The New Geography of Innovation: India, Finland, Science and Technology

Kirsten Bound, Charles Leadbeater, Paul Miller & James Wilsdon

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Foreword

Sitra's India Programme continues to produce information about the "India phenomenon", the expanding economy, the strengthening research activities and opening society of India, and the opportunities this offers for Finnish-Indian cooperation.

With this new report the floor is given to the researchers of British think tank Demos, who provide us with an analysis of the Indian innovation system. India has set itself the objective of making its scientific research world class. Despite the serious problems that continue to trouble India, such as massive poverty and heavy environmental loads, it is, nevertheless, already a significant producer of R&D work, and its standards of technological competence and training are, to an extent, topclass. All this is something that research departments and organizations should notice in Finland, too.

For this report, Demos researchers have done work also in Finland. They have, for example, interviewed some important Finnish players in the field of science and R&D concerning their views on India. And the central conclusion of this report is that, in order to thrive and maintain its innovative capacity in the future, Finland will need to develop new reciprocal relationships with India.

By producing this report with Demos, Sitra's India Programme also internationalises its activities one step further. In today's globalised conditions, Sitra's mission to promote the future success of Finland is best served by cooperating also with international partners.

I would like to offer my sincere appreciation to all of the contributors to this study. In particular, I would like to thank two of them, Paul Miller and Kirsten Bound, with whom I had most contacts during this project. Cooperation with them and with Demos has been a good and successful experience.

Helsinki, November 2006

Vesa-Matti Lahti
Director
Sitra's India Programme

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About the authors

Demos is a research organisation and think tank based in London. We focus on six areas: public services; science and technology; cities and public space; arts and culture; global security, and public communication. Our partners include policy-makers, companies, public service providers and social entrepreneurs. Our international network – which extends across eastern Europe, Scandinavia, Australia, Brazil, India and China – provides a global perspective and enables us to work across borders.

Kirsten Bound is a Researcher at Demos, Dr James Wilsdon is Head of Science and Innovation at Demos, Charles Leadbeater and Paul Miller are Demos Associates.

1 Introduction

1.1 The Deal: why the future of India matters to Finland

A quick signature and the deal was done: Indian software and IT services company Wipro bought Finland-based Saraware for €25 million.[1] Saraware, a company with 200 employees located in Rovaniemi, provides design and engineering services to telecom companies including Nokia. Wipro is valued by the market at over €15 billion. It was the first such takeover by an Indian firm that Finns had witnessed.

For those who noticed the Saraware deal, the conclusion was unmistakeable. The Indian economy was no longer 'third world' or just a place for Europeans and North Americans to invest. Neither was it a place limited to the 'outsourcing trend'. While it's true that you just have to ring a helpline number to feel the thrust of globalisation as your call is answered from the outskirts of Mumbai or Bangalore, the deal suggested there was something more going on. And just a few weeks later it happened again. Sasken Communication Technologies, another Indian company, acquired the Finnish firm Botnia Hightech for €35.5 million.[2]

The Indian economy has grown at above 7 percent over the last three years, and future expectations for growth are even higher.[3] At last year's India Economic Summit, Prime Minister Manmohan Singh said that India should be targeting 10 per cent growth. But his overarching vision is that of an "inclusive, prosperous, democratic and equitable India" and he is courted by global leaders because of India's economic might and influence over the future.

Finland, by almost any international measure, is an incredibly successful nation. It has topped the World Economic Forum's competitiveness rankings. Its education and health systems are the envy of the world and the quality of its environment is ranked among the best on the planet.

Much of this success is based on innovation. Finland has a strong science, technology and engineering base both in its universities and through

companies in telecommunications, biosciences as well as more traditional industries such as chemicals and paper. It has thrived because it has been able to develop and apply new technologies and processes and then sell these to the rest of the world. In relation to its population, Finland is one of the most active scientific publishers in the world, ranking fourth among OECD countries in 2002. Finland's share of all OECD publications has also developed well. It grew from 0.8 per cent in 1990 to 1.1 per cent in 2002.[4]

Finland's success is also based on an ability to look beyond short-term pressures and understand the changing global context. When recession started to bite in the early 1990's Finland opened up its economy and began the shift towards becoming a knowledge economy but also realised that there was benefit in retaining social security and investing in public services such as education and healthcare. Finland furrows the brows of neo-liberal economists because it retains a level of equality between its citizens as well as generating massive wealth. Prime Minister Singh's aim for India of being prosperous and equitable could be said of Finland more than it could for many other countries.

Yet there is an uneasiness about Finland's position at the top of the global podium. With an ageing population, the drain on financial resources of maintaining social welfare could prove to be crippling for the economy. The only solutions to the long-term problem of an ageing population are: "Either you make more babies, or you make immigrants," as Manuel Castells told a seminar in Helsinki in June 2005. The problem says Castells is, "Finland is allergic to immigration."[5]

Competing in a fast-moving, quickly changing world means that no nation can stand still. Every country needs to constantly renew, to build its capacity to innovate. And the past decade has seen a gradual realisation that there are two new powers in particular that the established developed world needs to contend with and understand: China and India. Each with a population of over a billion people who are rapidly becoming more educated and affluent. Both countries have attracted significant foreign investment. Both countries have firms that compete on a global stage.

There is little doubt that China is at present a greater force in advanced technology in terms of sheer volume of product and the investment attracted from overseas. Indeed the level of trade between Finland and China is currently greater than that between Finland and India. However, India is quickly catching up and the two countries have very different potential trajectories for the future. India will overtake China in terms of population in approximately 2030 and will maintain a demographic advantage (with more young people of working age than people reliant on them) well into the second half of the century. Perhaps most importantly for Finland, India seems to be muscling in on Finns' traditional economic territory. India has become a powerhouse at

just the things that the country built its success on during the 1990's. India has surged ahead on mobile telecoms and software. It has a strong and quickly moving pharmaceuticals industry and it is rapidly developing capacity in high tech areas such as biotechnology and nanotechnology, even if this capacity is small at present.

1.2 The big numbers: India v Finland

The contrasts between India and Finland on almost all measures of scale are extreme. It is particularly when it comes to questions of human resources that India's statistics can look daunting. India has a population over 200 times greater than Finland and a demographic advantage in that over 50 per cent of its population is under 25 years old.

	Finland	India
Population	5.2 million	1.1 billion
Population growth rate	0.14%	1.38%
Gross Domestic Product	$161.5 billion	$3.611 trillion
GDP per capita	$30,900	$3,300
GDP growth	2.2%	7.6%
Land area	304,473 sq km	2,973,190 sq km
Unemployment rate	7.9%	9.9%
Internet users	3.3 million	50.6 million

Yet India is a paradoxical country. Statistics – while important – can sometimes be misleading. For almost every statement one can make about the nation, the opposite is almost certainly also true. In a country so huge that even if 90 per cent of the population believe one thing or behave in a particular way, it still means that over 100 million people – still nearly twenty times the population of Finland – do not.

It is also important to realise the paucity of reliable statistics available about India. While in some areas statistics are good in others information is difficult to find – and often contradictory if you can find it. Take statistics from 1989 for the number of engineering and technology doctorates for example. They vary from 238 to 586 depending on which government source you consult, with all four in disagreement.[6] It is always worth maintaining a healthy degree of scepticism about grand claims made for the country.

1.3 The small numbers: India and Finland today

Compared to other countries in Western Europe and North America, Finland has very weak links with India. According to Statistics Finland, there were only 1,618 Indian citizens living in Finland on 31 December 2005 (although this number is gradually rising – it was only 270 in 1990)[7]. Each year, Finnish universities take only approximately 30 students from India. Compare this with the UK which hosts over 17,000 Indian students at any one time and has an estimated 1.3 million people of Indian descent living in the country and bear in mind that India has an estimated diaspora of 20 million people around the globe.[8]

Nokia and India

Perhaps the widest channel of people flow between Finland and India is because of Nokia's dominance of the handset market in India and strong manufacturing presence in the country. According to research agency ORG Gfk, Nokia's market share for mobile handsets in India, as of February 2006, was a staggering 78.8 per cent.

This means that travel by employees and contractors is regular. However Indian Nokia engineers tend to spend only a short time in Finland, usually in stints of between three months and a year.

Nokia inaugurated its manufacturing facility in Sriperumbudur, Chennai, India in March 2006. From the beginning of building to the first phone rolling off the production line took only 23 weeks. It was an important moment - Prime Minister Matti Vanhanen and Jorma Ollila, Chairman & CEO of Nokia were there to see it happen. Ollila said "India is amongst the top 5 telecom markets in the world. Setting up this manufacturing facility in India reiterates our long term commitment to the Indian market."

The Chennai manufacturing facility currently employs 1,100 people and expects to significantly expand its work force in India over time. Nokia will invest approximately €120 million in the plant, which will serve the growing demand for mobile handsets in the Asia Pacific region.

Total exports from India to Finland were valued at around €100 million per year between 2003 and 2005, which amounts to 0.2 per cent of Indian exports globally. The largest share of exports from India to Finland is pharmaceutical products, which make up 15.6 percent of the total.[9]

Total exports from Finland to India over the same period were around €225 million per year, with 43.9 per cent of these being electronic machinery and electronics.[10]

There are also a small number of educational collaboration projects between the two countries. For example, ELECTRA is a European-Asian online programme on intercultural education for university students which includes Indian and Finnish students.[11] Its principal aim is the promotion of cultural understanding, cultural sensitivity and intercultural competence among participating students and the establishment of international network by means of new information and communication technologies. Partners in the pilot phase are the University of Joensuu, Finland, the Central University Jamia Millia Islamia (Delhi, India) and the University of Manchester (UK).

As well as taking ownership of Saroware, Wipro opened a development centre in Tampere, Finland in November 2002 and has the strongest presence in Finland of the Indian IT services giants. Typically, Wipro conducts 70 percent of its work for European customers in India and the other 30 percent at local development centres like Tampere.

It is fair to say though that, other than a few small pockets of activity, interaction between Finland and India is at a very low level. Culturally, economically and scientifically prospects for collaboration between the two countries start from a very low base compared to relationships between many other countries that have a similar international standing to Finland.

1.4 The challenge to the national innovation system model

Understanding innovation is a tricky business. Christopher Freeman defines innovation as, "... a 'coupling' process, which first takes place in the minds of imaginative people somewhere at the ever-changing interface between science, technology and market. The coupling is more than an intuitive flash; it is a continuous creative dialogue over a long period of research, experimental design, and development."[12]

While companies like Nokia invest as much as a third of their expenditure in research and development, it is difficult to predict where breakthrough innovations will come from or what they will be. While Linux, like Nokia, has its origins in Finland, the value generated has been spread globally and hundreds of thousands of people have been part of the innovation process. It came from a very different set of motivations and thrived on a very different model of development.

In the early 1990's, the concept of a 'national innovation system' was developed to understand the innovative capacity of a nation as an outcome

of the interactions of its institutions. It was first applied to Finland and has helped to shape the Finnish technology sector from the early 1990's to the present day. As it is explained by Finnish Science and Technology Information Service, "the major components of the innovation system are education, research, product development and knowledge-intensive business."[13]

Of course it is recognised that a national system must have global links – "the system is permeated by wide-ranging international cooperation" – but in a quickly changing environment the rise of India challenges the idea of this coming second. It may be that innovation is becoming global first and supported by national innovation systems second. This goes contrary to a historical Finnish pride in keeping innovation close to home. We were told that Finnish companies – even if they do outsource research and development – will often not tell anybody that they do. A national pride in innovation is admirable, but without a focus on global links to the new sources of human capital and powerhouses of innovation, Finland and Finns could lose out.

National competition might not have the relevance it once had. We are entering an age of global interdependence of innovation. It is no longer enough to focus on the capacities and relationships between institutions within a single country to predict its future innovative capacity. Individual companies spread their operations and networks across several countries, they compete in some areas with particular companies but collaborate on other tasks. They open up innovation processes to users in some instances and maintain high secrecy around others.

Although public institutions might have played a part in the development of Indian innovative capacity, the main source of motivation has been from demand for low-cost high-skilled remote labour from North America and Europe. As we will see later in this report, India is showing a completely different innovation process based on messy networks of key individuals, finance and research institutes and a vast education system, pumping out graduates by the hundred thousand but with wildly fluctuating quality. India's success in science and technology represents the antithesis of a national innovation system, it is truly dependent on the global flow of people, finance and knowledge. India is highly dependent on international networks of non-resident Indians, working for multinational companies or as academics.

It should not be assumed that India is a threat to Finland. Recent history tells us that technological globalisation is not a zero-sum game. While the US and Europe have imported more and more from India, they have also exported more and more. But in order to thrive in the future, Finland will need to turn itself inside out. To face outwards into the world, and to become a global hub where new relationships are formed and talent attracted through strong networks.

1.5 This report

The report sets out to understand the future of science and technology in India and make recommendations to Finnish policy makers about how they could best build the potential for and then grasp the opportunities that India-Finland collaborations might offer. We will examine whether Finland can draw on its existing relationships and develop new relationships with India to continue and build on its tradition of innovation into the future.

We recognise that we need to look at the full 'pipeline' of science and technology in order to understand the future. This includes basic science through to innovative tweaks of existing technologies. We set out to understand Indian innovation over the next 10–15 years. It is unlikely that theoretical breakthroughs will migrate to market in such a short period of time, but also unlikely that tweaks to technologies – such as a new plugin for a piece of software – will still be relevant over such a long period of time.

The Atlas of Ideas Programme

This report is part of a larger Demos programme of work on emerging patterns in global innovation called The Atlas of Ideas. Since 2005, we have been working with a range of government departments, companies and institutes in the UK, Ireland and the Netherlands as well as Finland to examine the implications of the growth of science and technology in India, China and South Korea. Our research has been based on extensive fieldwork in the countries, interviewing scientists, business people, academic experts and policy makers and a detailed study of statistics, research and literature about each of the countries.

A major international conference will be hosted in January 2007 in London to launch the findings from the first phase of the programme and to announce a second phase of work to take place over the next two years.

The report is structured into four main sections. First we look briefly at the history of science in India and then lay out the main characteristics of the innovation system in India. Second we look at the emerging trends and models of innovation in India that we believe will have particular relevance over the next 10–15 years. Third we examine how other countries have built relationships and collaborations with India and draw out the major themes which Finland could learn from. Fourthly and finally, we make a series of recommendations about what Finland should do.

Summary of key points in chapter one

- India has risen up the global agenda in the past decade with good reason. It is increasingly economically powerful, with much of this growth based on technology-related industries and vast reserves of human capital able to provide services to the rest of the world.
- Finland, while incredibly successful in the past decade, faces new challenges from global competition and an aging population.
- Finland has a very low level of interaction with India compared to other similarly developed nations.
- The idea of a national innovation system may not be sufficient to understand the rise of India.
- India's success is dependent on the global flow of people, finance and knowledge. India is highly dependent on international networks of non-resident Indians, working for multinational companies or as academics.
- Finland should not see India as a threat but as a strategic opportunity.

2 The past and present of Indian innovation

2.1 A brief history of Indian science and technology

When we meet, Professor Dipankar Home is very concerned that he gets us the right biscuits to go with our tea, and perhaps even some cake, 'yes cake that would be nice' he says to himself as he slips his assistant twenty Rupees to go and find us 'some nice fruitcake.' Back in 1917, JC Bose, the first Indian fellow of the Royal Society and discoverer of microwaves, founded the Bose Institute in Calcutta. Today the Institute is moving on. The grand ramshackle, crumbling set of poppy-red buildings are no longer fit for a world-class research facility. As Professor Home guides us around the aging buildings, we see a maze of corridors and strangely-placed hobbit-sized doors that lead to seminar rooms, labs and rooms stacked high with dog-eared lab books and PhD theses ready to move to the new building a few kilometres away.

The Bose Institute is a symbol of India's rich scientific past. With three scientific Nobel prize winners (albeit that the work for two of them took place in the US) and countless discoveries, India has a scientific heritage that belies its 'developing country' tag. Amartya Sen – in his book *The Argumentative Indian* – even puts forward the case that India has a scientific heritage much stronger than Europe or North America.[14]

The Vedas religious scriptures that form the core of the Brahminical and Vedic traditions within Hinduism date from the 2nd and 1st centuries BC. They contain relatively advanced theories of mathematics, astronomy and chemical processes. Ayurveda, the science of longevity, which still plays a significant role in modern medicine in India, has its roots in scholarly writings as far back as 800 BC. Indian mathematicians can also stake strong claims to being the inventors of the mathematical concept of zero in around 600 AD as well as the decimal system. Even Pythagoras is said to have learnt his basic geometry from the Sulva Sutras. The widely held belief that modern science began following the European dark ages neglects the fact that the dark ages were not dark eve-

rywhere. India was the world's largest economy in the first millennium, producing a third of global GDP.

Next came a period of scientific dependence that created institutions like the now crumbling Bose Institute in Kolkata. 'Modern science' was introduced to India under the shadow of British colonialism. This was the period when the structures, foundations and guidelines for science were laid down. As the British founded the first universities in India in the late 19th century and imposed English education, which was rapidly appropriated and propagated by the Indian elite, more and more training was received in Europe and Indians were directed into scientific lines of enquiry laid down by the West in institutions that followed Western design.

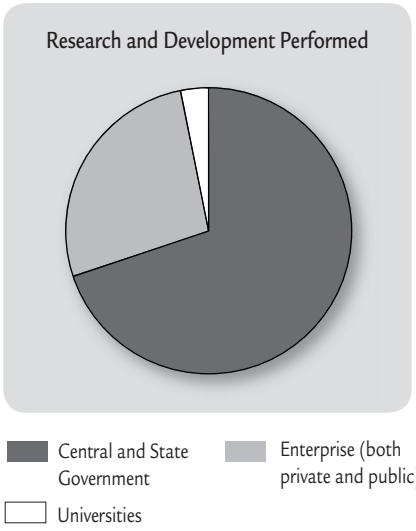
Now India is transitioning to a period of scientific interdependence. There has been a revolution in thinking about internationalism in India since post-colonial times. Then science was principally a national activity for national purposes, now science is a global activity, dependent on international networks of knowledge sharing and discovery. Although it might be fair to say that international collaboration is still largely an elite exercise in India, there is a widely held aspiration amongst scientists and a central push from government to become a global science hub through multiplying international linkages.

2.2 The balance of research in India

Today the government is responsible for the vast majority of R&D undertaken in India in government-funded labs such as the 40-lab-strong CSIR network. Seventy percent of R&D is directly government-funded, whilst if indirect government funding of R&D is included, the tally rises to almost 85% of the total.[15] This includes research across a wide range of disciplines and applications. Figure 1 shows how the funding of research breaks down.

A high percentage of Central Government R&D performed is military research. There are as many as 50 labs working under the auspices of the Defence Research and Development Organisation, however this report will not cover the details of science and innovation related to military applications.

Figure 1 Research and development performed in India by source of funding



Universities are responsible for a very small overall percentage of research and development spending but are a vital part of the innovation process in India, creating the highly trained young scientists and engineers who go on to work in research and development elsewhere.

Private sector research is made up of R&D undertaken by Indian firms and that done by multinational company (MNC) labs. Evidence suggests that the investment into research and development done by foreign companies in India has grown rapidly in the past decade. There is very mixed evidence about whether Indian companies – both large and small – are increasing the amount of money spent on R&D.

It is the aim of the current Indian government to stimulate much greater levels of research and development in the private sector and in universities. At a recent event in London, Dr Mashelkar, Director General of the CSIR labs, said that he expected the percentage of Indian research undertaken by government to fall in the next decade, although the absolute levels would continue to rise.

The rest of this section of the report examines in greater detail the major features of the three types of research and development in India: public science, universities and private science. A final sub-section examines the venture capital industry in India and the role that start-ups are beginning to play in creating linkages between different institutions over time.

2.3 Public science in India

"The Indian space programme has always been for the common man," Rajeev Lochan, tells us as we sit in a meeting room at the Indian Space Research Organisation (ISRO) in the suburbs of Bangalore. The majority of ISRO projects, he says, have been clear in how they benefit ordinary Indians. Satellites were put up so that educational TV could be beamed into the villages. They were sent to gather weather data so the monsoon could be better predicted. When Indian communication satellites first went up in the 1960's, they changed India forever. What was once a huge, diverse, disconnected subcontinent, became smaller – almost overnight. "If you wanted to make a phone call to Delhi you used to have to call the operator to book time on the line and then wait maybe seven hours for them to call back. Satellites changed all that," says Dr Lochan. The Space Department is one of only two government departments to be headquartered outside Delhi, so ISRO have their political masters on site to make decisions as they want. It also reports directly to the Prime Minister.

They never build anything just for the foreign market, instead they sell on any spare capacity from Indian needs. So if there's room on a launch vehicle putting an Indian satellite into orbit they'll take other payloads up. If other

countries want to use their satellites when they're not over India, they'll sell that capacity on. But they won't work just for foreign masters. Self reliance and independence from other space programmes are the name of the game. Their private arm is called Antrix and was founded in 1992. Its revenues are unpredictable because of the long-term nature of the business but it has made $500 million in the past three years.

The story of ISRO illustrates a mindset that we found often in publicly funded science in India: the idea that science and technology should be relevant to the needs of as many Indians as possible. Since Independence in 1947, the Indian government has seen key to the country's development. Nehru called science, 'the very texture of life' and declared that 'science alone… can solve problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening customs'. However this was a different vision of science to Ghandi's idea of 'every man a scientist and every village a science academy'. Nehru placed science in the hands of the complex of national laboratories of the Council for Scientific and Industrial Research (CSIR).

The CSIR was established in the 1950's and consists of a network of 40 laboratories, two co-operative research institutions and 100 extensions and field centres. It was the focus of reform in the 1980's when a set of government controls were introduced that required each lab to raise a third of their funds independently. The labs responded in different ways: the National Chemical Laboratory by doing contract R&D, Leather Research Institute by commercialisation of technologies and the Salt and Marine Chemicals Institute by renting out facilities and contract testing.

Prof Rishikesha Krishnan of the Indian Institute of Management in Bangalore has studied the effects of the reforms on the CSIR labs. 'Only between 8 to 10 labs are really performing as they should,' he tells us, 'there are quite a few at the bottom of the heap that should have been closed. Someone needs to bite the bullet and close them.' Although he regards the Director of the CSIR Mashelkar as a visionary, he believes he hasn't quite taken on the full challenge, only focusing on improving the excellent labs without taking into account those that consistently under-perform. The social implications of closure are just too politically undesirable.

Examples of CSIR labs

The Centre for Cellular and Molecular Biology (CCMB) in Hyderabad undertakes ongoing research in three major categories - high quality basic research in the frontier areas of modern biology, research relevant to societal needs, and application-oriented research towards commercialisation. (http://www.ccmb.res.in/)

The National Aerospace Laboratories (NAL) is a CSIR-funded R&D centre for civil aeronautics located in Bangalore. NAL has about 350 research staff and is equipped with wind tunnels and facilities for investigating failures and accidents in aerospace. (http://www.nal.res.in/)

The National Chemical Laboratory (NCL) is located near Pune. It has approximately 200 scientific staff working on polymer science, organic chemistry, catalysis, materials chemistry, chemical engineering, biochemical sciences and process development. It awards about 50 students PhDs each year – the largest number of PhDs in Chemical Sciences in India. (http://www.ncl-india.org/)

2.4 Universities in India

The top-level statistics about universities in India are staggering. According to the University Grants Commission, the Indian university student population is currently 9.2 million students. According to McKinsey, the management consultancy, the pool of young Indian university graduates (those with 7 years or less of work experience) is about 14 million. That is 1.5 times the size of China's and almost twice that of the US. This reservoir of talent is topped up by 2.5 million new graduates in IT, engineering and life sciences each year, 650,000 postgraduates and 4,000 – 6,000 PhDs.[16]

There is little doubt that the elite of India's universities are among the best in the world (see box for an introduction to the top level science- and technology-related universities in India).

Indian Institutes of Technology (IITs)

The crown jewels of the Indian education system are the IITs, created to train an elite of scientists and engineers after Independence. The seven IITs are located in Kharagpur, Mumbai, Chennai, Kanpur, New Delhi, Guwahati, and Roorkee. IIT Kharagpur was the first IIT to be established, in 1951. Each IIT is an autonomous university, linked to the others through the IIT Council, which oversees administration. They have a common admission process, the Joint Entrance Examination, to select around 4,000 candidates a year. At the time of writing there are about 15,500 undergraduate and 12,000 graduate students studying in the seven IITs. Part of their allure is the folklore that has built up around alumni of the IITs (IITians as they are known). These include Arun Sarin (CEO Vodafone), Vinod Khosla (co-founder of Sun Microsystems) and Asok, a character in Scott Adams' Dilbert cartoons.

The Indian Institute of Science (IISc)

IISc Bangalore was founded in 1909 by J.N. Tata. It provides only post-graduate education but is ranked as India's best research institution as measured by citations and impact of published papers. It has around 2000 active researchers working across almost all areas of science and technology.

IIMs

The Indian Institutes of Management (IIMs) are based in Ahmedabad, Bangalore, Indore, Kolkata, Kozhikode, and Lucknow. They award post-graduate diplomas in management (equivalent to an MBA). All the IIMs, although autonomous, are owned and financed by the government of India. They play an important role in the education of business people and entrepreneurs.

IIITs

The Indian (sometimes International) Institutes of Information Technology have been created to fill the gap in skills required by both multinational and Indian IT companies for highly trained computer engineers and programmers.

NITs

Originally Regional Engineering Colleges (RECs), National Institutes of Technology (NITs) began to be created in 2002 in an attempt to create greater capacity for elite science and engineering university places along the same lines as the IITs. Legislation being considered in 2006 will introduce new investment and standardised admission processes to the NITs in an attempt to create a uniform, prestigious education brand. There are currently 19 NITs, the latest being NIT Raipur.

However, the Indian system of education, like its society more widely, is divided. First there's the basic availability of university education. India spends 0.34 percent of GDP on higher education, a much lower proportion than the developed economies that it seeks to compete with.[17] As one CSIR laboratory researcher told us, "We would need 6,000 universities in India to reach the global average of universities per capita. We have about 300." Then within that there are further divides: "Our education system is extremely diverse in standards. At the one end you have the IISc's and IITs and at the other you have universities where the lecturers don't even have undergraduate degrees themselves."

And many of the best Indian students go abroad to university, particularly for postgraduate study. There were 80,466 students from India studying in US universities in 2005 for example, of which nearly three out of every four were postgraduates.[18] Financing education abroad is not a problem for a growing group of Indian students with loans being available at reasonably low interest rates and often no collateral required for loans of up to $16,000.

While he acknowledges the value that NRIs and returnees are bringing to business one professor told us, "The superstar academics aren't coming back." The incentives to work in an Indian university if you've made it in Europe or the US are almost non-existent. Chandar Sundarum of Microsoft also says one of the main challenges is finding motivated people to teach at schools and universities. One downside of the IT boom is that graduates can earn much more working for service companies than by teaching the next generation. On our visit to IIT Delhi, one of the most prestigious institutes, we were surprised to hear that they were unable to fill a number of academic positions.

Chandar Sundarum of Microsoft is also sober in his assessment of the curriculum taught by the Indian education system, "there's enough talent in terms of numbers" he says, "the question is one of quality". He talks about how easy it is to find people who have all the technical skills Microsoft need but how rare it is to find people who combine those skills with flair and creativity. Chandar blames this to some extent on history, "In India young people have traditionally been guided by the guru. They never questioned back. It was only much later in life that you did things for yourself."

Traditionally the role of universities in India has been limited to education and training. In some cases these lines are blurring, especially (or perhaps uniquely) in the case of the Indian Institute of Science (IISc) in Bangalore and the network of seven Indian Institutes of Technology (IITs). But R&D in universities is still very limited. The mid-term review of the tenth 5-year biology plan identifies a significant decline in R&D activities being carried out by universities due to erosion of the research base. Policy-makers are only now considering the concept of a research project as a part of the degree requirement for postgraduate courses. The limited role of R&D in universities has been blamed by some for the failure in the past of India to adequately industrialise R&D. One professor told us, "I believe in Solomon's Wisdom. That the greatest thing isn't money or strength but knowledge. I also believe it's much easier to turn knowledge into money than money into knowledge." He was cynical about attempts to link outside (particularly corporate) funders to CSIR labs because he felt it distorted the research.

Research and development in Indian universities is a very small part of innovation in India. Universities play a much more important role in producing the human capital necessary for India to become a global player in science and technology.

2.5 Private science and innovation

In the mid-1990's Philips had a problem. As their electronics were becoming more and more dependent on software, Europe was running out of programmers. They were finding they just couldn't hire people to work at Philips full-time and were having to buy in skills from a host of smaller companies, often based in a number of countries. Trying to co-ordinate development efforts across borders and languages was proving impossible.

They chose India as the solution to their dilemma. Bob Hoekstra (who set up the centre) tells us because out of the 3 'I's (Ireland, Israel and India) the countries with large enough numbers of low-cost highly trained software developers, India had demographics on its side 'moving to Ireland or Israel would have been like trying to take a long-haul flight in a plane that can only make it up to 3,000 feet – they'll soon run out of people. Whereas in India half the population is under 25.'

From day one, the aim was to create a centre that was the equal of Philip's R&D in the Netherlands. 'That doesn't happen overnight though' says Bob pulling out a diagram and showing us the ten-year plan for the centre and teams working on specific technologies. It starts at a very basic level. 'Give or take a year or two it takes 10 years to get to the top level' he says. 'The main competitive advantage of India is that you can scale up R&D very quickly, not that you can go straight to the top of the value chain'.

In *India Unbound* Gucharan Das admits exasperation that ever since 1991 *The Economist* has been 'constantly trying to paint stripes on India' – but India is not, and might never be an Asian tiger. Instead he turns to the over-used metaphor of the elephant: 'It is an elephant that has begun to lumber and move ahead. It will never have speed but it will always have stamina.' Liberalisation may not have been immediately radical but its effects have been all pervasive on India's culture, business and global confidence.[19]

Over 100 MNCs have set up shop in India. In many cases they are involved in R&D, but critics claim this is mainly 'blue-collar' R&D. In pharmaceuticals and agrichemicals R&D–to-sale ratios of many companies grew from less than 2% in 1990 to almost 6% in 2004, indicating the growing prominence of R&D activities in these sectors. [20]

The list of multinationals which have set up R&D centres in India includes General Electric, Microsoft, IBM, Cisco, Intel, General Motors, Astra Zeneca, Motorola and Texas Instruments. The best-known Indian R&D companies are in pharmaceuticals — for example Ranbaxy, Dr Reddy's Labs and Sun Pharma. Biotechnology is one area of rapid development, with Biocon and Shanta Biotech leading the way. Reliance Life Sciences is recognised by the US National Institutes of Health for stem cell research.

As an indication of the level and distribution of R&D underway in the private sector in India, of the 1,216 patents filed in 2004, 1,108 were filed by MNC development centers, while Indian companies account for just 104. Similarly, for among 336 patents granted, for which data is available, 327 were granted to MNC development centres.[21] This means only 9% of the patents filed in India are from Indian companies.

Information Technology and Mobile Telecoms

Indian software exports grossed US$12 billion in the financial year 2004–05, up from US$ 9.2 billion in 2003–04, indicating growth of 30.4 percent for the year. IT exports are predicted to account for 35% of the total exports from India in 2008. By 2008 India is also expected to have overtaken Japan as the third biggest mobile market in the world after China and the US. By 2010, India is expected to have over 20 million 3G subscribers.

Despite the meteoric success of IT in India it has been the site of very little R&D expenditure. There are around 3,000 IT companies in India today, and the Indian IT industry is currently exporting to 150+ countries across the globe. But even the now globally renowned Indian software giant Infosys spends only 0.86 percent of its sales on R&D.

Pharmaceuticals

The Indian pharmaceutical industry is in line to become one of the top ten global markets in the next few years, already holding 13th place in the global league table. It achieved sales of almost $4.6 billion in 2004, with indications that this will reach $8.3 billion by 2009, an increase of 80% in 5 years.[22] India's 10 largest drugs firms invested $142 million on R&D in 2004. According to a recent report, 37 drug candidates are currently in development.

But the Indian pharmaceuticals industry is not attempting to imitate the model of Western Big Pharma (company participation and control of every stage of research in the hope of finding blockbuster drugs). As Swati Piramal, Director of Strategy and Communications for Nicholas Piramal Pharmaceuticals in Mumbai explained, the inspiration for the future model of pharma research in India is far more likely to come from Michael Dell. To cut costs, time and enhance opportunities, research

and the rest of the innovation chain should be carried out in many different parts of the world.

Biotechnology

In March 2005 Kapil Sibal, the Indian science minister lauded biotechnology as the "best batsman" in his team and argued that it would be the "next big success story" in India, vital to the future of affordable health care and the alleviation of poverty. [23] Yet biotechnology is only at the start of its research career in India, '*a 2- to 3- year old baby*' according to one pharmaceuticals CEO we spoke to. The industry is growing rapidly though. In 2004–5, the revenues of India's biotechnology sector grew by 37 per cent to $1.1billion (£600million)[24]. The National Biotechnology Development Strategy set a target for increasing that figure to $5billion by 2010[25].The strategy includes an open door for foreign direct investment into the sector which should make India more attractive for contract research, clinical trials and validation studies for multinationals.

Nanotechnology

India was a late starter in nanotechnology, but a rash of activity began in 2001 with the launch of the government's Nano Science and Technology Initiative. India is still well behind the leading pack in terms of government investment, allocating $4 million for this field in 2002 compared to $200 million in the same period in China. So far around $24 million has been spent through the NSTI, largely on infrastructure and basic science projects. From the second half of 2006 the nanotech initiative will expand and be subsumed into a national nanotech mission plan investing $200million over the next five years in areas such as nanotube based solar power cells, diagnostic kits and drug delivery.[26]

Thus far there is limited evidence of a vibrant private sector in the field. One exception is Yashnanotech, a company that collaborates closely with UK-based Cientifica, who announced a joint venture in May 2005 to "turn India into a nanotechnology superpower", cooperating to provide services spanning the nanotechnology value chain[27].

Some sectors in India, like pharmaceuticals, are experimenting in new models of global discovery and innovation that are setting even private-sector science and technology on a path to global integration, which follows the worldwide example of India's IT success.

However, perhaps even more revolutionary than the growing global interdependence of Indian science are the growing connections at a national level between different parts of the 'innovation system' – between education and research, and between science and wealth creation.

Bob Hoekstra at Philips tells us collaborations with universities are at a much earlier stage in India than in Europe. They have just funded their first professor - effectively a chair in 'bottom of the pyramid' studies at the Manipal University – to look at the potential of cheap screening technologies to improve healthcare in India. Hoekstra is proud of this but says it's small fry compared to 46 professors Philips has funded in universities in Europe.

The last few years have seen growth in cross-sector links, particularly between universities and enterprise, although this doesn't yet happen on the same level as in American universities. One of the academic organisations encouraging students to be entrepreneurial is the Indian Institute of Science (IISc) in Bangalore. The university has a special unit called the Society for Innovation and Development (SID), which aims to encourage the next generation by fostering close links between the students and industry. Professor S Mohan, CEO of SID, says the aim is not just to prepare students for jobs at big multinational companies. He told Silicon.com, "We want to see our students motivated to become entrepreneurs."

The entrepreneurship centre opened in 2003 and provides free consultancy advice from Ernst & Young for IISc students who form a start-up as well as giving them free office space and computers, internet access and telephones. Private-sector companies can also rent research lab space in the centre. Indian IT company Satyam has a dedicated innovation facility there with around 20 people while Cookson Electronics has a lab looking into electronics assembly and packaging using non-toxic materials.

2.6 Start-ups and venture capital

Vijay Anghadi is one of Bangalore's growing group of venture capitalists. His large office decked out with luxurious leather sofas is in a residential area outside of central Bangalore. He says he used to base himself in the city centre but the traffic got too bad and now he is just a short ride from his house, a much better solution.

Prior to 1990, the prospect of a venture capital industry in India was utopian. A complex bureaucratised economy, commitment to socialism, and a business community wary of financial risk provided poor raw materials for a venture capital industry. Due to the high concentration of R&D within government it is perhaps unsurprising that the first venture capital initiatives arose in the public sector and venture capital policy guidelines were first issued as late as 1988. Effects were very limited, since only small investments were permitted.

The processes of economic liberalisation that began in 1991 has facilitated a transformation in the economy into a genuinely global force. Even the youngest start-ups seem to have an innately global outlook now, where this was an inconceivable only 20 years ago. The 20-million-strong diaspora of Indians spread around the globe, once regarded as deserters, are now playing a bigger role in India's scientific future than ever before. As science attempts to solve more difficult problems scientists become more specialised and equipment becomes more advanced. International cooperation becomes necessary rather than just desirable.

From 1995, overseas private investors, most notably in the early years from Silicon Valley played a major role in Indian venture capital. Anghadi agrees that the non-resident Indian population's desire to come home is making a big difference to the start-up culture in India. He describes their lifestyle: "They're happy spending half their time in each country" he says "whether that's a month here and a month there, or 15 days of each month in California and 15 days in India."

Bureaucratic obstacles to the venture capital industry remain significant. Currently, only six industries have been approved for investment: software, information technology, pharmaceuticals, biotechnology, agriculture and allied industries.

By 2001 there were 70 venture capital funds operating in India, with US$5.6 billion (29 billion in US$ PPP) in assets under management. VCs include public sector banks, private venture capital firms (eg IL & FS Venture and Walden International) and government agencies such as the Technology Development Board.[28]

NASSCOM have tracked the rise in venture capital in India since the mid-1990s. From $10 million in 1996-7, investment grew rapidly to $1.2 billion in 2000-01. India broke the billion-dollar mark less than a decade after significant amounts of technology investment started to flow into the country. Venture investment is down since the peak of the technology bubble, but it remained nearly $800 million in 2003 (calendar year).[29]

Vijay Anghadi describes India as "The Last Bus to Asia" for investors because China, Korea and Singapore are all saturated with financial institutions and venture capitalists. "You can still just about come to India as a new entrant and make money. It's an investor's market." While Anghadi bemoans

the lack of business talent in India he admits that there are more companies to invest in which he believes will be successful than he has the time or resources to investigate and invest in.

However the environment is not supportive, especially according to IIM Bangalore Professor Rishikeshakrishnan, if the company is working on a genuinely new technology or process. 'On paper, there are a lot of VCs, but they are far too cautious to support real startups.' There have been efforts to change, the creation of business incubators for example. There is a genuine recognition of the need to put business in touch with technology and science, but the government don't know how to support it, 'We might have the schemes on paper, but they don't really operate like that.'

'There's a lot of talk about the knowledge economy, but the biggest impact has been from folklore, stories of people who made it big in Silicon Valley. People now know that you need high-tech entrepreneurship to facilitate economic growth.'

None of the students we talked to thought they would be entrepreneurs in the near future, setting out on their own to build a business empire. "What if you thought you had the next Windows?" we ask. Then we'd go to the States they say, the support for entrepreneurs is much better there, better venture capital. Just look at Sabeer Bhatia (the creator of Hotmail). It's no accident that although he grew up in Bangalore he made his millions in Silicon Valley.

If they are going to be entrepreneurs they will do it in 20 years' time. When they're older and wiser and have money to invest. But now they are happy working for the big firms and don't mind whether they're international firms like Microsoft or Indian like Wipro or Infosys – the important thing to them is to be doing interesting work and they'll choose where they work on that basis. They don't have any desire for a job for life. They know that if they work in one place and prove what they can do, they can move a few years later to get better money and stay at the cutting edge.

Summary of key points in chapter two

- India has a strong scientific heritage.
- Publicly funded research and development accounts for the majority of science undertaken in India. Other sources are expected to grow in the future.
- While the overall number of science and engineering students graduating in India is very high, there are questions over the quality of the

education they receive, which varies widely. There appears to be a shortage of good academics and university teachers in the country.

- Private research and development has not traditionally been strong amongst Indian firms. MNCs moving to India are setting up R&D labs now though, some of them comparable to European and North American facilities.

- Links between different types of research and development (for example between universities and the private sector) are weak compared to Europe or America.

- Venture capital is a growing but underdeveloped sector in India. The start-up culture is not as strong as California or other leading innovation centres.

3 The future of Indian innovation

So far we've looked at recent developments in Indian science and technology. The picture of science in India that emerges is:

- Strong support from government for research and development through publicly funded institutions such as the CSIR.
- A large pool of educated young people, with mixed levels of quality of education
- Some highly talented scientists and engineers, either trained in the elite of Indian universities or educated abroad.
- A very small number of excellent university research departments
- Growing investment from MNCs in research and development centres in India
- A mixed picture of entrepreneurship, with technology start-ups usually led by older returnees and NRIs
- A gradually improving venture capital environment

This chapter attempts to draw out what these developments might tell us about future models of Indian science and technology before they happen. These are trends or emerging models of research and development and innovation that will have increasing importance in the next decade or so. We return in a later chapter to examine how Finland could make the most of the opportunities these trends in India present.

3.1 From coolie to creative

Anil Ghosh has a small clean and tidy office not far from the entrance to the building. He's wearing a chemical stained labcoat and has wispy grey hair and thick glasses. He's small and slight but has a powerful voice and manner. When anybody else enters the room from the company, there's no doubt that Ghosh is in charge. He grills us about our project, why we're there, what it's going to achieve, and tells us that he's fed up of delegations coming to see him wide-eyed at what Chemgen Pharma has achieved and how advanced they are. He tells us how he was awarded an NSF grant for his work at MIT in 1977, "I could compete with the best then so why don't people think I can compete with the best now in India?"

In his early career Ghosh worked in university labs and for a number of the large drug companies in Europe and America on drug discovery. He says that even then he knew he wanted to start a research lab in India, it was just that at the time he didn't know how.

He tells us that he also founded Chembiotek, another Contract Research Organisation (CRO) company just down the road. He left and started up again because he wanted to move up the value chain, he wanted to be doing more advanced research and eventually to be developing new drugs and owning the intellectual property. "I knew I wanted to have a better lab than Glaxo" he says with a smile.

"In this business, imagination is just as important as knowledge" he says, and that is where the Indian education system is letting down the future of science and technology in the country. But he has no doubt, India will become a new centre for drug discovery and he will make a lot of money out of it.

The last ten years have seen India gain greater access to learning about all parts of the value chain. This is partly because the Indian middle classes have attracted the attention of almost every global consumer company and will continue to do so. It has been estimated that the affluent consumer market in India grows by nearly 20 million people per year. This makes small amounts of growth in consumer markets in Europe and North America pale in comparison. There is money to be made, especially if you can establish your brand and good reputation early. The decision by multinational consumer brands to begin operations in India was described to us as a 'no brainer' more than once. This means that as well as shifting back-office and manufacturing to India, most consumer MNCs have marketing and strategy personnel in India – India is as much a shop-front as a factory.

Even if it is taking place informally and outside of particular companies, this increasing concentration of knowledge in India about an increasing array of business stages is strengthening Indian potential for developing new successful technologies to be sold either at home or abroad.

One indicator of this is that design in India is beginning to take off as well, as MNCs discover the inexpensive but well regarded consultancies such as Elephant Design. The Indian government is also increasing funding of the National Institute of Design. The commentator Niti Bhan writes, "In the international economy, China is a commodity player. India's promise lies in its control of cultural particulars. And by this I mean, India understands and participates in the culture of the First World West in ways China does not."

These are all examples of India moving up the value chain and increasingly taking control of the creative elements of developing new technologies, over and above the 'coolie' tasks epitomised by manufacturing, call-centres and contract research. While the more mundane, lower value services have fuelled Indian economic growth and . In the next ten years we can expect India to increasingly move from 'coolie to creative'.

3.2 Global Indians

Rakesh Mathur is a global Indian. Rakesh is in his mid-forties and a graduate of the Indian Institute of Technology in Mumbai. He left Intel to strike out on his own in the early 80s. His most successful venture, a comparison-shopping service called Junglee, was acquired by Amazon in 1998 for $241 million. Since then, he's been a founder of three technology start-up companies and has been an early stage investor in several other companies.

His current ventures include Webaroo, a start-up due to go public in spring 2006. Rakesh tells us that he felt it was more important than ever before that he run his newest venture from India. 'It's the cost and the leverage most of all I suppose; here, if you raise $5 million you can make five times the mistakes!' Rakesh has big ambitions for Webaroo – 'Webaroo will be a really disruptive force in the search market, where there are a lot of incumbent players – it will revolutionise search on the mobile.'

Rakesh visits India at least once a quarter, and is proud to have 'hired more IITians than Bill Gates in the past year!' He says the software story in India isn't really the phenomenon that people think it is. 'So far India has just been grabbing the low-hanging fruit – but Indians are realising that this isn't the most juicy! Now things are being invented here for the first time – we need to ignore the washing machine stage that has been so profitable for China, and concentrate on the rockets and anti-gravity boots!'

Global Indians like Rakesh are an important factor in the country's success. There are an estimated 20 million Indians outside the country, which is a small percentage of the total population, and an even smaller group are what could truly be called global Indians, travelling widely and with strong networks

into innovation networks, but they have a large impact in finance, entrepreneurship and research and development.

Continental Airlines started direct flights between Newark and Delhi on 1 November 2005. American Airlines began direct flights between Chicago and Delhi two weeks later on 14 November. Delhi to Chicago becomes the longest direct flight in operation globally, requiring two sets of pilots (one set sit in first class until half way through the flight) to get around working time agreements which normally prevent any flight over 12 hours. Use of Boeing 777 planes, where much of the planes is adapted for business and first-class accommodation suggests that airlines are aiming the flights directly at multinational companies. American suggested during the buildup to the inaugural flight that they expected most of the standard-class seats to be filled by people of Indian origin visiting family or traveling as tourists.

Finnair's first direct flight from Helsinki to New Delhi began in November 2006, further opening up Finland to the potential flow of global Indians. However Indians living in Finland that we met said there had been times when they felt uncomfortable and they thought there were many barriers to Indians living in Finland, even for short stays of a number of months or a few years. Unlike the UK or other large European countries, Finland doesn't have the critical mass of Indians to foster a thriving community and develop a unique Finland-Indian culture in the same way as an Anglo-Indian culture has developed in the UK.

Non-resident Indians (NRIs) used to be regarded as deserters in India. Now this group carries a huge burden of hope and expectation as the social class which will transform India. They are providing otherwise rare leadership and management skills, financial and risk capital and success stories that are driving momentum in Indian science and innovation. Where other countries rely on an innovation system linking research to business, India relies on an innovation cadre – a diaspora of global Indians. And as wealth in India increases and more and more Indian firms play on the global stage, the number of global Indians is sure to increase. They may only be numbered in the thousands but global Indians play a disproportionate role in innovation and will continue to do so.

3.3 The fortune at the bottom of the pyramid

The changes sweeping though India are yet to make an impact on the lives of most Indians – the bullock cart drivers and families living beneath plastic sheeted tents on the side of the road. About 390 million people in India live on less than $1 a day.[1] For them India is largely standing still.

In his book *The Fortune at the Bottom of the Pyramid* C K Prahalad writes about the potential for companies to develop products and services that are affordable and appealing to the hundreds of millions of people with an income of just a few dollars a day. This requires a very different model of innovation on the part of companies and researchers.

One example is Hindustan Lever Limited (HLL) who set out to tackle social problems in India while making profit by developing new approaches to marketing. 2 million children die each year from diarrhoea but a simple prevention is available which could reduce the death rate by 50 per cent – washing hands with soap before eating. HLL developed dyes that show up bacteria under UV light and so could go to villages and show the difference between washing hands using contaminated water and using soap. They went into schools and showed children what a difference soap made to hygiene. As Prahalad writes: "The children became the activists and the advocates of good and healthy practices at home and HLL reaped new profits."

Thus far 'The Bottom of the pyramid' has perhaps not yielded the breakthroughs that some expected and the number of products and services that cater for the full 1.1 billion Indian citizens is very small. However, the logic of the argument still holds and as research and development increasingly relocates and grows in India, closer to the people who constitute the bottom of the pyramid, more socially conscious yet profitable innovations will be seen.

3.4 Redistributive business

The LV Prasad Eye Institute (http://www.lvpei.org/) has an unusual financial model for its work. The premise is to charge for some treatments or services in order to pay for treatment for poorer patients. So the clinic uses the money generated by completing operations and treatments on rich patients from outside India to perform vital cataracts operations on poor Indians.

Health tourism is seen as a growing market, especially in India. According to a study by McKinsey and the Confederation of Indian Industry, medical tourism to India could become a $1 billion business by 2012.[31] More than 200,000 overseas patients were expected by the end of 2005 for major operations, sometimes for a fifth of the cost they would be at home. Bangalore's Narayana Hrudayalaya, a specialist cardiac outfit, is building a 'health city' with 5,000 beds spread between 10 hospitals in Kolkata and Bangalore.[32]

A recent article in Wired magazine points out that pharmaceutical trials are becoming popular in India. With such a large population finding large enough groups with particular characteristics is easy. The law used to be that drugs had to be tested in their country of origin before clinical trials could be undertaken in India but that law was changed at the beginning of 2006. The fees obtained

for clinical trials are then ploughed into local healthcare for poor Indians. It is another example, albeit a more controversial one, of a growing trend of using the demand for products among the rich to benefit the Indian poor.

3.5 Indian IQ for Indian IP

Behind Srini Rajam on the wall of the Ittiam boardroom are two certificates he is proud of. Ittiam were chosen as one of Red Herring's top 100 Asian Companies in 2005 and are the world's most preferred Digital Signal Processing company – that's the electronics and software that makes portable devices like digital cameras, video players and mp3 players work. In front of Srini on the table are a selection of toys he has ready to show us. He scoffs at the iPod we're using to record the interview. "I hate them" he says with a laugh "Our player is much better than theirs".

A phrase we heard a number of times was 'Indian IQ for Indian IP'. This is the driving force behind companies such as Ittiam who don't aim to do any manufacturing, instead they develop technologies and then license their inventions to household brands. Their USP is speed to market. If a manufacturer like LG or iRiver wants to develop a new product, they can either set off on their own R&D which might take two years or they can license Ittiam's technology which they could have in the shops in months. In such a fast moving arena as consumer electronics, more and more companies are choosing to use Ittiam.

Srini had a long career with American giant Texas Instruments, who were the first of the Indian tech companies to open up in Bangalore back in the 1970s. He progressed through the company, working in the US and then returning to India to eventually become Managing Director for TI in India in 1995 – a role he held for 5 years. But he knew what he eally wanted to do and in 2001, with six other colleagues he set up Ittiam. "We wanted to do something that was beyond just entrepreneurship. We thought that India needed to create giants of its own. That it needed companies with drive and passion, even nationalism."

The history of the generic drugs industry in India shows how intellectual property rules can shape business success. Exports by Indian companies to Africa, especially Cipla and Ranbaxy, helped drive the annual price of antiretroviral treatment down from $15,000 per patient a decade ago to about $200 in 2005. They also simplified therapy by putting three AIDS drugs in one pill.

In a piece for the Wall Street Journal, Richard Wilder and Pravin Anand claim that, "India is rapidly evolving into Asia's innovation center, leaving China in the dust. Its secret weapon? Intellectual property-rights protection. In recent years, New Delhi has taken big steps to protect these rights, and the results have been dramatic."

The battle for the neem tree

Neem is a fast-growing tree in the same family as mahogany, native to India, Vietnam and Laos. It has been used by Indians for its medicinal and health providing properties for centuries.

However, several patents on the use of neem were taken out by international companies and this led to an international group, spear-headed by the Indian environmentalist Dr Vandana Shiva, taking the case to the European Patent Office, claiming you can't patent ancient knowledge, and calling it 'bio-piracy'. She told the BBC, "We wanted to reveal what bio-piracy is, this patenting of indigenous knowledge and bio-diversity. We thought a patent that's held by the biggest superpower of the world and one of the biggest chemical giants would be an effective patent to take on." The patent was revoked in 2005.

The question is what is the best way for the value of the neem to be spread to ordinary Indians? Dr Ramesh Saxena, head of the Neem Foundation in India, has pioneered the use of neem as a natural pesticide in South Asia, the Philippines, East Africa and Australia. He believes it can have an impact on some of world's greatest problems including malaria, dengue fever, Aids and human population growth. However, he warns that India has to act fast to realise neem's potential and profit from it as China and Brazil are rapidly overtaking India, each cultivating millions of neem trees each year.

The clash between different groups over the best route to reap the benefits of India's intellectual property can seem paradoxical to outsiders and is still in flux. We can expect further change in the years to come.

3.6 The risks for the future of India

Just after 6pm on Tuesday July 11th 2006, seven bombs ripped through the metal carriages of commuter trains in Mumbai. 179 people died. The world condemned the terrorist attacks and the Prime Minister blamed "elements across the border" in Pakistan for financing and organising the attack. Just a few months before, explosions had rocked the holy capital of Varanasi in the north-east of the country. And just a few months before that on December 28th 2005, one scientist was killed and four injured at a conference at the IISc in Bangalore when gunmen jumped from a white Ambassador car and started firing at random using automatic rifles. An unexploded bomb was also found nearby.

India is a country of paradox and tension. All political and economic debates have to be approached in the context of inequalities and ancient rivalries between different ethnic and religious groups. While a democracy, India is a delicate one. Crime and corruption are rampant in some walks of life. Politics is fought bitterly and varies widely across the country. Policy in one state will almost certainly not be the same as any other.

Multinational companies choosing to operate in India do so with much greater uncertainties – both political and economic – than they would investing in facilities in Europe or North America. This has to be borne in mind when considering the opportunities and positive story about India's future.

There are a series of weaknesses in the Indian situation that Finnish businesses and policy makers should take note of:

- India has little experience of commercialising ideas from the point of conception. It has no clearly established path from idea to market and a history of little or no disruptive innovation. It is difficult to think of world-beating products invented in India.

- Not all Indian educations are created equal. Many universities are far from adequate, some even with undergraduate lecturers.

- India's demographic boon could turn to crisis if handled badly due to its collossal poor underclass. As Newsweek noted, "The country might have several Silicon Valleys, but it also has three Nigerias within it, more than 300 million people living on less than a dollar a day. India is home to 40 percent of the world's poor and has the world's second largest HIV population."

- There is still a great deal of bad regulation and red tape in India. It is difficult to start a business, there are difficulties hiring and firing and soft loans for entrepreneurs are very difficult to obtain. And then there's corruption. As the Newsweek article noted recently,"Nearly a fifth of the members of the Indian Parliament have been accused of crimes, including embezzlement, rape and murder."

- What you see isn't what you get in India. Contradictions as standard, statistics unreliable, hard to fathom and to plan for – why so many MNC R&D heads are returnees, difficult for outsiders to understand.

- Infrastructure is still a huge issue for India. In cities such as Bangalore, the roads and utilities are almost unusable in places. It takes decades for improvements to be made.

- Only a nascent environment for entrepreneurs – little acceptance of young ones – and to bring numbers up to critical mass but still very difficult conditions for entrepreneurs.

Summary of key points in chapter three

- There are a number of emerging models of innovation that could become increasingly important in further driving India's success:

- From coolie to creative: India will increasingly move up the value chain away from simple out-sourcing into high-value-added roles.

- The global Indians: highly educated and mobile Indians with overseas degrees and experience with MNCs will create new enterprises and drive innovation

- The fortune at the bottom of the pyramid: increasingly products and services to tap the market of hundreds of millions of poor Indians and aid development.

- Redistributive business: research and development which uses revenues from supplying services to rich Indians and foreigners to provide free services to poor Indians is on the increase.

- Indian IQ for Indian IP: Indian entrepreneurs are increasingly keen to own their own IP and even build businesses based on purely IP models.

- Despite these emerging innovation models, India also has a series of problems that could undermine its future success and which should be noted by Finnish business people and policy-makers.

4 How other countries are working with India

Here we outline the approaches of some other countries in dealing with India and attempt to draw out the main features of models of collaboration they use.

4.1 France and India

The French model of collaboration is more 'top-down' than most. It involves the establishment of joint centres for research where everything is split 50:50. Perhaps the most high profile of these is the Indo-French Centre for the Promotion of Advanced Research, which was set up in New Delhi in 1987 as a joint and equally funded project between the Indian and French governments. It supports and finances joint research projects, bilateral workshops, seminars and exchange visits, bringing together scientists from the two countries. The current director is Prof. Shiva Prasad who was previously at IIT Mumbai.

The Centre has so far received 700 project proposals, of which 250 have been accepted. These projects have resulted in more than 1,700 exchange visits, nearly 1,200 research papers published in international journals and more than 100 PhD theses. Four patents have been granted from two of the projects. The projects have also offered more than a hundred post-doctoral positions in French institutions to young Indian researchers.

The French government established wider and longer-term collaborations in 2004. Of the ten laboratories announced, six were set up in Bangalore, involving water science technology, organic chemistry, solid state chemistry, mathematics, bioinformatics and IT.

4.2 The United States and India

In 1987, the United States and India established a $110 million "Rupee Fund" to promote and fund science and technology collaboration and educational and cultural exchanges. That fund continued until 1998. Negotiations about deeper collaboration broke down in 1993 over disagreements about the intellectual property regime in India

The Indo-US Science and Technology Forum, established in 2000, explores and identifies fruitful areas of cooperation by sponsoring workshops, scientist exchanges and meetings.

The governments signed their most recent treaty – the Science and Technology Umbrella Agreement – in 2005. The agreement is designed to accelerate cooperation between Indian and US scientists working in government agencies, the private sector and academia and includes support for basic sciences, space, energy, nanotechnology, health and information technology. The agreement was touted by Secretary of State Condoleezza Rice as, "another dramatic illustration of the fast-growing bilateral relationship we are building between the United States and India."

Silicon Valley is the main channel for scientific and technological links between India and the USA, closely followed by the Boston area.

Networking among Indians living and working in the Valley is thought to be strong factor behind their success. Indian professionals began utilising their networks in the 1990's through groups like The Indus Entrepreneur (TIE). TIE has been an incredibly successful networking organisation which has assisted with the creation of businesses with market values of over $200 billion. Although founded in Silicon Valley, TIE has now spread to nine countries across the world.

4.3 Sweden and India

2005 saw a week-long visit to India by a 40-member delegation of Sweden's leading companies and universities. The visit was organised by the Royal Swedish Academy of Engineering Sciences. King Carl Gustaf was part of the delegation in his capacity as patron of the Academy.

Sweden has taken what might be called an 'average' approach to building relations with India with a steady flow of delegations and a small number of formal collaborations between academics or businesses in both countries.

4.4 The UK and India

Lord Patten, Chancellor of Oxford University travelled to India in March 2006 with an explicit mission to recruit more Indian students to study at Oxford, one of the UK's most prestigious and highly-performing universities. The first Indian students came to Oxford way back in 1871 and there's a long history of good students since, but in recent years Patten feels that Oxford (and the UK more generally) has slipped behind in attracting Indian students. Many more Chinese students come to Oxford than Indian students and the UK is slipping behind compared to the US, Singapore and Australia. "One of the problems in India is that we have a rather conservative, stuffy image. People do not realise the flexibility and modernity of our courses," Lord Patten said.

He went on to say, "I am particularly keen to establish in our business school a centre for the study of Indian business. Secondly, we do want to promote more collaboration with Indian institutions. We do a huge amount at the moment in the field of health -- on cancer, infectious diseases, chemistry -- but there's much more we could and want to do."

British universities offer around 600 scholarships for Indians to study in the UK each year. Many UK universities advertise and organise tours of Indian colleges and universities. Not everyone is complimentary about this model of attracting students. The most striking feature of UK universities at the moment, an evident source of frustration for those academics and admissions tutors interviewed, is how forcefully they prospect for students in India. As one Indian academic told us, "There are a huge number of Indian students coming to study ropey degrees at old polys in the UK to subsidise students from the EU. Very few Indian students study at the good universities – there are only 169 in Cambridge! It is a danger and must be recognised as a major threat to the reputation of UK education in India. If we carry on like this are we really going to get another science visionary, another Mashelkar (Director General of CSIR) coming from a UK university?"

There are less high-profile success stories of Indians gaining a UK based education. Even Arun Sarin, current chief executive of Vodafone and one of the UK's most high-profile Indian business people born in India, undertook postgraduate study in the United States, not the UK. The UK doesn't offer the same image as a place where people go to dramatically improve their employability - a vital aspect of a foreign education for the most talented young Indians, especially those who may go on to work in high technology and science-based companies.

It is difficult to measure the real extent of collaboration between India and the UK outside of student numbers because so much activity is decentralised and informal on both sides. However, the measures we do have show no room for complacency in the UK about the future of its collaboration with

India. India is well placed to increase its presence in global collaborative research, whilst rapidly improving capacities make it an increasingly important scientific partner. Whilst Britain had the monopoly on collaboration during colonisation, in recent years it has been dramatically challenged by India's capacity to forge scientific links with other countries. New models of collaboration such as the UK India Education and Research Initiative (UKIERI) mark positive progress, but it is questionable whether the UK is working rapidly enough and exploiting the most effective opportunities.

5 The future of collaboration between Finland and India

5.1 The advantages of India

This chapter makes a series of recommendations to Finnish policy-makers about how to make the most of opportunities that India presents for Finland's future. There are three categories of action that need to be taken to build collaborations between India and Finland:

- Cultural foundations: activities to build awareness and acceptance of Indian culture in Finland and Finnish culture in India.
- Network building: facilitating the meeting of Indian and Finnish scientists, engineers and entrepreneurs.
- Practical initiatives: funding and facilitating direct particular collaborations in an instrumental way.

Before we outline those opportunities though, we should return to an important question: why collaborate with India as opposed to other countries? India has a series of advantages:

As a potential market for Finnish exports and services: as China's population is predicted to start to contract within the next 30 years, India's is predicted to continue to grow. India, it is thought, will become the most populous nation on the planet by 2030. India's so-called 'middle class' of consumers and educated workers grows by 20 million each year.

Because it offers a highly skilled complimentary science and technology workforce: as skills in Europe become short in supply, India will increasingly offer options for European companies. India's huge graduate pool is boosted by over 2.5 million graduates in science, IT and engineering annually. The number of enrolments increases year on year. At the top end of the education market, graduates like those from the Indian Institutes of Technology are sought after worldwide.

Because doing science and innovation is cheaper in India. There are currently around 150 multinational R&D centres in India benefiting from this attribute, which has been a driving force in outsourcing success. Drugs trials can be undertaken at only 60% of the cost in the West. This brings advantages of speed to Indian science, and the addition of increasing quality of manpower and science, is a powerful competitive cocktail. So far this has been limited to lower reaches of the value chain such as call centres or contract research, but as time goes on and India "learns as it earns", Indian companies will offer high value services as well.

Innovation in India could be disruptive as well as incremental: While it is difficult to point to disruptive products from India, the IT services model of Infosys and Wipro has transformed business processes across the globe. While there are many weaknesses to the Indian innovation system, it is well connected to key sites around the world such as California, Singapore and London. In small pockets, it has access to all the resources necessary for creating and commercialising world-beating innovations. While it is always impossible to predict where disruptive innovations will come from, India is a strong candidate.

India is the world's largest democracy and remarkably stable. Despite the fact that it is not the most utopian exemplar of democracy and corruption is rife, India has a colossal amount of soft power with Western nations. India is a champion of multilateral institutions, making it a favourable partner at the global level, whilst the US push to 'counterbalance' China with India gives the country a status that the rest of the word finds impossible to ignore.

India's enormous civil society pushes scientific debate into the public eye, forcing scrutiny, but also attempts to engage the masses in understanding the effects of scientific decision making and activity. Many would argue that freedom is a critical requirement for innovation.

Because India's diaspora connects science and technology globally. More than an international network, the worldwide web of Indians comprises over 20 million people – four times the population of Finland. A significant proportion of these are highly skilled professionals and scientists. They are driving innovation and entrepreneurship in India,

returning to the country in significant numbers to provide leadership and management experience, creating waves in the upper echelons of Indian science that are beginning to spread throughout the system. What is important in this story is not just the reversal of brain drain to brain gain, or even the beginnings of "brain circulation," it is the constant and multiple connectivity that is driving Indian capacity for innovation and entrepreneurship and becoming a significant source not only of scientific influence, but political and economic power too.

India has an intellectual property rights system that works. India has proven a growing capacity to conform to global standards of intellectual property rights, particularly since the adoption of WTO TRIPS regulations. India also boasts an independent judiciary. What is interesting in India is not only the ability to conform, but also to challenge global norms of IP, through, for example, the creation of systems to protect huge swathes of indigenous knowledge.

India has an increasingly dynamic private sector. Faced with gradually increasing global competition since liberalisation in 1991, certain sectors are beginning to undergo an innovation overhaul. Particularly interesting sectors include pharmaceuticals, which has seen a 400% rise in R&D investment in the last 5 years.

5.2 Cultural foundations

The first step in enabling Finland to grasp the opportunity that collaboration with India presents is to build understanding between the two countries. It may seem obvious but it is important to note that there are two sides to this:

- A greater awareness of India in Finland
- A greater awareness of Finland in India

The contrast between everyday life in India and Finland is very high. Knowledge and awareness about Finland in India is at a very low level. According to people we spoke to though, Finland has the advantage of not having a negative image in India. "It's very exotic to an Indian," one Indian in Helsinki told us, "If they know anything, it will be something about Santa Claus, snow and the midnight sun."

Indians with some knowledge of the country have a perception of Finland as very dominated by the state. They see it as difficult to navigate a very

well organised, efficient welfare state, which although fair, has many rules. The need for your social security number. They find health and education systems difficult to understand compared to the chaos of India. "I've been to the US and the UK, but it was only when I came to Finland that I really felt I was in a country foreign to India. If there's a journey that's the definition of 'culture shock', it is surely the one from India to Finland."

However, Finland has a number of advantages over other European countries when it comes to building links to India in the future and it should promote its image in India to project these:

- **The prevalence of English:** a number of Indians we spoke to in Finland said they were "able to get by" in a way they have found difficult in other European countries because English is widely spoken. "Even if the person you are speaking to doesn't speak English, you know that somebody nearby will," one told us.

- **High standards of living:** Helsinki in particular is seen as a desirable city to live in and comes high in rankings for liveability. For a growing group of middle-class Indians the environment they live in and the availability of culture, fashion and music is becoming important.

- **Egalitarianism:** Finland's reputation as a country that values equality will play well in India. This may be especially true among young Indian women who feel excluded by aspects of academic and business life in India.

Finland should promote itself through existing networks such as its embassies, but should also investigate establishing a Finnish Institute in India to build cultural links.

5.3 Network building

The next step after building greater cultural awareness between Finland and India is to develop networks between Finnish and Indian people.

The first route to developing medium- to long-term relationships is to promote Finnish education in India so that students from India come to Finland and spend time learning both academically and about the country and its people. In order to attract the best of Indian students, particularly at post-graduate level, to Finnish universities there is a great deal of work to do. Al-

though Finland has universities that are amongst the best in the world, their profile in India is almost non-existent. And even if their profile was higher, they would have to be able to demonstrate that they provide extra earning potential when the degree is finished, either in India or elsewhere.

This is a change of culture that will take a number of years, if not decades, to achieve. American universities, followed by the UK and then a number of other larger nations have a massive head start because they have a stream of high-profile examples of their universities dramatically increasing the earning potential of students. The alumni networks act as powerful recruitment campaigns, through family and friendship networks in India for new students ready to invest in their own futures because they know that the particular foreign university, whether it be Stanford or Oxford, will be respected and more likely to get them a highly paid job upon completion.

Another advantage that American or UK universities have is the ability of their labour markets to provide jobs for recent graduates so that foreign students can put their knowledge into practice and demonstrate that their skills are valuable in the economy.

To attract Indian students to the country, Finland must:

Promote Finnish universities in India. In an atmosphere of such international competition for Indian students, Finland should highlight certain advantages of its higher education system:

- The fact that courses are increasingly taught in English,
- The extremely high standards of Finnish education and the increased earning potential provided by Finnish degrees
- Funding bodies should also investigate 50:50 scholarships, where Finnish agencies provide half of any bursaries made available to Indian students on the condition that the other half is paid by an Indian donor. Perhaps the emerging business relationships between Indian and Finnish firms could provide a starting point for this type of arrangement.
- Finnish universities should develop a special welcome process for Indian students, perhaps in collaboration with Indian citizens already living in Finland.
- The government should allow and promote the possibility of a period of work in Finland for Indian students after postgraduate study in the

country. This has proved to be an important factor in the success of universities in the US and UK attracting Indian students.

Finland should develop its intelligence about India and make information more widely available to business people and policy makers so they can form new relationships of their own more successfully. Finland needs just as much intelligence and knowledge about Indian science and technology as it does about the United States.

In order to do this government bodies and public agencies (such as Sitra) should:

- Collate and make available information from publicly funded fact-finding trips to India
- Participate in future international research networks about India
- Undertake more research to inform Finnish business and policy-makers

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As we have noted throughout this report, the cadre of global Indians are an important force in innovation and building links between other countries and India. Finland should do more to attract these people both for short and more extended periods of time.

- Finland should develop expert exchange programmes between India and Finland. These should include university research and teaching staff and public policy makers.
- The Finnish government should encourage Finnish companies to hire outsiders at senior levels, particularly looking at the potential of hiring Indian employees at a senior level.
- Finnish agencies, universities and institutes should examine the potential of organising international conferences and events that appeal to Indian themes and extending travel bursaries to Indian delegates.
- Start-up opportunities should be promoted for Indian firms in Finland by Finnish agencies such as Tekes and Sitra, with the role of global Indians Particular noted.

5.4 Specific collaboration initiatives

As cultural understanding improves and networks are built between India and Finland around science, technology and innovation, specific collaborations will begin to emerge. It is impossible at this stage to predict or prescribe what these should be, but there is one principle that we were told during our fieldwork specific collaboration initiatives should uphold: initiatives that are funded 50:50 and based on equal collaboration have a higher chance of success. Indian science is a proud enterprise and any image of grants or support from Finland as being "aid" or "development funding" will be poorly received.

5.5 A virtuous circle

Finland's mid- to long-term future innovative capacity is dependent on choices made in the near future about its place in the world. The rise of India points to a change in the global balance of science. At the moment there is little doubt that the innovation balance of the second half of the twentieth century remains but it is shifting from Europe and North America to Asia.

Each of the three types of activity above reinforces the others and all are required for a successful, sustainable relationship between the two countries in science and technology. A supportive context where people have an understanding of one another's cultures leads to working relationships and conversations between people which in turn lead to formal and productive collaborations. In turn collaborations lead to greater cultural understanding and new networks being created around the edges of successful projects which may lead to yet further collaborations.

The ideal is to create a virtuous circle where government uses a light touch to begin processes but over time activities become second nature as both sides realise the benefits of collaboration and resource each of the three stages themselves.

Increasingly national innovation systems rely on an international innovation system that is beyond the control of national governments, individual transnational companies or other institutions. Successful innovation is a complex blend of knowledge, creativity and resources and the ways that those three things come together successfully is increasingly important. There is no magic formula for creating innovations, although many organisations and people have tried. None of the recommendations here will lead to breakthroughs on their own, but taken together as a set of balanced options we feel they can make innovation and value creation which benefits both India and Finland more likely.

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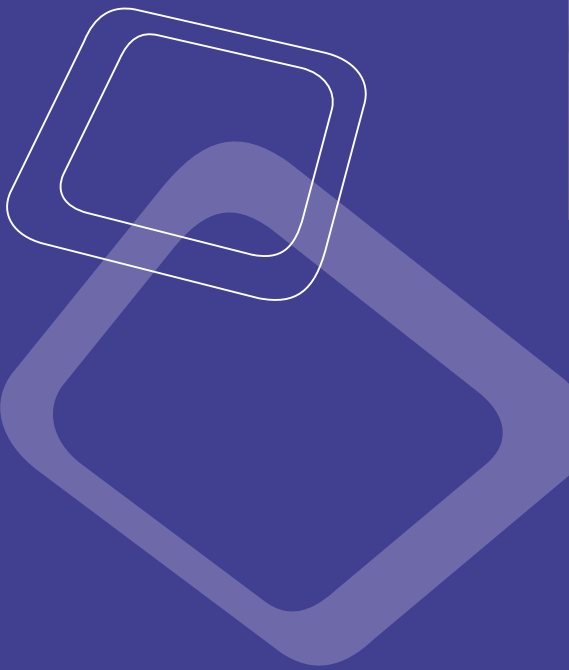
The past decade has seen the rapid rise of a new scientific and technological power – India. With a population of over a billion people who are rapidly becoming more educated and affluent, the country has attracted significant foreign investment and developed many home-grown companies that compete on a global stage.

Yet, apart from a few small pockets of activity, interaction between Finland and India is at a very low level. Culturally, economically and scientifically, prospects for cooperation between the two countries start from a very low base. This report by Sitra's India Programme argues that in order to thrive and maintain its innovative capacity in the future, Finland will need to develop new collaborative relationships with India.



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