expenditure on R&D as a proportion of GDP 2010-2011 was 2.22 per cent. Australia's share of world research output was 3.2 per cent. However, according to OECD rankings, Australia is lagging behind OECD averages, indicating Australia is not converting strong scientific outcomes into commensurate economic benefits. In the Australia Innovation System Report 2011, the three components of the innovation system were identified as networks, innovation activities, and framework conditions which collectively function to produce and diffuse innovations with economic, social and/or environmental value. The 2012 report focused on the need for improving productivity and competitiveness through innovation and innovative businesses. Australia also recognises a need to focus more on SMEs and on linking research institutes and industry more effectively. There are various national and state government schemes working towards these goals, such as the Cooperative Research Centres (CRC) program.

Old friends and new partners

The Hon Dr Craig Emerson

Australia and India have a shared history within the Commonwealth and a growing and diversifying economic and investment relationship.

While trade in recent years has been made up principally of resources, Australia's world-class education system has also drawn tens of thousands of Indian students to its universities and vocational education institutions.

This has made education services Australia's fourth-largest export to India, and the ideal platform on which to develop links in science and research between the two countries.

We both need to develop cooperation in these areas if we are to harness and take full advantage of the wonderful array of opportunities arising from the rapid growth of Asian economies.

Our future prosperity will depend on turning research into the next generation of products, services and production processes.

Australian Prime Minister Julia Gillard recently described the relationship between our countries as one of "old friends" and "new partners".

This timely report looks at how we can use our long friendship and history of cooperation to strengthen partnerships in science, technology and innovation.

That's why we have both invested to strengthen research collaboration.

I welcome this report, *Science Technology, Innovation: Australia and India*, which looks at how our countries might further science, technology and innovation engagement in these fields.

Australians and Indians are great innovators and both countries stand to benefit by working more closely with each other.

Dr Craig Emerson

Minister for Tertiary Education, Skills, Science and Research
Minister for Trade and Competitiveness
Minister Assisting the Prime Minister on Asian Century Policy

Science and technology links acquiring a new salience

His Excellency Mr Biren Nanda

I would like to congratulate the Australian Academy of Technological Sciences and Engineering and the Australia India Institute for publishing this report *Science Technology Innovation: Australia and India*. I would particularly like to commend the efforts of the co-leaders of the Task Force, Dr Ramesh Mashelkar FRS FTSE and Professor Robin Batterham AO FREng FAA FTSE, for their leadership in bringing this important project to fruition.

For over a decade the Indian economy has grown at an average of 8 per cent per annum and both manufacturing and services have performed impressively. Sectors like information technology have had a larger than life image in this process of change. The spread of prosperity has been visible and the population below the poverty line has been reduced by a quarter over the last five years of the previous decade. Rising foreign direct investment figures convey both the potential for business and global confidence in our success. India is also making its economic presence felt abroad, both through trade and acquisitions.

However, there are important supply-side constraints including resources, energy, skills, education, science and technology and innovation that need to be overcome if we are to sustain this rate of growth in the coming decades. It is no surprise, therefore, that these supply-side constraints are a driving force behind the rapid expansion of ties between India and Australia.

Consequently, scientific and technological collaboration is acquiring a new salience in Australia's relations with India. A number of Australian universities are pursuing research collaborations with Indian universities. India and Australia have a highly successful joint strategic research fund that supports scientific and technological collaboration in the areas of agricultural research, astronomy and astrophysics, environmental sciences, microelectronics, nanotechnology, renewable energy, marine sciences and earth systems sciences. Many of these collaborative projects touch the daily lives of people in India. We need to strengthen such collaboration in the future.

India's first Prime Minister, Jawahar Lal Nehru, spared no effort to establish a modern, national science and technology organisation after India became independent in 1947. The objective was to promote and sustain the cultivation of the sciences and scientific research, and to secure the many benefits that could accrue to the Indian people through the acquisition and application of scientific knowledge.

As the economic development of India at that time had not reached the stage at which the private sector could play a leading role in the development of science and technology, it was decided that government should provide the initial momentum.

Today, India has broad-based science and technology infrastructure under national and state governments, as well as in the private sector, working in diverse areas ranging from agriculture and health care to nuclear and space research.

The Department of Atomic Energy is engaged in developing technology for producing nuclear power using uranium and thorium. It also extends applications of nuclear research to agriculture, health care and industry to improve quality of life. It builds research reactors, develops technologies related to accelerators and lasers, and supports basic research in areas related to nuclear energy and other frontiers of science.

The Indian Space Research Organisation is responsible for planning and executing the space program which develops satellites and launch systems and provides space-based services in the areas of communications, meteorology, resources, etc. Our satellite communications network has changed the way we live. Vegetable vendors have mobile connections, illustrating the broad reach of affordable communications technology. India has among the largest number of television channels in the world. We provide distance education, tele-medicine and agro-meteorology services. Remote sensing generates valuable information about cyclones, climate change and resources on land and in the oceans, and assists in forestry and in disaster management. We develop satellites for communications, remote sensing, and weather forecasting and have sent a spacecraft to orbit the moon. We announced a Mars Mission this year.

India is among the few developing countries which have achieved self-sufficiency in food production. India has developed supercomputers based on parallel computing. In the field of aeronautics, we have developed and successfully flown an all-composite trainer aircraft and the Light Combat Aircraft. Technologies have been developed for industrial catalysts and for the production of life saving and prolonging drugs such as AZT (azidothymidine), a critical drug in the global fight against HIV-AIDS. In the area of biotechnology, a yeast strain has been developed for the conversion of molasses into ethanol.

Under the National Action Plan on Climate Change, the Indian Government has launched eight national missions in important areas such as sustainable agriculture, water, energy efficiency, solar energy and forestry. All national missions have strong components of science and technology.

India has emerged as a global R&D hub for sophisticated sectors such as network equipment, medical equipment, semiconductor design, aerospace, automotive, computation and biotechnology. More than half of the world's Fortune 500 companies have set up their own R&D operations in India. Foreign and Indian multinationals are leveraging the Indian talent pool for cutting-edge technological developments. The complexity of the technology being developed in India has increased exponentially and our quality standards hold their own in a highly competitive global environment. Further fuelling the success of innovation in India in the R&D environment is our very vibrant entrepreneurial ecosystem.

One aspect of innovation in India is that Indian entrepreneurs are increasingly focusing on serving consumers at the bottom of the income pyramid. As a result, a number of new innovative products and services have recently come onto the Indian market. Successful examples of technological and business innovation in this demographic include the Tata Nano car, which has 34 design patents and was initially priced at $US2500; the Chotukool, a small refrigerator which weighs 7.5kg, has an electricity bill of $US1 a month and costs $US75; an ATM that uses four per cent of the energy used in a conventional machine; a low-cost water purifier which incorporates 14 patented innovations and costs $US25; and the world's cheapest tablet computer, Akaash, priced at $US36.

There has been a renewed focus on science and technology policy in India as we seek to find ways to sustain our rapid growth and overcome the supply-side constraints of energy, food, water and resources.

Broadly, Indian Government policy seeks to:

- Increase science and technology spending to 2 per cent of GDP and increase the quantity and quality of research publications, patents and PhDs
- Put incentives in place to attract the private sector to spend more on research and development. To date spending on science and technology has mainly come from government
- Rebalance India's research focus by increasing spending on applied research that would directly benefit different groups in the population. This would also focus science and technology research more on basic sciences
- Encourage universities to increase their focus on research. To date India's scientific research has mainly been the preserve of government laboratories under the CSIR and the central and state governments
- Promote links between scientific research and industry. A weak link has been the lack of connectivity between laboratories and industry.

These developments in Indian science policy, and innovation initiatives in India's science and technology sector, will open up new opportunities for scientific collaboration and commercial activities between India and Australia.

India and Australia are also establishing new institutional platforms that will widen the scope for science and technology cooperation in the future. For example, the Water Technology Partnership will allow India to benefit from Australia's experience in river-basin modelling. We have also recently concluded an MOU on cooperation in space sciences which will open up an important area for our collaborative endeavours.

We welcome Australian participation in the global R&D hub in India as well as the vibrant innovation arena which serves the bottom of the pyramid in the Indian market, an immense market with a similarly expansive scope for new ideas.

We hope to see a continuation and expansion of our collaborative research activities under the Australia-India Strategic Research Fund. Apart from the outstanding work produced through this endeavour, perhaps the most enduring contribution of such collaboration is the networks forged between the scientific and educational institutions of the two countries. These networks are already opening up new opportunities for the commercialisation of scientific and technological innovation in India.

BIREN NANDA

High Commissioner for India in Australia

CHAPTER ONE
International perspectives on innovation

Collaboration is a key in innovation priorities

By Robin Batterham[1]

Both India and Australia recognise the importance of innovation in delivering the best possible outcomes for their people going forward in an ever more competitive world.

In India, the coming 10 years have been declared a Decade of Innovation, with appropriate priorities and initiatives. In Australia, National Innovation Priorities have been introduced over the past few years (and measurements reported against them) as well as National Research Priorities of long standing.

Innovation is seen by all countries as important. Focusing on India and Australia, there are some significant similarities in areas that need more attention, particularly that of collaboration between researchers and end users which is essential in translating good, new ideas into practical outcomes with meaningful, real-world applications. More collaboration can lead to more rapid and effective innovation to achieve this end.

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 supplies of clean water, provide quality health care and live sustainably. That is, enjoy the benefits of increasing prosperity. It is innovation that delivers on these basic requirements and aspirations.

By innovation we mean much more than creativity, good ideas, or R&D – the essential starting points. Innovation refers to the exploitation of such new ideas or developments so that they can change the way we do things, most often by bringing new, better products, processes, services and practices into the market place. The new idea at the beginning of the innovation pathway can be new to the world, to the country, or merely to one small group of end users.

Much of the discussion about innovation gets very confused, however, because the generation of ideas and all the creativity that sits behind that important process – and the ongoing march of science – is often billed as innovation. It is not. It may eventually 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.

Many of the benefits we enjoy today from lower prices in real terms stem from innovation. When you consider the way commodity prices have fallen for at least two centuries, it is succeeding waves of stepwise innovation and ongoing, continuous improvements in between that have steadily driven prices ever lower. There is no other explanation. Demand, at least for commodities, keeps rising and in the mineral and energy areas grades or availability keep falling, yet prices also keep falling in real terms (see **Figure 1** for copper prices. Other commodities are similar).

Innovation around the world

The OECD has for 10 years published an annual scorecard on Science, Technology and Industry. The latest (OECD 2011) indicates that while there are many measures relevant to innovation there is no single measure of innovation that tells the whole story.

There are currently marked differences in innovation profiles between countries, both within the groupings of developed countries and developing countries and between the two groups. The change in some developing countries over the past 10 years has been truly remarkable. There are some who would argue that the world's developing countries have different ways of innovating.

[1] Professor Robin Batterham AO FREng FAA FTSE was Chief Scientist of Australia from 1999 to 2005, and then President of the Australian Academy of Technological Sciences and Engineering, a position he held until December 2012. Professor Batterham, currently the Kernot Professor of Engineering at the University of Melbourne, is a technologist and innovator with a distinguished career in the public and private sectors. He was the former Group Chief Scientist, Rio Tinto Limited and, until 1998, worked with CSIRO, with responsibility for minerals-related research (Chief of Division) and significant innovations in mining, mineral processing, mineral agglomeration processes and iron making.

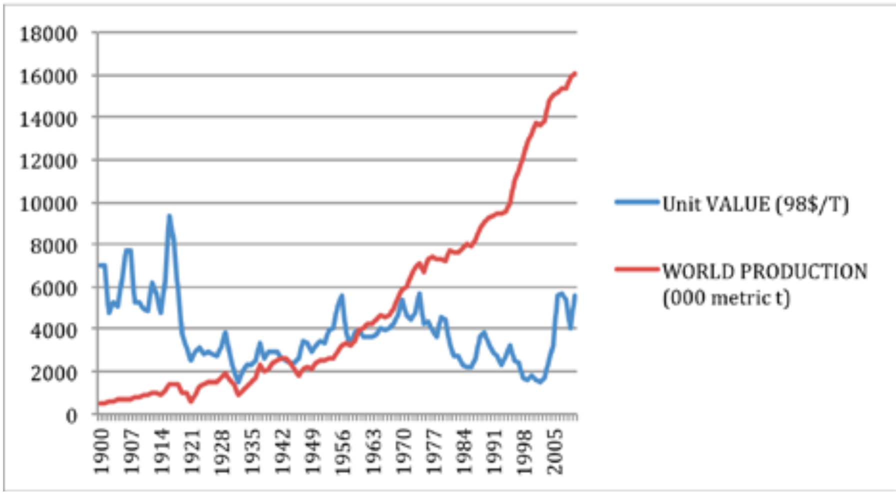

Figure 1. Copper as an example of how innovation drives real prices down, despite ever increasing demand. Source: United States Geological Survey, Copper statistics. Available from http://minerals.usgs.gov/ds/2005/140/ds140--coppe.pdf Updated by RJB (2012)

Yoslan Nur 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 the financial system, but there is also interaction between NGOs, informal companies, grassroots inventors, local and indigenous knowledge.

All this suggests that each country must tailor its innovation system to its own particular needs and its own local conditions. The slavish replication of one country's apparent model (e.g. the co-location seen in California between research institutions and start-up companies) by other countries is rarely effective. India's success in encouraging IT investment around technology parks may be the leading example, contradicting as it does the experience elsewhere in the world where such parks tend to struggle for a profitable existence.

A standard joke in some areas is that in some of the technology parks built by regional governments in collaboration with universities, the only truly commercial activity after several years is the cafeteria serving people food during working hours.

The OECD has also published a special report focusing on innovation strategy (OECD 2010), with several points relevant to the special case of Australia and India – and their opportunities to learn from each other and to collaborate in innovation.

Much is made of triadic patents or patent families in the OECD work. (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). While patents are an output and not an outcome in terms of innovation, triadic patents 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's economy. 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 forging connections between researchers and those in 'end-user land' who must make innovation happen.

Australia's poor performance cannot be explained away by the structure of our industries. Australia has a relatively low number of researchers working in industry and an above average number (by OECD standards) working in higher education (Pettigrew 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 leads the OECD 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 per cent of patents filed come from the public sector while the OECD average is 6 per cent and in Australia we see 8 per cent. It would be of value to know more about the uptake of government-led patenting activity. Of patents filed, the percentage actually granted after six years is much higher for India than for Australia (OECD 2010).

Other indicators also point to significant structural differences between Australia and India. The number of newly registered enterprises per year, as a percentage of all registered enterprises, gives some indication of the relative ease or otherwise of setting up enterprises. India, at 4 per cent a year, is clearly in a different space to Australia, with one of the higher OECD rates of 14 per cent. This is consistent with the number of days needed to set up a business – with India somewhat above the OECD average and Australia below.

Innovation for Global Challenges

Food, energy and water security, together with health and climate change are global challenges to which no single government can provide all of the solutions. Equally, solutions demand innovation. There are areas in which innovation is needed and must of necessity involve international collaboration.

A recent study by the OECD (2012) looked at several different examples of international cooperation for innovation to tackle global challenges. It is clear that international collaboration can and does work but there is no particular model that necessarily performs better than others. Some principles stand out as mandatory for success – for example, priority-setting. Collaboration can involve different levels of involvement and control by different parties, yet without clearly defined processes and priorities collaboration can produce results inferior to those that could be expected if the parties acted individually. That is, in poorly conceived collaborative ventures the results can be less than the sum of the parts. These and other lessons learnt suggest it is counterintuitive for national governments to spend money on international collaboration, rather than focusing on their own national effort. Therefore, the collaboration message can be tough to sell to voters, but it is extremely important for governments to do so.

Collaboration

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 cost of the work, let alone the cost of generating the consequent competitive advantage once the results of the R&D are published.

India has a greater perceived need for more researchers than Australia and the recent decision to allow the CSIR to award higher degrees in its own right is an interesting move. Although considered from time to time in Australia (for CSIRO), this has not been seen as necessary. An alternative approach is the move by the Queensland Government to attach their rural R&D researchers to the University of Queensland. This will facilitate more PhDs 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.

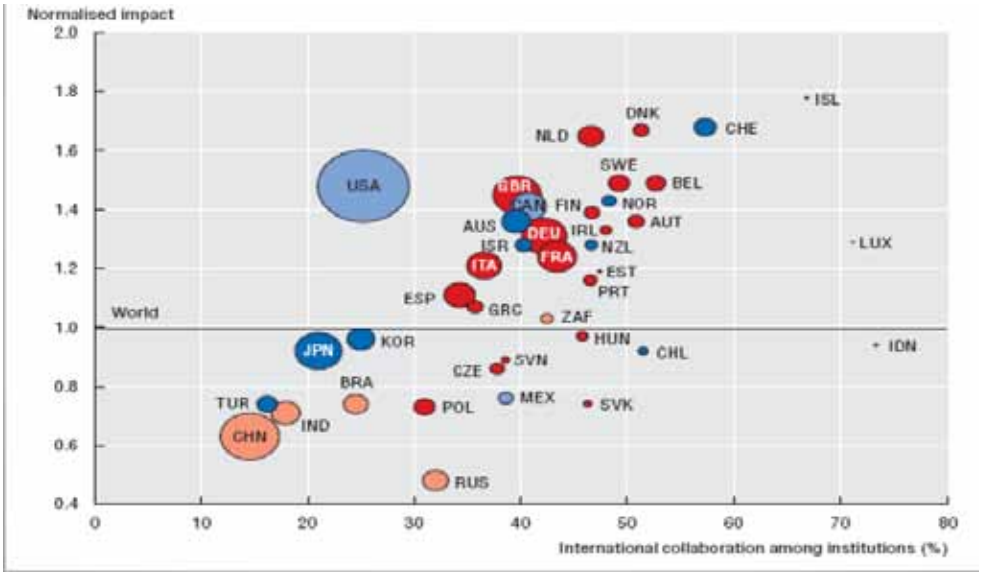

Figure 2. The effect of scientific production and the extent of international collaboration (OECD 2011)

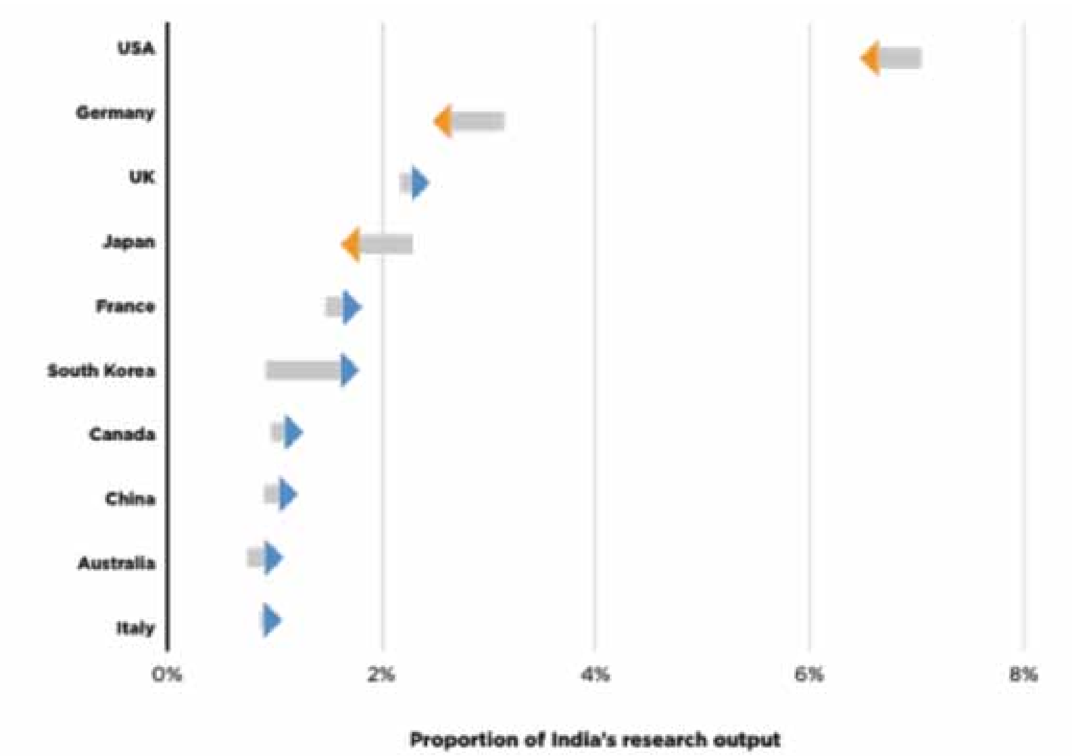

Figure 3. Research collaboration with India: relative changes between countries in the last 10 years

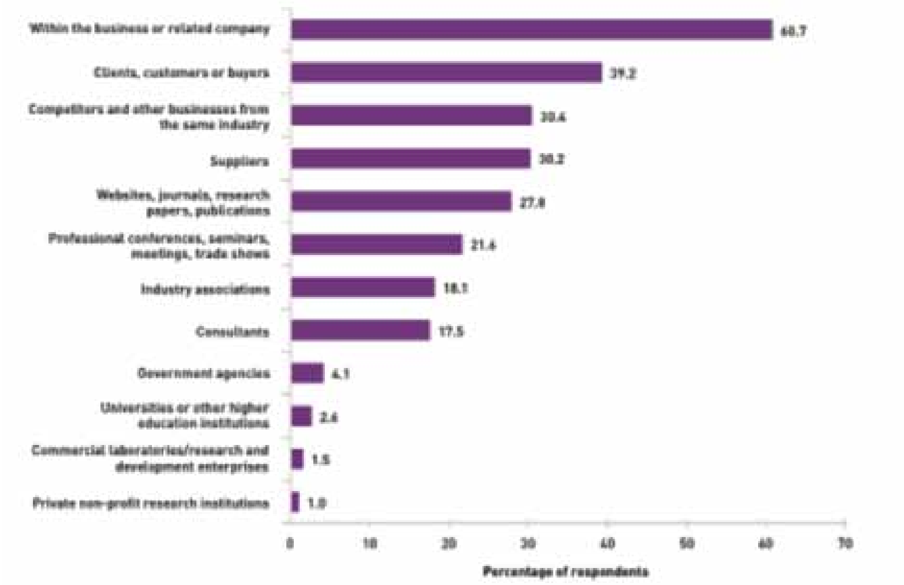

Figure 4. Sources of ideas or information for innovation-active firms in Australia 2008-2009 (Department of Innovation, Industry, Science and Research, Australian Government, 2011)

Figure 2 shows that at a country level, the more a country collaborates, the greater the scientific impact of its R&D. Again, we come to the same conclusion – 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 3**).

However, there is another side to collaboration where both India and Australia are not faring as well as they could. This is the extent to which businesses collaborate with researchers in universities and government institutions. From the Australian Government's Innovation Report (2011), we note that Australia is below the OECD average. Anecdotal comments suggest India is also trailing in this regard. The realities are that companies do not source a significant number of ideas for innovation from universities or government institutions, as noted in **Figure 4**.

When one considers the extraordinarily low interaction between innovating firms and researchers in universities and government institutions, this is clearly an area for improvement facilitated by government.

In the UK, a survey of firms that collaborate with universities (D'Este and Perkmann, 2010) revealed 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 themselves and is all the more reason to concentrate on improving the collaboration between firms and universities and government research organisations.

It is pleasing to see that both the Indian and the Australian Governments recognise the importance of the collaborative plank of the innovation system – evident in the Indian Government's strategy to 'provide the right mechanism for collaboration, training and support to drive innovation' (Office of Advisor to Prime Minister of India, 2011) and the Australian Government's launch of Industrial Transformation Research Hubs and Training Centres.

Hopefully, future performance measures for universities and institutions will focus more on collaboration as equally important as existing measures of 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 intention of driving more innovation.

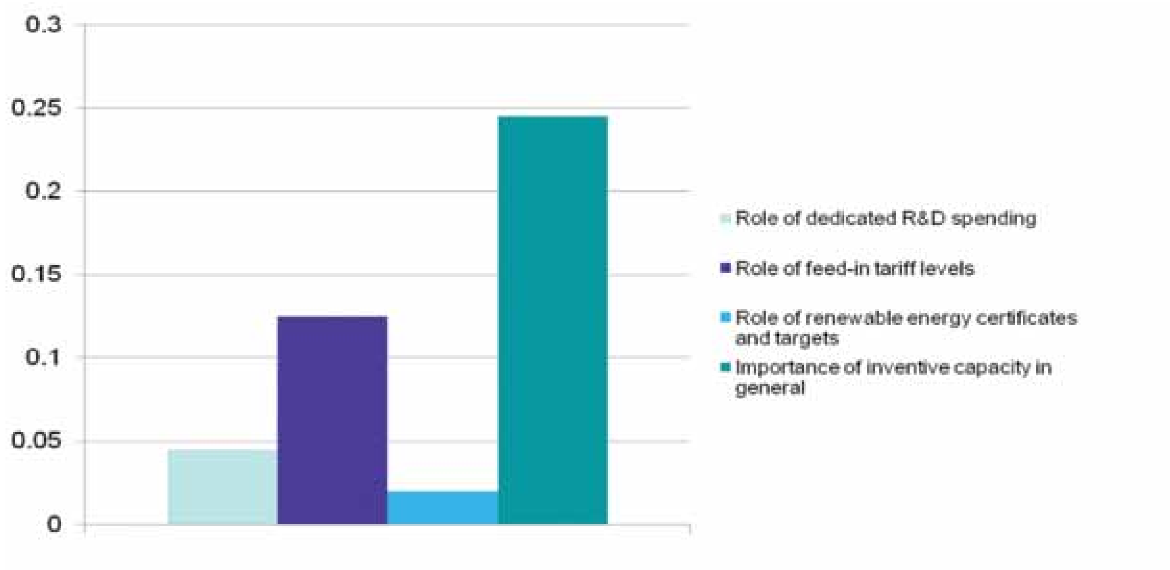

Figure 5 Effect of different factors on innovation for renewable energy (Johnstone 2010)

Frugal innovation

A recent review by Bound and Thornton (2012) gives data from over 130 interviews with Indian policymakers, entrepreneurs and academics. It suggests that India has developed a particular style of inclusive innovation that is meritorious and effective and, indeed, worth emulating in other countries.

India is producing products and services that are dramatically lower in cost, that outperform alternatives in the market and that can be made available at large scale. This is in response to the large and increasingly aspirational Indian middle class, which is very price-sensitive. It builds on a tradition of creative improvisation and fits well within a policy of getting more for less.

Frugal innovation is based on the principles of:

- Better things, not just cheaper things
- Services as well as products
- Re-modelling, not just de-featuring

Low cost always, high tech if needed.

It is a model that seems to have no disadvantages and could and should be replicated in other countries, including developed countries such as Australia. Again we arrive at the same conclusion that more international collaboration in innovation is mutually beneficial.

Innovative capacity

The OECD has undertaken a global study of the renewable energy sector (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 (for example, how much is invested in a country in an emerging area such as renewable energy. There is much controversy around the world over the appropriate drivers of the investment needed for innovation to happen in this sector).

The Johnstone analysis focuses on such drivers as the role of dedicated R&D, market mechanisms established by governments such as feed-in tariffs or mandated renewable energy targets or certificates, and, finally, the overall capacity for innovation in a country, rather than innovation associated with renewable energy.

Given the lack of agreed measures of the innovative capacity of a country, the Johnstone analysis uses the total number of patent families (similar to triadic patents) as the measure of general, national innovative capacity. The results shown in **Figure 5** are somewhat extraordinary in that they reveal that general, national innovative capacity has far more influence on outcomes than specially targeted measures. There is a lesson here that is fully consistent with the notion that to improve our innovation systems, innovative capacity should be emphasised and that we should encourage more collaboration between researchers in universities and government institutions.

Globally, innovation is recognised 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.

Developing countries have features in their innovation systems that differ from those of 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.

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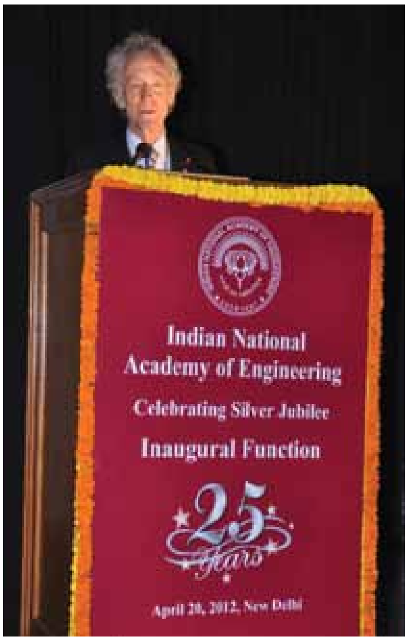
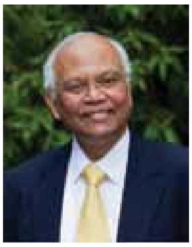


Professor Robin Batterham at the Indian National Academy of Engineering's Silver Jubilee Inaugural Function, April 2012

CHAPTER TWO

Inclusive innovation

Value for money means value for many



By R.A. Mashelkar[2]

Innovation today is widely recognised as a major source of competitiveness and economic growth for all countries – advanced and emerging economies alike. Its significant role in creating jobs, generating incomes and improving living standards is now well-understood.

However, instead of viewing innovation strictly in terms of competitiveness and as a strategy to support high value-added employment, it should also be conceived as a means of promoting inclusive growth. Inclusive growth embraces the have-nots and brings them into the mainstream of the economic system as customers, employees, distributors and intermediaries.

Inclusive growth will lead to resource-poor people gaining access to necessities of life at affordable prices. Inclusive growth can be accelerated through inclusive innovation.

Inclusive innovation is any innovation that leads to affordable access to quality goods and services while creating livelihood opportunities for the excluded population – mainly those at the base of the economic and opportunity pyramid – that is sustainable over the long term.

There are five key characteristics of inclusive innovation:The first characteristic is affordable access. Affordability depends upon where exactly 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 goods and services cannot be just low-cost. They must be ultra-low-cost.

Such inclusive innovation will have to be aimed at an extreme reduction in both the costs of production and distribution. For example, to how many of the questions below can we answer *yes*?

- Can we make a hepatitis-B vaccine costing $US20 per dose available at one-fortieth of the price?
- Can we make a comfortable, safe and fuel-efficient car available not at $US20,000 but at one-tenth of the price?
- Can we make an artificial foot costing $US10,000 available for $US33?
- Can we make high-quality cataract eye surgery available for $US30, not $US3,000?
- Can we make a prostate treatment drug costing $US10,000 available at one-sixtieth of the price?
- Can we make a computer tablet available at $US40 compared to $US400?

Incredible as it may sound, all these extreme-reduction targets have been met.

The second characteristic of inclusive innovation is that it must be sustainable. This means that in the long term, affordable access must not depend on government subsidies or generous government procurement support systems but must find a legitimate place in the same free market in which businesses compete.

The third characteristic is the provision of quality goods and services and livelihood opportunities – quality, because we have to recognise the basic rights of the people at the base of the economic pyramid to enjoy more or less the same level of quality of basic services as people at the top of the pyramid.

The objective of truly inclusive innovation, therefore, would not be just to produce low-performance, cheap knock-off versions of more expensive technologies so that they can be marketed to poor people. That is getting less for less. Inclusive innovation helps people get more from less. This requires truly sophisticated scientific or technological innovation or truly creative non-technological

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innovation to invent, design, produce and distribute goods and services in a price-performance envelope that creates goods and services that are affordable for the majority of the people.

The coexistence of low price and high quality may seem contradictory. But there are a number of examples of this being achieved. For instance, the Aravind Eye Care System in India does cataract surgery at one tenth to one hundredth of the cost of the same treatment in the Western world with a quality of service equal to or better than those available at hospitals in the UK. Heart surgery can be done at 5 per cent of the prevailing cost in the US, with quality comparable to that of New York hospitals, thanks to innovation in work flow initiated by Devi Shetty and his team.

The emphasis on livelihood opportunities refers to the attainment of social and economic well being. Inclusive innovation should force us to measure the opportunity generated by the innovation. That is, what people actually get to enjoy – as opposed to just an increase in their means. Does the innovation generate local opportunities for good jobs rather than just access to cheaper goods? In important ways, this rationale invokes a return to the traditional case for innovation – its ability to produce breakthrough improvements in the quality of life – alongside the usual objective of competitiveness.

The fourth characteristic is an innovation's potential to reach the excluded population, primarily at the base of the pyramid. The excluded population could include the poor, the disabled, migrants, women, the elderly, certain ethnic groups, and so on. For true inclusion, it is obvious that 2.6 billion people with income levels less than $US2 per day should be the primary beneficiary of inclusive innovation.

So far in this working definition of inclusive innovation, we have looked at the demand side. On the supply side, the providers of such innovation could range from individuals to institutions to enterprises, motivated by simultaneously achieving public and private good.

The providers of inclusive innovation could be individual grassroots innovators. This means innovation by the people for the people. Inclusive innovation can arise through organised research done through the formal science, technology and innovation ecosystem of a country, in which the dominant players are the national laboratories, universities, etc. Inclusive innovation can, equally, be triggered and fostered by enterprises with strategies to tap the next billion-consumer market which is emerging as the economies of developing nations grow.

Such economic growth gives rise to hundreds of millions of new customers with aspirations, who seek low-cost but high-quality products. Enterprises in the developing world that have excelled in inclusive innovation over the years have catered to customers with a limited capacity to pay, but who are nonetheless seeking quality products and services. The fifth characteristic is significant outreach. If true inclusion is to be achieved then the benefits of inclusive innovation should reach a large scale – a significant portion, rather than just a small section, of the population. (In many cases the total target population may only be a few hundred thousand or a few million – and not necessarily hundreds of millions – for example, psoriasis patients or premature babies.)

The Role of National Governments

National governments can act as facilitators in promoting inclusive innovation. They can act as a catalyst by financing or facilitating the financing of research and technology development, using their role as market participant in the provision of public goods, forging partnerships across sectors and across the world, and promoting industry.

Different countries are at differing stages in their support for inclusive innovation. Their approaches range from ad hoc efforts by individual ministries and agencies to focused and synchronised national programs.

Ad hoc policies attempt to solve discrete national problems. For example, the Ministry of Health in Uganda mandated government health-care centres to use the K1 auto-disposable syringe, which limits the retransmission of blood-borne disease by being non-reusable. The mandate complements Uganda's efforts in HIV prevention.

More comprehensive approaches vary in their maturity and scope. In 2005, South Africa's Department of Science and Technology instituted the Science and Technology for Social Impacts program to advance poverty reduction under the 2002 National Research and Development Strategy. The strategy called for greater access to 'innovations that accelerate development and provide new and more effective solutions than those utilised previously'.

In Vietnam, the Deputy Prime Minister, the Minister of Science and Technology, leaders from major universities and the private sector are committed to integrating inclusive innovation into the country's science, technology and innovation (STI) reform agenda and to directing World Bank assistance to strengthening Vietnam's capacity to pursue inclusive innovation by launching a Vietnam Inclusive Innovation Project (VIIP).

At the other end of the spectrum is India's national inclusive innovation program - a multipronged and coordinated effort aimed at comprehensively fostering inclusive innovation. Given its robust technological base, vibrant private sector, the enormous size of the Bottom of Pyramid (BoP) groups within the population - and daunting challenges of inequality - India has taken concrete steps to formalise and institutionalise the mission of inclusive innovation.

The program builds on efforts to strengthen India's overall innovation ecosystem: the Indian Government set up a National Innovation Council (NInC) with the objectives of creating an innovative India and facilitating the establishment of state innovation councils in each state.

The NInC is adding inclusive innovation to frontier innovation to connect the national innovation ecosystem to serve the BoP needs. In November 2011, the NInC launched the India Inclusive Innovation Fund, which will eventually grow to $US1 billion. The fund, being managed as a public-private partnership, seeks to promote enterprises engaged in developing inclusive solutions and will combine commercial and social returns.

To maximise its impact, this fund will seek potential investors from four sources: public and private sectors in India and abroad. The fund will solicit interested enterprises through open broadcasts: the outreach publicity surrounding its launch and initial operations is expected to attract a high level of demand from innovative enterprises. It will tap angel and venture capital networks with established investments in early and mid-stage SMEs, using institutionalised social-venture interest communities to provide an important source of potential investees. Given the developmental focus of the fund, community organisations (such as non-profits and NGOs) are expected to prove a rich source of entrepreneurs and enterprises, given appropriate mentoring and incubation support.

To support grassroots innovators, whose needs-driven creativity and indigenous knowledge can spur the development of inclusive products while simultaneously creating income-generating opportunities, India's Department of Science and Technology established the National Innovation Foundation-India (NIF) a decade ago. Its main goal is to provide institutional support in scouting, spawning, sustaining and scaling-up grassroots and green innovations and assisting them in transitioning to self-supporting activities. In 2010, the NIF became a grant-in-aid organisation of the Department of Science and Technology, Government of India. NIF has also partnered with other non-government organisations, research councils, industry associations as well as micro-finance organisations, thereby harnessing the infrastructural, financial and intellectual resources of these organisations.

The core functions of the National Innovation Foundation include:

- To screen, document and verify the claims about innovations through various networks of scientific and other institutional initiatives
- To formalise research into traditional knowledge
- To share the innovations permitted by the knowledge providers to be put in the public domain
- To help in prior art search so that innovators can maintain their competitive edge
- To provide assistance to grassroots innovators to enter into licensing arrangements with entrepreneurs for transferring technologies.

Role of Research and Technology Institutes

Research and technology institutes – both in developing countries and developed countries – have served as wellsprings of pro-BoP innovation. There is an increasing awareness and recognition of the role of STI in poverty alleviation in developing countries.

The Millennium Development Goals (MDGs) have added a compelling, output-driven framework for policies leveraging STI for poverty eradication and human empowerment. Public research councils and laboratories in some developing countries have focused on both exploring the frontiers of knowledge as well as serving the needs of the BoP.

In developed countries, leading universities and research centres have established dedicated laboratories and departments focused explicitly on inclusive innovation. D-Lab, for instance, is a program at the Massachusetts Institute of Technology (MIT) in the US which is seeking to improve the quality of life of low-income households world-wide through the creation and implementation of low-cost technologies. D-Lab's portfolio of technologies also serves as an educational vehicle enabling students to gain an optimistic and practical understanding of their potential roles in alleviating poverty. D-Lab's output to date has been very promising, and includes a stove run on rurally-ubiquitous pine needles and a portable, pedal-powered washing machine. MIT has also sponsored an innovation competition, allocating grant money to projects aimed at serving BoP needs.

Role of Private Sector Firms

For the private sector, inclusive innovation is emerging as perhaps the biggest business opportunity of the coming decade. New models are evolving in which the private sector is not only doing well and doing good, but doing well by doing good. This is in stark contrast to the old world view in which catering to the needs of the BoP was seen through the prism of philanthropy. That BoP markets remain under-developed and under-satisfied is increasingly seen as evidence of their lucrative potential – not as a reason to ignore them in favour of higher-priced market segments. This means the perception that inclusive innovation is part of corporate social responsibility is changing.

Indeed, most of the growth in consumer spending is expected to come from people in emerging markets, who have a much lower spending capacity than traditional middle-class consumers in developed countries. This is leading firms to first pursue inclusive products and to then move higher up the price curve to serve the emerging middle class – and even consumers in advanced economies, rather than working the other way around.

By 2030, the size of the emerging middle class – those earning $US4 to $US20 a day – will triple to around 49 per cent of India's population, or 725 million people, and may for the first time exceed the number of people earning less than $US4 a day. This explosion of consumer demand – spread across a range of low- and middle-income segments – will allow businesses to experiment with different scaling strategies. Indeed, inclusive innovation by firms in STI-proficient developing countries which are also able to satisfy the performance requirements of more mature consumer markets may pose a threat to established suppliers in developed countries – a reality not lost on multinationals loath to be shut out of any market.

If inclusive business innovation models are to thrive and, in turn, drive accelerated inclusive growth, what kind of leadership qualities will be required?

- Inclusive innovation CEOs must develop a deep commitment to inclusive growth, which will force them to think of un-served customers, whether the rural poor without access to telephones, for example, or the urban poor, without access to services such as emergency medical services. Companies often start by asking: 'Given our cost structure, which segments can we serve?' Instead, they should ask: 'Given that we need to cater to the unserved, what should our cost structure be?'
- Inclusive innovation CEOs must have clear vision with a human dimension. They must, for example, recognise the benefits of helping poor Indians travel safely and affordably with their families, using connectivity to improve people's work and lives and enabling patients to buy cheap medicines.
- Inclusive innovation CEOs must establish ambitious goals and clear time frames for achieving them. Companies should ask: 'What is our on-the-moon project?' Or, as they do in India's boardrooms: 'What is our Nano project?'
- Inclusive innovation leaders must force project teams to work within self-imposed boundaries that stem from a deep understanding of consumers. That will result in a novel, outside-in view of innovation. The language inside their organisations should characterise consumers as people, suppliers as partners, and employees as innovators. Inclusive innovation CEOs must continuously ask: 'What if we change the way we operate to reduce costs and focus on return on capital employed, not just on operating margins? If we reduce prices enough and make our products available to the poor, won't there be explosive growth as they quickly find uses for and buy our offerings?'

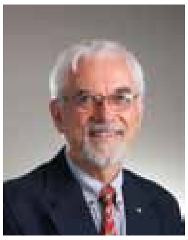
It is clear that inclusive innovation, anchored on the solid foundation of affordability and sustainability will help us design a sustainable future for mankind.

Finally, doing well while doing good will be a mantra the corporate world can benefit from as it will not only be able to provide value for money but value for many.

CHAPTER THREE

The Australia India Strategic Research Fund

Seven years of successful bilateral cooperation




By John Webb[3] and Anne Houston

In June 2006, the Working Group on Asia, chaired by Mr Hutch Ranck, provided a report to the Australian Prime Minister's Science, Engineering and Innovation Council (PMSEIC) titled *Strengthening Australia's position in the new world order*.

Recognising the implications for Australia of the growth of China and India, the council had asked the working group to examine the growth of these two emerging countries as global economic and technological players and provide advice to the Government on what this means for Australia.

Specifically the brief was to identify complementarities between Australia's research and innovation capability and that of China and India; threats that the growth of these two countries might pose to our quality of life; and opportunities presented by the new global order. The working group was also asked to recommend strategies for capitalising on opportunities to significantly and sustainably benefit Australia's own global position.

The report identified four priority areas for cooperation – energy, water, agriculture and health – together with, as emerging areas of interest, biotechnology, medical devices, engineering design and animal health.

Three recommendations were provided to enable Australia to benefit from opportunities for cooperation with both India and China.

- Australia needs to capture the opportunities created by the emergence of China and India by encouraging business engagement in our four priority areas, stimulating business investment in R&D, and simplifying private company access to publicly funded intellectual property.
- Australia needs to enhance linkages with China and India by developing a whole-of-government strategy for engagement and by investing in collaborative knowledge infrastructure.
- Australia should strengthen the foundations of its education system by increasing investment in higher education, attracting higher-quality Australian students into science and engineering, strengthening science and maths teaching and curricula in schools, and attracting higher-quality doctoral students from China and India.

The second recommendation had particular implications for science and technology research collaboration. It recognised the important role of governments in getting this engagement under way. Page 21 of the report noted:

> Governments have an important role to play in encouraging S&T and business links with China and India. In the absence of government encouragement, investment in collaboration with these two countries is clearly much less than is desirable, given the future size, purchasing power and political importance of these two economies. Both China and India place considerable importance on government-to-government agreements and investment in collaboration, such as through joint research, exchange of personnel and symposia in areas of emerging interest.
>
> We need to urgently upgrade Australia's science and innovation capacity through our interactions and collaborations with India and China as their

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Ms Anne Houston joined the Australian Academy of Technological Sciences and Engineering in 2009, and administers a number of international missions, workshops, delegations, exchange programs and reports, focusing on priority countries. These activities link emerging and senior Australian researchers to international research frameworks that focus on national priorities and contribute to policy debate. Anne graduated from The University of Exeter in History and International Relations.

> capabilities expand rapidly over the next decade. The creation of new, dedicated bilateral funds to support this activity is essential in order to focus attention on, and to achieve, such collaborations.
>
> Multidisciplinary centres of excellence, innovation precincts or joint institutes, which draw on Australian expertise supported by bilateral government funding, would showcase our capabilities and provide us with new R&D opportunities. Such collaborations would build Australia's profile in-country and have flow-on benefits into other disciplines for collaboration between Australian, Chinese and Indian researchers.

These issues being considered by Australian science policy makers were also attracting attention globally. Thus, the UK think tank *Demos* undertook a broader review, including China, India and Korea in a project; *The Atlas of Ideas: How Asian innovation can benefit us all* (Leadbeater and Wilsdon; Wilsdon and Keely; Bound; Webb, 2007). The project, funded by the UK Government and a consortium of public and private sector partners, sought to map what it saw as the new geography of science. The *Atlas* identified China as the 'next science superpower' and India as 'the uneven innovator'.

The strategic intent of the report was to provide 'the first comprehensive account of the rising tide of Asian innovation. It pinpoints where Asian innovation is coming from and explains where it's headed. And it sets out a roadmap for how the UK can prosper in a world of global innovation networks by taking the capacity for collaboration to new levels.'

Clearly, much of this research was closely related to the work of the PMSEIC Working Group. The *Demos* report makes these observations of innovation in India:

> Indian science confounds easy clichés. Many Indias co-exist, all moving at different speeds. World-class science exists alongside grinding poverty. But India's uneven innovation brings significant strengths as well as weaknesses. Flows of people, ideas and culture, both within India and across its global diaspora, are generating new businesses, new opportunities and a growing sense of national confidence. Understanding the future of science and innovation in India is not simply a matter of benchmarking its success against that of Europe or the US. Instead, it depends on recognising how India can pioneer an interdependent model of knowledge creation, drawing on its distinctive culture and historical resources. The UK risks squandering a historic opportunity to be part of this future: India's emerging strengths as a global centre of innovation require a new approach to collaboration.

Fund establishment

The establishment of the Australia-India Strategic Research Fund (AISRF) during the visit to India by the then Prime Minister, John Howard, in early 2006 came in this context of growing awareness within the Australian political and international relations community of the importance of engaging constructively and substantially with India in non-trade and investment ways.

Australia was increasingly being characterised in India as a trading partner, but one uninterested in collaboration. The trade balance was strongly in Australia's favour with sales of commodities and minerals, as well as services, dominating.

Services meant mainly education services, with growing numbers of Indian students coming to Australia for higher education and vocational education. An oft-used metaphor was to describe Australian education providers as having a mercantile approach, pushing the proverbial supermarket trolley to collect/recruit students for study in Australia, collecting tuition fees but leaving nothing in India as a result of this exchange.

Mr Howard's visit to India came some months after his visit to Pakistan, reciprocating the visit of Pakistan's President Pervez Musharraf to Australia in mid-2005. The resulting people-to-people initiative was a significant set of 500 scholarships for Pakistani students to study in Australia. The scholarships sent a clear signal that education was a key component of the bilateral relationship. Such scholarships were funded from the AusAID budget as a development assistance initiative. However such an initiative was considered inappropriate for Pakistan's neighbour, India, where AusAID's bilateral program of assistance was being wound down as the Indian economy grew. India had indicated its future intention to engage with only major donor countries, which did not include Australia.

The PMSEIC Working Group on Asia's report provided a persuasive justification for a new initiative in science cooperation that could be seen as a genuine, non-mercantile commitment to bilateral cooperation with India. When bilateral discussions and the internal processes of each government were finalised, agreement was reached to commit significant funds to a new collaborative research fund which became known as the Australia-India Strategic Research Fund (AISRF).

Australia committed $20 million over five years to the program, with India committing matching funds. The approach was not to create a joint fund, rather for each side to administer its own funds, awarding grants to joint research teams. Thus Australian funds were awarded to the Australian research team and Indian funds to the Indian side of the research team. The same application was submitted to each country's agency and considered by assessors in each country, with the final rankings of grants for funding being agreed on by a joint Australian–Indian committee. Because of the different purchasing power of currencies in the two countries, the monetary amount awarded to the Indian research team was usually less, sometimes significantly less, than that awarded to the Australian side.

Joint Indo-Australian research projects won the majority of grants in the initial years. The process constituted a bottom-up approach, with researchers creating joint proposals for assessment. However, part of the funding was reserved for what could be termed top-down initiatives that were more strategic in nature under the Targeted Allocations Fund. These were of much greater value than the others, which were limited on the Australian side to $300,000 over three years, or $400,000 if end users were involved in the project. Small grants for hosting bilateral workshops in priority areas were also available.

The fund's duration was extended and additional funds provided during Prime Minister Kevin Rudd's visit to India in November 2009. This increase in funding maintained the AISRF as Australia's largest fund dedicated to bilateral cooperation in science, while it remained one of India's largest sources of support for international cooperation in science.

The two prime ministers reaffirmed their commitment to this science and technology research partnership in a joint statement: 'India and Australia are building a broad knowledge partnership, ranging from developing collaborative projects in education, from primary school up to university, to conducting joint research in many fields. Science and technology cooperation is a critical part of this partnership.'

The AISRF was established through agreements signed by the Australian Department of Education Science and Training (DEST) and two Indian Government departments, the Department of Science and Technology (DST) and the Department of Biotechnology (DBT). The overall fund then had two components: the Indo-Australian Science and Technology Fund and the Indo-Australian Biotechnology Fund.

Applications were made to one of these funds for consideration. Priority areas for funding were agreed bilaterally:

- Science and technology – agricultural research; astronomy and astrophysics; earth systems science; environmental sciences; marine sciences; micro-electronic devices and materials; nanotechnology; renewable energy and information technology
- Biotechnology – bioenergy and biofuels; biomedical devices and implants; bioremediation; nutraceuticals and functional foods; stem cells; transgenic crops; vaccines and medical diagnostics.

These priority areas encompassed those identified by the PMSEIC Working Group, with the exception of engineering design and animal health.

To date there have been six rounds of projects funded, encompassing 84 projects and 20 workshops. This is a very significant scale for bilateral cooperation, bringing together around 1500 researchers on each side of the collaboration. A final round of grants was due to be determined in early 2013. The fund has attracted much interest from the research community in Australia and India, although the resulting large number of applications has meant that the success rate of approximately 10 per cent is disappointingly low.

Later in the life of the fund, following the increase in funding with Prime Minister Rudd's visit to India, a new component of the fund was initiated – the Grand Challenges Fund. This was designed to provide substantially greater funding for joint collaborative projects that could be seen to provide research-based solutions to the problems of 'the common man'.

Funds of three million dollars over three years on the Australian side were available with the second round being opened for applications in 2013.

Most recently, the fund has included a fellowships program, administered outside government bureaucracy – in Australia, by the Australian Academy of Science (AAS) and in India by the Indian National Science Academy (INSA). Thus, over the first six years of the fund, the range of activities supported has grown and diversified to include joint projects, bilateral workshops, strategic initiatives, grand challenges and fellowships.

Results of these activities are available on the Australian Government web site for the AISRF:

http://www.innovation.gov.au/Science/InternationalCollaboration/aisrf/Pages/default.aspx

Projects and Workshops

The scale and scope of this component of the AISRF can be gauged from the results of the earliest round as shown on the AISRF web site.

Under the **Science and Technology Fund**, 12 projects, including five workshops, were funded to a total of nearly $2.2 million. On the Australian side, grants were distributed across the country: five to universities in Victoria (Deakin University was the only university to receive two large grants), three to CSIRO groups, two to universities in South Australia and one each to universities in the Australian Capital Territory and Western Australia.

Five groups on the Australian side were led by Australians of Indian origin, or, in Indian terminology, Persons of Indian Origin (PIOs). This was not surprising since such researchers in Australia with established connections to India were ready to form the research collaboration teams in the time available to prepare the application. From the Indian side, grants were distributed quite widely across the country: The seven large grants were awarded to institutions (universities, Indian Institutes of Technology, research institutes) across the country – two in the National Capital Region (University of Delhi), two in Tamil Nadu with one each in Orissa, West Bengal and Punjab. The size of the grants ranged generally from $282,000 to $380,000 (although one was for $107,000). Grants for workshops were naturally much less, in the range of $10,000-$20,000.

The grants made under the **Biotechnology Fund** show some differences from the Science and Technology Fund results. Grants had a wider range and much higher upper amounts, from $192,000 to $536,000. A total of more than $2.3 million was allocated to six projects and two workshops. Queensland was successful in winning funding for two projects, New South Wales one and Victoria-based researchers were most successful, with two projects and one workshop being funded.

Indian grantees were based in five states, with Karnataka being the most successful with three grants. Other grants went to institutions in Andra Pradesh (one), West Bengal (two), NCR (one) and, one of the more remote states, Assam (one).

Biotechnology remains a high priority for Indian Government investment and has emerged as a sector for other initiatives such as the Indo-Queensland Biotechnology Projects Fund for agricultural and medical biotechnological projects. The Indo-Australian Biotechnology Conferences series is also worthy of note.

Led by Queensland researchers, and held in turn in each country, the seventh such conference was held in 2010.

The geographic distribution of AISRF funding gives some indication of the centres of innovation in both countries. Although most awards appear to have been made in recognised centres of research and knowledge creation, less well-known institutions were also successful. Within India, the southern states were very prominent, as was the NCR region around New Delhi where many national institutions are located. Of some interest is the success of applications from CSIRO and CSIR laboratories, though not necessarily collaborating with each other but with non-CSIR or non-CSIRO research groups.

Data to date indicates that, within Australia, CSIRO laboratories have received the largest number of grants (12 out of 84) with three universities located in Victoria being among the most successful universities – Monash (nine), Melbourne (eight), Deakin (seven) – and two universities in Sydney completing the top six successful institutions, the University of NSW (nine) and Sydney University (six). On the Indian side, recognised centres of excellence dominate the awards with the Indian Institute of Science, Bangalore, receiving 12 grants, significantly ahead of the next most successful which is IIT Bombay with five, then the National Centre for Radioastrophysics, IIT Madras, LV Prasad Eye Institute and the International Centre for Genetic Engineering and Biotechnology (ICGEB) – all of which have been awarded three grants.

Targeted Allocations Fund

The first round, when funding began in 2007, also saw the first grants under this top-down component of the AISRF. The largest amount was assigned to a strategic partnership between the CSIRO and the CSIR with a $3.5 million allocation. A second grant of $1.5 million was made to support the establishment and operation of a joint research academy between Monash University and IIT Bombay (see http://www.iitbmonash.org/).

This second initiative has created much interest internationally in that the collaboration involves postgraduate research students spending significant periods of time working in both countries and receiving degrees that are awarded/badged by both institutions.

The Monash-IITB Research Academy's board of directors has equal representation, at senior level, from both IITB and Monash, assisted by an impressive Research Advisory Council whose chair is the well-known N.R. Narayana Murthy, founder and chief mentor of Infosys. The advisory council also includes Dr Ramesh Mashelkar, Dr Megan Clark, CEO of Australia's CSIRO, as well as executives from Tata Power, Orica Mining Services, Piramal Healthcare, the Government of India's DST and Professor Gustav Nossal.

This council and its associated industry partners can forge the link from research to innovation that the academy seeks to engage in 'theme-based and use-inspired strategic research' for 'societal research goals in partnership with government and industry'. A $10 million facility on the Powaii campus of IIT-Bombay will support the research of up to 350 PhD students by 2015. In late 2012, 43 students from India were enrolled. The inaugural CEO, Professor Mohan Krishnamoorthy, has previously held academic and professional positions at Monash University and CSIRO. Although it is still early days for the academy, established in 2008, these achievements are already considerable.

The close and extensive links forged with strong corporations in key sectors are particularly interesting in the context of innovation. Some of these corporations are also represented on the academy's advisory council; others include Reliance, BHP Billiton, the Jindal JSW Foundation with Tata Consulting Services (TCS) listed as a supporter. The early investment from the AISRF of $1.5 million from the Targeted Allocations Fund would seem already to have yielded a considerable dividend in university-industry-government collaboration, university-university collaboration for IITB and Monash as well as the recruitment of a large number of talented young researchers as PhD students.

Industry partnerships can be expected to provide a fruitful environment for innovations that have the potential for market success. Areas of research focus at the academy include some that are high on the priority list for both India and Australia – nanotechnology, biotechnology and stem-cell research, water, clean energy, infrastructure engineering, advanced computational engineering simulation and manufacturing.

CSIRO has joined the academy as a foundation partner and has committed to sponsor up to 30 PhD research projects over five years. This involves hosting the student in a CSIRO laboratory, most commonly in Melbourne, where Monash University is located. This then becomes a three-way collaboration between CSIRO, Monash University and IIT Bombay, increasing the range of facilities and staff available to the student and raising the level of complexity by creating a project that meets the priorities of all three partner institutions.

Further grants under the Targeted Allocations Fund were made in years two and four of the AISRF, including the funding of four workshops on priority topics – solar energy, nanotechnology, biomedical devices and implants, and the remote sensing of marine ecosystems. Two grants in year two concerned nanocomposites for electronics and a third award, $2.25 million on IT security, focused on protecting critical infrastructure from denial-of-service attacks. This project, involving researchers in Queensland and Tamil Nadu, has produced a major monograph published internationally.

Overall, Targeted Allocations Fund grants have totalled $8.295 million, including three grants of more than $1 million – the CSIRO-CSIR partnership, the Monash-IITB Research Academy and the Queensland University of Technology-IIT Madras project on IT security.

Grand Challenge Fund

This program emerged as the AISRF became established, as an initiative that committed significant funding to projects addressing critical issues. The aim was to make a significant contribution to the welfare of 'the common man'. The upper limit for funding was $3 million over three years, exceeding the magnitude of the project grants. The first-round themes – food and water security, and the environment – produced three grants, all associated with food security:

- A project to protect grain harvest from insect threats by University of Queensland and Tamil Nadu Agricultural University
- A project to develop crop plants that remove their own major biotic constraints by Melbourne University and ICGEB (mentioned above)
- a project to develop stress-tolerant chickpeas by the Australian Centre for Plant Functional Genomics in South Australia and the International Crops Research Institute for the semi-arid Tropics (ICRISAT) near Hyderabad.

Many researchers in the first two projects had been involved in earlier projects funded by the AISRF, positioning the partners well to compete in the Grand Challenges program. ICRISAT had been a research partner in a project in round five of the AISRF though with a research partner in Western Australia focussed on securing chickpea productivity under abiotic pressures of heat, drought and salinity.

Applications for the second round will address the themes of energy and health.

Fellowship Fund

A pilot program has been launched to support fellowships between Australia and India, with $1 million for the first year. The program has two components – one to support early career researchers for a research visit of several months and one for senior researchers whose visits are of about two weeks' duration. The first round provided 49 awards to Australians, with 33 to senior researchers. The intent behind the fellowships is laudable – providing people-to-people mobility for researchers both at the summit of their careers and at the early stage when forming their professional networks and collaborations. From the Indian side, administered by INSA, fewer short-term senior awards were made (11) while 21 early-career visiting fellowships have been announced. More than half were for 12 months, with the shortest being for 3.5 months. The AAS has not posted the duration of the Australian early-career awards.

The geographic distribution of the awardees and their host institutions provides parallels with the AISRF research grants.

The Indian institutions involved include the IITs, IISc Bangalore, IICT Pune, ICGEB in New Delhi, ICRISAT, but also the private hospital and university Manipal, based in Mangalore, Karnataka, with a growing international reputation in teaching and research. Indian fellows came from across the country with the largest number (six) from institutions in Tamil Nadu. One each came from Assam and Jammu with three from Odhisha (Orissa).

Australian awardees also came from across the country with the largest number from institutions in Victoria. Five of the senior awardees were fellows of the AAS.

The AISRF Fund has developed into a solid platform for supporting a range of collaborative programs in science and technology research. Successful researchers funded by the AISRF in both countries have the potential to form networks to take their collaboration to higher levels. The Government has initiated a review to assess the impact of the grants awarded in terms of outcomes. This will provide further quantitative information of much interest.

The challenge remains to build on the achievements of the fund's activities to deliver innovations from the extensive research programs. In particular, an emphasis on research-based innovation would seem to provide the next promising dimension of this bilateral research partnership.

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CHAPTER FOUR

Innovation and globalisation

By V V Krishna[4]

The impact of globalisation, understood in terms of Thomas Friedman's *The World is Flat* (2005) or in terms of the increasing interdependence of nation states, is not confined to the social, economic and political spheres.

Globalisation has penetrated into the very institution of science and technology, changing the way knowledge is produced, owned, developed and marketed.

The locus and structure of R&D, which is at the very core of this knowledge matrix (known as the innovation process) has been transformed by globalisation. R&D and innovation have not only become buzz words in our everyday lives but have come to play a significant part in science, technology and innovation policies.

Whether we are seeking to exploit new science-based technologies (such as nanotechnology, biomedical, electronic and material sciences) to meet the challenges of SMEs, poor and vulnerable people, climate change and sustainable development, or even the demands of the entertainment and leisure industries, R&D and innovation have come to play very significant roles.

While incremental innovation refers to small social and technical changes which do not necessarily involve R&D, radical innovations are greatly dependent on the R&D pursued in universities, publicly funded research laboratories and business enterprises including transnational corporations (TNCs).

This article focuses on understanding innovation and globalisation – the way in which globalisation has transformed the process of R&D and innovation over the past few decades; the different phases underlying this transition; and how these developments have given rise to a new geography of innovation encompassing Asia.

Historically speaking, TNCs and the government-sponsored strategic research in these firms in North America, Western Europe and Japan (the triad) have been the dominant source of R&D and innovations. Much of the world's technological innovation and the development of various consumer products emanated from these global corporate giants. The whole process of scientific research, R&D and innovation was a closely guarded, hierarchical and profitable enterprise, mainly confined to the corporate headquarters of TNCs.

Three trends

Three trends have emerged as a consequence of globalisation over the past decade and a half, redefining the relationship between innovation and globalisation.

First, until the mid-1980s, much R&D and innovation was sourced from the respective home country base of TNCs. The R&D units and laboratories of these firms which did move out of their home base were in large measure restricted to the triad region. Beyond the triad region in the developing world, support laboratories were established which used their comparative advantage to repackage R&D coming out of the home base at a lower cost. The innovation capacity of the developing country, its market and its processes of adaptation of technology, among other factors, characterised these types of support laboratories.These support laboratories were mainly involved in technology transfer linked to the local adaptation of designs – a flow that can be characterised as a one-way internationalisation of R&D.

From the late 1980s to the 1990s a significant new trend emerged in which TNCs went beyond support laboratories and technology transfer to performing R&D abroad, outside the triad region. TNCs established so-called *locally integrated laboratories* (Pearce and Singh 1992; Pearce 2005). Laboratories of this type were involved in the production and

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consumption of R&D for local, national and global markets and were often linked to manufacturing and marketing entities.

Hence a new phase emerged, characterised by the upgrading of support laboratories into locally integrated laboratories (i.e. the globalisation of R&D) which shifted various types of regional, global and corporate technology and R&D units beyond the triad regions and into the developing world (Reddy 2005).

From the one-way pattern of R&D and technology transfer to host country locations, the pattern was transformed into two-way knowledge flows. R&D performed beyond the triad regions began to feed into the process of innovation, technological changes and the creation of new products emanating from the TNCs.

Hence R&D in the developing world, particularly in emerging Asian economies, was transformed from adaptive to creative. However, although some innovation processes were carried out by the TNCs in the developing world, this phase did not fully open up the innovation chain.

Various factors then coincided to catalyse the globalisation of R&D.

- Global competition coupled with the globalisation of consumer tastes and preferences worldwide created a need for learning.
- The science base of many new technologies required multiple sources of R&D.
- R&D and innovation from the home or triad regions of TNCs had limited capacity to respond quickly to changing market and consumer demands around the world.

The rise of information and communication technologies (ICT) and the new structure of science-based technologies fostered the decoupling of R&D and manufacturing activities of TNCs in the triad region during the decade from the mid 1980s.

The decade following the 1990s paved the way for yet another trend. The outsourcing of business and knowledge processes, R&D and technical services and other institutional and organisational operations to foreign locations began to intensify by the end of 1990s (Turpin and Krishna, 2007). This era witnessed the introduction of new economic reforms in emerging economies, which promoted liberalisation and foreign direct investment (FDI) in financial institutions, services, retail and a host of sectors including R&D. The first decade of the 21st century witnessed more than $US110 billion FDI flow into Asia every year.

Second, as we progressed into the first decade of the new millennium, the economic rise of Asia, propelled by China and India and emerging BRICS (Brazil, Russia, India, China and South Africa), fuelled new middle-class demands in the developing world. New consumerism and the globalisation of lifestyles (for instance in automobiles and electronic data processing technologies) increased the demand for R&D, technological change and innovation.

New designs and lifestyle products emanating from R&D laboratories became obsolete or classified as 'old generation' even before reaching production and consumers – such was the pace at which global R&D and innovation were moving to serve markets driven by the world's middle and wealthy classes in the 21st century.

Unable to meet market demand, the corporate model of R&D and innovation pursued within home country locations within the physical boundaries of the corporate firm quickly began to erode (*The Economist* 3 March 2007). The ICT revolution coupled with advances in electronics and telecommunications dismantled geographical barriers, creating a new potential for innovation at different levels of the value chain.

Products such as mobile phones, computers and laptops, electronic goods and automobiles came to exemplify a new pattern of knowledge production, distribution and consumption. Each product has a number of components and every component or group of components is separately developed in a specialised laboratory or R&D unit. Outside certain traditional industries such as wine making and liquor processing in France or Great Britain or Darjeeling Tea in India, it is now difficult to find a TNC or a firm which carries out all elements of R&D, innovation, packaging, distribution and marketing itself.

This fragmentation of the knowledge and production process culminated with the emergence of new knowledge hubs and knowledge-based innovation hot spots from Bangalore, Shanghai, Singapore, Hong Kong, Seoul, and Beijing to Sao Paulo, Cape Town, and other locations. A large number of TNCs such as IBM are in no position to generate all the diverse resources, capabilities and bodies of knowledge internally (Ernst 2005). For example, IBM previously did not operate its R&D operations beyond Washington and Paris. Today, it has eight laboratories throughout the world, four of which are in India and China where more than 4500 scientists and engineers work on creative technologies and innovate products for the global market.

According to a recent study, there are more than 1350 R&D units and laboratories established in India and China by TNCs (Krishna et al 2012). While earlier trends of internationalisation and globalisation of R&D continue, all these developments have given rise to what may be termed the globalisation of innovation.

This trend in innovation is exemplified by TNCs such as Apple, Motorola, IBM, Siemens, Intel, Adobe and GE. These companies and others generate a surplus from global R&D, innovation and manufacturing supply chains which is globally distributed. Further, there is a convergence of technologies and fields of research with non-science and technology factors such as finance, banking, social, culture and entertainment.

All the crucial elements enabling innovation are becoming impossible to locate in corporate home country R&D sites in North America and Western Europe. TNCs and big firms no longer have a monopoly on specialised knowledge and its potential. It is now geographically distributed around the knowledge hubs and innovation centres of the globe.

The innovation footprint has come to represent networks of dispersed actors. Various components of knowledge production and consumption chains – which are no longer hierarchical – are horizontally connected and geographically dispersed and managed and regulated by different agencies and institutions at different locations.

According to an INSEAD Survey (2006), 'optimising the configuration and integration of R&D networks' is becoming crucial for improving the speed of innovation for global TNCs. This survey covered 186 global companies in 19 countries (which spent $US76 billion in R&D in 2004) operating in 17 sectors. The survey asked companies to respond as to what was driving their selection of future R&D sites.

	China	India	Brazil	USA
Qualified workers	12	25	21	17
Technology cluster and academic institutions	13	13	14	27
Low-cost skill base	24	30	11	3
Proximity to production facilities	17	11	18	12
Others(business/markets)	34	21	36	41

Drivers of Future R&D Sites (figures in % in responses from 186 global firms)

The survey revealed that global firms would like to strengthen their 'optimally configured' R&D network over the next five years by opening up new R&D sites in China (22 per cent), India (19 per cent), USA (19 per cent) and Western Europe (13 per cent). These developments are also closely related to planned growth patterns of R&D human resources. By the end of 2007, the survey indicated that India (contributing 23 per cent) and China (contributing 16 per cent) would account for a total 39 per cent of global R&D staff, up from 19 per cent (India 14 per cent and China 5 per cent) in 2004.

Another insight from the survey is that 45 per cent of foreign R&D sites are seen to be important (by 186 global TNCs) due to core technology research and full development capabilities; and 55 per cent of R&D foreign sites are important due to specific development capabilities coupled with customisation for local markets.

The demands for speed and quantity in innovation for global competition are driving TNCs to enter into new forms of strategic partnerships and collaborations. Asian countries such as India, Singapore, South Korea and China, have come to occupy a significant new position in globally dispersed, networked innovation. This is not merely due to their low-cost skill base, which was the main attraction of Asia in the 1980s and early 1990s, but also due to knowledge hubs and innovation hot spots in places like Bangalore and Shanghai. Chesbrough (2003) termed this geographical knowledge-scouting process an open innovation system.

Third, the rise of Asia as the new growth engine of the world economy in the 21st century has begun to shape a new geography of innovation. According to science and technology indicators issued in 2012 from the National Science Foundation (NSF), between 1999 and 2009 the US share of global R&D dropped from 38 per cent to 31 per cent, while the Asia region's share grew from 24 per cent to 35 per cent.

According to other estimates from NSF, as of 2008-09 Asian countries accounted for 40 per cent of global R&D spending measured in purchasing-power parity terms at $US494.4 billion, overtaking the US which accounted for 30.1 per cent at $US365 billion, and Europe with 23.9 per cent at $US288 billion. The tilt in favour of Asia in this global R&D funding pattern is also reflected in the science output measures issued by Thomson Scientific Data. While the global share of science publications for Europe and North America declined by 7 per cent and 6 per cent respectively, from 2001 and 2006, the Asian share of science publications registered an increase of 87 per cent over the same period (Gaillard 2009).

Going beyond the quantitative data, the new geography of innovation points towards some Asian economies as emerging new sources of specialised knowledge and as innovation hot spots of learning. The concepts of frugal and reverse innovation, which overlap each other in varying forms, originated in a large measure from the experiences of India, China and other Asian countries.

Reverse innovation refers broadly to the process by which goods developed as low-cost models to meet the needs of developing nations (for example battery-operated medical instruments and inexpensive motor bikes in China or the world's most economical car, the Nano, developed by the Tata group of companies in India) are then re-engineered to suit consumers in higher income brackets across the world.

Frugal innovation refers to 'achieving more with fewer resources' for more people.

Disruptive innovation, a term coined by the Harvard scholar Clayton Christensen, describes the process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors.

Experiences in India and China illustrate that these types of innovations are not merely products and services that are scaled down for emerging economies only to be scaled-up (reverse adaptation) when introduced in the industrially advanced or developed world. They are entirely new technologies coming out of well-established R&D laboratories and reach global markets because they are more sustainable from an economical or environmental point of view.

For example, the Tata Nano, which began with the price tag of $US2000 for a basic model, has been granted 34 patents. Steel is replaced by aluminium for the engine and the firm introduced several innovations in this small car that gives a mileage of 24.5kms per litre of fuel. There are also now about 50 million battery-operated motorbikes running in Beijing and Shanghai, which are in high demand around the world. The price of hepatitis B vaccine has been brought down from $US15 per injection to less than 10 cents as a result of the R&D carried out by two pharma firms in India. A Bangalore-based company has introduced a diagnostic tool to test for tuberculosis and infectious diseases that costs $US200 compared to $US10,000 for comparable equipment in Western Europe or North America.

Stiff competition

Innovations in a globalised world now face stiff competition from knowledge hubs and innovation hot spots spread all over the world, particularly in Asia. The ability to reverse-engineer products to produce alternative or similar products is available worldwide. Biosimilars – products approved for production more cheaply following the expiry of a patent – in the biomedical and pharma sector and the introduction of the Galaxy range of tablets and mobile phones by Samsung to compete with Apple iPad or iPhone are good examples. Given the expanding Asian market (for instance, by 2020 India and China alone will be home to nearly a billion middle-class consumers) every big firm and TNC from the triad region needs to operate in Asia, just as Asian firms are operating beyond their borders.

The concept of the globalisation of innovation goes beyond a range of knowledge-based products from automobiles to electronics or consumer durables. Asian and other leading economies in the developing world are partnering with big science and high-technology programs in the EU and US, a process earlier confined within the triad region. For instance, India, China, South Korea – and other countries such as Russia – are partners in various big EU-based science and innovation programs such as the International Thermonuclear Experiment Reactor (ITER), the EU version of a global positioning system, the Galileo project, the Facility for Antiproton and Ion Research (FAIR), as well as initiatives in ICT and nanotechnology.

The headquarters of the Human Genome Organisation and its president have for the first time been located in Singapore over the past few years. Similarly, India and China are partnering with the US in various new science and innovation programs from clean energy to space and climate change.

It can be concluded, whether in the area of big science and innovation or market-driven technological innovations, the globalisation of innovation has dismantled the divide between nations.

Given the increasing interdependence between nations and firms in geographically distributed, systematic knowledge production, learning and catching up in innovation have become an interactive process.

The globalisation of innovation is leading to the co-production of knowledge and co-innovation worldwide.

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CHAPTER FIVE

Knowledge networks the key to innovation ecosystems

Innovation and inclusion

By Anil Gupta[5]

Institutional policies for supporting creative and innovative individuals in formal and informal sectors shape the vigour and richness of the innovation ecosystem in any country.

There are several indicators by which one can measure a society's hunger for innovative solutions to problems. I argued nearly 30 years ago [Gupta, 1984] that 'a change not monitored is a change not desired'. A society which does not track the way different innovations emerge, evolve, incubate and spread perhaps does not want them at all.

This article

- describes the indicators for monitoring the health and vigour of the innovation ecosystem
- identifies the processes through which such a system can be galvanised to spur more innovations and strengthen the knowledge networks among innovators and various stakeholders
- suggests some institutional innovations which may help strengthen the links between formal and informal sectors of innovation.

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Indicators of innovation ecosystem health

Senior policy makers such as ministers of science, technology and innovation or the office of the Prime Minister must monitor policy reforms (their speed, scale and scope) to spur innovation in each sector.

Naturally, different levels of government, civil society and even corporations will ask different questions about innovation in general. However, the frequency of such questions will depend on society›s patience with or tolerance for the speed of reform and the time it takes for results to appear once change has been effected in a given context. Certain problems must be monitored day by day, while for others quarterly or yearly will be enough. Different indicators reveal the health of different subsystems of an ecosystem.

Macro-indicators

- How many ideas from the grassroots were learnt, analysed, abstracted and scaled-up in different ministries?
- How many programs were stopped, modified or started on the basis of the feedback from the grassroots?

Meso-indicators

- Were appropriate institutional changes brought about to support technological innovations at different levels in the public and private sectors?
- How many student teams were mobilised in different parts of the country to benchmark energy use, material inputs, waste generation and recycling by micro, small and medium enterprises (MSME) and what steps were taken to ameliorate the conditions?

Micro-indicators

- How many grassroots innovators have received support from formal R&D, design and fabrication institutions?
- How many children and technology students received support or were linked with prototyping centres for converting their ideas into products?
- How many communities were supported for *in situ* conservation of biodiversity so as to keep local supplies of knowledge-based products intact?
- How many women innovators received support to take their ideas forward in different sectors of the economy?

These indicators are illustrative only and can be modified to suit a society's socio-cultural needs. The point to be underlined is that if these questions are not asked, then certain kinds of institutional and policy changes will not take place. The fact that the number of conferences and meetings on inclusive development has increased in the recent past proves that even in OECD countries the business-as-usual approach is being questioned.

Many developing countries are trying to pursue inclusive and/or harmonious development. But synchrony among technological, institutional and cultural factors is not being systematically pursued, even in India.

In most innovation ecosystems, the interrelationship between technology, institutions and culture is a matter of chance. If innovations have to be supported and there is no network of mentors and chroniclers, then most innovators may remain unattended and unconnected with each other.

Under such circumstances, institutional development is vital. Organisations such as the Honey Bee Network (a volunteer network spread across 75 countries which is engaged in the development of a sustainable knowledge eco-system) provide a platform for empathetic institutions to evolve.

But institutions alone are not enough if their culture does not meet local needs. A culture of service and subservience towards knowledge holders takes time to evolve. Every country has to pay attention to cultural issues or the ecosystem will not nurture innovation. In service institutions it has to be remembered that innovators are the masters.

Processes for strengthening the innovation ecosystem

The future of any society will not be safe if children do not acquire the values of compassion, collaboration and co-creation. Unless children become impatient about problems, inertia is inevitable.

The experience of IGNITE competitions organised by the Indian National Innovation Foundation (NIF) over the past few years demonstrates that children today are far less patient about social problems than previous generations – a reassuring indicator for any society. The pity is that most countries have creative children, but that creativity is rarely recognised by local institutions. It does not become the centrepiece of social consciousness.

How can children's ideas become the fundamental building blocks of a country's innovation ecosystem?

Igniting the minds of children

Most school textbooks make little reference to the creative ideas of the general public or children. Fortunately, India is thinking seriously about providing a scholarship to 1,000 children based on their imagination and creativity. In science and technology outstanding scholastic performance wins lifelong scholarships – yet similar support has not hitherto been available for being creative.

The importance of creativity can be illustrated by a personal experience. I was invited by the Ministry of Science, Technology and Innovations, Malaysia [MOSTI] to help in structuring a national innovation fund. A discussion about seeking ideas from different levels of society led to an experiment to test the idea whether children are truly creative or not. At a nearby residential school in Shah E Alam, students were asked to invent solutions to different problems, first alone and then in groups.

Some of the ideas which came out were so much ahead of their time. The innate creativity of the children could not be doubted. The question, then, is why the creativity of children is not harnessed in every school, and their ideas not recognised and rewarded.

In China, there is CHIN (China Innovation Network) at Tianjin University of Finance and Economics (TUFE) supported by the Honey Bee Network and SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions, an Indian non-governmental organisation set up to strengthen the creativity of grassroots inventors, innovators and ecopreneurs engaged in conserving biodiversity and developing eco-friendly solutions to local problems).

Students' ideas have been pooled together in a database containing more than 7,000 innovative ideas from children and ordinary people. Some children have suggested solutions to problems that everyone faces in life. Lessons based on some of these ideas will hopefully become part of the curriculum.

No single individual or institution alone possesses the magic of uncovering innovations. Anyone can do it anywhere – so long as creativity is given its due and benefits are shared with all. A kind of inverted model of innovations has emerged – where children invent, engineers fabricate, and companies commercialise.

Engaging technologically aware young people in solving social problems and augmenting grassroots innovation

The next level of creativity that needs to be harnessed is that of college students. SRISTI has organised a platform techpedia.in which has information on more than 100,000 projects pursued by 350,000 students from more than 500 colleges and institutions. Many of the ideas have the potential to change industry standards and help conserve energy, reduce drudgery and improve efficiency.

Theoretically every student is capable of being an innovator. During the past year, many of the student teams from Gujarat Technical University mapped the problems of MSMEs during summer, with the university giving credit not only for identifying a problem but also for trying to solve it. Hundreds of solutions were developed by student teams in close cooperation with their faculty and MSME entrepreneurs. (Many of the entrepreneurs gave them recognition for their contribution).

Every country has this huge untapped potential of young technology students, which unfortunately has remained unexplored for a long time. Educationists around the world must question this inertia urgently. A technology platform of this kind can address several other challenges.

- It can encourage collaborative learning among the students from different disciplines, colleges and cities.
- An idea developed in part at one place or institution can be developed further elsewhere in what we call a *kho-kho* model or relay approach to problem solving.
- The current levels of energy use, and material and waste management in different MSME units can be benchmarked and eventually improved.
- Unsolved social problems can be put on students' agendas as final-year projects.
- Grassroots innovations and outstanding traditional knowledge practices can be taken up for validation and value addition and possible entrepreneurial development.

Involving individual inventors for strengthening inclusive development

Four Inventors of India conferences organised at the Indian Institute of Management, Ahmedabad (IIMA) during 1998-2008 explored the possibility of linking the formal and informal innovation sectors. The Centre for Innovation, Incubation and Entrepreneurship [CIIE] at IIMA was set up following the first Inventors of India workshop with the help of the Gujarat government and the support of NIF.

The idea was that mass-impact and high-tech innovations would be targeted, although over time this focus has been lost and general entrepreneurial activities have been taken up to a large extent. There is a need to develop more focused incubators, aimed not only at *ex situ* but also *in situ* incubation.

Ex situ implies the innovator has to reside in the incubator, whereas *in situ* implies that mentoring support is distributed to innovators wherever they live. Most incubators have failed to find enough incubatees for *ex situ* incubation.

NIF and the Grassroots Innovation Augmentation Network (GIAN) have followed an *in situ* incubation model. Being distributed and requiring much more coordination and monitoring, it costs more in both effort and money. But in emerging economies where many professionals and others must still shoulder their family responsibilities, there is no escape from *in situ* incubation. This is why all incubators put together in India may not have more than 500 incubatees.

If an *in situ* incubation model was followed, thousands more innovators could have been included. Individual inventors can mentor grassroots innovators: a creative person from an organised sector can perhaps empathise better with another creative person from an informal sector.

One particularly disappointing finding of a survey of meaningful inventions filed by individuals in an Indian patent database was that none of the identified individual innovators had ever been approached by any angel fund (capital from an investor for a start-up business) or pre-angel fund managers (from a closer source, such as family or friends). The plight of individual inventors who wanted to commercialise their ideas in the organised sector was only slightly better than the plight of individuals in the informal sector.

Innovators from the informal sector are entitled to support from the NIF, but the scale of that support is constrained by resources. In real terms, the budget of NIF is still the same as it was in 2000.

Golden triangle for rewarding creativity: linking innovation, investment and enterprise

It is unlikely that an innovator will have sufficient investment funds as well as relevant entrepreneurial skills and orientation to commercialise their ideas. Thus, one has to reduce the *ex ante* and *ex post* transaction costs of linking innovators, entrepreneurs and investors, noting that the three actors need not be in one place but may be across the world.

Thus an entrepreneur from, say, Canada or Denmark could pick up an innovation from India and set up an enterprise in China or South Africa. The potential of this globally-distributed knowledge management can be harnessed to support innovators. To achieve it, an on-line incubation platform is needed with multimedia and multi-language capability so that the transaction costs of the different agents can be reduced.

Linking formal and informal science and technology

This linkage is needed to improve the productivity and sustainability of grassroots innovations. NIF has memorandums of understanding with the Indian Council of Medical Research (ICMR) and the Council of Scientific and Industrial Research (CSIR), and has worked with more than 180 public, private and civil-society sector R&D laboratories. Several hundred research projects have been pursued.

Every country should have dedicated laboratories – preferably in partnership with civil-society organisations and actors – to combine sophisticated scientific knowledge with entrepreneurial passion.

SRISTI set up a natural product laboratory dedicated completely to linking formal with informal science and technology. It adds value to people's knowledge, takes resultant products to markets and shares the benefits with the knowledge providers. It is the only laboratory dedicated completely to adding value to people's knowledge when there should actually be thousands around the world.

At least six steps are needed to build this linkage between formal and informal R&D.

1. Public and private sector R&D laboratories must dedicate at least 10 per cent of their resources to adding value to people's knowledge from the informal sector, and must include the research findings in their annual report.
2. Every public-sector educational and research institution should offer at least 50 postgraduate scholarships each to young scholars to work on this linkage in different sectors.
3. Decentralised R&D facilities must be created in the 50 most impoverished regions in every country to ensure *in situ* value addition and thus improvement in standards of living.
4. Every laboratory should report the number of experiments started, stopped or modified due to feedback from local communities.
5. The intellectual property rights (IPRs) of local communities and creative individuals must be protected. While scientists may become co-authors or co-inventors in any patent application, the benefits ideally must flow entirely to the innovators after any laboratory overhead costs are deducted. Where co-authorship is not possible, the genesis of the idea should be described in the text of the paper, those responsible named, and credit acknowledged and attributed appropriately. If benefits emerge from commercialisation, a reasonable share must go back to the people.
6. The relationship between the formal and informal sectors should be clearly reciprocal, so that research findings are shared with the people from time to time in their local language, and proper references given in subsequent citations. Local communities' capacity to understand and assimilate results should be increased. Local protocols developed by communities must be used to validate the process. Community members should be invited to visit the lab and explore the possibility of using the formal R&D system for pursuing their own ideas.

Linkages could be strengthened in many other ways besides, but these six points provide the minimum frame of reference.

Making formal open innovation platforms reciprocal and respectful of the informal sector

A large number of private-sector companies around the world have initiated the so-called open innovation platform to source ideas from the masses. In most cases, no acknowledgement of an idea's origin is made in any subsequent R&D or product development, nor is any attribution made in publications or patents.

Some idea providers may be paid some money, but it is extremely rare for them to be given access to internally generated knowledge and/or institutional facilities to pursue their own ideas. The corporate sector is willing to absorb and receive but rarely to share, collaborate or reciprocate. Openness, therefore, is limited.

Greater mutuality between corporations and the unorganised sector is desirable, and should benefit both sides. Corporations will learn frugal, flexible and friendly ways of fabrication and design, while local communities will benefit from access to larger markets and improved environmental and economic conditions.

Distributed product development and incubation funds

Every country needs decentralised funds. Thanks to the 13th Finance Commission, every district in India has the rupee equivalent of $US200,000 available to support innovations in public systems and by ordinary people. The program's seven key purposes are to support

- product development
- testing
- calibration
- value addition
- design
- fabrication
- market testing and commercialisation (or social diffusion).

Unfortunately, most countries do not recognise the need for such risk funds at the community level. The world has thousands of conferences on micro finance, but no major initiative on micro venture finance.

As a follow-up to the International Conference on Creativity and Innovation at Grassroots, at IIMA, 1997, the first risk fund, the Grassroots Innovation Augmentation Network (GIAN), was created with the help of the Gujarat government. Then in 2003 NIF created a Micro Venture Innovation Fund with the help of the Small-scale Industries Development Bank of India (SIDBI) to provide financial support to innovators under single signature and without any collateral security or co-applicant. (Most people paid back their loans.)

The question is how long society can ignore the need for such important links in the innovation ecosystem. If risk capital is critical for information and biotechnology, why wouldn't it be relevant for grassroots technological and institutional innovations?

In some countries, including India, inclusive innovation funds are being set up to invest in companies in ways which disregard six of the seven attributes mentioned above. Such funds will inevitably fail to address the needs of individual inventors who may not yet have proved their concept sufficiently, or identified a market for it, or who may have made only a preliminary prototype as a part of an undergraduate or postgraduate course or as individual backyard R&D.

Most individual inventors from the professional sector, let alone the unorganised sector, will remain deprived of funds from this source. Where then is inclusion? Funding models that may work for IT start-ups will not often work for hard manufacturing or service technologies.

The costs of testing, calibration, certification, etc, are also often not differentiated for an innovation-based startup, vis-à-vis a normal corporate client. Most MSMEs cannot obtain subsidies for incubating innovation, while larger companies may be able to. Fiscal, taxation and other policies should be reviewed to make the policy and institutional environment more inclusive for innovation-based enterprises.

Nurturing social innovations

Conventionally even social enterprises have been expected to recover their costs from clients regardless of the latters' ability to pay. Requiring clients who cannot pay to be served only by public services eliminates entrepreneurial intermediation. Such an approach excludes the needy.

Entrepreneurial mediation is necessary. Specific financial instruments and mechanisms must be developed to cross-subsidise social ventures in fields such as education, common property resource development, long-term rehabilitation of degraded or damaged natural resources, and so on.

Social change agents may try to fill the gap, but they lack financial support. Innovations in the social sector must also be supported through social venture funds – of which there are few.

Embedding inclusion in educational and cultural systems

Hardly any lessons in college or school textbooks deal with inclusive, self-triggered and self-inspired innovations. Unless the younger generation is exposed early to such innovations, it may not be inspired to take voluntary initiatives in later life. Cultural institutions including popular media can be very effective here.

The producer Vidhu Vinod Chopra and the director Raju Hirani, makers of the blockbuster *Three Idiots*, discussed the film's plot at length as a way to pick up grassroots innovations to be depicted in it. Two innovations most viewers will remember, were a scooter-mounted flour mill (Sheikh Jahangir, Jalgaon, Maharashtra) and a cycle-based sheep-shearing device (Mohammed Idris, Meerut, Uttar Pradesh).

The first served poor people who had to buy their grain daily. Since big flour mills will not grind small quantities of grain, consumers had to buy flour ready milled, and thus lose margin. A service provider with a scooter mill can go from door to door to mill wheat for poor people. The innovator had a shack on the roadside when he made this invention.

Stories of this kind will inspire viewers and make them aware of inclusive innovation. Special efforts should be made in every country to persuade the media to publicise grassroots innovations. Special awards can be instituted for the best portrayal of inclusive innovation and UNESCO or CSIRO can take the lead in collaboration with the Honey Bee Network.

Multimedia, multi-language databases should fill the gap wherever three essential conditions for learning are absent – literacy, language and localism. The first such database was presented by Honey Bee Network at its inaugural Global Knowledge Conference, at Toronto in 1997. This meeting remains the only one of its kind.

We must ask ourselves why such basic tools for inclusion are not used more widely. As elsewhere, UNESCO or other organisations can play an active role here.

An inclusive ecosystem for promoting innovation

The broad contours of an inclusive ecosystem for promoting innovations that serve disadvantaged sections of society and often arise from among them have been outlined.

The changes required at the technological, institutional, cultural and educational levels will improve the access, assurance, ability, and attitudes of managers as well as consumers of various services and products.

In any socio-economic transformation there are always risks and uncertainties which must be absorbed or reduced. With climate change, the frequency, intensity and distribution of such risks may increase. Traditional knowledge as well as contemporary grassroots innovations will become even more important by providing mechanisms for reducing these risks. A global initiative is needed to document, share, validate and value-add the community perceptions and creative responses to various climate-induced and other risks.

The innovation ecosystem must recognise that society's capacity to absorb risks is uneven. Proper insurance and assurance mechanisms have to be generated in every policy dealing with inclusive development. Here multimedia, multi-language databases are especially important. Their specific role is to trigger cross-cultural validation and to spread creative coping strategies across the world. Different societies struggling with similar problems may develop similar or dissimilar solutions; sharing such solutions can help overcome civilisational inertia and improve the quality of life of the people.

Policies and supporting institutions are not enough, however. Appropriate indicators must also be developed to monitor the degree of inclusion achieved. General and context-specific indicators at different levels and of different complexity are needed. Communities should also be empowered to monitor the performance of policy makers as well as academic and other communities.

The various actors must be accountable to each other if an innovation ecosystem is to harness creative tensions for the common good. Currently, no global database exists either at CGIAR (Consultative Group on International Agricultural Research) or the UN Food and Agriculture Organisation, or even UNESCO to indicate how many initiatives, technologies, or R&D programs have been stopped, started or modified based on contributions from creative communities and individuals. Discussion of such indicators and collection of systematic data will add accountability.

Honouring grassroots innovators where they live and sharing knowledge with them and other community members strengthen the innovation ecosystem at the most basic community level. Sustainable, inclusive development will be achieved if interventions at different levels and in different sectors reinforce each other, reducing the transaction costs of disadvantaged social groups.

Exclusion not only increases social alienation but also decreases mutuality and dignity in the development process. Social violence is only one consequence. The alienation of younger generations can impose unimaginably high costs in terms of dealing with lack of social trust and mutual accountability.

It is important to remember that the ethical principles underlying organisations such as the Honey Bee Network will remain valid. Cross-fertilisation of ideas, overcoming anonymity and ensuring the formal sector acknowledges the contribution of creative communities and individuals, and shares fairly the value-added knowledge and benefits accruing from those contributions – these together are a *sine qua non* of an inclusive innovation ecosystem.

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CHAPTER SIX

International collaborations across institutions

Research partnerships offer best likelihood of success

By Anne Houston and John Webb

This chapter is based on interviews with leading Australian and Indian researchers involved in collaboration programs established between their institutions

Sustainable partnerships and growth are only possible with long-term support. Many international collaborations focus on a certain project and last as long as the associated funding grant. For a more durable model, institutional involvement and support are necessary, with individual projects being part of a long-term strategic objective.

To date there are a number of Australia-India STI partnerships: the Monash-IITB Research Academy (Monash University and Indian Institute of Technology, Bombay); the TERI-Deakin BioNanotechnology Research Centre (Deakin University and The Energy Research Institute); the IICT-RMIT Research Centre (the Indian Institute of Chemical Technology and RMIT University); the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Council of Scientific and Industrial Research (CSIR); Queensland University of Technology's (QUT) partnerships with various institutes and the University of New South Wales's (UNSW) work with the Indian Institute of Technology Patna (IITP).

Getting Going

Over recent years, Indian and Australian higher education institutions have grown increasingly familiar with potential counterparts for institutional collaboration.

From an Australian perspective, the Indian higher education system is large, complex and unfamiliar. Its various histories, governance structures and policy priorities are significant points of difference. Nevertheless many institutional partnerships are in place or under consideration, including joint ventures and teaching programs, student-exchange and study-abroad programs and, of particular relevance to the Task Force, research partnerships that involve PhD students in fields of science, technology and innovation.

Some recent helpful accounts and critiques of India's higher education are available (Agarwal 2009; Rizvi and Gorur 2011) and policy settings and government initiatives continue to evolve. India's Planning Commission will release its next five-year plan in 2013, including plans for the higher education sector. The Australian government is assessing these developments, aided by analysis conducted by Australian Education International (AEI) and, increasingly, publications of the Australia-India Education Council.

As noted, research partnerships seem to offer the greatest likelihood of success. As in any collaboration, the choice of partner is of paramount importance. Here the differences between the university sectors of the two countries are stark. Australia's research-intensive universities offer a comprehensive range of faculties; in India no equivalent institution exists. Research in Indian higher education is overshadowed by undergraduate teaching which takes place in myriad affiliated colleges. Postgraduate work is generally undertaken at the university campus.

Science and technology research in India has developed largely through institutes established and funded by the central government (INSA 2001), although university research activity is now increasingly funded and productive. A particularly interesting parallel in the research sector is the system of national laboratories – CSIRO in Australia and CSIR in India. Both are world-renowned, and on the face of it would appear suited to having an institutional link between them. Efforts in this direction are continuing.

Australian institutes want to become more research-focused, and need international collaboration to attain this goal. A desire to attract overseas research postgraduates to Australian laboratories was identified by several interviewees as their main motive for international collaboration.

Australian institutes have a key advantage in the support provided by staff in the Australian High Commission in Delhi with responsibility for science and education. They can help Australian delegates identify complementary organisations in India and open communication channels. Posts are also maintained in India by Australian state governments (including NSW, Queensland, Victoria, South Australia and Western Australia) and universities (including La Trobe, the University of Melbourne and the University of NSW).

The model could be usefully replicated with more representatives from India in Australia, making successful bilateral relations easier to establish. Current staff include the High Commissioner of India to Australia, and the Consuls-General of India in Sydney, Melbourne and Perth. The knowledge which national bodies possess may also have a role to play – including that within university groups (the Group of Eight, the Australian Technology Network, the Association of Indian Universities) learned academies (such as the Indian National Science Academy, the Indian National Academy of Engineering, the Australian Academy of Science, the Australian Academy of Technological Science and Engineering), and industry bodies (such as the Confederation of Indian Industry, the Federation of Indian Chambers of Commerce and Industry, the Australian Chamber of Commerce and Industry, the Australian Industry Group, the Australia India Business Council).

Many Australian institutions recognise India as a priority country, and senior delegations (for example, of vice chancellors) visit frequently to meet key stakeholders. This process may include the signing of a memorandum of understanding – although this does not indicate the partnership will materialise into anything more substantial and enduring. The Indian Institute of Science currently holds more than 80 MoUs, and has 39 past MoUs. Together, Australian universities in the Group of Eight hold 2330 MoUs, ranging from 200 to 510 per institution. Currently, India is not in the top ten source countries for international agreements (Universities Australia 2012). Although such visits show institutions want to collaborate, a strategic signing is not enough to build a fruitful relationship. For this to happen, first the capabilities and expectations of each partner need to be fully understood.

For such institutional relationships to develop into productive linkages, operational-level researchers need to be involved. These can begin to build a relationship with counterparts and assess how the partnership might benefit both sides (The IICT-RMIT collaboration was initiated from the bottom up). However any partnership requires strong leadership and institutional support and resources during its gestation. An institution would have to see value in the linkage, and be willing to invest in it. This is a strategic rather than an opportunistic decision.

Persistence

India is one of the most expensive places in the world to do business, due to the time and money required for frequent visits. Even after partners are identified and perceived to have a strategic alignment, partnerships may not develop as expected. With time it can become clear that the goals and understandings of the partners were not as close as first thought. As Professor Mohan Krishnamoorthy, CEO of the IITB-Monash Research Academy told the Task Force, 'You have to buy lots of pairs of shoes'.

Institutional and enterprise partnerships work best where the initiative is championed strongly, where the governance bodies are aware of benefits and risks in advance, and where the timing is right. All parties must have similar ideas about what the partnership will offer. These diverse factors can take time to realise.

To succeed, respondents frequently observed that the relationship needs nurturing: communication must be kept open and trust built, with face-to-face meetings to sustain enthusiasm and cooperation and maintain collaboration. Personal and professional relationships must be developed. As the partnership develops it must allow, in L.Yuncken's words, 'flexibility to change direction, grow or shrink as the partners learn more about one another and as new opportunities arise'. Throughout, strong leadership is necessary to keep driving the partnership, with leaders on both sides having a sense of equal ownership and dedication to the cause. The partnership must also be robust enough to survive any change in vice chancellors or directors.

Forging lasting partnerships

For a relatively new partnership, many interviewees advised starting with student and staff exchanges to develop a network and enhance understanding at all levels of the organisations, especially the operational level. Exchanges can familiarise participants with the capabilities of the partner organisation as well as with cultural issues.

Industry partnering is an important path for institutions looking for traction and sustainable growth models. Interviewees said partnerships with enterprises, particularly internships, gave academic researchers the opportunity to gain experience in a business setting. The experience could be valuable in cases where a particular problem might be better investigated at a sister laboratory, or when overseas colleagues with access to commercial partners might be able to provide insights on gaining access to a particular market.

Although the long-term goal should always be in mind, the steps along the way must be measured, too. In Mannepalli Lakshmi Kantam's words: 'A partnership must be structured in such a way that it keeps delivering at regular intervals, or it runs the risk of being terminated due to a perceived lack of value.' This may involve joint publications for research institutes engaged in the collaboration. It is also worth remembering that joint research may not be undertaken for the same purpose on both sides. The same research may produce different commercialisation opportunities, just as different research areas can contribute to the commercialisation of a different technology. This is where goals and expectations must be clearly defined.

Regular, clear communication is vital in establishing, developing and sustaining a relationship. For this, an in-country representative can be valuable (Monash, Deakin and QUT all have in-country representatives for their joint ventures). With current collaborations, there are several institutional representatives in India, enabling the partnership to prosper. The position facilitates communication between the organisations, improves understanding on both sides of what is needed and expected, acts as a contact point for researchers and staff, provides leadership, understands the different systems, and builds partnerships in academia and industry through meetings with stakeholders. The role may adapt as the partnership grows, but it is vital in developing and maintaining substantial institutional relationships.

Government also influences the development of institutional collaboration. Partnerships value the support of government (noting some of those in existence began with funding through AISRF), while also maintaining independence from it. The expectations of governments may differ from those of collaborating institutes and enterprises. The partnership may be used for political traction, which can become an obstruction. The level of government involvement must be limited and clear.

Interviewees discussed examples where governments might for political gain hamper collaboration where it is not seen as important. They noted that government was often the funding source for the partnerships, and therefore support was needed. Recognition of the linkage's importance to state and national economies and of its long-term benefits would help.

Industry Partnerships

There are a number of reasons why industry should be involved in sustainable models of innovative collaboration. Industry involvement can provide insight into market needs, is guided largely by economics and opportunity, and generates solutions to problems addressing industry and societal needs which can be marketed worldwide.

Industry can sponsor scholarships, provide strategic advice and introduce different networks. In these partnerships it is essential to ensure that expectations – measured largely in terms of meeting delivery times – are fulfilled. Industry also provides an important source of funding, that is, public-private partnerships with dollar-for-dollar funding, which allow mutual ownership and access to necessary funds.

Indian industrialists are unfamiliar with the Australian system. Indian managers have often been educated in the US, and are more likely to seek partnerships there, instead of in a system of which they know little. Australian institutions seeking partners in India need to demonstrate to CEOs in that country the strengths of the Australian innovation system, with significant examples, in order to build their reputation.

The same can also be said of demonstrating the quality of research based in India to Australian businesses.

To date, Deakin University, through the Deakin India Research Initiative (DIRI) has partnerships including Biocon, BigTec, VIMTA, Sankara Nethralaya - Eye Research Foundation, and Tata Steel; and the IITB-Monash Research Academy has partnerships with BHP Billiton, Infosys Technologies Ltd, Orica Mining Services, JSW Foundation and the Reliance Group.

Although the Australian Government's white paper *Australia in the Asian Century* recommended that more Australian students should study in Asia, the benefits to Australian researchers of working in India may not be immediately obvious. These should be made clearer. While many Indian STI students still look to the US, an increasing number are now looking towards Australia. This trend should be encouraged so that the Australian system is better understood and linkages are established between Australia and India for the future.

Case study – how to gain recognition

Discussion with Professor Peter Hodgson FTSE, Deakin University (joint BioNanotechnology Research Centre with TERI; DIRI), confirmed the importance of a research track record for lead researchers on both sides, and also the need for persistence in meeting with and recruiting partners. Deakin's aim was to build a strong cohort of PhD students. Deakin University had previously taken a number of IIT students for summer internships. The prestigious link to IIT had enhanced Deakin's reputation in India, and senior scientists (IIT graduates) recognised the opportunity which time at Deakin would give to students. Deakin has also been hosting IIT Masters students for six months. Together these programs have led to an influx of PhD students from India. (Deakin's Institute for Frontier Materials had 38 students from India among a total of 150 PhD students in 2012). Another attraction which Deakin University offers Indian researchers is its partnerships with leading businesses such as Biocon and Tata Steel. The advantage from all this is clear. 'There are benefits for both countries from their involvement in DIRI [Deakin India Research Initiative]. India gets the industry-ready PhD students it needs to meet the demands of its growing academy, while Australia has access to a host of potential new markets and opportunities.' (Hodgson, P)

Sustainability

Durability is essential in the partnership. When key individuals move on in their careers, corporate knowledge and familiarity with the relationship can move with them. This can cause problems for partnerships they may have been involved in. Even where such movements are few, a partnership has to be able to withstand such changes and not disappear when its champions, vice chancellors and directors for example, are no longer in their role.

The IITB-Monash Academy model shows that this is possible with the right outlook and set-up. The board consists of five directors from Monash and five from IITB. Since its establishment eight of these ten directors have changed, yet the model is still robust. Without such durable governance structures, which support and encourage the progress and understand the importance and significance of the partnership, it would be difficult to ensure a sustainable model.

Such arrangements also encourage strong teams and relationships between researchers, with the governance body able to require 'that professional advancement is contingent upon maximising opportunities such as these' (Bhargava, S).

The next steps

The *Australia in the Asian Century* white paper noted the importance of long-term engagement with Asia. Partnerships between research institutes and enterprises, following models designed to ensure durability and stability, will be essential in achieving the white paper's strategic goals.

The obstacles impeding Australian institutions from achieving those goals are limited resources and limited knowledge of strategically aligned institutions to work with. Currently, too, many stakeholders consider the here-and-now far more than they look ahead to the future. That thinking must change.

The AISRF has taken a broad view of Australia-India collaborations, encouraging smaller projects and workshops while also funding larger initiatives including institutional partnerships. Funding is still needed to initiate partnerships, to help them grow and to develop institutional collaborations. It would be better for applicants if the different levels of funding were reflected in the paperwork (i.e. a smaller form for smaller grants) to encourage industry inclusion and make the ranking clearer.

It can also be important to have more than one partner in each country, to give access to different expertise and market options. Assembling the best team from various universities and firms makes a wider range of capabilities and resources available to deal with national and global issues. It would also allow a more flexible PhD program – though credit transfers and the badging of degrees would need to be clearly defined.

Senior visits, such as that of Kapil Sibal, then Minister of Science and Technology, and Kiran Mazumdar-Shaw, managing director of Biocon, who holds a postgraduate degree from the University of Melbourne, have promoted Australia-India scientific linkages to Australia's advantage. These visits have highlighted Australia's prominence in scientific research, and added weight to the relationship. The respondents suggested more such visits should be organised.

Interviewees also discussed the benefits of a visit to India by a delegation of senior Australian scientists (including Professor Ian Chubb AC, Australia's Chief Scientist). Not only would this show India that Australia was serious about continuing collaboration, and provide opportunities to demonstrate the depth and quality of Australian science, but it would also allow India to showcase the quality of its science in return.

Each country should do more to promote its strengths to the other. Delegation visits would allow the development of a long-term strategic plan. This could be mediated independently by a professional group or the learned academies and their counterparts.

Visits by early/mid-career researchers should also be considered. These could be funded by individual institutes or a university group, to introduce researchers to international colleagues, broaden the network, establish linkages and develop relationships.

Showcasing national STI internationally was important, as demonstrated by the Science for our Future Festival in Indonesia, organised by the University of Western Australia in October 2012, at which leading Australian scientists engaged with Indonesian students and teachers to promote science, especially Australian science. Such events are vital to promoting a country's skills.

Many opportunities exist for collaboration between India and Australia, but much work remains to be done before they can be exploited.

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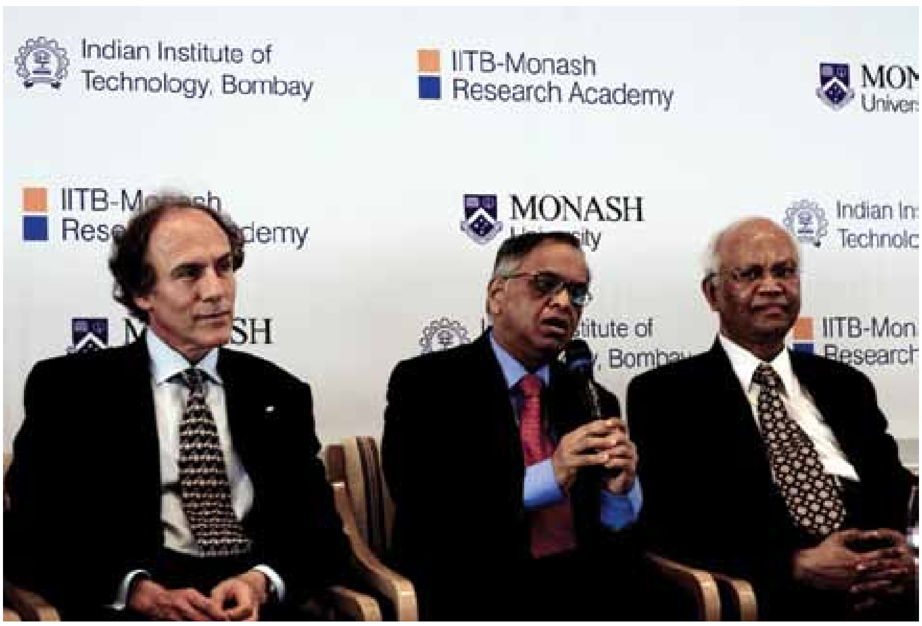

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Interviewees

Professor Tam Sridhar AO FAA FTSE – Dean of Engineering, Monash University

Professor Mohan Krishnamoorthy – CEO, IITB-Monash Research Academy

Professor Peter Hodgson FTSE – Director, Institute for Frontier Materials, Deakin University

Professor Alok Adholeya – Director, Biotechnology and Bioresources Division, The Energy and Resources Institute (TERI)

Professor Suresh Bhargava FTSE – Deputy Pro Vice Chancellor, RMIT University

Dr Mannepalli Lakshmi Kantam – Chief Scientist & Head, Inorganic and Physical Chemistry Division, Indian Institute of Chemical Technology

Ms Elizabeth Yuncken – Advisor, Europe, India and Middle East, CSIRO

Associate Professor Sri Bandyopadhyay – School of Materials Science and Engineering, The University of New South Wales

Mr Eric Hall – General Manager, Information Security Institute, Queensland University of Technology

Emeritus Professor Ed Dawson – Science and Engineering Faculty, Electrical Engineering, Computer Science, Computational Intelligence and Signal Processing, Queensland University of Technology

Associate Professor George Mohay – Information Security Institute, Queensland University of Technology

Professor Sheel Nuna – Director-South Asia, Queensland University of Technology

The opening of the RMIT-IICT Centre, 2011

CHAPTER SEVEN

Innovation: who pays?

By Supriyo De[6]

This article explores diverse aspects related to the financing of innovation, with particular emphasis on ways to leverage cooperation between Australia and India.

Economic theory perceives innovation as a major force driving economic growth (Romer, 1986; Aghion and Howitt, 1992). The experiences of different countries show the significant role innovation plays in enhancing the development potential of an economy.

The Japanese, Korean and other East Asian growth stories are particularly relevant here. In many developing countries, too, innovation can help improve inclusion and equity through socio-economic interventions. The financing of innovation is thus a matter of great policy importance.

Despite innovation's global and national economic significance, its financing faces hurdles. These include high risks, uncertain outcomes, and long gestation periods with negative initial cash flows. If financial markets always had perfect information available to them, and contracts could always be equitably enforced, these factors might be evaluated, and appropriate risk-return profiles established. Financing innovation might not then be a problem.

Unfortunately, financial markets are far from perfect – and especially with regard to innovation finance. Information asymmetries, moral hazard problems and immeasurable risks plague the financing of innovation. As a result, innovation is – in all probability – severely under-funded. This needs to be addressed by policy intervention. The nature of financing problems and possible policy solutions are the focus of this article.

Challenges to the financing of innovation

Innovation requires various inputs including human capital, knowledge and expensive research equipment. Each poses peculiar financing challenges. Human capital is embedded in individuals who are mobile. A skilled employee trained by a firm can easily move to another firm taking accumulated acumen and knowledge. Codified knowledge can be retained, but unless onerous secrecy norms are in place, such knowledge tends to spill over to other firms.

Research equipment is specialised and expensive. Where a project does not yield sufficient returns its salvage value is minimal, resulting in significant sunk costs.

A firm can choose to finance innovation through internal resources (retained earnings) or external sources (equity or debt). For small new and medium enterprises all these forms of finance are difficult to obtain (Hall and Lerner, 2010). For new entrepreneurs, internal resources are limited since the project's cash flow is negative. The founder's own savings or funds informally garnered from family and friends are often the only source (United Nations, 2009).

With regard to formal sources of finance the very nature of innovation poses certain challenges.

Asymmetric information

This refers to the phenomenon where the entrepreneur or inventor has a better idea of the true nature and chances of success of the proposed project than potential investors. This results in a 'lemons' problem, where investors demand a significant premium since they cannot distinguish between viable and unviable projects. (The lemons problem [attributable to Akerlof,1970] suggests that if there are varying qualities of items (investment options) offered in a market and the buyer (investor) is not able to distinguish the good from the bad, she would be willing to offer only the average price – which is lower than that for the better quality item but higher than that for the worse item [Varian, 2003]. Consequently,

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the person offering the better good either opts out of the market or settles for a lower price. In the case of innovators this lower price is the equivalent of having to offer the financer a higher rate of return – the lemons premium).

This premium is much higher in the case of R&D and innovation, given their long-term and highly uncertain nature (Hall and Lerner, 2010). While this is the more discussed aspect typical of developed and organised financial markets, it may be hypothesised that – in the case of grassroots and frugal innovation in the developing world – the information asymmetry may flow in the reverse direction. The inventor, being unaware of the full potential of the innovation, may have less idea of its commercial viability than a savvy financer. As a result the inventor may obtain finance only at exorbitant rates or, worse still, part with their idea (intellectual property) without adequate compensation. In either case, lower returns to the innovator would tend to dampen innovation activity.

Moral hazard

This arises where, in a principal-agent situation, the principal (shareholders) cannot observe the actions of the agent (managers). Where the goals of the two diverge, the outcome is likely to be sub-optimal. In the case of innovation this can result in lower funding – either because managers spend more on activities that benefit themselves or because they are more risk averse and spend less on R&D than is desired by the shareholders (Hall and Lerner, 2010).

Negative cash flows and long gestation

Innovative projects often have negative cash flows (United Nations, 2009). They may also take a long time to yield returns. This is likely to deter many investors.

Uncertainties and undefined risks

An innovative activity is by its very nature untried and untested. Its chances of success are impossible to predict. Consequently, the associated risks and related risk premium or risk-return profile for financing are virtually undefined (Hall and Lerner, 2010). In contrast, most conventional economic activities have at least partly defined risk profiles based on past experience.

Intangibility and absence of collateral

Innovative activities yield intangible outputs. They also usually require substantial intangible inputs such as human capital and knowledge. Hence, neither the inputs nor the output can be collateralised to obtain initial or subsequent debt finance of the conventional sort (De, 2012; Fukao, *et al*, 2009).

Stages of innovation financing

Typically, innovative firms develop across several stages. The issues and challenges associated with each stage are somewhat different. Given the peculiarities of each stage, different financing options, organisational forms and governance structures are associated with each (United Nations, 2009).

Before discussing policy or market interventions, it is useful to visualise these stages.

1. *Seed stage:* This encompasses initial R&D, exploring commercial prospects and business viability, examining technical feasibility and market potential. Broadly, at the seed stage, founders' or family funds or public feasibility grants are the only available financial supports. In organisational terms the enterprise is small, has a nebulous structure and only informal governance norms.
2. *Start-up stage:* This includes product development and prototype testing, market outreach and initial market research, and formalising organisation of the business. At this phase business angels and venture capital funds are the usual funding sources. The organisation is small. Given the need to reduce information asymmetries, business angels or venture capitalists have a substantial say in governance. This also allows the enterprise to build on the experience and networking provided by the angels or the venture capitalists.
3. *Early growth stage:* Nascent commercialisation, operational commencement, market entry and building the basis for scaling up are characteristics of this phase. In this phase a combination of venture capital and more conventional bank debt provide financing. The enterprise would usually now be larger and its governance structures would be more established.
4. *Expansion stage:* In this phase the organisation grows in scale, market size and organisational attributes. In this phase the venture capitalist generally looks to exit and the enterprise is ready to be listed in public stock markets. Henceforth, conventional debt and equity together with internal funds become the financing mainstays. The organisation is enlarged and formal corporate governance frameworks as required by the local laws and regulations are put in place (United Nations, 2009).

Generally, depending on the stage of growth and corresponding cash flow and risk profile of the innovative enterprise, different forms of financing arrangements turn out to be optimal. At the seed stage, founder's funds and feasibility grants are the norm. The start-up and early growth phases are usually funded through business angels and venture capital funds. The expansion stage is often characterised by the exit of venture capitalists and the public listing of the enterprise. Debt instruments including bridge loans and public equity then become available (United Nations, 2009).

While this is a broad characterisation of innovation funding, the assurance and smoothness of these processes are by no means preordained. Various factors such as economic development, debt levels and maturity of financial markets, social attitudes to risk-taking and regulatory frameworks facilitate or hamper the process of innovation finance.

Policy interventions and market development can address some of these issues.

Policy interventions and market solutions

Given the financing challenges described above, several policy interventions and market solutions have evolved to bridge the innovation-financing gap.

Feasibility grants

These are funds provided by government agencies as seed financing for innovative enterprises. They are intended to help transcend the information asymmetry between entrepreneurs and investors and have a public-good characteristic – that is, they seek to address a market failure. The funds are not usually expected to yield direct returns to government. Rather they strive to create a positive externality by increasing the pool of innovative enterprises through the provision of adequate seed capital.
Such funds could be designed to encourage university start-ups or greenfield enterprises. Essentially, these programs provide more than financial support. They give new ideas a fertile breeding ground, provide them with crucial nurturing space-time and promote subsequent viability for future private funding. To combat the problem of free-riding, disbursements are usually phased, with each successive phase subject to the achievement of certain clear-cut objectives and milestones towards project viability. However, disbursements of such funds are prone to politico-bureaucratic interference and capture by special interest groups. Therefore their processes need to be carefully designed. The selection process should ideally involve external professional expertise to ensure projects are properly appraised, and governance problems avoided. The Small Business Innovation Research (SBIR) program in the US and the START initiative in the Russian Federation each have characteristics typical of feasibility grants (United Nations, 2009).

Microcredit

Microcredit involves the disbursal of small loans for entrepreneurial activity among groups traditionally not served by conventional financial systems. These would include cases where high transactional costs and risks make lending unviable for banks and other lenders (United Nations, 2009). Microcredit, the development of which is largely attributed to the Bangladeshi Nobel Laureate Professor Mohammed Yunus, uses group-based activities and payment assurances to mitigate these costs and risks (Varian, 2003). Microcredit is not strictly a form of innovation finance. However it can serve as a useful source of initial finance for small innovators, low-cost innovations and social-sector innovation programs. Microfinance institutions (MFIs) are usually specialised in nature and have specific processes for credit appraisal, joint lending and business facilitation. They also provide linkages to more organised markets and involve generally marginalised elements of society. Consequently they have a strong social focus and are often non-profit in nature. Government can play a significant role in supporting microfinance activities through grants, technical support, co-financing and tax incentives (United Nations, 2009). Nevertheless, the regulation of MFIs has recently become a matter of concern. This is a delicate issue which if not handled appropriately can kill the proverbial golden goose.

Business angels

These are individuals who invest equity in entrepreneurial activities and also provide networking assistance and expertise. Alternative forms of such finance include convertible loans and guarantees. They are usually high net worth individuals who can risk losses from a large part of their investment portfolios because they are more than made up by large gains from a few highly successful projects. Business angel activity is characterised by substantial direct involvement in early-stage enterprises including the provision of operational and market advice. Since business angels and potential entrepreneurs are hard to find and match, Business Angel Networks (BANs) have evolved. They provide a pool of finance, knowledge and information and provide useful matching and selection processes. Policy support for business angels can include a liberal capital gains and dividend tax regime, contractual efficiencies and deep financial markets (United Nations, 2009).

Venture capital

Venture capital (VC) is defined by Hall and Lerner (2009) as 'independently managed, dedicated capital focusing on equity or equity-linked investments in privately held, high-growth companies'. The funds are generally contributed by institutions and wealthy individuals through partnership arrangements. They are invested in nascent enterprises usually in lieu of preferred stock and other privileges. As the enterprise matures the venture capitalists sell off their interest to other acquirers or through a public listing.

Venture capital arose in the US and played a significant part in the rise of innovative enterprises, particularly in Silicon Valley. Institutional and regulatory factors played a significant role in the growth of venture capital in the US. These include the non-payment of capital gains taxes by limited partnerships and allowing pension funds to invest in venture capital (Hall and Lerner, 2010). VC activity can be encouraged through tax incentives, public-private partnerships for financial participation, regulatory ease and financial market development.

Innovation finance in Australia and India

Research and development (R&D) forms the backbone of an innovation system. The broadest measure of the financing of innovative activities is the ratio of R&D expenditure to the nation's gross domestic product (GDP). **Figure 1** (see over page) depicts the evolution of this measure for certain country groups and some economies including Australia and India. Australian R&D expenditure to GDP has been rising steadily since around 1999. In comparison the measure for India is fairly stable at around 0.75 per cent. However, given India's rapid economic growth, in absolute terms, R&D expenditure in India has risen dramatically. Nevertheless, this is less than the growth of the intensity of R&D expenditure displayed by some East Asian economies including Singapore and China. It may also be noted that despite the increases, the OECD average remains much higher.

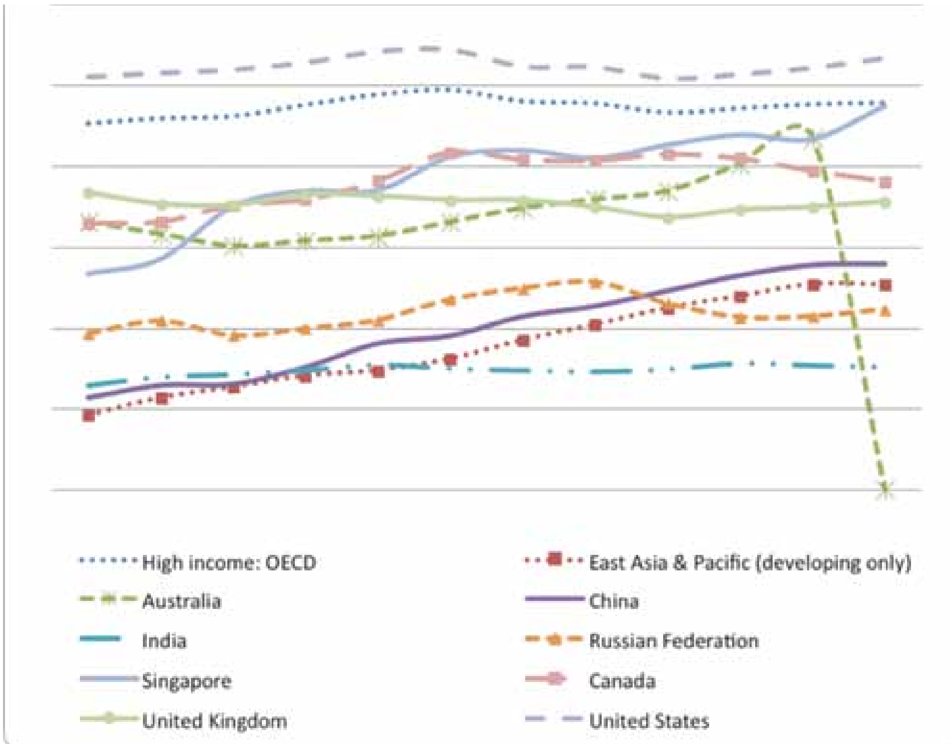

Figure 1: R&D expenditure to GDP for various economies and country groups
Note: Data on Australia available for alternate years till 2007 have been averaged to address gaps in the series.
Source: World Bank data, http://data.worldbank.org/, date accessed – 12th August 2012

The results of China's large R&D expenditures are visible in terms of the large number of patent applications filed by its residents, which has risen to surpass the US in 2009 **(Figure 2a)**. In comparison, the number of Australian patent applications has risen slowly, those from India have increased more rapidly while those from UK have declined **(Figure 2b)**.

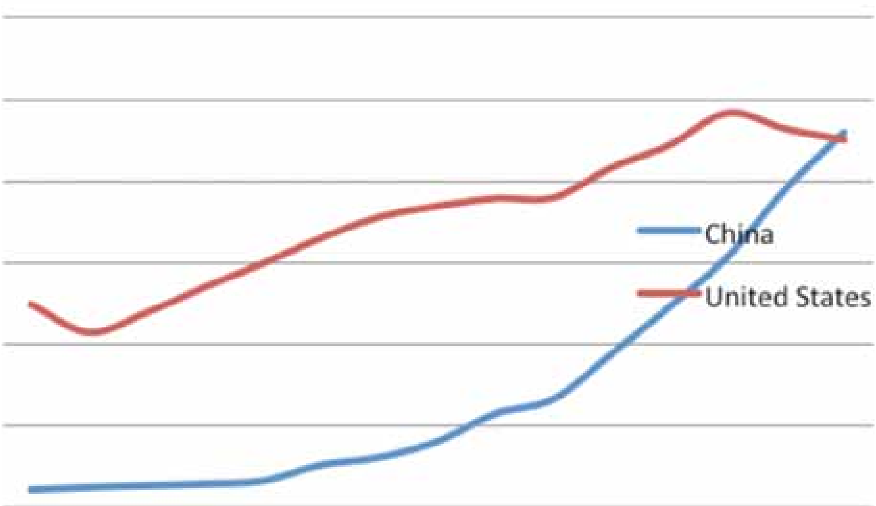

Figure 2a: Patent applications of residents for China and the United States
Source: World Bank data, http://data.worldbank.org/, date accessed – 12th August 2012

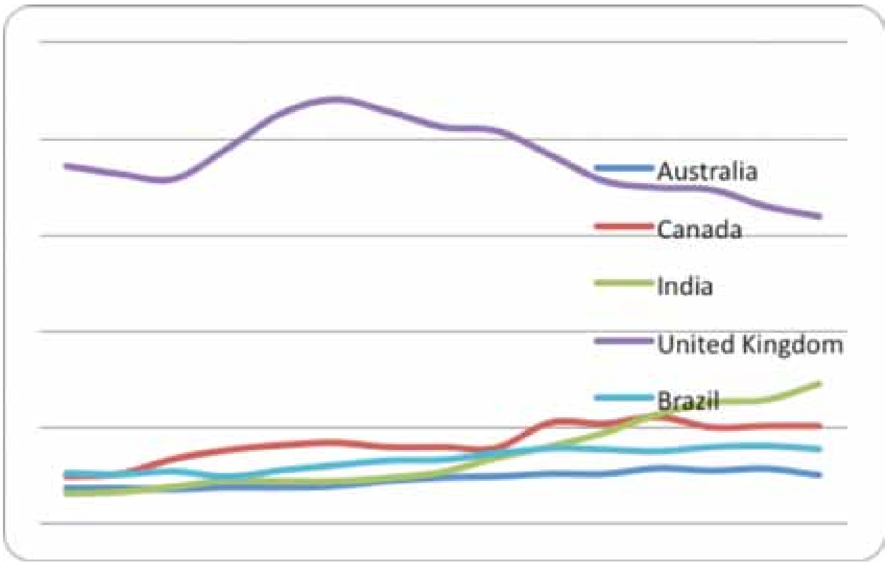

Figure 2b: Patent applications of residents for Australia, Canada, India, United Kingdom and Brazil
Source: World Bank data, http://data.worldbank.org/, date accessed – 12th August 2012

In net commercial return from intellectual properties (IP) the performance of India is better than that of China, and that of Australia is far superior to both when seen in terms of the ratio of royalty and other IP receipts to payments (though this may include some mining-related royalties). It is probably indicative of significant commercial success of IP endeavours **(Figure 3)**.

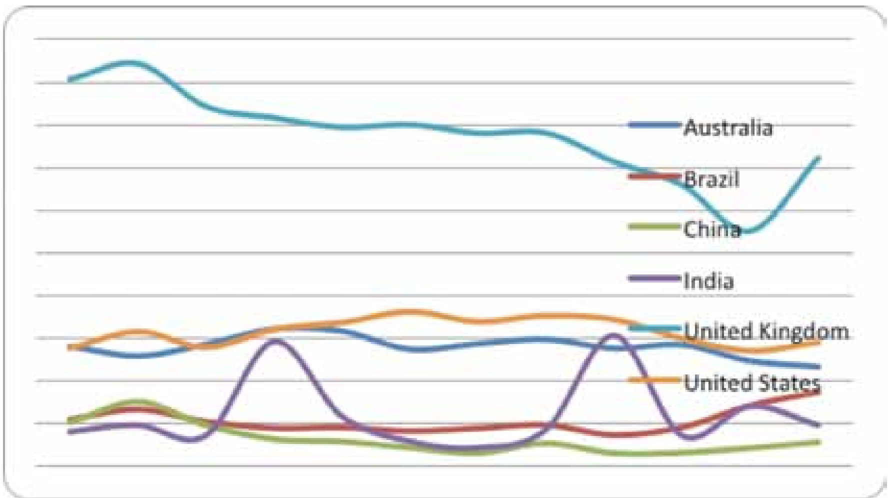

Figure 3: Royalty and license fees, receipts-to-payments ratio for various economies
Source: World Bank data, http://data.worldbank.org/, date accessed – 12th August 2012

With regard to the sources of R&D expenditure, there has been a distinct change in India's case. While the contribution of the Central and State governments has decreased, private-sector R&D expenditure has increased its share across the period from 1999-2000 to 2007-08 **(Figures 4a and 4b)**.

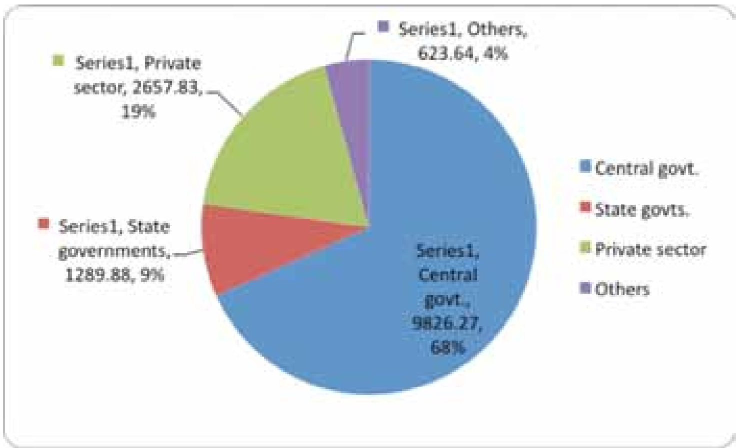

Figure 4a: Shares of various sectors in R&D expenditure in India in Rs. crores (FY 1999-2000)
Source: CMIE, Business Beacon dataset, date accessed – 23rd August 2012

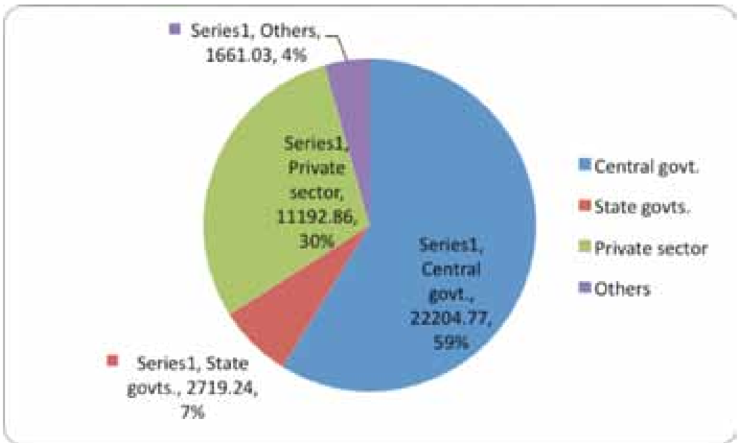

Figure 4b: Shares of various sectors in R&D expenditure in India in Rs. crores (FY 2007-08)
Source: CMIE, Business Beacon dataset, date accessed – 23rd August 2012

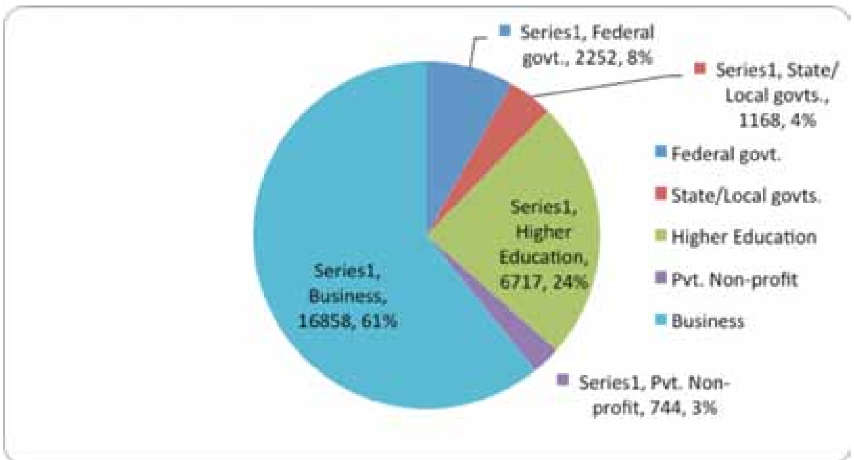

Figure 5a: Shares of various sectors in R&D expenditure in Australia in $A millions (FY 2008-09)
Source: DIISR, 2011 based on Australian Bureau of Statistics

In Australia the business sector had a much greater share of expenditure on R&D **(Figure 5a)**. In 2008-09, business funding of R&D was 60.5 per cent of total Australian R&D expenditure compared with 44 per cent in 1992-93. For Australia we also have break-ups of the sources of funding **(Figure 5b)**. In that respect also the business sector is the largest contributor, increasing its share from 44.1 per cent in 1992-93 to 60.8 per cent in 2008-09. The Federal Government's share fell from 41.3 per cent to 30.2 per cent across the same period even though the amount increased from $2.7 billion to $8.4 billion. The Federal Government contribution to business R&D expenditure through grants and other programs was about $345 million in 2008-09. Thus businesses funded the bulk of their R&D expenditure. However they also received $1.4 billion in R&D tax incentives (DIISR, 2011).

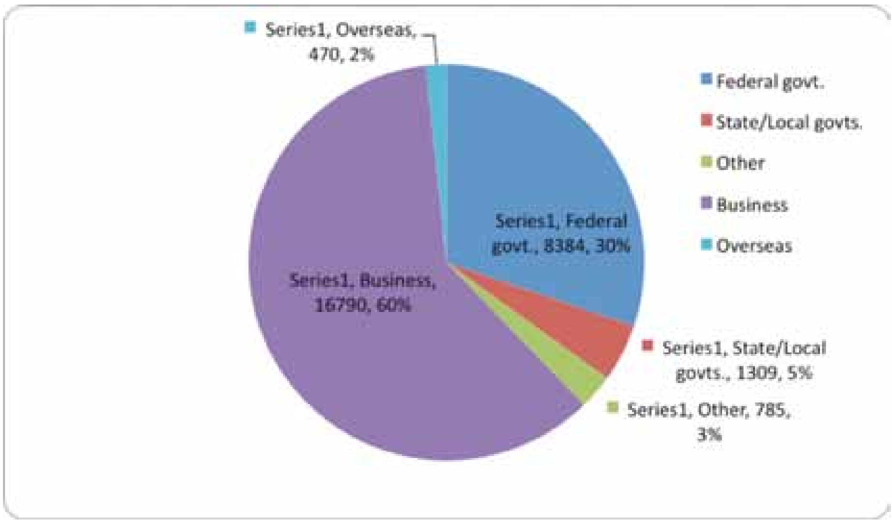

Figure 5b: Shares of various sectors in R&D funding in Australia in $A millions (FY 2008-09)
Source: DIISR, 2011 based on Australian Bureau of Statistics

Private sector R&D

It is interesting to observe the different behaviour of India's private sector in R&D expenditure **(Figure 6)** (see over page). If we measure intensity as the ratio of R&D expenditure to sales, the drugs and pharmaceutical sector shows the highest values, which have climbed rapidly in recent years. The R&D success of this industry is also mirrored by its rapid lowering of external IP payments as a ratio of sales **(Figure 7)** (see over page). The success of this industrial sector is partly attributable to legal changes arising from amendments to the Patents Act of 1970 which allowed patenting only of processes, not products, and unleashed significant incentives for discovering new processes (Dahlman, Dutz and Goel, 2007).

In Australia, business R&D expenditure in 2008-09 was $16.8 billion or about 1.35 per cent of GDP. Large firms contributed about 80 per cent of business R&D growth. R&D may help firms maintain market share and economies of scale in sectors such as finance, mining and construction (DIISR, 2011).

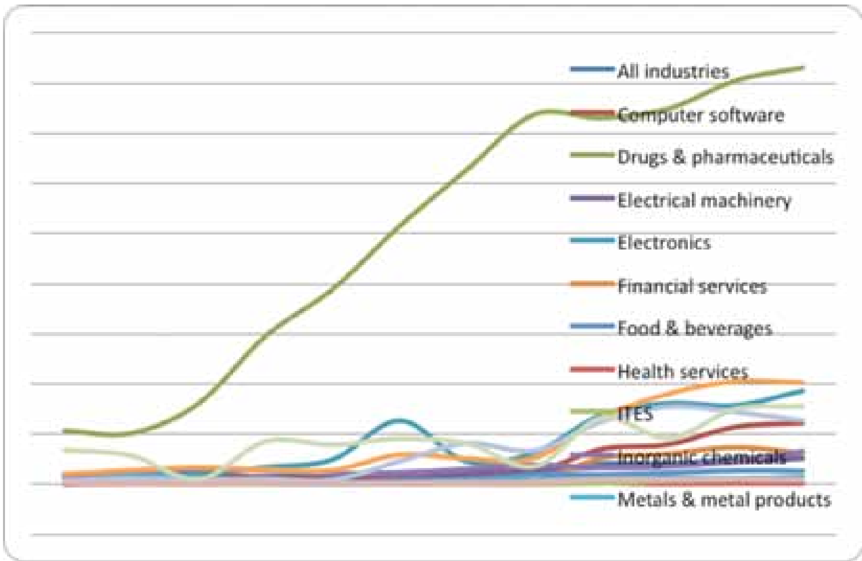

Figure 6: R&D expenditure to sales ratios for various sectors in India
Source: CMIE, Prowess dataset, date accessed – 23rd August 2012

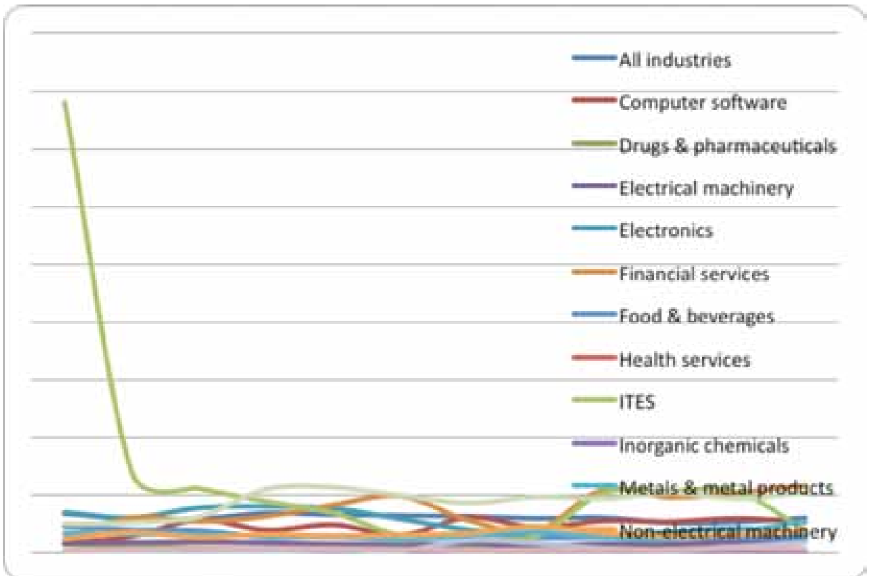

Figure 7: IP payments to sales ratios for various sectors in India
Source: CMIE, Prowess dataset, date accessed – 23rd August 2012

Government programs and public-private partnerships

Given market failures and low private commitments to innovation, most governments provide direct institutional and financial support to R&D and innovative activities.

The Indian Council of Scientific and Industrial Research (CSIR), set up in 1942, is the premier civilian research body. Other government agencies involved in research include the Defence Research and Development Organization (DRDO), the Indian Council of Agricultural Research and the Indian Council of Medical Research (ICMR). In recent years, government programs have been established to encourage private R&D and public-private partnerships (PPPs), including the Sponsored Research and Development (SPREAD) program spearheaded by the Industrial Credit and Investment Corporation of India (ICICI) and the Small Business Innovation Research Initiative of the Department of Biotechnology. These programs generally provide soft loans and matching grants often with the express intention of encouraging collaboration between private enterprises and public research institutes. In addition, the Government has provided fiscal incentives such as income tax deductions for R&D expenditures by private firms, weighted tax deductions for publicly sponsored R&D, customs-duty exemptions for equipment and accessories imported by approved R&D units and institutions, and tax holidays for commercial R&D companies (Dahlman, Dutz and Goel, 2007).

Australian government financial support for business innovation includes tax concessions, support funds and service provisions. The R&D tax credit is a broad-based system providing a 45 per cent refundable tax credit (equivalent to a 150 per cent tax deduction) for small firms (annual turnover less than $20 million) and a 40 per cent non-refundable tax credit (133 per cent tax deduction equivalent) for large firms. Other schemes are Commercialisation Australia, which enables pilot project funding, the Enterprise Connect services and support for building capacity and venture capital co-funding through the Innovation Investment Fund and the Innovation Investment Follow-on Fund. Various state governments also run their own innovation grant programs (DIISR, 2011).

Venture capital activity

Private equity (PE) and venture capital (VC) activities in India have been driven by global factors including US and EU pension funds, insurance companies and wealthy individual investors. There was a major pickup from 2004 to 2007 when about $US28 billion in PE and VC funds flowed into India. The flows fell in 2009 but bounced back in 2010. From 2004 to 2009, annual deal values in the Australia-New Zealand (ANZ) region grew by 47 per cent (Compound Average Growth Rate (CAGR)) while that in India grew by 23 per cent.

However, following the global financial crises the growth prospects reversed. Between 2009 and 2010 ANZ deals shrank by 50 per cent whereas Indian deals increased by 111 per cent. Across this period the highest sectoral growth in India was recorded by energy (283 per cent), manufacturing (207 per cent) and banking and financial services (206 per cent). In contrast the erstwhile favourite IT and ITES deals shrank by six per cent (Bain & Company, 2011).

Despite its rapid growth, according to a recent analysis, VC/PE investments in India display certain skewed characteristics. The average duration of such investments was remarkably low at only 17 months; that is VC/PE investments in India are not patient capital, as they are supposed to be. Furthermore, almost 50 per cent of the investments were in mature companies (incorporated for at least eight years), contrary to the expectation that such investments should largely finance new ventures (Thillai Rajan and Kamat, 2010). Australia has a well-developed venture capital industry and the proportion of seed/start-up venture capital at 0.18 per cent of GDP in 2008 ranks it at 13th out of a selected group of 23 OECD countries. However, as noted earlier, the global financial crisis has negatively affected VC funding in Australia. Total VC investment decreased by 39 per cent from $683 million in 2008-09 to $419 million in 2009-10 (DIISR, 2011).

Finance for social and inclusive innovation

Social and inclusive innovation initiatives target social groups and individuals who are marginalised and distant from modern markets and commercial activities. They serve an important role in development, encouraging frugal innovation and the preservation/perpetuation of traditional and rural knowledge (*The Economist*, 2010).

In recent years, India has evolved a rich network of government and non-government programs that encourage inclusive innovation (Gupta, 2010a and 2010b). These include the non-government Honey Bee Network (HBN) and the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) and the government-led Grassroots Innovation Augmentation Network (GIAN) and National Innovation Foundation (NIF). Broadly, these networks facilitate the development, intellectual property protection, propagation, compilation and commercialisation of traditional knowledge and grassroots innovation (Utz and Dahlman, 2007). Besides government grants and non-profit funds, India's vibrant microcredit and nascent social entrepreneurship sectors can be tapped to provide socially-oriented but financially remunerative funding options for this sector.

In Australia, innovations directed at social outcomes have grown significantly. Private non-profit R&D expenditure in 2008-09 was $744 million with the largest chunk (92 per cent) being dedicated to health R&D. There are various government endeavours to encourage social innovation and entrepreneurship such as Social Enterprises Development and Investment Funds (SEDIF) which provide matching grants to supplement social investments by the corporate and philanthropic sectors (DIISR, 2011).

Towards a new cooperative compact

The outcomes of innovation, namely, knowledge and technological advancement, are globally beneficial in the long run. In the shorter term they can yield substantial benefits to individual economies or groups of countries. Therefore cooperation between Australia and India in research funding and financing deserves attention.

Some possible approaches are:

- *Resource pooling:* The simplest possible option is pooling together a part of government funding for encouraging bilateral joint private-sector ventures for R&D. Large transnational enterprises are already leveraging resources and talent across the globe for R&D. But smaller enterprises would incur disproportionately high costs in terms of researching and identifying suitable partners , due-diligence processes and administrative procedures to achieve similar objectives. A bilateral government-funding program, besides being a source of funds, would serve as a catalyst to bring together interested enterprises across the two countries and also mitigate some of these costs. The US-Israel joint endeavour named Binational Industrial Research and Development (BIRD) was set up in 1977 with seed capital of $US110 million with this intent (Dahlman, Dutz and Goel, 2007). Australia and India may reap great benefits from setting up such a program.
- *Business angel and venture capital networks:* Business angels and venture capitalists often operate across borders to select a diversified pool of high-risk, high-return ventures. Even though India and Australia both have significant business-angel and venture-capital activity the interaction between the two countries in this respect appears to be far below its potential. For instance, of 133 VC/PE investors without physical presence in India surveyed in 2009, 75 were from the US, 18 from the UK, 15 each from South-East Asia and the Middle East, six from Europe (other than UK) and three from China (Thillai Rajan and Kamat, 2010). The sample did not reflect any Australian investors. To encourage bilateral VC/PE and business angel activity, setting up a dedicated business angel and venture capital network could prove helpful. Existing bilateral business bodies such as the Australia-India Business Council could be encouraged in this respect.
- *Bilateral fund of funds:* A fund of funds is a venture capital entity that does not invest directly in enterprises but finances other venture capital funds (United Nations, 2009). To encourage bilateral funding activity, a fund of funds is a more viable instrument since it need not go into the minutiae of assessing and monitoring separate entrepreneurial ventures. It simply needs to fund some prominent and promising VC funds in the two countries. Given this administrative ease it is possible for the Australian and Indian governments to form a consortium with private players from the respective countries to set up a fund of funds to facilitate and finance VC activities in the two countries.
- *Social enterprise and innovation funding:* Social enterprises have the ability to reach out to marginalised sections of society. Funding such activity can yield significant social benefits that go beyond mere market returns. A joint mechanism for funding such enterprises in India and Australia, including through the capitalisation of microcredit institutions, could provide a valuable impetus to this sector.

Innovation encourages economic growth and social inclusion but suffers from financing difficulties due to issues related to asymmetric information, moral hazard, negative cash flows in the initial phase, long gestation periods, undefined risks and uncertainties, and the absence of collaterals.

Some general policy interventions and market solutions to address these financing challenges are considered. These include public feasibility grants for promising new ventures, microcredit for small enterprises, business angels and venture capital for targeting a diversified pool of high-risk, high-return ventures. Some of these solutions, besides providing critical finance, can also lend support through building market networks, reputational effects, managerial guidance and governance advice.

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CHAPTER EIGHT

Promote the relationship and help communication

Science technology innovation and collaboration

By Anne Houston and John Webb

This chapter presents highlights from interviews with leading figures in Science and Technology Innovation from Australia and India.

Innovation is recognised as 'the engine for the growth of prosperity and national competitiveness' (National Innovation Council) by the governments of India and Australia. In the Global Innovation Index 2012, Australia ranks 23 and India ranks 64.

Both governments have invested in strategies to improve their innovation systems, and want to encourage the best research and commercial outputs from their countries, with Australia's and India's research currently at 3.2 per cent and 3.5 per cent respectively of the world's output.

In science and technology, the term innovation can be confused with invention. Innovation is the translation of invention as technology is commercialised – whether for profit, or for environmental, medical or other purposes. Apart from translation, basic research is an important part of the process, as are other considerations not directly associated with R&D, such as business models.

One element which is widely recognised as vital for the promotion of innovation is strong academia-industry linkages (OECD 2012). Various models have been implemented to strengthen these linkages.

India has adopted business incubators and industry clusters, which bring together research institutes, industry, financiers and other associated stakeholders (the National Biological Research Centre; the UNESCO Regional Centre for Biotechnology), and which the Indian Government also promotes through the National Innovation Council's Innovation Clusters Initiative (National Innovation Council 2011). This model has also been applied to the Tata Consultancy Services (TCS) Co-Innovation Network (COIN), which connects academic research, emerging technology companies, venture funds, strategic partners and multilateral organisations in the technology landscape. From the interviews for this article it is clear that while in the US the network is able to offer the right connections and impel innovation, in other parts of the world where TCS would like to see this model implemented, including Australia, it has not yet taken off.

Many of Australia's research institutes have dedicated sections and industry-engagement offices to facilitate commercialisation, transfer technology and provide consulting and associated services to industry. Australian Government initiatives, such as the Enterprise Connect scheme and Cooperative Research Centres, encourage and enable connections between research and industry. State programs – for example the Victorian Technology Voucher Program – assist with connections by providing funding to business to utilise public-sector research.

However, despite these programs and initiatives, barriers to collaboration between university and industry still exist in both countries. The reasons include a relative lack of investment; restricted mobility across the sectors; the different working cultures of industry and academia; and their different priorities and measures of effectiveness. Measures of success in universities, such as the Excellence in Research for Australia (ERA) initiative, are heavily weighted towards citations. These, while an important measure of research quality, are less of a priority to industry, which is far more concerned with effects, technological outputs and prompt solutions.

The recent Excellence in Innovation Australia (EIA) trial by the ATN and Group of Eight demonstrated that the effect of research can be assessed (ATN Go8 2012). The university system should be 'flexible in recognising achievement in different forms … patents, ongoing partnerships with industry' (Monro, T).

Innovation Ecosystem

The term 'innovation ecosystem' has often been used when discussing steps for successful innovation – the right culture to promote innovation, including geographical location, networks, funding and communication. An ecosystem can be improved with various steps, such as better financing. In Australia, apart from some government funding schemes (such as the R&D tax incentive which aims to encourage R&D in smaller firms) there is a lack of investment for risky innovation, notably from external sources. Investors are often risk-averse, preferring to support a product they know will reach and be accepted by the market.

Acceptance that innovation can include failures would be beneficial and encourage a vibrant innovation ecosystem, as has been achieved in success stories such as Silicon Valley. A lack of simple financial models for translating invention into innovation, and difficulties in aligning the interests of inventors and innovators (Krishnan, A) are also current barriers in the system. More investment has to be sought from the private sector and other investors (S De).

Marketing also needs to be addressed in the current system. A product is more likely to succeed if it is customer-focused, when it should be relatively easy to market. Difficulties with marketing can arise from a lack of communication between engineers and the marketing team, or a lack of trialling, or inattention to customer feedback. The customer's needs have to be understood, and are often recognised when investors are considering backing an idea – they will only invest if there is a clear pathway to market. An innovation styled for the 'bottom of the pyramid' (R. Mashelkar) is as important when considering marketing opportunities, alongside acknowledging the consumer's wish for brand products.

The involvement of industry brings a greater awareness of the likely market for new technologies. Innovation may gain some initial impetus from research, but without market demand, a new product is unlikely to succeed. Whether it is government looking for technologies to monitor landscape and resources, or industry looking for a better drug delivery system, their requirements, along with the direction in which the sector is heading, need to be taken into account. A high level of communication is needed to ensure the strategic direction is consistent.

Frugal innovations (NESTA 2012) in India, such as the Tata Swach low-cost water purification system, are examples of successful products which are needed and of interest to the customer. The market may take time to appreciate what is being offered and to pay for it. Biocon's first anti-cancer drug took five years to take off, for a range of reasons, including questioning of the product's credibility.

Both these inventions commercialised in India were created to meet Indian needs and then translated into the global market. A further consideration is that in India there is a strong focus on brands. A premium innovation might only pay off as a branded product.

Regulation and Bureaucracy

The regulatory systems in Australia and India can be very complex, with each sector and state implementing different arrangements. The complexity and number of regulations in both countries can act as a barrier to innovation and economic progress.

Discussion among respondents noted that regulatory boundaries should be limited while still protecting the customer – especially consumer health. A simple regulation change can make a big difference. Australia changed regulations to allow food which was out of specification to be given to Foodbank, which distributes to about 88,000 people a day. Current regulations should be assessed to see if they can be adapted to allow important technological developments.

Governance was also a key issue discussed. Many red-tape processes within government slow decision-making and policy change. Many respondents indicated that in India, it is not expected that a bureaucrat will do anything out of the ordinary, making positive change difficult. The perspective of the Australian system is similar – with 'no surprises' expected by government officials. India ranked 132 out of 183 economies for ease of doing business, whereas Australia placed tenth (Doing Business 2013). India's lowest scores were for construction permits and the enforcement of contracts.

A contemporary issue in India is corruption (e.g. Coalgate) which hinders progress and economic growth. India's land tenure arrangements make acquiring land there very difficult. This halts development. Australia's system is very process-driven, with large amounts of paperwork, and is thus inflexible and difficult to work within.

Education and engineering

Education prepares and enables future leaders to deal with national and global challenges and develops student capabilities, with their knowledge becoming a basis for generating future wealth. An 'education system that encourages entrepreneurship and innovation' and one which equips 'students with tools for becoming more innovative' (Sastry, M) is desirable. Researchers would be better placed if they were taught business skills as undergraduates, and if postgraduate academic achievement was measured not only in the number of their publications but also in their record of work with industry. Researchers with access to strong industry linkages understand the structural differences between the sectors and can take this knowledge forward into their career.

There are not enough skilled engineers in Australia to meet demand. India could provide graduates to Australia to cover the skill gap and help the economy, as well as allow Australia access to some of India's best minds. India would benefit from having students trained in the Australian environment and learning different skills. Student mobility would transfer skills back to India as well, and globally. There is also the advantage that Australia is recognised under the Washington Accord, with its degree program recognised in a handful of countries, including the US and the UK.

In the IT sector in India, one of India's leading industrial sectors, fewer than 3 per cent of engineering graduates are ready to work without further training (Aspiring Minds, 2011). Australia is more advanced in training. In general, professors in India do not have the same drive to gain funding and begin new projects as their Australian counterparts, and teaching methods in each country are different. Several interviewees also mentioned that Australian researchers are primarily driven by the question 'why?', whereas in India, researchers are more likely to query what answer they should be looking for instead of discovering their own answers.

The relationship of the Indian National Academy of Engineering (INAE) and the Australian Academy of Technological Sciences and Engineering (ATSE) is also important in this context. Both academies are working to raise engineering standards domestically and internationally, and enjoy a strong bilateral relationship which encourages collaboration at various levels.

Networks

In any organisation, relationships between colleagues affect the work being undertaken (Pattison, P). Any partnership requires trust, and gaining it takes time, strong and clear communication between those involved, and honesty. Communication between India and Australia (as well as between different institutions and enterprises) can be a challenge, making partnerships more complicated.

Once trust is built, frank dialogue is possible about the state of the team and the partnership. Knowledge of past experience – failures as well as successes – can be shared, and a deeper investment made in the linkage. Trust can also combat the perceived self-interest of those involved. These affiliations should be maintained even if funding for collaborative activities is lacking, as it may become available again at short notice.

Strong leadership is also needed: a leading individual taking responsibility for the partnership can make decisions more efficiently, encourage commitment to the partnership and give the project a better chance of success. However, strong leaders may not stay at the same institution or enterprise for the lifetime of a project. All levels within an organisation should be engaged with the partnership, from the operational level, where ideas can be generated and encouraged to thrive, to the leadership, which sets the strategy. Allowing researchers to enjoy relative freedom to be creative can elicit new ideas which lead to innovation. A number of interviewees commented that this may be more of an issue for India, where a customary lack of autonomy means those in more junior positions may not follow initiatives that are not directed by their leaders. However this is changing.

Organisations should also consider using external networks to gain access to the best resources. On an international scale, access to an open, global market and to the best international talent is vital for success. Networks, by giving access to external stakeholders, enabling strategic partnering in relationships built up over time and based on trust, are vital to the innovation framework.

Finance

For a sustainable future, the proportion of funding from the private sector should be higher than that from government. This higher industry investment ratio exists in the US, Israel and Germany (which rank higher in the global innovation index). Collaboration could be a point of attraction for investors – by giving them access to the best skills, leading facilities and a broader market. Australia and India need to engage investors in conversations with researchers, entrepreneurs and companies, to promote risky innovation and encourage much-need financing of R&D.

Multinational organisations are increasingly investing more in India, with support for research centres. Multinational foundations are investing greatly in science to address global challenges. The Bill and Melinda Gates Foundation in 2011 funded more than $US4 billion in grants, with the majority going to global health. Non-governmental organisations also play an important role, with more than 1.5 million in India (NESTA 2012) adding necessary resources to the system. NGOs have the advantage of being close to a potential market (although problems may arise if they are too closely linked with politics). For Australian R&D, as it looks to the needs of a global market, these are potential sources of ideas and funding.

The next steps

International collaboration in publications is on the rise. Furthermore, internationally collaborative publications produce a greater citation impact (The Royal Society 2011). India is not in Australia's top three countries for international co-authorship (UNESCO 2010) and currently India has a low percentage of publications with international co-authors (OECD and SCImago Research Group 2011).

India and Australia have various collaborative funds such as the Australia-India Strategic Research Fund, state-run programs such as the Victorian Trade Mission Program and the Queensland Smart Futures Fund, and other smaller funds. However, Australian Government investment in science and technology has slowed, as demonstrated by the loss of the International Science Linkages program and the $499 million cut to the Sustainable Research Excellence program. This could harm the steps undertaken to build important relationships, putting at risk the R&D efforts which Australia has established. Conversely the Indian Government is recognising the need to increase investment. To meet the recognised need for greater investment in collaborative research, it is time to look to industry. Industry partners were not always encouraged with the AISRF. Collaboration would allow Australia to benefit from new funding sources in industry, if schemes promoted these partnerships.

Considering the significant number of countries which have leading research skills, innovation ecosystems and strong industry linkages, why is it so important that Australia and India improve their collaboration in science, technology and innovation?

Australia and India have many common research priorities and challenges, as well as complementary gaps which can be filled by the capacity of colleagues in the other country, exchanges of knowledge, and access to different markets, industry and facilities. Enhanced communication is required between the two scientific communities to understand the full breadth of these collaborative opportunities and how complementarities can be bought together.

Areas of complementarity include: agriculture, water management, biotechnology, ICT, and innovation systems. Australia, for example, might learn from aspects of frugal innovation.

These will draw in skill sets possessed by India and Australia which are 'unique and complementary' (Sastry, M). A full list of suggestions can be seen in Appendix A. It is imperative to build on the extensive government-to-government discussions and current Australia-India networks, and to engage various stakeholders.

Both governments should continue to focus on their respective national priorities and scientific strengths, with emphasis on developing the innovation ecosystem to improve capacities. To further define areas of collaboration, Australian and Indian experts should be brought together in workshops on particular topics. Not only would the time spent in discussion be valuable, but the broader interaction between innovative communities would make the first step towards meaningful linkages which might generate new ideas and stronger networks. Industry representatives, financiers and agencies which can support linkages should be included.

Stakeholders could draw up a long-term plan, in line with the vision of both governments and in coordination with research institutions' strategic plans. The plan would also allow for shorter-term outputs, including joint research projects, joint publications, workshops, and short- and long-term student and staff exchanges.

Respondents revealed support for the establishment of an Australia India Foundation, with a remit similar to the British Council, to promote cultural understanding and science diplomacy, and to broaden dialogues between the communities. This would allow for better mutual understanding and would be a foundation on which to build relationships, and an opportunity for networking.

Perceptions need to change for collaborations to be successful. Australian confidence can come across as arrogance, which can affect the relationship. It was also suggested that many in the Australian community view linkages as of more benefit to India, to help decrease poverty and improve Indian infrastructure. However, Australia has much to gain, including lower prices for products, better trade relations with an increasingly stable India and better access to the global economy. Australia would see much-needed investment in R&D (Indian companies are already looking to invest in Australian R&D, especially in pharmaceuticals), access to a skilled workforce, jobs and wealth creation.

It is important that the Australia-India STI relationship continues to develop. The experts interviewed believed that both countries need champions (like Minister Sibal) to encourage the partnership, and that there needs to be:

- A line of communication between various groups, including academia, industry, government and financiers, to understand the capacity of India and Australia and areas which are important to both countries;
- A road map created with a long-term vision; and
- Multilayer funding from government and investment from other sources

An effective strategy to promote the relationship and help communication would also be of extreme value. Each country needs to consider regulations; an improved innovation eco-system including a push for the funding of risky innovation; and education systems which include teaching entrepreneurial skills.

This is a path on which Australia and India can share thinking and build a future together, learning from each other's successes and failures.

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Interviewees

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Dr Leanna Read FTSE – Director, BR Angels Pty Ltd

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Appendix A

Suggested STI areas for collaboration

The areas below were suggested by those interviewed for this report as fruitful for collaboration between Australia and India.

Specific topic areas

- Water – including water resource management; sustainable use of groundwater and surface integration; water efficiency for high use for food
- Health – including sports medicine; biotechnology; telehealth;
- ICT – including computational intelligence and signal processing; computer human interaction; information security; networks and communications; robotics and aerospace systems; IT systems managing critical infrastructure; linking with minerals and materials, water, energy, agriculture, software, mobility and social media.
- Energy – including power engineering; solar; distribution of renewable energy and delivery systems; more efficient energy systems and a better means of cooling
- Agriculture – including food security, food production and the food supply chain
- Transport systems – including urban transport systems
- Environment – including climate risk, change and adaption
- Nanotechnology
- Manufacturing
- Mining
- Fisheries
- Education
- Regulatory system
- Frugal/Gandhian Engineering

Approaches

- India's strong engineering with Australia's strength in basic research
- Collaborations should be large, ambitious, goal-focused, well-funded; have potential to create a broad impact; be based on common national research priorities.
- Enhance capabilities through longer-term joint activities; researchers could train in Australia, with the incentive being a job promised on their return to India.

Mechanisms

- Through the Australia-India Strategic Research Fund (AISRF)
- Similar mechanisms as exist in successful joint centres
- Broader and more flexible PhD exchange/collaboration program not limited to one institution
- DIISRTE councillor in Delhi, a similar position from India based in Australia
- Student exchange – students become business people.

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For more information about innovation systems

India

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